Nicotine & Tobacco Research, 2015, 1–8
doi:10.1093/ntr/ntv007
Original investigation

OXFORD

Original investigation

Assessing Constituent Levels in Smokeless Tobacco Products: A New Approach to Engaging and Educating the Public

Eugene Borgida PhD[1], Barbara Loken PhD[2], Allison L. Williams BA[1], Joseph Vitriol MA[1], Irina Stepanov PhD[3], Dorothy Hatsukami PhD[4]

[1]Department of Psychology, University of Minnesota-Twin Cities, Minneapolis, MN; [2]Department of Marketing, Carlson School of Management, University of Minnesota-Twin Cities, Minneapolis, MN; [3]Division of Environmental Health Sciences, University of Minnesota-Twin Cities, Minneapolis, MN; [4]Department of Psychiatry, School of Medicine, University of Minnesota-Twin Cities, Minneapolis, MN

Corresponding Author: Eugene Borgida, PhD, Department of Psychology, 75 East River Road, University of Minnesota, Minneapolis, MN 55455, USA. Telephone: 612-625-3381; Fax: 612-626-2079; E-mail: borgi001@umn.edu

Abstract

Introduction: Providing accurate information about the constituents in nicotine-containing products may help tobacco users make informed decisions about product choices. An experimental study examined a novel approach for presenting accurate constituent information about brands and types of smokeless tobacco (SLT) that could be understood by the general public.
Methods: Participants were recruited through Amazon's Mechanical Turk and presented information online about 2 constituent dimensions of SLT products—nicotine and/or toxicity (for simplicity, "toxicity" in this study refers to carcinogenic constituents) Participants completed measures of knowledge and tobacco health risks at 2 time points: before and after exposure to constituent information.
Results: Participants were found to increase their knowledge that toxicity contributes to disease risk and nicotine contributes to addiction, that SLT products vary in their levels of nicotine and toxicity, and that both SLT and cigarette products have higher toxicity than medicinal nicotine replacement therapies (e.g., nicotine lozenges). Study results showed no differences when presenting toxicity information alone versus presenting it in conjunction with nicotine information, and found no misperceptions or confusions about the relative harmfulness of cigarettes, SLT, or nicotine replacement therapy.
Conclusions: Providing tobacco constituent information to smokers and nonsmokers will improve their knowledge about the relative toxicity across products and variations within a class of tobacco products without compromising the health risks associated with tobacco use.

Introduction

All tobacco products come with health risks, and these risks vary depending on the product, with combustible products presenting the greatest risk.[1] Yet both youth and adults, and even medical and tobacco control professionals, have misperceptions about the relative harm of various tobacco products. People lack an understanding about the health risks of smokeless products (SLT).[2] Furthermore, many believe that cigarette smoking is about equally as harmful as using smokeless tobacco products.[3–5] In addition, many smokers have misperceptions about nicotine replacement therapies (NRTs), believing they are as harmful as cigarettes or that nicotine alone causes cancer and heart attacks.[6–9]

Given the recent reporting requirements by tobacco companies of nicotine and harmful and potentially harmful constituent (HPHC) levels of their products, as specified by the Family Smoking Prevention and Tobacco Control Act of 2009, the FDA and health professionals are uncertain about the best ways to educate people about these levels. The evolution of smokeless tobacco products in the marketplace, the lack of reduction over time in levels of carcinogenic tobacco-specific nitrosamines (TSNA) in popular brands,[10] the high variability in TSNA across brands,[11] and the rapidly changing consumer environment, call for a need to determine effective strategies for keeping the public informed about constituent levels in specific brands and types that would not result in misperceptions about the harmfulness of tobacco products (as required by Section 904(d)(1) of the Feeral Food, Drug, and Cosmetic Act).

Research that seeks to educate people about the harmful constituents in noncombustible tobacco products is encouraging but sparse.[2,3,12] Borland et al.[13] provided smokers with a fact sheet about the harmfulness of SLT and NRT relative to cigarettes; 1 week later, knowledge increased and smokers reported more interest in SLT (and to a lesser extent NRT), but misperceptions about the relative harm from SLT and NRT were still common. Biener, Bogen, and Connolly[2] found that adult smokers increased their perceptions of health risks associated with two brands of heated tobacco products (Eclipse and Advance) after receiving constituent information about them. Biener and colleagues[12] found that tobacco control professionals can improve their knowledge about TSNA and nicotine in tobacco products using health education materials. However, what is also needed are techniques that do not require extensive training and that provide the broader public with engaging formats that educate but do not confuse consumers about the constituents in a variety of brands and types of SLT products. The objective of our study was to develop and test a format for educating the public about nicotine and carcinogenic TSNA content in SLT. Nicotine is the major known addictive constituent in tobacco products.[14,15] TSNA represent a major group of abundant and potent carcinogens in smokeless tobacco, with the two carcinogenic TSNA, *N′*-nitrosonornicotine (NNN) and 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone (NNK), inducing cancers that are most strongly associated with smokeless tobacco use, such as oral, esophageal, and pancreatic cancers.[16,17] Nicotine, NNN, and NNK are included in the HPHC list and thus are among the constituents that will have to be disclosed by FDA to the general public.[18] In this study, the TSNA content (the sum of NNN and NNK) was termed "toxicity" to simplify our tested format and to minimize potential confusion of our study participants over a more complex term such as "carcinogenicity." Specifically, our objective was to increase people's basic understanding that: (a) brands and types of smokeless tobacco products differ from one another in nicotine content and toxicity; (b) nicotine contributes to addiction and toxicity contributes to disease risk; and (c) both smokeless and combustible products have higher toxicity than medicinal nicotine delivery products such as nicotine lozenges. We also investigated whether our developed format avoids creating additional misperceptions or confusions about the relative harmfulness of cigarettes, SLT, and NRT.

