Effects of flavor availability and modified risk messages on abuse liability of electronic cigarettes

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ABSTRACT

Introduction: There is limited evidence on the extent to which electronic cigarette (e-cigarette) flavors and messaging affect the likelihood of physical/psychological dependence, or “abuse liability.” An experiment using a behavioral economics-based approach was conducted to measure the abuse liability of e-cigarettes compared to conventional tobacco cigarettes (CTC) under various flavor and message conditions.

Methods: Two studies were conducted using 2x2 within-subjects factorial designs with factors of e-cigarette flavor (Study 1: tobacco vs. menthol flavor; Study 2: cherry vs. no flavor) and accompanying message (Study 1: reduced harm vs. no message; Study 2: reduced exposure to carcinogens vs. no message) with current CTC smokers (total N=36). Abuse liability was assessed for own brand (OB) CTC and across e-cigarette conditions. Outcomes included crossover point (relative monetary value of the product) from the multiple choice procedure (MCP) and breakpoint (price where consumption is zero) and demand elasticity (price sensitivity) from the cigarette purchase task (CPT). Linear mixed effects models were used to evaluate outcomes.

Results: In the MCP, all e-cigarette conditions except tobacco flavor (message and no message conditions) had significantly lower crossover points than OB CTC. Demand elasticity was significantly higher for menthol with no message and no flavor with reduced exposure message conditions relative to OB CTC.

Conclusions: The flavor of the e-cigarette liquid and the modified risk messages included with e-cigarette devices and components may affect the abuse liability of these products among individuals who smoke cigarettes, suggesting regulatory pathways to influence demand for both conventional and alternative tobacco products.
**IMPLICATIONS**

Our experiments add preliminary evidence that e-cigarettes have lower potential for abuse among current cigarette smokers naïve to e-cigarettes compared to the smokers’ own brand of cigarette. However, the flavor of the e-cigarette liquid and the modified risk messages included with e-cigarette devices and components may affect the abuse liability of these products among individuals who smoke cigarettes.
INTRODUCTION

Little is known about the effects of electronic cigarette (e-cigarette or electronic nicotine delivery device) flavor availability and product messaging in comparison to traditional, combustible tobacco cigarettes (CTC). In May 2016, the United States (US) Food and Drug Administration (FDA) Center for Tobacco Products deemed e-cigarettes to be under their regulatory authority. With this rule, the FDA banned use of modified risk message descriptors (“low,” “light,” “mild”) without a Modified Risk Tobacco Product (MRTP) designation and required warning labels but has not prohibited characterizing flavors in e-cigarettes. However, evidence is needed to understand the effects that future modified risk messages (i.e., as part of MRTP designation) and flavor availability might have on these products’ abuse liability, particularly among smokers. Abuse liability, or the degree to which a psychoactive drug or formulation would be used for nonmedical purposes and lead to physical/psychological dependence, is an important public health and policy outcome predicting likelihood of continued use of a drug or tobacco product.

E-cigarettes use liquid—generally containing nicotine, flavorings, propylene glycol, and glycerin—which is heated into an aerosol and inhaled. Part of their appeal is the variety of flavors. The literature reports up to 7764 different flavors, and flavor availability is a main factor cited by users as influencing continued e-cigarette use and intention to quit CTC. Menthol CTC smokers report more difficulty quitting than non-menthol CTC smokers, so flavor may play a role in CTC cessation. Menthol flavoring may also increase e-cigarettes’ appeal, particularly at high concentrations of nicotine. Further, young adult smokers respond more to e-cigarette flavor availability than do older smokers, suggesting a role for flavors in
attracting youth. However, aside from this work, there is a dearth of experimental research addressing how flavor affects consumer e-cigarette choices.

In addition to flavors, messaging may play a significant role in tobacco product choice. The FDA regulates the use of words like “light” or “mild” because of their suggestion of safety. One study revealed that e-cigarette advertisements emphasizing health-related differences (e.g., “healthier,” “helps to quit smoking”) between e-cigarettes and CTC produced the most desire in trying e-cigarettes among current CTC smokers. Interestingly, research on the relative reinforcing efficacy, or the behavior-strengthening or -maintaining property of a drug compared to another drug, of alternative tobacco products measured via behavioral economic tasks reported that advertisements have minimal effect on demand elasticity, or how demand for a product responds to changes in price. Taken together, these data suggest messaging associated with e-cigarettes may alter intention toward and use of e-cigarettes, but messaging effects on behavioral economic measures of abuse liability are unclear.

