Original investigation

The Effect of Price on the Consumption of Reduced Nicotine Cigarettes

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Abstract

Background: Price affects the demand for cigarettes, indicating that smokers, perhaps especially lower income smokers, may choose low nicotine cigarettes (LNC) if they were commercially available and cost less than fully nicotine cigarettes. The present study tests the hypothesis that smokers will prefer purchasing LNCs at a lower price point than conventional cigarettes given a fixed budget.

Method: A laboratory-based, within-subject, 3 (nicotine level) × 3 (price) factorial design provided smokers opportunities to purchase standard (0.7 mg per mg tobacco), moderately reduced (0.3 mg), and very low-nicotine (0.03 mg). Spectrum research cigarettes according to an escalating price structure (low-nicotine costing the least, high-nicotine costing the most) given a fixed, laboratory-provided “income.” Participants were 20 overnight-abstinent smokers who previously smoked and rated each of the three cigarettes.

Results: Overall, smokers rated LNCs as less satisfying compared with standard nicotine cigarettes (SNC), $t(18) = -5.40$, $p < .001$. In the free-choice session, subjects were more likely to choose LNC that cost less compared with SNC that cost more, even after an 8-hour abstinence period, $F(2, 19) = 4.32$, $p = .03$. Those selecting LNC or moderate nicotine cigarettes after abstinence smoked more cigarettes per day, $t(17) = 2.40$, $p = .03$ and had higher dependence scores on the HONC, $t(18) = 2.21$, $p = .04$ than those selecting SNC.

Conclusion: The results indicate that smokers’ response to price points when purchasing cigarettes may extend to LNC if these were commercially available. Differential cigarette prices based on nicotine content may result in voluntary selection of less addicting products.

Implications: The Food and Drug Administration has proposed a rule that would reduce nicotine content in commercially available cigarettes. However, it is not known how smokers may respond in an environment where products of differing nicotine content and of differing prices are available. This study demonstrates that price may be an important factor that could lead smokers to select reduced nicotine products voluntarily, even if those products are rated as inferior or less satisfying.

Introduction

The Food and Drug Administration (FDA) recently issued an advance notice of proposed rulemaking to set a maximum nicotine

level for cigarettes below that contained in commercial cigarettes currently sold in the US marketplace. No specific level of nicotine has been proposed, but cigarettes with very low nicotine levels of about 0.5 mg nicotine/g of tobacco are under consideration. The

proposed rule requires determining the efficacy of reducing addiction to tobacco and the risks to smokers switching to lower nicotine products.¹ The general feasibility of progressively switching to reduced nicotine cigarettes (RNCs) was considered to be feasible by the American Medical Association and other authoritative groups.^{2,3} In practice, however, smokers may experience withdrawal symptoms from RNC and may supplement intake with other nicotine products. It is also possible that smokers may attempt to obtain fully nicotine cigarettes from a “black market” if RNC were the only products available commercially.⁴ Given that there are still a number of questions about how such a rule may be best enacted, and the possibility that such a rule may be challenged by the tobacco industry, the enactment of such a rule may not occur for many years. However, there may be potential solutions to increase the use of RNC outside of a policy-induced, industry-wide shift.

The taxation of tobacco products is an effective tobacco control measure for reducing consumption.^{5,6} It has also been shown that price sensitivity of individual smokers is related to their cigarette budget. This has led suggestions that smokers would preferentially choose RNCs at lower price points than conventional cigarettes. Federal excise taxes on tobacco products are based on public law, but setting the tax level for tobacco products based on their nicotine content⁷⁻⁹ rather than regulating the nicotine content is an alternative strategy to reduce cigarette consumption. Indeed, it is possible to use policies based on economic principals to leverage consumers downward sloping demand curve to shift their consumption to products that may be perceived as less desirable. Further, smoking patterns are not immune to the principles of economics,¹⁰ and higher prices on high nicotine cigarettes could lead smokers to seek lower-priced alternatives. From a public health standpoint, if smokers were voluntarily selecting RNC because of their lower price, the goals of the FDA nicotine reduction policy might be achieved if proposed rules on tobacco product standards for nicotine cannot be enacted. Specifically, if smokers selected RNC due to a lower price, corresponding levels of addiction may drop, which would make cessation more feasible for many smokers. Additionally, tobacco use among young people may be more influenced by price than adults.^{10,11} This would suggest that for youth, their relative lack of economic resources might require them to select lower priced less or nonaddicting tobacco products.