Increasing accuracy about perceptions of relative harm is important not only for SLT users, but also for cigarette smokers and non-tobacco users. To this end, we included cigarette smoking status (cigarette smoker or not) as a factor in our research design. Accurate understanding among smokers about the relative harm of smoking cigarettes compared to other nicotine-containing products may aid in improving the efficacy of quit attempts or disease risk-reduction outcomes. Educating nonsmokers may also benefit consumer awareness since nonsmokers represent an audience of people who may communicate with family and friends, including youth, about tobacco. Educational formats should also not produce unwanted inferences, for example, that smokeless tobacco products are construed as a safe alternative to cigarettes or that smokeless tobacco products might increase[19] or decrease smoking initiation among nonsmokers and especially among youth.[20,21] In addition, the benefits of examining smoking status derive from prior research findings that smoking has been linked to individual self-identity. This variable should be linked to people's motivation to attend to tobacco warning information and may be a psychological filter through which health information is received and evaluated. Cigarette smokers have (in many instances) invested in a lifestyle that includes tobacco products, so, consistent with prior research on selective exposure,[22,23] smokers may be less willing than nonsmokers to expose themselves to information on health and tobacco constituents that squarely challenges the wisdom of their smoking behavior.

Method

The research described here uses a professionally designed and visually appealing poster presentation of a gradient of representative brands and types of smokeless tobacco products. In the poster, nicotine content was abbreviated as "NIC" and carcinogenic TSNA content—the sum of NNN and NNK—was abbreviated as "TOX." As mentioned in the introduction, the term "toxicity" was used in this study in reference to TSNA content for simplicity. For consistency purposes, we will refer to TSNA content as "toxicity" in this manuscript. Ten brands and types of smokeless tobacco products were included (Figures 1 and 2), ordered in toxicity and/or nicotine content from lowest (at the bottom of the scale to highest (at the top). The effectiveness of these formats was examined in an experiment using an online heterogeneous sample of adults.

Tobacco Analysis and Poster Development

Tobacco Analysis

Smokeless tobacco products used in the development of the scale were purchased in 2010 and 2011 as a part of various projects. Chemical analyses were performed according to standard validated procedures routinely used in our laboratory.[11,24] Nicotine was analyzed by gas chromatography—mass spectrometry—selected ion monitoring. The Henderson–Hasselbalch equation was used to calculate free (unprotonated) nicotine content, based on the measured total nicotine and product pH (11). The levels of free nicotine were chosen for the scale development because the pH-driven content of the biologically available free nicotine has been shown to vary significantly across SLT products[25] and contribute to product addictiveness.[26–28] NNN and NNK were analyzed by gas chromatography interfaced with a thermal energy analyzer.[11] The scale was developed based on the levels of nicotine and TSNA (the sum of NNN and NNK) in 96 samples from 13 types and brands of smokeless tobacco products available on the U.S. market in 2012. These samples came from both the popular conventional products and the newer spitless tobacco or snus, and presented a wide range of free nicotine and TSNA content. NNN and NNK were chosen to represent toxicity of SLT products because they are among the constituents that will be reported by tobacco companies to FDA and have been classified as human carcinogens by the International Agency for Research on Cancer.[17] All analyses were performed in the same laboratory by standard validated methods and with inclusion of quality controls.[11]