To date, experimental work has assessed behavioral economic indices of e-cigarette abuse liability broadly. The first published examination of e-cigarette abuse liability compared choices individuals would make between own brand CTC puffs and money, e-cigarette puffs and money, and e-cigarette puffs and own brand CTC puffs using a method called the multiple choice procedure (MCP). Results indicated that current CTC smokers were willing to forego more money for their own brand CTC puffs than for e-cigarette puffs and valued ten puffs of an e-cigarette at three own brand CTC puffs, suggesting lower abuse potential for e-cigarettes than own brand CTC. More recently, this design was partially replicated among current CTC smokers, and results were consistent with participants valuing own brand CTC higher than e-cigarettes. Another behavioral economic measure of abuse liability is the cigarette purchase
task (CPT), in which smokers are asked how many cigarettes they would smoke at a variety of incrementally increasing prices.\textsuperscript{5,19-21} From this measure, demand elasticity and other indices related to the relative value of the product can be calculated, where higher relative value indicates greater abuse liability. For example, evidence from MacKillop and colleagues using the CPT suggests that more nicotine-dependent smokers are less elastic and less likely to reduce their demand when cigarette price increases.\textsuperscript{19}

This paper presents evidence on the abuse liability of e-cigarettes and CTC from two studies that varied in e-cigarette flavor and accompanying message. Two behavioral economic methodologies were used to allow a robust understanding of e-cigarette abuse liability related to flavor and messages in a sample of current CTC smokers.

METHODS

Sample and Recruitment

From February 2015 to July 2016, participants were recruited through online advertisements, flyers, and word of mouth. Interested individuals completed an online or phone screening questionnaire determining initial eligibility, followed by an in-person screening to confirm eligibility and verify physiological measures (heart rate, blood pressure, pregnancy status, and carbon monoxide levels) and informed consent. Eligible individuals were scheduled for laboratory visits. Inclusion criteria included being 18-55 years old, smoking $\geq$5 cigarettes daily for $\geq$1 year, having a strong preference for either menthol or non-menthol cigarettes (i.e., smoke one type $\geq$80\% of the time), and self-identifying as African American or White. These latter design considerations allowed the study to 1) control for CTC menthol preference which may interact with the effects of menthol flavoring in EC liquid and 2) control for any racial/ethnic
differences that may interact with effects of menthol flavoring in EC liquid, an issue that arose in previous work concerning menthol and CTC behavior.\textsuperscript{10} Exclusion criteria included a history of regular e-cigarette use (i.e., weekly or more often for $\geq$1 month), desire to quit smoking in the next month, chronic medical or psychiatric conditions, current pregnancy or breastfeeding, current illicit drug use (other than cannabis), and having used cannabis or alcohol $\geq$20 of the past 30 days.

A total of n=1169 participants were prescreened, 169 were determined eligible, 88 were screened in-person and 62 were enrolled. Of the 62 enrolled, 44 completed Study 1 or Study 2. Our analytic sample consisted of 36 participants with complete data following a procedural change in the tasks, of whom 17 participated in Study 1 and 19 in Study 2. Across both studies, 27 (75.0\%) were male, 24 (66.7\%) were African American, and 28 (77.8\%) preferred menthol. On average, participants smoked 15.0 cigarettes per day (standard deviation = 6.4) and were 37.8 years old (standard deviation = 11.4 years). No significant differences were observed between studies on these demographic factors.