There are several economic principles that suggest smokers make select cigarettes based on price. The concept of price elasticity suggests that increasing or decreasing price affects changes demand for the product. For tobacco products, increased prices changes a range of smoking behaviors, including reducing initiation and the number of cigarettes per day and increasing interest in quitting; a price increase of 1% may reduce consumption by as much as 0.78%.¹² The economic principle of choosing normal versus inferior goods as a function of income has been demonstrated in smokers who often choose discounted cigarettes instead of their preferred premium brand when income is lower. Accordingly, smokers may choose to purchase cigarettes with varying but lower nicotine content than their usual cigarettes if they were commercially available, but the selection would depend upon income and the perceived value of the good in relation to its price where value is based on the cigarette nicotine content. In a study of preferred brand (“normal” good) and least-preferred brand (“inferior” good) of cigarettes, DeGrandpre et al.¹³ demonstrated that when experimenter-provided income was high, participants selected their preferred brand, even if it was more expensive. Conversely, participants voluntarily selected inferior

goods (least-preferred brand of cigarettes) when those products were less expensive and income was low. These findings highlight how tobacco products may serve as substitutes for one another; “inferior” goods (least preferred brand) may substitute for normal goods (preferred brand) when income is lower.¹³ Extending this principle to RNC, reduced nicotine products may be viewed as an “inferior good,” and smoker may voluntarily select these products if they were less expensive than full-nicotine “normal goods”¹⁴ when income is lower. Consideration of price and income may be especially applicable to today’s marketplace where the majority of smokers have lower income levels.

Whereas studies of normal and inferior good typically examine the impact of income on the selection of goods of differing prices, the current study determined the choice of tobacco products according to nicotine content in relation to experimental price when provided with a fixed income, thus isolating the effect of price independent of income. We further determined whether choosing a lower nicotine cigarette resulted in compensatory smoking since the potential benefits of RNCs in lowering addiction must be considered in relation to potential risks of increased toxin exposure.

Methods

Participants

Subjects were recruited from central Pennsylvania between 2015 and 2017. Eligibility criteria included ages 18–65, currently smoking a minimum of five cigarettes per day within the previous 30 days, and spoken English language. Exclusion criteria included the current use of nicotine replacement products at the time of the study, regularly smoking menthol cigarettes (to avoid a potential interaction of flavoring), intentions to quit smoking within the next 6 months, or any smoking-related illnesses. Female participants were excluded if they provided a positive pregnancy test at any point during the study.

Procedures

The study was a within-subject, 3 (nicotine level) × 3 (price) factorial design. Subjects attended five separate, 3-hour laboratory sessions as follows: (1) Exposure session: initial exposure to three separate Spectrum research cigarettes provided through the NIDA Drug-Supply program with varying nicotine content: (A) low nicotine (0.07 mg), (B) moderate nicotine (0.3 mg), and (C) standard nicotine (0.7 mg). Participants smoked several puffs of each cigarette in counterbalanced order and did not pay for puffs, (2) standard nicotine session: only standard nicotine cigarettes (SNCs) were available at a fixed cost with a fixed income, (3) Moderate nicotine session: only moderate nicotine cigarettes (MNC) were available at a fixed cost with a fixed income, (4) Low nicotine session: only low nicotine cigarettes (LNCs) were available at a fixed cost with a fixed income, (5) Free-choice session: standard-, moderate-, and low nicotine cigarettes were available according to an escalating price structure (low-nicotine costing the least per puff, high-nicotine costing the most per puff) on a fixed income. Sessions 2–4 were counterbalanced to reduce an order effect. Sessions 2–4 examined the effect of price on smoking behavior in the absence of alternative choices; that is, there were only cigarettes with one nicotine level available at a time. To create an environment that reflects the most naturalistic smoking patterns and decisions as possible in the lab setting, participants were not blinded to nicotine content, there were no restrictions on how frequently smokers made puff purchases, or how many puffs could be purchased at a time.

