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The Experimental Tobacco Marketplace II: Substitutability and sex effects in dual electronic cigarette and conventional cigarette users

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ABSTRACT

Aim: The aim of the current study was to evaluate tobacco product purchasing in the Experimental: Tobacco Marketplace (ETM) among male and female smokers who also use e-cigarettes. We hypothesized a high substitution profile for e-cigarettes and that males would purchase more Snus than females.
Methods: The ETM is an online market used in clinical abuse liability research to mimic real-world purchasing patterns. Tobacco products, including each participant's usual choice of conventional and e-cigarettes, were presented along with a price and description of nicotine content. Participants were endowed with an account balance based on the number of cigarettes and e-cigarettes consumed per week. Each participant was exposed to four ETM sessions in random order during which the price of conventional cigarettes was manipulated.
Results: Cigarette consumption decreased as price increased. A mixed factor three-way ANOVA revealed a significant main effect of price (i.e., more alternative products were purchased at higher cigarette prices), product (i.e., more e-cigarettes were purchased than gum, lozenges, and Snus), and sex (i.e., males purchased more than females). A significant three-way interaction indicated that males purchased more e-cigarettes, Snus, and dip than females at higher cigarette prices.
Conclusion: This study suggests that the user profile of cigarette smokers is associated with behavioral economic measures of alternative product substitution and indicates that the evaluation of nicotine replacement products should be considered for both males and females separately.

1. Introduction

We are in a moment of profound change with the advent of numerous novel tobacco products and a high incidence of morbidity and mortality related to smoking (Jamal et al., 2015; United States Department of Health and Human Services, 2014; World Health Organization, 2011). The behavioral economic assessment of elasticity of demand (i.e., sensitivity to price) and the interaction of commodities as either substitutes, complements, or independents have provided an important framework representing the factors that govern tobacco consumption (Bickel et al., 1995). To explore those factors, we created the Experimental Tobacco Marketplace (ETM), an online store in which the researchers can manipulate price, product availability, and other variables of interest, in an experimental forum resembling the real-world marketplace (Epstein et al., 2012, 2010; Quisenberry et al., 2015).

A fundamental observation of behavioral economics is that the type and number of products in a marketplace can alter demand elasticity and the type and degree of interaction among products (Johnson et al., 2004; Quisenberry et al., 2015). As a result, the ability to achieve the tobacco control goals of reducing product consumption may be informed via the economic processes of substitution and complementarity (Bickel et al., 1995). Substitution defines one end of a continuum representing interactions between two commodities and is described as an increase in the consumption of a fixed-priced product (e.g., Coca-Cola®) while the cost of another commodity (e.g., Pepsi Cola®) is increased. At the other end, commodities function as complements, which refers to the decreased consumption of a fixed-priced product (e.g., soup crackers) in response to an increase in the price of another commodity (e.g., soup). Between these two extremes is independence, which occurs when changes in the price of one commodity (e.g., Coca-Cola®) have little or no effect on consumption of a fixed-priced commodity (e.g., soup crackers). Substitution, complementarity, and independence are measured by cross-price elasticity of demand.

Manipulating price to assess cross-price elasticity of demand using an alternate behavioral economic method of self-administration (Bickel et al., 1995; Johnson et al., 2004) is achieved by increasing the response cost required (i.e., number of plunger pulls). Using this method,

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Nicorette gum has been shown to function as a substitute (Shahan et al., 2000) when concurrently available with increasing price of cigarettes. An additional study that varied product availability revealed that Nicorette gum and denicotinized cigarettes functioned as a substitutes when each was available independently, but when both were available concurrently denicotinized cigarettes were a greater substitute than Nicorette gum (Johnson et al., 2004).

Product availability has also been shown to influence level of substitution using the ETM methodology (Quisenberry et al., 2015). A two-experiment study where the price of conventional cigarettes was manipulated found differences in the substitution profiles of alternative products when cigarillos were or were not available. In the presence of cigarillos, e-cigarettes and cigarillos were substitutes. However, when cigarillos were removed from the ETM, both e-cigarettes and Camel Snus® functioned as substitutes.

Just as important as the products available are the characteristics of the consumer. For example, e-cigarette substitution of factory made and roll your own cigarettes in New Zealand smokers differed such that consumers of roll your own cigarettes purchased more e-cigarettes than consumers of factory made cigarettes (Grace et al., 2015). With the popularity of e-cigarettes increasing, exploring substitution among different dual users is necessary.

Sex is another important consumer characteristic that influences consumption. Indeed, noticeable sex differences exist in tobacco product use. For example, 9% of females globally smoke cigarettes versus 40% of men (WHO, 2010). Among alternative tobacco products, sex differences exist such that Camel Snus® is more likely to be sampled by males in North America (Biener et al., 2014; Biener and Bogen, 2009) and Sweden (Norberg et al., 2011). In addition, evaluation of the reinforcing efficacy (i.e., the relative ability to maintain or change behavior) of Snus in a self-administration paradigm concluded that Snus administration was associated with decreased latency to smoke cigarettes in males, but not females (Barrett et al., 2011). Similarly, in a naturalistic demand assessment study, males were more likely to purchase Snus than females (Bickel et al., 2017; Stein et al., 2016).