\textbf{Procedure}

The experiments included a baseline session followed by 2x2 within-subjects factorial design with factors of e-cigarette flavor (Study 1: tobacco vs. menthol flavor; Study 2: cherry vs. no flavor) and accompanying message (Study 1: reduced harm vs. no message; Study 2: reduced exposure to carcinogens vs. no message). Participants came into the lab for five sessions, each of which was preceded by 12 hours of nicotine/tobacco abstinence confirmed with expired air carbon monoxide levels ($\leq$10 parts per million). During the 4-hour baseline own brand CTC session, participants completed both the MCP and CPT for their own brand CTC as a baseline measure of abuse liability. Following own brand CTC assessment, participants sampled the two
e-cigarette liquid flavors consistent with their study design (approximately 20 puffs of each flavor; sampling order was counterbalanced across participants). The subsequent four 3-hour sessions assessed abuse liability for each of the four experimental conditions; condition order was determined with a Latin square. In each session, the CPT was completed first, followed by five consecutive trials of the MCP. Subjective questionnaires assessing perceptions of tobacco products presented were administered at the conclusion of each session. These items are not included in the current analysis.

**E-cigarette device and liquid flavor conditions**

The e-cigarette device used in all e-cigarette conditions was an eGo 3.3 V, 1000 mAh battery with a 1.5-Ohm, dual-coil, 510-style cartomizer\textsuperscript{22} loaded with 1 mL of e-cigarette liquid (70% propylene glycol/30% vegetable glycerin\textsuperscript{23}). The e-cigarette liquid flavor conditions assigned to participants included tobacco or menthol in Study 1 and cherry and no flavor in Study 2. Menthol was chosen because it is the only “characterizing” CTC flavor still available in the US marketplace. Cherry was chosen based on current e-cigarette market research suggesting among fruit flavors purchased from the top three e-cigarette brands, cherry is most popular.\textsuperscript{24} The unflavored liquid condition was chosen to test how any e-liquid flavor vs. no flavor impacts abuse liability. The nicotine concentration of all e-cigarette liquid was 36 mg/mL and was verified independently prior to use. This concentration, in the e-cigarettes used here after consuming 10 puffs, has been shown to approximate the plasma nicotine concentration after smoking an own brand CTC in current smokers naïve to e-cigarettes (average “boost” of 12.5 ng/mL\textsuperscript{25}).

**Message conditions**
The FDA’s Modified Risk Tobacco Products draft guidance indicates that the industry can apply for either a risk modification or exposure modification order, which directly applies to the potential messages evaluated here. In the message conditions, a card was presented showing either “No message,” or “Reduced harm relative to cigarettes,” in Study 1, or “No message,” or “Reduced exposure to carcinogens relative to cigarettes” in Study 2, following FDA’s definition of modified risk tobacco product marketing as that which communicates (in brief) 1) lower harm or 2) lower exposure to, or the absence of, unhealthy substances (see 26 for the complete definition).

Multiple Choice Procedure (MCP)

The MCP is a measure of abuse liability which asks participants to make choices between a dose of a drug—here, 10 puffs of an e-cigarette or their own brand of cigarettes—and various amounts of money (Figure 1). The values of money are $0.01, $0.02, $0.04, $0.08, $0.16, $0.32, $0.64, $1.28, $2.56, $3.84, $5.12, $6.40, $7.68, $8.96, and $10.24. Within each of the five sessions, participants completed five MCP trials. After each trial, one randomly chosen decision between money and tobacco product was reinforced. The participant would draw a number 1-15 from an opaque bag, where the number corresponded to one of the series of decisions participants made between the tobacco product and various amounts of money. Participants were given a 10-minute consumption period to receive money or consume the tobacco product, followed by a 20-minute rest period before the next MCP trial.

The last price at which participants chose tobacco product over money is the crossover point. This price was the primary outcome for analysis (Figure 1). This is a conservative measure in that it represents the lower bound of the maximum amount a participant would pay for a drug—that is, the largest dollar amount at which participants still chose the tobacco product
over the money. For example, if a participant chose puffs until they chose money at $1.28, their crossover point is the next lowest price, $0.64. This crossover point is compared across conditions to provide an estimate of the value of different products. Participants who preferred money at every point were assigned a crossover point of $0.00, which is lower than the lowest price in our task; participants who never reached a crossover point because they preferred puffs at every price had a crossover point of $10.24.