The current analyses are based on the free choice session. Before all laboratory sessions, subjects were abstinent from all nicotine products for a minimum of 8 hours, verified with a CO reading of >12 ppm using the Covita Micro+ Basic Smokerlyzer.¹⁵ Before laboratory session numbers 2 through 5, participants were provided with a \$5.00 “income” which they could use to purchase puffs of cigarettes during that session. They could continue to purchase puffs until their income had been exhausted; however, they could not leave the laboratory or use any other nicotine product until the completion of the full 3-hour session. On the free-choice day the pricing structure was based on nicotine content: LNC costs \$0.10 per puff, MNC cost \$0.25 per puff, and SNC cost \$0.50 per puff. These prices were the same as those used in sessions 2–4 where only one product was available per session. The price structure was calculated to be consistent with a previous study of price elasticity in relation to cigarette puff consumption of a SNC.¹⁴ In our study, the least preferred product (ie, LNC) cost one-fifth of the preferred product (ie, standard nicotine), and a typical smoker could not purchase a typical number of puffs per hour on a SNC product. That is, an average smoker consumes approximately one cigarette per hour with an average of between 6 and 12 puffs per cigarette. Thus, with the fixed income and the escalating price structure, a smoker could purchase no more than 10 total puff of a SNC across the 3-hour lab session. This design then would force the subject to make decisions regarding both cigarette type and puffing behavior. That is, participants knew they could only continue to smoke as long as they had “income” available to purchase puffs. Thus, they had to make decisions based on cost/nicotine content and alter smoking behaviors (eg, puff duration/volume) accordingly.

All subjects provided written consent and were compensated a total \$250 for completing the study (\$50 per session). All materials and protocols were approved by the Institutional Review Board of the Pennsylvania State University.

Assessments

Subjects provided demographic information and completed a series of computer-administered questionnaires on smoking behaviors including age at onset, cigarettes per day, and dependence using the Fagerstrom Test of Nicotine Dependence (FTND^{16,17}) and the Hooked on Nicotine Checklist (HONC¹⁸).

Cravings/Desire to Smoke

The desire to smoke was measured at the beginning, halfway, and at the end of each session, using the Questionnaire of Smoking

Urges—Brief (QSU-B¹⁹). The Modified Cigarette Evaluation Questionnaire (mCEQ²⁰) was administered at the end of all sessions to evaluate participant’s experience of the reinforcing effects of the cigarettes smoked during that session.

Smoking Behaviors

All cigarettes were smoked through a Smoking Puff Analyzer (SODIM SAS, Fleury-les-Aubrais, France) topography device that measures puff frequency, puff duration (seconds), and puff volume (mL).

Analytic Methods

Descriptive analyses were used as the primary approach to examine patterns of cigarette nicotine choice, smoke exposure, and satisfaction. Paired and independent samples *t*-tests, ANOVA and repeated-measures ANOVA analyses were conducted to examine within- and between-group differences and potential interactions. Repeated measures within-subjects analyses examined differences in puff topography across the session. Analyses were powered to assess an effect of $f = .30$ using repeated measures within factors designs. Power analyses suggested a sample size of 18 to achieve power of .80 with alpha of .05. We were not powered to detect differences by gender; initial *t*-test analyses on key variables show that there are no differences based on gender, therefore we used the full, pooled sample of participants. To correct for potential Type I error, we utilized false discovery rate²¹ methods and all *p*-values are false discovery rate corrected values.

Results

A total of 20 smokers (15 male) between the ages 21 and 46 ($M = 29.3$ years, $SD = 9.1$) were enrolled in the study and completed all sessions. Subjects had smoked on average for about 11 years. See Table 1 for all sample descriptive statistics and *t*-test by gender for key baseline variables.

Ratings of LNC, MNC, and SNC

In each session before the free-choice day, participants rated each cigarette smoked using the mCEQ. The mCEQ measures five dimension of nicotine dependence: (1) satisfaction, (2) psychological rewards, (3) aversion, (4) enjoyment, and (5) craving reduction. Across these sessions, participants rated LNC as significantly less satisfying than both MNC, $t(18) = -4.26, p < .001$ and SNC, $t(18) = -5.40, p < .001$. There were no significant differences between satisfaction for MNCs and SNCs or on ratings of any other dimensions of the mCEQ.