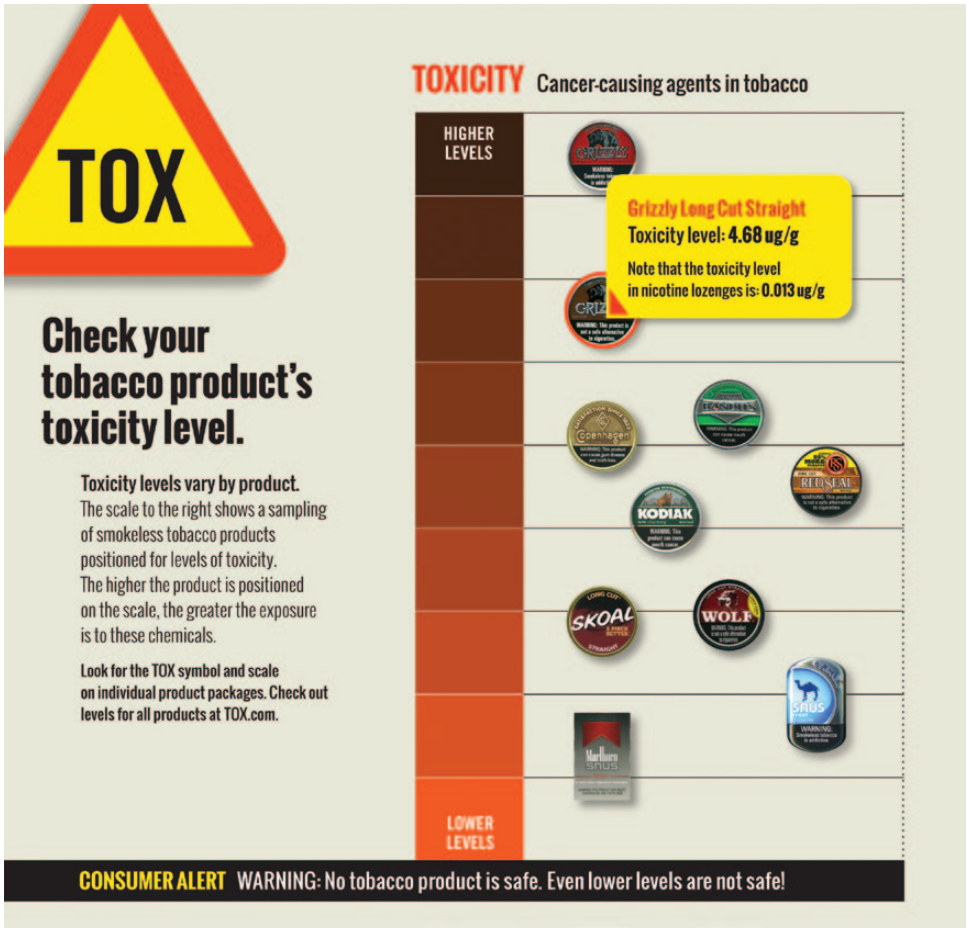

Figure 1. Informational poster presented to participants in the nicotine content condition.

Constituent Scale and Poster Format

The results of product analyses were used to produce the scale that represents the gradient of constituent levels in SLT. To construct the scale, the average and *SD* were calculated for each constituent and the obtained values were used to build the scale, with the average value corresponding to the center of the scale and each section being equal to ½ *SD*. This scale was used as the basis for poster development

The poster information in the present research was developed for online use, but is potentially adaptable to a number of contexts, including other online formats and point-of-purchase displays. The online procedure allowed respondents to scroll over the various products shown, and, by moving a computer mouse over a particular brand icon (the mouseover timing and count data was collected using javascript coding embedded in the web survey), read an informational pop-up containing that product's actual nicotine levels (in the NIC/TOX condition) and toxicity levels (in both NIC/TOX and TOX conditions). A comparative figure for nicotine lozenges, a commonly-known NRT, was also shown on each pop-up.

Sample, Design and Measures

Sample and Measures

Participants were recruited online at two time points through Amazon's Mechanical Turk. Time 1 (T1) included a "lifestyle" survey with items on eating, physical activity, tobacco, and demographics; it also included cigarette smoker-nonsmoker identity measures (see Supplementary Materials for the first survey posted on-line). Three days later, at time 2 (T2), the same respondents were shown the poster presentation followed by survey measures specific to tobacco (see Supplementary Materials for the second survey posted on-line). Smoking status, measured at T1, was defined as whether the respondent had smoked a cigarette in the prior 30 days (yes or no).

A high proportion (82.7%) of respondents completed both surveys; those who did not were dropped from subsequent analyses, with a resulting sample size of 397. The final sample included 213 women and 183 men (one participant declined to indicate his or her gender) with a mean age of 34.07 years (*SD* = 12.01). A majority of respondents (*N* = 351) identified as Caucasian, while 22 identified as Black or African American, 20 as Asian, and 16 as Hispanic or Latino. The final sample also included 73 cigarette smokers and 324 nonsmokers. Only a small number of SLT users appeared in both smoker and nonsmoker groups (*n*s = 3 and 6, respectively) and no data analyses were affected by their inclusion. As a result this study did not include smokeless users as a third group and instead examined how cigarette smokers rather than smokeless tobacco users responded to the information on the posters. Individuals who dropped out at T2 included 29 cigarette smokers and 54 nonsmokers, which represented a higher rate of cigarette smokers than found in the remaining sample.