Cigarette Purchase Task (CPT)

The CPT also measures abuse liability by having participants respond with how many times they would consume 10 puffs of their own brand CTC or of an e-cigarette at incrementally increasing prices (Figure 1). The prices in the CPT were the same as in the MCP except the inclusion of $0.00. The CPT provides several measures of abuse liability. Breakpoint is the price at which participants would no longer consume the tobacco product being offered; this can be considered analogous to the MCP crossover point used here and was defined as the last price at which participants still chose any number of puffs before choosing zero puffs for all subsequent prices. Intensity is consumption at $0.00 \( Q_0 \), Omax is the maximum amount of money hypothetically spent on the tobacco product (e.g., the maximum of the price times the number of cigarettes consumed), and Pmax is the price associated with Omax. Finally, demand curves were fit to each individual’s consumption data across prices, the slope of which provided an estimate of demand elasticity \( \alpha \). The exponential demand equation relating consumption \( Q \) and price \( C \) is reproduced below:

\[
Q = Q_0 \times 10^k(e^{-\alpha Q_0 c^c-1})
\]

The span of the demand function in log units \( k \) was set at 4 to provide the best fit for demand curves.
To determine which participants’ data would produce valid demand curves, CPT data were excluded based on three criteria: 1) trend, or whether a participant showed a general increase in consumption from the first (lowest) to last (highest) price; 2) bounce, or whether a participant reported higher consumption at sequential higher prices; and 3) reversals from zero, or whether a participant reported zero consumption at two consecutive prices but then reported any consumption at a higher price.\textsuperscript{29} From Study 1, across conditions, 5 participants were excluded due to trend, one of whom also failed the bounce criterion; from Study 2, across conditions, 3 participants were excluded based on trend, one of whom also had a reversal from zero.

**Data Analysis**

Linear mixed effects models were estimated to compare abuse liability across own brand CTC and e-cigarette flavor and message conditions, after controlling for menthol vs. non-menthol own brand CTC preference and, in MCP regressions, for trial number (1-5). Pairwise differences between e-cigarette conditions were also tested using follow-up Wald tests for all MCP and CPT outcomes. A threshold of \( p<0.05 \) was used for all significance tests. CPT demand curves were produced using GraphPad PRISM 6 (GraphPad Software, La Jolla, California) and all other analyses were conducted in STATA 12 (StataCorp LP, College Station, Texas).

**RESULTS**

**Study 1**

Average MCP crossover point was significantly lower in both menthol e-cigarette conditions compared to own brand CTC (Figure 2, Panel A). Participants would pay, on average, $0.42 (95% confidence interval [CI] -$0.74, -$0.11) less for the menthol e-cigarette with no
message and $0.32 (95% CI -$0.64, -$0.01) less for the menthol e-cigarette with reduced harm message (Appendix 1). Neither tobacco e-cigarette condition average MCP crossover point was significantly different from own brand CTC; there were no significant pairwise differences between e-cigarette conditions.

There were no differences between own brand CTC and any e-cigarette conditions on most CPT outcomes (Table 1). Only the menthol with no message condition showed significantly higher demand elasticity compared to own brand CTC. Pairwise comparisons of e-cigarette demand elasticities revealed significant differences between the menthol with no message and tobacco with no message conditions ($p<0.02$), and between menthol with no message and menthol with reduced harm message conditions ($p<0.04$). Specifically, elasticities in the tobacco with no message and menthol with reduced harm message conditions were significantly lower, indicating participants were less willing to reduce their demand for these products when prices increased than in the menthol no message condition. The only other CPT measure with significant differences between own brand CTC and e-cigarette conditions was intensity. Here, participants reported wanting nearly 7 to 10 fewer 10-puff bouts with any e-cigarette compared to their own brand CTC when each product was offered for $0.00 ($ps<0.05$).

**Study 2**

Average MCP crossover point was lower in all conditions compared to own brand CTC (Figure 2, Panel B). Average differences ranged from approximately $1.00 lower in the no flavor with reduced exposure to carcinogens message condition (95% CI -$1.16, -$0.84) to approximately $0.73 lower in the cherry with reduced exposure to carcinogens message condition (95% CI -$0.90, -$0.57; see Table 1). Follow-up pairwise comparisons of condition regression coefficients revealed that, relative to the no flavor with reduced exposure to
cancerogens message condition, the average MCP crossover point was significantly higher in the cherry with no message and cherry with reduced exposure to carcinogens message conditions ($p<0.05$). Relative to the no flavor with no message condition, average MCP crossover point was significantly higher for cherry with reduced exposure to carcinogens message condition ($p<0.01$).