Table 1. Sample Characteristics of Cigarette Smokers Enrolled in a Study of Freely Choosing Cigarettes by Nicotine Content

	Male, N = 15		Female, N = 5		Total		t-Test	
	M	SD	M	SD	M	SD	t	p
Age	29.33	9.14	35.40	7.30	30.85	8.95	-1.34	.19
Age started smoking	17.87	4.64	17.80	3.70	17.85	4.33	-0.54	.59
Cigarettes per day	13.29	6.66	14.20	7.12	13.53	6.59	0.26	.79
FTND total score	3.93	2.63	3.20	2.28	3.75	2.51	0.45	.65
HONC total score	17.00	2.20	17.20	1.92	17.05	2.09	-0.18	.86
CO baseline	6.80	2.51	6.40	3.05	6.70	2.58	-0.73	.47
CO post session	12.87	6.50	15.40	7.83	13.50	6.73	-0.14	.89
	N	%	N	%	N	%		
Race/ethnicity								
Non-Hispanic white	10	66.7	5	100	15	75.0		
Asian/Indian	4	26.7	N/A	N/A	4	20.0		
Hispanic white	1	6.7	N/A	N/A	1	5.0		

Initial Puffing Purchases

On the free-choice day all study participants elected to purchase puffs in “clusters” (>1 puff purchased in rapid succession—like one would if they were smoking outside the laboratory) as opposed to purchasing single puffs. That is, participants could select to purchase puffs at any time or in any number; all elected to purchase two or more puffs sequentially rather than individual puffs (Table 2). Participants selecting LNC in the first purchasing opportunity took significantly more puff than those selecting either MNC or SNC, $F(2, 19) = 4.32$, $p = .03$ (Table 2). Those who selected LNC or MNC in the initial purchase cluster reported smoking significantly more cigarettes per day, $M = 14.8$, $SD = 7.8$, than those who selected SNC, $M = 10$, $SD = 1.4$, $t(17) = 2.30$, $p = .03$. Similarly, those who selected LNC and MNC in the initial purchase cluster reported higher levels of nicotine addiction as measured by the HONC, $M = 17.7$, $SD = 1.8$, than those who selected SNC, $M = 15$, $SD = 1.5$, $t(18) = 2.19$, $p = .04$. There was no difference between FTND scores based on nicotine content choice.

Second Puffing Purchase

Following the initial purchase, participants waited, on average, 63 minutes, $SD = 21.4$, before purchasing additional puffs. Those who initially selected LNC purchased a second cluster of puffs soonest, $M = 58.2$, $SD = 23.3$, followed by those who initially purchased SNC, $M = 60.5$, $SD = 21.3$. Those who purchased MNC in the initial purchase waited the longest before purchasing additional puffs, $M = 70.1$, $SD = 20.1$; however, these differences were not statistically significant. Two participants made no puff purchases after the initial purchase. From the initial purchase to the second purchase, 50% ($n = 9$) of the 18 participants who made purchases switched from a higher level of nicotine to a lower level, 11% ($n = 2$) switched to a higher level, and 39% ($n = 7$) chose the same level of nicotine (Figure 1). In the second purchase, participants again purchased puffs in “clusters” of at least four puffs, with an average of 6.4 puffs, $SD = 2.9$.

Third Puffing Purchase

A total of 14 participants made a third purchase of at least four puffs, with an average of 5.57 puffs, $SD = 2.1$. The six participants who choose not to smoke beyond the second purchase opportunity smoked an average of 9.7, $SD = 3.0$, cigarettes per day, and scored an average nicotine dependence rating of 16.2, $SD = 1.7$, on the HONC and 2.2, $SD = 1.60$, on the FTND; however, participants were not significantly different on these measures compared with those who continued to purchase puffs. Following the second purchase, participants waited, on average, 56 minutes, $SD = 20.4$, before purchasing additional puffs. Those who selected LNC in the second purchase cluster smoked soonest, $M = 52$ minutes, $SD = 22.4$, followed by those who purchased MNC in the second purchase cluster, $M = 57.5$ minutes, $SD = 20.3$; these differences were not significantly different. The single participant that chose SNC in the second purchase cluster waited 75 minutes before purchasing additional puffs. In the third purchase opportunity, 50% ($n = 7$) switched from a lower to a higher level of nicotine, 7% ($n = 1$) switched from a higher to a lower level of nicotine, and 43% ($n = 6$) did not switch. Those selecting LNC in the third purchase opportunity took significantly more puffs than those selecting either MNC or SNC, $F(2,12) = 9.62$, $p = .003$ (Table 2).