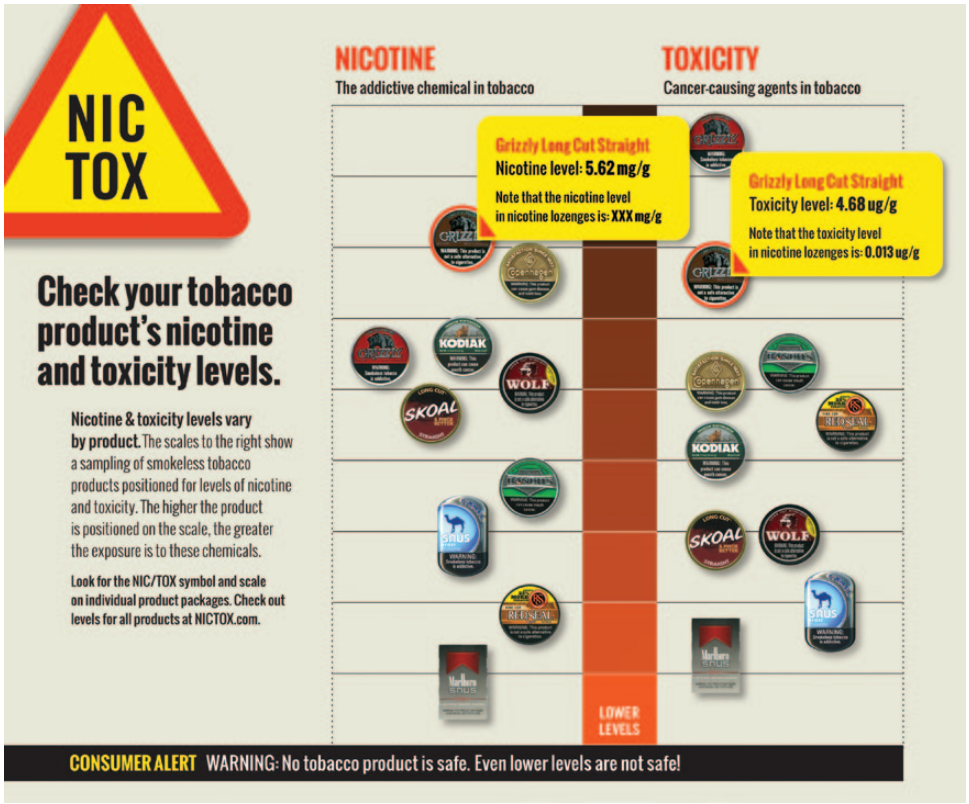

Figure 2. Informational poster presented to participants in the nicotine content/carcinogenic tobacco-specific nitrosamine content condition.

Participants that dropped out before T2 (vs. those who returned) showed no differences at T1 in knowledge about the relationship between nicotine and cancer, nicotine and addiction, and toxicity and addiction, but were less knowledgeable that toxicity contributes to cancer ($t(106) = -2.01$, $p < .05$; includes a statistical correction for variance heterogeneity). Although returning participants appeared to be slightly older than participants who were not retained for T2 ($M = 34.07$ vs. $M = 30.02$, $t(137) = -3.279$, $p < .001$; statistical correction applied for variance heterogeneity), the composition of the two samples did not differ in terms of gender ($\chi^2(1) = 2.04$, $p < .15$) or race (Fisher's exact test for all race categories, $p > .10$). Moreover, returning participants held similar attitudes about cigarettes, including product health risks and perceptions of cancer vulnerability ($t(477) = -1.322$, $p < .18$ and $t(477) = -1.128$, $p < .26$, respectively) and about SLT products, including product health risks and perceptions of cancer vulnerability ($t(109) = -1.293$, $p < .19$ and $t(107) = -1.500$, $p < .136$, respectively; statistical corrections applied for variance heterogeneity). This suggests that our final sample is representative of our initial recruitment efforts. In both surveys (T1 and T2), respondents completed measures of knowledge and tobacco health risks. T2 also included information search measures: (a) the total number of smokeless tobacco products for which respondents viewed pop-ups on the poster, and (b) the total amount of time (in seconds) they spent viewing the pop-ups on the poster.

Experimental Design

Participants randomly were assigned to receive one of two alternative poster presentation formats for conveying constituent information—either a gradient of toxicity levels alone (labeled as TOX on the poster, see Figure 1) or a gradient of both nicotine and toxicity levels (labeled as NIC/TOX on the poster, see Figure 2). Our two alternative information formats allowed us to compare effects of one or both dimensions of constituent information on people's perceptions. Since people are limited in processing ability, too much product and constituent information can be overwhelming (e.g., both nicotine and toxicity information may lead to overload in processing and inaccurate perceptions). Alternatively, too little information (e.g., when toxicity information alone is provided) could lead to unintended inferences about nicotine or defensive posturing about toxicity levels. A poster with only nicotine (and not toxicity) levels would have limited value and therefore was not included in our design.

Prior to viewing the poster, basic definitions of nicotine and toxicity were provided to explain the nature of the poster descriptors to research participants. Nicotine was described as the chemical that increases addictiveness and makes it difficult to quit, and toxicity was described as the amount of cancer-causing chemicals in tobacco products. The poster presentation was also prefaced with a statement that, of cigarettes and SLT products, regular cigarettes are known to have the highest levels of toxicity. We also hypothesized that providing people with confirmation that they were successful in learning these key constituent definitions would serve to counter individuals' proclivities to both resist processing tobacco-related health information and rely exclusively on their intuitive understanding of these concepts. "Accuracy confirmation" was expected to increase individuals' confidence that they have a valid and accurate understanding of the recently acquired information, compared to people who are not provided with this type of accuracy confirmation. To that end, the

nicotine and toxicity definitions that were provided prior to respondents' viewing of the poster were followed by a brief test of knowledge of the definitions of nicotine and toxicity. Respondents in the accuracy confirmation condition were told whether their responses were correct or incorrect, and in the case of an incorrect response, were allowed to return to the original definitions and try again until they correctly answered all questions. Respondents in the control condition were not told whether their answers were correct or incorrect. No significant differences on these definitional questions occurred between the four experimental (NIC/TOX vs. TOX crossed with confirmation vs. no confirmation) conditions, and, in fact, 82.2% of respondents correctly answered all definition questions on the first try.

Results

Constituent Levels and Scale Ranges

The levels of free nicotine in the products included in the development of the scale ranged from 0.5 to 8.7 mg/g product, averaging 3.7 (±1.5) mg/g. The sum of NNN and NNK varied from 0.4 to 14.6 µg/g product, averaging 3.0 (±1.6) µg/g. Since occasional tobacco products or individual samples may contain extremely high or very low levels of constituents, the highest and the lowest scale bars represent not a set range of values, but any levels higher than "average plus 3 ½ *SD*" or lower than "average minus 3 ½ *SD*," respectively. Only 4.6% of all tobacco samples had higher, and 5.7% lower, levels of free nicotine than the average ± 3 ½ *SD*; for NNN + NNK, these numbers were 3.1% and 0%, respectively.