Only the no flavor with reduced exposure to carcinogens message condition showed a significantly different demand elasticity in the CPT relative to own brand CTC (Table 1). This finding suggests lower abuse liability of this e-cigarette flavor/message combination: small increases in price yielded larger decreases in consumption. Follow-up pairwise comparisons for demand elasticity indicated significantly higher estimates for the no flavor and reduced carcinogen exposure message relative to all other e-cigarette conditions ($p<0.05$). For intensity, all e-cigarette conditions showed lower consumption at $0.00$ compared to own brand CTC. When the product was hypothetically free, participants would have consumed between 5 and 9 fewer 10-puff e-cigarette bouts compared to own brand CTC ($p<0.05$).

**DISCUSSION**

These studies provide preliminary evidence that e-cigarette liquid flavor and modified risk messages may affect behavioral economics-based measures of abuse liability among current CTC smokers. Using the MCP, significantly lower crossover points were observed for most e-cigarette conditions compared to own brand CTC, regardless of flavor or message. The exception was the tobacco e-cigarette conditions, where average crossover points were not significantly different from own brand CTC. One might expect that menthol e-cigarettes would be closer in abuse liability to own brand CTC—that is, smokers would have valued them more highly—than
tobacco e-cigarettes, because most of our sample preferred menthol CTC, and similar flavors may make e-cigarettes more appealing. The pattern observed in Study 1 could be attributed to the tobacco-flavored e-cigarette being more similar in taste to CTC, while the menthol e-cigarette may not have matched the flavor profile of a menthol CTC as closely. Similarly, the specific brand of menthol flavor e-cigarette liquid used may not have been appealing, even to smokers who preferred menthol CTC. While the current analyses controlled for own brand CTC menthol vs. non-menthol preference, the coefficient for this variable was not significant, and results were not sensitive to excluding this variable, suggesting that own brand CTC flavor preference was not the driving factor in the lower abuse liability detected for the menthol e-cigarette conditions.

There were no significant differences in MCP crossover points when comparing only the tobacco and menthol e-cigarette conditions for Study 1, but when comparing the no flavor and cherry e-cigarette conditions for Study 2, cherry flavor increased abuse liability when the reduced exposure to carcinogens message was presented. This effect was replicated in the CPT measures of demand elasticity, but a similar effect was not found when comparing cherry flavor to no flavor in the absence of the message in either MCP or CPT. These results suggest a potentially important role for e-cigarette liquid flavor. The different flavors in the two studies could explain some of the discrepancies between studies; perhaps the difference in characterizing flavors between cherry flavor and no flavor is greater than the difference between tobacco flavor and menthol flavor, which are more familiar flavors for current CTC smokers. Regulators may want to consider how restricting flavor availability will affect EC and CTC use, given stark differences in the appeal various EC flavors appear to have among smokers.

Relative to own brand CTC, demand elasticity (assessed by the CPT) was significantly higher for the menthol with no message condition and no flavor with message condition. Follow-
up tests for Study 1 revealed that compared to a menthol e-cigarette with no message, *introducing a reduced harm message or restricting flavors to tobacco* increased abuse liability as measured by lower demand elasticity. However for Study 2, compared to an unflavored e-cigarette with a reduced carcinogens message, *introducing a modified risk message* decreased abuse liability as measured by a higher demand elasticity, while *introducing a cherry flavor* increased abuse liability as measured by a higher MCP crossover point. These results suggest tradeoffs in the abuse potential of e-cigarettes across combinations of flavors and modified risk messages.

The current findings highlight differences between behavioral economic tasks, despite conceptual similarities in the MCP and CPT. Notably, in the CPT, most of the e-cigarette conditions were not significantly different from the own brand CTC, despite large and significant differences between own brand CTC and e-cigarette conditions in the MCP. Several differences between the CPT and the MCP might contribute to this. First, in the MCP, after each trial participants are reinforced for one randomly drawn choice that they made, while the CPT does not provide reinforcement. This incentive-compatible design may have caused participants to reveal more accurately their demand for tobacco products in the MCP than CPT. Further, the MCP was administered after the CPT; the extra period of nicotine/tobacco abstinence before administration of the MCP may have affected demand for tobacco products in the MCP among this sample of CTC smokers. Third, the CPT may be conceptually more difficult for participants than the MCP. More participants from the CPT than the MCP were excluded due to nonsystematic data. Related to this issue, participants only completed one trial of the CPT per condition, but five MCP trials. The extra MCP trials may have allowed participants some practice, so their results may reflect greater understanding of the task. Finally, the difference in
time horizons between the tasks likely affected participants’ estimates of consumption: the MCP asks participants to make a choice to be immediately reinforced, while the CPT asks participants to report how much they would consume over an entire day.