Subsequent Puffs

Only six participants made more than three purchases of puffs, with six making fourth purchase, and two making a fifth (Table 2).

Spending

Overall, 35% ($n = 7$) of the participants spent the entire researcher provided income of \$5.00 on purchasing puffs. Those who spent all of their money had higher average FTND scores, $M = 4.1$, $SD = 2.8$, and higher overall exposure (determined by summed total of puff volume across all puffs; $M = 1253.3$, $SD = 605.1$, however, these were differences were not statistically significant). Those selecting LNC spent significantly less money than those selecting MNC and SNC, $F(2, 19) = 14.39$, $p < .001$ in the first purchasing opportunity. By the third purchasing opportunity those who purchased LNC had significantly more money remaining than those who had selected MNC or SNC, $F(2, 12) = 9.8$, $p = .003$ (Table 2).

Total Puffing Behavior and Exposure by Nicotine Content

The total puff volume was calculated by summing the puff volume for each puff taken. The total amount of exposure to nicotine was calculated by multiplying total puff volume by the nicotine content. Findings, shown in Table 3, demonstrate that, across the full laboratory session, participants purchased significantly more puffs from LNC compared with both MNC and SNC, $F(2, 36) = 10.7$, $p < .001$. However, despite the difference in total puffs, there was no statistically significant difference in total puff volume or total puff duration. Consequently, there was no significant difference in total exposure to smoke. However, as expected, there was a significant difference in total exposure to nicotine by cigarette type, $F(2, 36) = 37.30$, $p < .001$ (Table 3).

Puffing Across Laboratory Session

Repeated measures ANOVA determined that those selecting LNC in their initial puffing session after abstinence had significantly longer average puff duration across the 3-hour session, regardless of their subsequent nicotine selections, compared with both those MNC and SNC, $F(3, 1.5) = 8.4$, $p = .003$. There were no significant differences in either puff number, $F(3, 63) = .31$, $p = .82$, or puff volume, $F(3, 171) = .92$, $p = .46$.

Discussion

It is well established that smokers respond to price when purchasing cigarettes.²² Many smokers choose to smoke discount-brand cigarettes or purchase loose tobacco for rolling their own cigarettes because these products cost less than name-brand cigarettes.²³ The current study determined whether smokers are willing to pay a

Figure 1. Frequency of nicotine choice by puff purchase cluster.

