Original Investigation

Initial Reactions to Tobacco Use and Risk of Future Regular Use

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Abstract

Introduction: Studies suggest that initial smoking pleasure influences future smoking behavior. We investigated how initial reactions to cigarettes or Swedish smokeless tobacco (snus) were associated with future use among 10,708 adults from the Swedish Twin Registry.

Methods: The Early Smoking Experience questionnaire captured physiologic reactions to initial tobacco use. Binary recursive partitioning (BRP) identified combinations of initial reactions predictive of regular tobacco use. Analyses, stratified by sex, were conducted separately among those who experimented with only cigarettes (EC), only snus (ES), and both products (EC+S).

Results: Among EC, 39.8% of men and 43.7% of women became smokers, while among ES, 78.6% of men and 53.7% of women became snus users. Among EC+S, 31.3% of men and 20.0% of women became dual users. BRP identified different reactions as predictive of future smoking for men (buzz) and women (dizziness, difficulty inhaling). No initial reaction predicted future snus use among men, but pleasant sensations, later age at first use, and relaxation predicted future snus use for women. Among EC+S, future exclusive use of either product was associated with a favorable initial reaction to that product. Dual users experienced higher prevalence of pleasant reactions and lower prevalence of unpleasant reactions in response to both products.

Conclusions: Our findings support that those who progress to regular tobacco use may be sensitive to the rewarding effects of nicotine but suggest that initial reactions differ by tobacco type. A high proportion of men became regular snus users regardless of initial reactions.

Introduction

Cigarette smoking and smokeless tobacco use are typically initiated during adolescence. In the United States, youth cigarette smoking rates declined until mid-2003, but have since plateaued (Lantz, 2003), whereas rates of smokeless tobacco use among youth have recently increased (Centers for Disease Control and Prevention [CDC], 2008). These patterns highlight the importance of continued public health interventions to reduce youth tobacco experimentation and progression to regular tobacco use. Insights into the mechanisms underlying progression to regular tobacco use may inform public health strategies to reduce tobacco use among young people. The goal of this investigation was to evaluate the role of subjective reactions experienced during initial tobacco exposure in predicting future regular use.

Subjective reactions experienced during initial exposure to cigarettes are believed to reflect the physiological and pharmacological effects of nicotine. The sensitivity model of tolerance to nicotine by Pomerleau, Collins, Shiffman, and Pomerlau (1993) proposed that people who go on to become regular smokers experience greater positive, as well as aversive, reactions to nicotine compared with those who remain nonsmokers. Positive, or pleasant, reactions include buzz, euphoria, and relaxation, whereas unpleasant reactions include nausea, difficulty inhaling, and coughing. The symptom of dizziness is considered both a pleasant and unpleasant symptom (Rios-Bedoya, Pomerleau, Neuman, & Pomerleau, 2009). Prior studies suggest that pleasant experiences in response to early experimentation with smoking lead to regular smoking and that pleasant experiences play a stronger role than unpleasant experiences in the transition to regular smoking (Pomerleau, Pomerleau, & Namenek, 1998;

Pomerleau, Pomerleau, Namenek, & Marks, 1999; Pomerleau et al., 1993; Rios-Bedoya et al., 2009). Recently, Haberstick, Ehringer, Lessem, Hopfer, and Hewitt (2011) reported that initial reactions to cigarettes are due to both heritable contributions and unique environmental experiences, and in line with this finding, Sherva et al. (2008) found an association between a genetic variant in *CHRNA5* and enhanced pleasurable responses to initial cigarette use in regular smokers.

A smokeless tobacco product of increasing relevance among young people is Swedish snus, which was recently introduced to the American market. Given that the prevalence of snus use is higher than the prevalence of cigarette use in younger Swedish men (Furberg et al., 2008; Rosendahl, Galanti, & Gilljam, 2008) and sales of snus are increasing in the United States (Biener, McCausland, Curry, & Cullen, 2011), examining how early experiences with snus impact future regular use is important. To our knowledge, no prior study has investigated this issue.

Here we analyzed data from a large, population-based study in Sweden to describe reactions experienced during initial cigarette smoking and initial snus use. We applied binary recursive partitioning to evaluate how combinations of initial reactions may influence risk of becoming a regular user for each tobacco type.

Methods

Study Population

The Swedish Twin study of Adults: Genes and Environment (STAGE; Lichtenstein et al., 2006) is a prospective, population-based study among 20,117 individuals from within the Swedish Twin Registry (http://ki.se/twinreg; Pedersen, Lichtenstein, & Svedberg, 2002). Beginning in May 2005, 43,000 twins were invited to participate in the study and answer questions about common complex diseases and lifetime tobacco use history. The response rate for the baseline tobacco use assessment of STAGE was 47.0%; as described previously, higher proportions of nonparticipants were male, had at least one parent born outside of Sweden, had been convicted of a crime, had lower education levels, and had been diagnosed with a psychiatric disorder (Furberg et al., 2008).