Few studies have examined abuse liability of e-cigarettes compared to cigarettes among smokers. Two, using the MCP, found significantly higher abuse liability for CTC than for e-cigarettes. Our work corroborates this, adding that the lower abuse liability of e-cigarettes may be sensitive to flavors and modified risk messages. While we have not identified any studies that directly measure demand elasticity for e-cigarettes using the CPT, we note that our elasticity (alpha) estimates for own brand cigarettes are similar to those found in CPT studies of cigarettes. However, our study may not be entirely comparable to others due to how we defined breakpoint. Other studies define breakpoint as the first price at which demand is fully suppressed to zero, but to be comparable to our MCP, we defined breakpoint more conservatively as the last price at which participants still chose any amount of the tobacco product, immediately before consumption reached zero.

Beyond the CPT and MCP, one discrete choice experiment found that increasing the set of available flavors did increase selection of e-cigarettes over cigarettes or nicotine replacement therapy for young adults and those who have not used e-cigarettes in the past month, but not for older adults or past month e-cigarette users. Further, the presence of a modified risk warning label was not associated with differences in choice of e-cigarettes over other tobacco products.

Limitations

These were pilot studies and as such, sample sizes were small. However, crossover points for own brand CTC were similar between Study 1 and 2, as were demographic characteristics and sample sizes, allowing for comparisons between studies. Due to low enrollment, the
inclusion criteria was altered halfway through recruitment to include people who smoked at least 5, rather than 10, CTC per day. Results from this study may not generalize to other locations, to people of other races, to non-smokers, or to smokers with more e-cigarette experience. Further, the flavors chosen were not representative of the panoply of flavor choices available in the US market currently. In addition, as study recruitment spanned more than 1 year, e-cigarette liquids were reordered and replaced (nicotine levels re-confirmed) to ensure expired liquids were not used, and for the cherry flavor, the identical flavor combination originally ordered was unavailable from the vendor when ordering the second batch. A similar cherry flavor was used for 12 participants.

**Conclusions**

Taken together, our results contribute to an early corpus of literature pointing to both flavors and messages playing important roles in e-cigarette abuse liability among current CTC smokers; however, more evidence is warranted. The extent to which the vast array of potential combinations of flavor availability and modified risk messaging may interact to influence the abuse liability of e-cigarettes among smokers is so far unclear. As e-cigarette regulations move forward, it will be important to consider how these factors, among others (e.g., nicotine concentration), affect abuse liability. Both experimental and epidemiological investigations targeting both smokers and non-smokers will be required. Our study begins to provide empirical evidence that adult smokers value e-cigarettes less than their own brand of cigarettes, but that this pattern is sensitive to the presence of different flavors and messages about the relative harm of e-cigarettes.

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DECLARATION OF INTERESTS

The authors declare no conflicts of interest.

ACKNOWLEDGEMENTS

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23. AVAIL Vapor LLC. Richmond, Virginia, USA. https://www.availvapor.com/


Figure 1. Examples of Multiple Choice Procedure and Cigarette Purchase Task.

### Multiple Choice Procedure

For each choice below, please select whether you prefer 10 puffs of a menthol-flavored e-cigarette or to receive money. After you make your decision for each choice below, one choice will be drawn at random and you will either receive money or be given time to take 10 puffs of the menthol-flavored e-cigarette.