Search, Knowledge and Belief Change

Results, shown in Table 1, confirmed that viewing the poster (and constituent meaning information) led to increased knowledge about tobacco constituents. An increased proportion of both smokers and nonsmokers, from T1 to T2, correctly reported that toxicity (but not nicotine) refers to chemicals that contribute to cancer. Degree of confidence in this knowledge also significantly increased. With regard to nicotine content, all but one respondent already knew at T1 that nicotine leads to addiction, but both smokers and nonsmokers increased their reported confidence in this belief. In addition, both groups significantly increased their knowledge and confidence that nicotine is not the chemical that contributes to cancer. Knowledge of constituent information did not vary by poster condition (NIC/TOX vs. TOX).

Another test of understanding would be demonstrated by participants correctly applying their knowledge of toxicity to actual brands. To that end, participants were asked to identify on the poster the brand with the highest toxicity. Participants were overwhelmingly accurate in identifying the brand with the highest toxicity level, with 87.9% of the sample correctly selecting the brand with the highest level of toxicity (i.e., Grizzly Fine Cut Natural) plus 10.3% of the sample selecting the second-highest brand (i.e., Grizzly Long Cut Straight). Less than 2% of participants were inaccurate which simply could be due to random error. No differences in the proportion of correct identification of the brand with the highest toxicity level emerged as a function of the information condition, the accuracy confirmation condition, or smoker status (all *p*s for χ^2 analyses of these frequencies > .10). Results did not vary by poster condition (NIC/TOX vs. TOX).

Perhaps even more important from the perspective of FDA initiatives, results confirmed that viewing the poster significantly increased the perceptions of both smokers and nonsmokers that individual brands of SLT vary in their amounts of nicotine and toxicity (Table 1). Note, too, that the T1 means on these questions were lower than the scale midpoint, indicating that overall neither smokers nor nonsmokers initially believed that the brands varied on these dimensions; but after receiving the poster information at T2, beliefs about constituency

Table 1. Knowledge of Constituents (Nicotine and Toxicity), Brand Variability, and Search Behavior

	Smokers		Nonsmokers	
	T1	T2	T1	T2
Knowledge that toxicity:				
refers to the chemicals that contribute to cancer				
% correct	0.85 (0.36)	0.97 (0.17)**	0.93 (0.25)	0.99 (0.08)***
confidence (0–10)	7.37 (2.49)	9.41 (1.00)***	7.20 (2.50)	9.47 (1.43)***
leads to addiction				
% correct	0.82 (0.39)	0.92 (0.28)*	0.81 (0.39)	0.96 (0.19)***
confidence (0–10)	6.92 (2.76)	8.56 (2.13)***	6.95 (2.53)	8.84 (2.06)***
Knowledge that nicotine:				
refers to the chemicals that contribute to cancer				
% correct	0.85 (0.36)	0.99 (0.12)***	0.75 (0.44)	0.98 (0.16)***
confidence (0–10)	7.75 (2.47)	9.26 (1.21)***	6.95 (2.65)	9.28 (1.66)***
leads to addiction				
% correct	1.00 (0.00)	1.00 (0.00)	0.99 (0.08)	1.00 (0.00)
confidence (0–10)	9.26 (0.96)	9.68 (0.78)***	8.84 (1.82)	9.59 (1.42)***
Knowledge that brands of SLT vary in:				
Nicotine (1–7 scale)	3.86 (1.48)	5.64 (1.54)***	3.94 (1.38)	5.89 (1.21)***
Toxicity (1–7 scale)	3.67 (1.54)	6.27 (1.13)***	3.63 (1.37)	6.26 (1.05)***
Time spent on (in seconds):				
Product pop-ups	18.58		18.42	
Poster (TOX condition)	44.77		125.58	
Poster (NIC/TOX condition)	96.10		78.75	

NIC = nicotine content; SLT = smokeless tobacco; TOX = carcinogenic tobacco-specific nitrosamine content.
Mean differences between pretest and posttest values are significant at: *$p < .05$; **$p < .01$; ***$p < .001$.

variability were quite strongly held. Knowledge of variability was not affected by poster condition (NIC/TOX vs. TOX).

Search behavior measures included both the total amount of time spent on the poster and the total number of pop-ups that were opened in order to assess the viability of the poster format for users and non-users alike. Since the patterns of results were similar for the two measures, we report here only the total time measure. The NIC/TOX information condition had pop-ups for both nicotine and toxicity information, and therefore by definition respondents would spend more time (than the TOX condition) on nicotine information. Since these search times for nicotine have little meaning across conditions, the means in the table reflect the total time spent solely on the toxicity information. Both count and time variables were extremely skewed, so the small number of cases with values exceeding three times the mean were excluded, and the dependent variable then log-transformed, to provide a more accurate representation of the data.

As shown in Table 1, nonsmokers in the TOX condition appear to have spent more time than smokers on the poster; however, due to high variances, all differences between smokers and nonsmokers were nonsignificant ($p > .05$).

As shown in Table 2, the poster information did not increase or decrease smokers' or nonsmokers' beliefs that cigarettes or SLT have a high amount of chemicals that cause cancer nor did it increase or decrease their beliefs that either type of tobacco posed a health risk. These results confirmed our expectation that viewers would not form misperceptions that SLT products are risk-free. In fact, it increased nonsmokers beliefs that "I would feel very vulnerable to getting cancer sometime in my life" if they were to either smoke cigarettes or use SLT, and increased the same belief in smokers if they were to use SLT.