Table 2. Summary of Purchasing Data and Smoking Behavior

	Low	Moderate	Regular	
Initial purchase				
N	6	10	4	
Puff number	7.00 (2.70) ^a	5.20 (1.29)	3.75 (0.96) ^b	$F(2, 19) = 4.32, p = .03$
Puff duration	3.08 (0.83)	2.94 (0.78)	4.08 (0.99)	$F(2, 18) = 2.22, p = .14$
Puff volume	69.82 (26.6)	70.84 (27.5)	75.70 (17.26)	$F(2, 18) = 0.05, p = .94$
Exposure	444.85 (90.5)	360.46 (133.3)	253.24 (73.3)	$F(2, 18) = 2.85, p = .09$
Money remaining	4.35 (0.32) ^{a,c}	3.67 (0.33) ^{a,b}	3.12 (0.47) ^{b,c}	$F(2, 19) = 14.39, p = .000$
Second purchase				
N	11	6	1	
Puff number	7.64 (3.17)	4.67 (0.816)	4.00	$F(2, 17) = 2.92, p = .08$
Puff duration	2.76 (0.82)	3.01 (4.52)	4.08	$F(2, 17) = 1.61, p = .23$
Puff volume	67.03 (26.71)	73.06 (19.0)	72.43	$F(2, 17) = 0.127, p = .88$
Exposure	482.41 (204.9)	345.20 (122.0)	289.71	$F(2, 17) = 1.41, p = .28$
Money remaining	2.95 (0.78)	2.44 (0.82)	1.50	$F(2, 17) = 2.03, p = .17$
Time between	71:27 (23:51)	52:29 (11:49)	51:00	$F(2, 17) = 1.85, p = .19$
1st and 2nd puff purchase				
Third purchase				
N	4	4	7	
Puff number	8.0 (2.44) ^{a,c}	5.25 (.96) ^b	4.29 (.49) ^b	$F(2, 14) = 9.62, p = .003$
Puff duration	3.21 (0.42)	3.31 (0.39)	2.90 (0.98)	$F(2, 14) = 0.45, p = .65$
Puff volume	66.58 (26.83)	74.99 (12.74)	85.75 (36.54)	$F(2, 14) = 0.550, p = .59$
Exposure	498.24 (165.7)	393.10 (92.9)	369.26 (159.8)	$F(2, 14) = 1.01, p = .394$
Money remaining	2.60 (0.68) ^{a,c}	0.67 (1.04) ^b	0.61 (0.61) ^b	$F(2, 14) = 9.79, p = .003$
Time between	39:44 (15:30) ^c	80:20 (7:34) ^b	57:42 (19:21)	$F(2, 14) = 6.34, p = .013$
2nd and 3rd puff purchase				
Fourth purchase				
N	3	3	0	
Puff number	5.33 (.57)	4.67 (.57)	N/A	$t(4) = 1.41, p = .230$
Puff duration	3.26 (.34)	3.49 (.40)	N/A	$t(4) = -1.757, p = .491$
Puff volume	90.02 (22.86)	85.78 (8.81)	N/A	$t(4) = 1.300, p = .779$
Exposure	485.45 (158.9)	398.04 (40.9)	N/A	$t(4) = 1.177, p = .409$
Money remaining	1.71 (1.27)	.83 (.76)	N/A	$t(4) = 1.029, p = .361$
Time between	38:00 (8:39)	49:40 (9:42)	N/A	$t(4) = 1.554, p = .195$
3rd and 4th puff purchase				
Fifth purchase				
N	1	1	0	
Puff number	4.00	4.00	N/A	
Puff duration	2.92	3.74	N/A	
Puff volume	111.40	103.33	N/A	
Exposure	445.60	413.32	N/A	
Time between	40:00	35:00	N/A	
4th and 5th puff purchase				

Time = (minutes: seconds).

^aSignificantly different from regular nicotine cigarettes.^bSignificantly different from low nicotine cigarettes.^cSignificantly different from moderate nicotine cigarettes.

premium price for higher levels of nicotine, or whether they are willing to smoke an inferior product (eg, lower nicotine cigarettes) to realize cost-savings given economic limits in purchasing cigarettes.

The findings indicate that given a choice of cigarettes with a range of nicotine content and a fixed amount of money to purchase puffs, smokers more often selected least preferred cigarettes that cost less compared with more highly nicotine cigarettes that cost more. The results occurred under experimental conditions of smoking abstinence for 8 hours verified by expired CO measurements. It might be expected that the choice of LNC would lead to compensatory smoking behaviors; however, our findings showed that whereas subjects selecting LNCs purchased more puffs, they took puffs that were of lower duration than those selecting SNCs, although these

differences were not significant. However, in a recent laboratory-based study of smoking topography among smokers with schizophrenia versus controls who switched from smoking their usual brand to smoking very low nicotine cigarettes, all smokers consistently took fewer puffs of the VLNC cigarettes. Although puff duration increased, total puff volume decreased.²⁴ These studies differ from earlier laboratory studies that involved switching from conventional cigarettes with varying high nicotine yields where switching to relatively lower nicotine cigarettes resulted in increased smoke intake.²⁵ The current results indicate that behavioral economics affects the choice of nicotine yields and consequently certain puffing behaviors. Under a scenario in which both fully nicotine cigarettes and RNCs are available in the marketplace, smokers may often prefer

Table 3. Total Puffing Behavior by Nicotine Type

	Low nicotine puff clusters (N = 13)	Moderate nicotine puff clusters (N = 16)	Regular nicotine puff clusters (N = 8)	ANOVA
	M (SD)	M (SD)	M (SD)	
Puff number	7.28 (2.56) ^{a,b}	4.98 (1.08) ^c	4.17 (0.50) ^c	$F(2, 36) = 10.73, p < .000$
Puff duration	2.86 (0.82)	3.01 (0.68)	3.22 (0.99)	$F(2, 36) = .504, p = .609$
Puff volume	66.06 (26.30)	71.27 (23.57)	84.62 (34.28)	$F(2, 36) = 1.19, p = .317$
Total puff volume	452.96 (171.7)	349.63 (115.11)	347.75 (154.41)	$F(2, 36) = 2.15, p = .132$
Total nicotine exposure	31.71 (12.01) ^{a,b}	104.89 (34.53) ^{b,c}	243.42 (108.1) ^{a,c}	$F(2, 36) = 37.30, p < .000$

^aSignificantly different from moderate puff clusters.