<table>
<thead>
<tr>
<th>Choice</th>
<th>Puffs</th>
<th>Receive Money</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10 puffs of a menthol-flavored e-cigarette</td>
<td>$0.01</td>
</tr>
<tr>
<td>2</td>
<td>10 puffs of a menthol-flavored e-cigarette</td>
<td>$0.02</td>
</tr>
<tr>
<td>3</td>
<td>10 puffs of a menthol-flavored e-cigarette</td>
<td>$0.04</td>
</tr>
<tr>
<td>13</td>
<td>10 puffs of a menthol-flavored e-cigarette</td>
<td>$7.68</td>
</tr>
<tr>
<td>14</td>
<td>10 puffs of a menthol-flavored e-cigarette</td>
<td>$8.96</td>
</tr>
<tr>
<td>15</td>
<td>10 puffs of a menthol-flavored e-cigarette</td>
<td>$10.24</td>
</tr>
</tbody>
</table>

### Cigarette Purchase Task

Imagine a TYPICAL DAY during which you smoke. The following questions ask how many times you would take 10 puffs of a menthol-flavored e-cigarette if they cost various amounts of money. The available e-cigarettes are menthol-flavored. Assume that you have the same income/savings that you have now and NO ACCESS to any cigarettes or nicotine products other than those offered at these prices. In addition, assume that you would consume puffs of an e-cigarette that you request on that day; that is, you cannot save or stockpile cigarettes for a later date. Please respond to these questions honestly. How many times would you take 10 puffs of a menthol-flavored e-cigarette if they were ____ each at the following prices?

<table>
<thead>
<tr>
<th>Price per 10 puffs</th>
<th>(Number of times you would take 10 puffs of a menthol-flavored e-cigarette)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0 (free)</td>
<td>____ (Number of times you would take 10 puffs of a menthol-flavored e-cigarette)</td>
</tr>
<tr>
<td>$0.01</td>
<td>____ (Number of times you would take 10 puffs of a menthol-flavored e-cigarette)</td>
</tr>
<tr>
<td>$0.02</td>
<td>____ (Number of times you would take 10 puffs of a menthol-flavored e-cigarette)</td>
</tr>
<tr>
<td>$0.04</td>
<td>____ (Number of times you would take 10 puffs of a menthol-flavored e-cigarette)</td>
</tr>
<tr>
<td>$7.68</td>
<td>____ (Number of times you would take 10 puffs of a menthol-flavored e-cigarette)</td>
</tr>
<tr>
<td>$8.96</td>
<td>____ (Number of times you would take 10 puffs of a menthol-flavored e-cigarette)</td>
</tr>
<tr>
<td>$10.24</td>
<td>____ (Number of times you would take 10 puffs of a menthol-flavored e-cigarette)</td>
</tr>
</tbody>
</table>
Figure 2. Multiple Choice Procedure Predicted Mean Crossover Points by Study and Condition.

Note: Crossover points reflect mean (+SEM) in US $ (United States dollars). Asterisks (*) indicate a significant difference relative to own brand CTC using linear mixed models adjusted for own brand CTC menthol/non-menthol preference and MCP trial (1-5) and brackets indicate a significant pairwise difference between those two e-cigarette conditions using Wald test ($p < 0.05$).
Table 1. Predicted Means for Multiple Choice Procedure and Cigarette Purchase Task Outcomes

<table>
<thead>
<tr>
<th>Measure</th>
<th>Multiple Choice Procedure</th>
<th>Cigarette Purchase Task</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Predicted mean (95% CI)</td>
<td>Predicted mean (95% CI)</td>
</tr>
<tr>
<td></td>
<td>Crossover point (US $)</td>
<td>Demand elasticity (alpha)</td>
</tr>
<tr>
<td>Study 1 Condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Own brand CTC</td>
<td>1.61 (0.88, 2.34)</td>
<td>0.01 (-0.06, 0.08)</td>
</tr>
<tr>
<td>Tobacco/No Message</td>
<td>1.32 (0.58, 2.05)</td>
<td>0.04 (-0.03, 0.11)*</td>
</tr>
<tr>
<td>Tobacco/Message</td>
<td>1.44 (0.71, 2.18)</td>
<td>0.06 (-0.01, 0.13)</td>
</tr>
<tr>
<td>Menthol/No Message</td>
<td>1.19 (0.45, 1.92)</td>
<td>0.13 (0.06, 0.20)**#</td>
</tr>
<tr>
<td>Menthol/Message</td>
<td>1.28 (0.55, 2.02)</td>
<td>0.05 (-0.02, 0.12)*#</td>
</tr>
<tr>
<td>Study 2 Condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Own brand CTC</td>
<td>1.47 (1.14, 1.81)</td>
<td>0.01 (-0.09, 0.11)</td>
</tr>
<tr>
<td>No flavor/No Message</td>
<td>0.55 (0.22, 0.89)^</td>
<td>0.03 (-0.07, 0.14)^</td>
</tr>
<tr>
<td>No flavor/Message</td>
<td>0.48 (0.14, 0.81)^*#</td>
<td>0.19 (0.09, 0.29)**^#</td>
</tr>
<tr>
<td>Cherry/No Message</td>
<td>0.67 (0.34, 1.01)^*</td>
<td>0.04 (-0.06, 0.14)^*</td>
</tr>
<tr>
<td>Cherry/Message</td>
<td>0.74 (0.40, 1.08)^*^</td>
<td>0.04 (-0.06, 0.14)^*</td>
</tr>
</tbody>
</table>