Also noteworthy are beliefs about medicinal nicotine products. As a result of viewing the poster information, both smokers and nonsmokers significantly reduced their beliefs that NRT products have chemicals that cause cancer and that using these products would increase their vulnerability to getting cancer sometime in their lifetimes (Table 2).

Smoking Status Interactions With Experimental Factors

The interaction effects of smoking status with the two experimental variables, poster type (NIC/TOX or TOX) and accuracy confirmation (yes or no), were examined using regression analyses. An interaction term was constructed between each of our experimental conditions and smoker status. We also included the T1 baseline measure of the dependent variable as a covariate for each appropriate model. This approach provided us with two distinct sets of models that allow us to test the moderating role of smoker status for the effect of our manipulations on each dependent variable, while controlling for the interactive effects of smoker status and the baseline measure of the dependent variable. In particular, each T2 dependent variable was regressed separately on (a) both experimental conditions, (b) smoker status, and (c) all lower-order and higher-order interaction terms. Simple slopes for significant effects were computed at 1 *SD* above and below the mean of the moderator, following the procedures recommended by Aiken and West.[29] In addition to significance levels for each effect, we also present the 95% confidence intervals for the coefficient estimates and measures of effect size. The four dependent measures included: (a) total time spent examining the brand icon pop-ups on the poster; (b) perceived cancer vulnerability from cigarettes; (c) perceived cancer vulnerability from SLT products; and (d) perceived health risk from cigarette use.

A significant three-way interaction emerged for search time ($F(1,347) = 4.365$, $p < .021$, $\eta^2 = .012$), and a significant two-way interaction between smoker status and accuracy confirmation emerged for both cigarette cancer vulnerability ($F(1,388) = 16.972$, $p < .001$, $\eta^2 = .042$) and SLT cancer vulnerability ($F(1,388) = 4.218$, $p < .05$, $\eta^2 = .011$). No significant effects emerged for perceived overall health risks of cigarette use. In order to interpret these results, we broke down the interactions by smoker status.

Among smokers, total search time increased when they received accuracy confirmation ($b = 1.905$, $SE = .77$, 95% CI = 0.362, 3.447, $p < .05$, $d = .59$), although neither information nor the interaction between accuracy confirmation and information reached significance. Among nonsmokers, neither accuracy confirmation, nor information, nor the two-way interaction obtained significance (all ps > .14).

For models assessing perceived cancer vulnerability, we again examined the effect of accuracy confirmation separately for smokers and nonsmokers. Among smokers, accuracy confirmation significantly increased perceived cancer vulnerability from both cigarette use ($b = 0.710$, $SE = .249$, 95% CI = 0.214, 1.207, $p < .01$, $d = .68$)

Table 2. Health Beliefs About Cigarettes, SLT, and NRT

	Smokers		Nonsmokers	
	T1	T2	T1	T2
Product has chemicals that cause cancer:				
Cigarettes (0–10)	8.84 (1.72)	8.90 (2.17)	9.29 (1.26)	9.30 (1.57)
SLT (0–10)	7.77 (2.63)	7.75 (2.18)	8.27 (2.01)	8.03 (1.92)
NRT (0–10)	4.29 (2.60)	1.27 (2.04)***	4.67 (2.81)	1.31 (2.21)***
Increased vulnerability to cancer:				
Cigarettes (1–7)	5.96 (1.16)	6.21 (1.41)	6.60 (0.97)	6.79 (0.75)***
SLT (1–7)	5.51 (1.50)	5.93 (1.58)*	6.12 (1.34)	6.43 (1.12)***
NRT (1–7)	3.10 (1.85)	2.03 (1.52)***	3.90 (1.90)	2.48 (1.83)***
Overall health risk of product:				
Cigarettes (0–10)	8.42 (1.76)	8.74 (1.94)	9.03 (1.41)	9.20 (1.43)
SLT (0–10)	8.04 (2.27)	8.01 (1.98)	8.45 (1.71)	8.51 (1.62)

Note. NRT = nicotine replacement therapy; SLT = smokeless tobacco.

Mean differences between pretest and posttest values are significant at: *$p < .05$; **$p < .01$; ***$p < .001$. Scale ranges are included in parentheses.

and from SLT use (b = 0.827, SE = .334, 95% CI = 0.161, 1.493, $p < .05$, d = .59). Among nonsmokers, accuracy confirmation did not improve perceived cancer vulnerability from cigarettes ($p > .10$; these beliefs were already very high) but it did increase perceived cancer vulnerability from SLT products (b = 0.261, SE = .121, 95% CI = 0.023, 0.499, $p < .05$, d = .24), though this was a smaller increase than that found for smokers.