The aim of the current study was to evaluate the reinforcing efficacy of conventional cigarettes and alternative tobacco products using the behavioral economic ETM. To this end, male and female dual conventional cigarette and e-cigarette users were exposed to the ETM and purchased products for potentially real use over the next week. We hypothesized that: (1) e-cigarettes would function as a strong substitute at high cigarette prices and (2) males would purchase Snus at a higher rate than females.

2. Materials and methods

2.1. Participants

Participants were recruited in the Roanoke, VA community via referrals, fliers, and Internet advertisements (i.e., Facebook and Craigslist) seeking electronic cigarette and cigarette smokers for research involving tobacco product purchasing and questionnaire completion. To participate in the study, participants must have met DSM IV (American Psychiatric Association, 2000) criteria for nicotine dependence, reported smoking between 10 and 40 cigarettes per day, smoked an e-cigarette in the last 30 days with the intention to continue, and provided a breath carbon monoxide (CO) level greater than 10 parts per million (ppm; Micro+ Smokerlyzer, coVita/Bedfont, Haddonfield, NJ). Individuals who were planning to move from the area prior to logistically being able to complete the study, individuals who reported unmanaged medical or psychiatric conditions or significant lung or heart conditions, and females who were pregnant or lactating were not eligible to participate. Participants who reported using nicotine products other than cigarettes or electronic cigarettes for more than 10 days out of the last 30 days were also ineligible to participate.

Twenty-two participants completed the study, however one participant's purchasing session was considered a pilot session. Thus, only 21 participants were included in data analysis. Of those 21 participants, 19% were African American (71% Caucasian and 9% reported other) and 52% were female. Based on the Timeline Follow Back (TLFB) (Sobell and Sobell, 1992), the mean number of cigarettes smoked per day was 18.94 (SD = 7.69) and was not different between females (M = 20, SD = 6.83) and males (M = 17.78, SD = 8.78) [t (19) = .034, p = .855]. The mean number of e-cigarette vaping episodes per day (M = 3.76, SD = 4.56) differed slightly, by sex (Females: M = 4.84, SD = 5.88; Males: M = 2.59, SD = 2.19) [t(19) = 1.14; p = .053]. The Fagerstrom's Test for Nicotine Dependence (Fagerstrom et al., 1996) (FTND) revealed a mean of 6.095 (SD = 2.12) and was not different between males (M = 29.80, SD = 8.89) and females (M = 38.09, SD = 10.19) [t(19) = 1.975, p = 0.063]. Median monthly household income for the sample was $721.00 (range $0–$5400; Females: median $1200; Males: median $721.00) and participants were, on average, 34.14 (SD = 10.27) years old. Age, education, account balance, remaining balance in actualized condition, and number of reported non-study products used at the follow-up session were not different between males and females (p's > .05). In addition, 42.9% of the sample were regular menthol-flavored cigarette users (78% female).

Alternative tobacco product use that did not render the participant ineligible to participate (see eligibility criteria) was minimal in the females sampled. Three females reported any use of alternative products (n = 3), which were all combustible tobacco products. Most males reported use of other products in the 30 days prior to participation (n = 8, 80%), both combustible (n = 3) and non-combustible (n = 3) products; two male participants reported limited use of both combustible and non-combustible alternative tobacco products.

2.2. Procedures

The Virginia Tech Institutional Review Board approved all procedures. Following an initial screening procedure to determine preliminary study eligibility via the telephone, participants visited the laboratory for two assessment visits. During the first visit, informed consent was obtained and smokers were then required to provide a breath CO level of 10 or greater to continue. After confirmation of smoking status, participants completed a set of computerized questionnaires including, the Questionnaire on Smoking Urges Brief (Cox et al., 2001) and the FTND (Fagerstrom et al., 1996). Participants were endowed with an account balance based on their reported consumption via the TLFB of one week's cigarette, electronic cigarette, and other tobacco product use. For example, if a participant smoked 280 cigarettes ($70.00 at market price of $0.25 per cigarette) and used 5 ml of Avail® Stargazer e-liquid per week ($4.00), their account balance would have been $74.00.

With their account balance, participants were asked to purchase nicotine products under 4 price conditions using the ETM (Quisenberry et al., 2015). In the ETM, the participant's usual brand of cigarette (price varied based on condition) and usual brand, type, and dose of electronic cigarette were available (price and mg content varied based on participant's usual choice). The following alternative products were available to participants in the units and at the prices (determined by local average price or in the case of internet purchases for electronic cigarette components, account balance was based on the internet price) indicated: their usual brand of cigarettes (packs, 19.6 mg of nicotine), winterchill flavor Camel Snus® (15-pouch tins, $2.89 each, R.J. Reynolds, Winston-Salem, NC, U.S.A., 27.75 mg of nicotine), classic flavor Skoal dip® (16.8-oz tins, $4.54 each, US Smokeless Tobacco Company, Richmond, VA, U.S.A., 62.4 mg of nicotine), white ice mint flavor Nicorette 4-mg nicotine gum® (20-count packages, $16 each, McNeil Consumer Healthcare, Fort Washington, PA, U.S.A., 80 mg of nicotine), and mint flavor Nicorette 4-mg nicotine lozenges® (20-count packages, $12 each, McNeil Consumer Healthcare, Fort Washington, PA, U.S.A.,