Note: **Bolded values** indicate a significant difference relative to own brand CTC determined using linear mixed effects models adjusted for own brand CTC menthol/non-menthol preference, and MCP estimates are also adjusted for trial (1-5) (p<0.05). Symbols (*, #, ^) indicate a significant pairwise difference between those two e-cigarette conditions using Wald test (p<0.05). No significant differences relative to own brand CTC or between e-cigarette conditions were observed for Omax, Pmax, or Breakpoint. Elasticity averages do not include those whose data were identified as non-systematic. US $ = United States dollars. CI = Confidence interval. Regression coefficients can be found in the Appendix.
### Appendix

Appendix Table 1. Adjusted Associations between E-cigarette Flavor and Message Conditions and Multiple Choice Procedure or Cigarette Purchase Task Measures.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Multiple Choice Procedure</th>
<th>Cigarette Purchase Task</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β (95% CI)</td>
<td>β (95% CI)</td>
</tr>
<tr>
<td>Crossover point (US $)</td>
<td>Demand elasticity (alpha)</td>
<td>Intensity (number of 10-puff bouts)</td>
</tr>
<tr>
<td><strong>Study 1 Condition</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Own brand CTC</td>
<td>referent</td>
<td>referent</td>
</tr>
<tr>
<td>Tobacco/No Message</td>
<td>-0.29 (-0.61, 0.03)</td>
<td>0.03 (-0.05, 0.11)</td>
</tr>
<tr>
<td>Tobacco/Message</td>
<td>-0.16 (-0.48, 0.15)</td>
<td>0.05 (-0.03, 0.12)</td>
</tr>
<tr>
<td>Menthol/No Message</td>
<td>-0.42 (-0.74, -0.11)</td>
<td>0.12* (0.04, 0.20)</td>
</tr>
<tr>
<td>Menthol/Message</td>
<td>-0.32 (-0.64, -0.01)</td>
<td>0.04 (-0.04, 0.12)</td>
</tr>
<tr>
<td><strong>Study 2 Condition</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Own brand CTC</td>
<td>referent</td>
<td>referent</td>
</tr>
<tr>
<td>No flavor/No Message</td>
<td>-0.92 (-1.08, -0.76)</td>
<td>0.02 (-0.12, 0.17)</td>
</tr>
<tr>
<td>No flavor/Message</td>
<td>-1.00 (-1.16, -0.84)</td>
<td>0.18 (0.03, 0.32)</td>
</tr>
<tr>
<td>Cherry/No Message</td>
<td>-0.80 (-0.96, -0.64)</td>
<td>0.03 (-0.12, 0.17)</td>
</tr>
<tr>
<td>Cherry/Message</td>
<td>-0.73 (-0.90, -0.57)</td>
<td>0.03 (-0.12, 0.18)</td>
</tr>
</tbody>
</table>

Note: **Bolded values** indicate a significant difference relative to own brand CTC determined using linear mixed effects models adjusted for own brand CTC menthol/non-menthol preference, and MCP estimates are also adjusted for trial (1-5) (*p*<0.05). Elasticity estimates do not include those whose data were identified as non-systematic. US $ = United States dollars. CI = confidence interval.