Discussion

The present research provides a compelling visual format for constituent SLT product information that has the potential to be used with a variety of populations and for educating both tobacco and nontobacco users.[30] Viewing the poster with 10 brands and types of smokeless tobacco products led to increased knowledge (a) about the meanings associated with toxicity and nicotine, (b) that the 10 SLT brands and types of products varied in their nicotine and toxicity content, and (c) that NRT products have low levels of cancer-causing chemicals and are not associated with high vulnerability of getting cancer. Increasing the public's understanding of the complexities of the tobacco marketplace is consistent with the goals of the FDA to reduce misperceptions of relative harm.[31] Simply understanding that SLT brands vary significantly from one another in their nicotine and toxicity content could be an important driver for smokers and SLT users in their search for specific information about the nicotine and toxicity levels for particular brands and types of tobacco, and for informing themselves about the relative health risks across products. In addition, the brand constituent information did not increase or decrease beliefs that cigarettes and SLT products have chemicals that cause cancer nor did it change beliefs about the overall health risks of these products. However, both smokers and nonsmokers increased their belief in the vulnerability of getting cancer in their lifetimes if they used SLT products. Therefore, providing information on levels of toxicity did not appear to lead to the misleading belief that some types of tobacco are safe.

An informational format such as the one tested here requires additional empirical research to determine its longer range effectiveness in conveying knowledge about the relative harmfulness of brands and types of SLT and in comparison to cigarettes and NRT. Following up on both smokers and nonsmokers over time, as well as tracking short-term and long-term behavioral consequences, would be essential to assessing whether exposure to brand constituent information influences rates of SLT use and consumer selection of specific tobacco products. Furthermore, while the information type—presenting toxicity information alone or in conjunction with nicotine information—did not impact knowledge or search behavior, it may nevertheless interact systematically with certain individual difference factors or with different cultural groups. The poster format developed for the current research, for example, is flexible and, after proper modifications to the constituent scale to account for potential differences in constituent levels, could be adapted to include ethnically-linked products used by subcultures in the United States (e.g., products like Paan that are used by South Asian immigrants) or perhaps even in developing countries. An in-depth analysis of such interactive effects is a worthy topic for future research. It is important to note that the term "toxicity," which was used for simplicity purposes in this study, has a well-defined meaning that is not equivalent to carcinogenicity and therefore does not adequately reflect the effect of TSNA on human health. Future studies should explore alternative definitions for carcinogen content in tobacco products that would be easily understood by the general public.

The effectiveness of the poster may also vary depending on the population sampled. Our online general population sample may be more motivated than some, and clearly, nonsmokers are less likely than smokers to show resistance to health warning information. Testing formats among nonsmokers has value in that the technique may well further inoculate nonsmokers with accurate beliefs about the harmfulness of various tobacco products. And clearly, the technique may provide smokers with more accurate information that could be useful for cessation efforts or for making reduced harm choices. However, more research on its effectiveness among SLT users, and among youth smokers and nonsmokers, is a crucial next step.

Finally, if shown to be effective under different conditions, the poster could be a useful format for showing a range of popular brands and types of SLT, with regular updates (e.g., 1–2 times a year) on constituent levels, by the FDA. Levels of constituents may vary over time within the same product,[11,32–34] and therefore continued monitoring of nicotine and TSNA in commercial products would be needed. A high percentage of our sample was able to learn definitional information and improved their knowledge about the health consequences of tobacco and NRT products. However, we also found that confirming the accuracy of toxicity and nicotine knowledge provided an additional motivational boost for cigarette smokers to search out constituent levels on the poster and assess their cancer vulnerability from SLT. A mechanism for including definitions of toxicity, carcinogenicity, and nicotine, as well as a statement that cigarettes have the highest levels of harmful constituents, therefore may heighten the effectiveness of the brand constituent information. This information could be added to the poster, to an online format, adapted to a phone app format (with a confirmation assessment), or become available through other media efforts such as public relations or advertising. The poster itself could be used, not only online, but to cue memory at the point of purchase such as in convenience stores.

Supplementary Material

Supplementary Materials can be found online at http://www.ntr.oxfordjournals.org

Funding

This work was supported by the Dean's Small Grants Program, Carlson School of Management, University of Minnesota; constituent analysis was funded by R01CA141531.

Declaration of Interests

None declared.

Acknowledgments

The authors gratefully acknowledge the assistance of L. Biener with the development of our stimuli and measures; J. Tilka and Tilka Design Inc. for creation of poster materials; T. Lindsay, Coordinator, Research Support Services, CLA Office of Information Technology, University of Minnesota, for computer programming and data collection; S. Williams and L. Manzara for data analysis and study design; and J. Liu for manuscript preparation. The project was conducted with University of Minnesota IRB approval #1207S16561 (July 16, 2012).