^bSignificantly different from regular puff clusters.

^cSignificantly different from low puff clusters.

the lower cost, RNCs without significant compensation in puffing behavior. Our calculations showed that estimated total nicotine exposure was significantly lower in the low nicotine group than the usual standard nicotine group. The medium nicotine group also was exposed to significantly lower levels of nicotine. The nicotine content of a cigarette is a proxy measure of biological exposure.

These results are supportive of a tax policy that favors RNCs. Of course, there are many other considerations that need to be made when considering policies that result in smokers changing their tobacco products. For example, lower nicotine cigarettes may be perceived to be of lower health risk,²⁶ and educational efforts will be needed to inform smokers that their nicotine intake will possibly be lowered which may lower their dependence or facilitate quitting, but the health risks from continuing to smoke will continue to be elevated. By providing a fixed income, study examined the independent effect of product price. Future studies may be able to further examine factors associated with product selection by varying income in an experimental setting. Furthermore, it is important to note that taxation of tobacco products is not within the regulatory scope of the FDA. Therefore, FDA regulatory policy on nicotine content would require a close collaboration with federal, state, and local legislative bodies to devise the optimal pricing strategies for conventional and reduced nicotine cigarettes to shift consumer purchasing, while also working against industry cross-pricing strategies to maximize their own profits and retain customers. It is worth considering that instead of purchasing only lower priced tobacco products, smokers could use money saved on RNC to purchase conventional cigarettes, e-cigarettes, or other higher nicotine products which could serve to supplement lower nicotine products.

Interestingly, those who selected lower nicotine cigarettes in their initial purchase had higher levels of addiction as measured by the HONC and smoked more cigarettes per day than those who selected SNCs. It is possible that those who are more addicted or who smoke more cigarettes per day made specific economic decisions that helped ensured they would not run out of cigarettes during the lab session, regardless of the quality of the cigarettes they were purchasing. This may suggest that product choice may be based on factors other than nicotine content alone. This effect is similar to the effect of income on the selection of normal versus inferior goods. For example, Bickel and Madden provided smokers with two brands of cigarettes of equal nicotine strength, one a preferred brand and one a disliked brand. When puffs of the disliked brand cost substantially less, smokers were more likely to purchase the disliked brand; however, when income was increased, smokers purchased more of preferred

brand.¹⁰ Although the present study did not vary income, it did vary the percentage of income that must be spent on more preferred products. Given the limitations of the fixed income, participants could buy 10 SNC puffs, 20 MNC puffs, 50 LNC puffs, or a combination of the 3 over the 3 hour session. As one cigarette typically consists of 6–12 puffs, if subjects spent all their money on a single type of cigarette this would represent one SNC cigarette, one-and-a-half to two MNC cigarettes, or five LNC cigarettes in 3 hours. Thus, as smokers typically have one cigarette per hour, it makes sense that smokers may want to evenly space smoking over a 3-hour period to avoid withdrawal, and may choose lower nicotine cigarettes to do this. As higher dependence means greater likelihood of experiencing withdrawal, it is logical that the most addicted smokers would be the most vigilant in evenly spacing out their smoking to maintain stable nicotine levels and avoid withdrawal.

The limitations of the current study include an experimental condition that includes only cigarettes, only nonmentholated cigarettes, and smokers who were only moderately nicotine dependent. Future studies in the behavioral economics of tobacco use might include other products, especially among young smokers who are more likely to choose them, or combination of products as recent trials of LNC smokers studies show that many smokers had difficulty in quitting. Future studies can increase power and the ability to determine differences by recruiting a larger, more diverse sample. Despite these limitations, this study represents a first critical step in understanding how price may be an effective tool in promoting the voluntary use of RNCs.

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Declaration of Interests

None declared.

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