References

1. US Department of Health and Human Services. *The Health Consequences of Smoking—50 Years of Progress: A Report of the Surgeon General*. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2014.
2. Biener L, Bogen K, Connolly G. Impact of corrective health information on consumers' perceptions of "reduced exposure" tobacco products. *Tob Control*. 2007;16:306–311.
3. Callery WE, Hammond D, O'Connor RJ, et al. The appeal of smokeless tobacco products among young Canadian smokers: the impact of pictorial health warnings and relative risk messages. *Nicotine Tob Res*. 2011;13:373–383.
4. Øverland S, Hetland J, Aarø LE. Relative harm of snus and cigarettes: what do Norwegian adolescents say? *Tob Control*. 2008;17:422–425.
5. O'Connor RJ, McNeill A, Borland R, et al. Smokers' beliefs about the relative safety of other tobacco products: findings from the ITC collaboration. *Nicotine Tob Res*. 2007;9:1033–1042.
6. Smith SY, Curbow B, Stillman FA. Harm perception of nicotine products in college freshmen. *Nicotine Tob Res*. 2007;9:977–982.
7. Bansal MA, Cummings KM, Hyland A, et al. Stop-smoking medications: who uses them, who misuses them, and who is misinformed about them? *Nicotine Tob Res*. 2004;6:S303–S310.
8. Cummings KM, Hyland A, Giovino GA, et al. Are smokers adequately informed about the health risks of smoking and medicinal nicotine? *Nicotine Tob Res*. 2004;6:S333–S340.
9. Shiffman S, Ferguson SG, Rohay J, et al. Perceived safety and efficacy of nicotine replacement therapies among US smokers and ex-smokers: relationship with use and compliance. *Addiction*. 2008;103:1371–1378.
10. Hecht S, Stepanov I, Hatsukami D. Major tobacco companies have technology to reduce carcinogen levels but do not apply it to popular smokeless tobacco products. *Tob Control*. 2011;20:443.
11. Stepanov I, Jensen J, Hatsukami D, et al. New and traditional smokeless tobacco: comparison of toxicant and carcinogen levels. *Nicotine Tob Res*. 2008;10:1773–1782.
12. Biener L, Nyman AL, Stepanov I, et al. Public education about the relative harm of tobacco products: an intervention for tobacco control professionals. *Tob Control*. 2014;23:385–388.
13. Borland R, Li L, Cummings KM, et al. Effects of a Fact Sheet on beliefs about the harmfulness of alternative nicotine delivery systems compared with cigarettes. *Harm Reduct J*. 2012;9:19.
14. U.S. Department of Health and Human Services. *The Health Consequences of Smoking—50 Years of Progress: A Report of the Surgeon General*. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2014.
15. U.S. Department of Health and Human Services. *The Health Consequences of Smoking: Nicotine and Addiction. A Report of the Surgeon General. Report No.: DHHS Publication No. (CDC) 88-8406*. Rockville, MD; U.S. Department of Health and Human Services; 1988.
16. Hecht SS. Biochemistry, biology, and carcinogenicity of tobacco-specific N-nitrosamines. *Chem Res Toxicol*. 1998;11:559–603.
17. International Agency for Research on Cancer. *Smokeless Tobacco and Tobacco-Specific Nitrosamines. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans*, Vol. 89. Lyon, France: IARC; 2007.
18. Food and Drug Administration, Center for Tobacco Products CTP. *Guidance for Industry. Reporting Harmful and Potentially Harmful Constituents in Tobacco Products and Tobacco Smoke Under Section 904(a)(3) of the Federal Food, Drug, and Cosmetic Act. Draft Guidance*. Silver Spring, MD: U.S. Department of Health and Human Services, FDA, Center for Tobacco Products; 2012.
19. Tomar SL. Is use of smokeless tobacco a risk factor for cigarette smoking? The U.S. experience. *Nicotine Tob Res*. 2003;5:561–569.
20. Foulds J, Ramstrom L, Burke M, Fagerström K. Effect of smokeless tobacco (snus) on smoking and public health in Sweden. *Tob Control*. 2003;12:349–359.
21. Ramstrom L, Foulds J. Role of snus in initiation and cessation of tobacco smoking in Sweden. *Tob Control*. 2006;15:210–214.
22. Frey D. Recent research on selective exposure to information. *Adv Exp Soc Psychol*. 1986;19:41–80.
23. Smith SM, Fabrigar LR, Norris ME. Reflecting on six decades of selective exposure research: progress, challenges, and opportunities. *Soc Personal Psychol Compass*. 2008;2:464–493.
24. Stepanov I, Biener L, Yershova K, et al. Monitoring tobacco-specific N-nitrosamines and nicotine in novel smokeless tobacco products: findings from round II of the new product watch. *Nicotine Tob Res*. 2014;16:1070–1078.
25. Richter P, Hodge K, Stanfill S, Zhang L, Watson C. Surveillance of moist snuff: total nicotine, moisture, pH, un-ionized nicotine, and tobacco-specific nitrosamines. *Nicotine Tob Res*. 2008;10:1645–1652.
26. Tomar SL, Henningfield JE. Review of the evidence that pH is a determinant of nicotine dosage from oral use of smokeless tobacco. *Tob Control*. 1997;6:219–225.
27. Hatsukami DK, Severson HH. Oral spit tobacco: addiction, prevention and treatment. *Nicotine Tob Res*. 1999;1:21–44.
28. Fant RV, Henningfield JE, Nelson RA, Pickworth WB. Pharmacokinetics and pharmacodynamics of moist snuff in humans. *Tob Control*. 1999;8:387–392.
29. Aiken LS, West SG. *Multiple Regression: Testing and Interpreting Interactions*. London, UK: Sage; 1991.
30. Hammond D. Health warning messages on tobacco products: a review. *Tob Control*. 2011;20:327–337.
31. O'Connor RJ. Non-cigarette tobacco products: what have we learnt and where are we headed? *Tob Control*. 2012;21:181–190.
32. Stepanov I, Jensen J, Hatsukami D, et al. Tobacco-specific nitrosamines in new tobacco products. *Nicotine Tob Res*. 2006;8:309–313.
33. Djordjevic M, Brunnemann K, Hoffmann D. The need for regulation of carcinogenic N-nitrosamines in oral snuff. *Food Chem Toxicol*. 1993;31:497–501.
34. Chamberlain WJ, Schlotzhauer WS, Chortyk OT. Chemical composition of nonsmoking tobacco products. *J Agric Food Chem*. 1988;36:48–50.