At baseline, information about use of cigarettes and snus were captured separately. Participants were asked about regularity of use (daily, occasional, just tried, or never) and status (current, former, never). Smoking at least one cigarette per day for at least 1 month defined daily smoking and using at least one snus pouch per day for at least 1 month defined daily snus use. Participants were asked to recall their age(s) at first use of tobacco and the initial reactions associated with first trying each tobacco product. Tobacco use information was available from 19,073 participants, 55.2% of whom were women. Ages of participants ranged from 20 to 47 years and mean age at interview ($\pm SD$) was 33.4 (± 7.7) years for men and 33.1 (± 7.6) years for women. Nearly half of the STAGE sample had attended university (45.2%), and 63.7% were married or cohabitating. There were 5,466 complete twin pairs ($N = 10,932$; 57.3%). Overall, 60.7% of men and 63.3% of women ever smoked cigarettes, and 59.9% of men and 25.4% of women ever used snus, prevalences comparable to other Swedish studies (Furberg et al., 2008).

For the purposes of these cross-sectional analyses, we restricted the sample to 10,708 participants who either experimented with only cigarettes (EC; $n = 4,297$), experimented with only snus (ES; $n = 1,737$), or experimented with both cigarettes and snus during their lifetime (EC+S; $n = 4,674$). Participants were excluded if they never tried cigarettes or snus ($n = 6,301$), were missing all initial reaction data ($n = 2,395$), or were missing data on smoking status ($n = 162$) or sex ($n = 10$). The high proportion of participants missing all initial reaction data ($n = 2,395$; 18%) likely resulted from the length of the STAGE questionnaire, which consisted of 1,300 questions within 34 sections (Furberg et al., 2008). We consider the potential impact of these exclusions on our findings in the Discussion section.

Assessment of Initial Reactions to Tobacco Use in STAGE

The Early Smoking Experience (ESE) questionnaire retrospectively captured physiologic reactions to initial cigarette and initial snus use including pleasant sensations, unpleasant sensations, nausea, relaxation, dizziness, and pleasurable buzz (Pomerleau et al., 1998). Two additional physiologic reactions, coughing and difficulty inhaling, were collected only for smokers as these symptoms are irrelevant for snus users. The ESE scale has been validated in different subgroups of individuals for the reactions buzz and dizziness (Perkins, Lerman, Coddington, & Karelitz, 2008; Pomerleau, Pomerleau, Mehringer, Snedecor, & Cameron, 2005), but to our knowledge, not for snus users. Responses on the ESE were rated on a four-point Likert scale of none, slight, moderate, and intense, and collapsed into the binary response of none versus any for all analyses, consistent with prior reports (DiFranza et al., 2004; 2007; Haberstick et al., 2011; Post, Gilljam, Rosendahl, Bremberg, & Galanti, 2010; Richardson, Okoli, Ratner, & Johnson, 2010). Among those who tried both tobacco products during their lifetime (EC+S), initial reactions to cigarettes and snus were combined into four categories without regard to temporal ordering of initial experimentation: none to cigarettes and none to snus, none to cigarettes and any to snus, any to cigarettes and none to snus, and any to cigarettes and any to snus.

Statistical Analysis

We first examined tobacco use characteristics by sex in the full study population, including twin pairs. Tobacco use characteristics included age at first use and whether a participant just tried, was an occasional user of, or was a daily user of cigarettes, snus, or both tobacco products. Occasional and daily users were combined into a single category representing those who continued to use the product after first trying it ("smoker" or "snus user") compared with those who just tried it ("non-user"). Participants who experimented with both cigarettes and snus (EC+S) in their lifetime were classified into four mutually exclusive groups: "non-user of both," "exclusive smoker," "exclusive snus user," or "dual user." A sandwich variance estimator with an exchangeable correlation structure estimated p values with adjustment for the correlation between individuals who formed twin pairs.

Next, Chi-square tests investigated differences in distributions of initial reactions between users and non-users separately among EC, ES and EC+S. Because 43.0% of the study population were members of a complete twin pair, and since a nonindependent

Table 1. Characteristics of 10,708 Subjects From STAGE Who Ever Experimented With Tobacco			
	Men (n = 5,367)	Women (n = 5,341)	p value[a]
Age at first use, Mean (*SD*; range)[b]			
Experimented with only cigarettes	15.6 (4.0; 5–40)	15.1 (3.1; 5–40)	<.001
Experimented with only snus	16.1 (4.2; 5–40)	20.3 (6.2; 6–40)	<.001
Experimented with cigarettes and snus	13.9 (3.1; 4–42)	14.5 (3.0; 5–33)	<.001
Experimented with only cigarettes, n = 4,297 (40.1%)			.019
Non-user	644 (60.2)	1816 (56.3)	
Smoker	426 (39.8)	1411 (43.7)	
Experimented with only snus, n = 1,737 (16.2%)			<.001
Non-user	283 (21.4)	193 (46.3)	
Snus user	1037 (78.6)	224 (53.7)	
Experimented with cigarettes and snus, n = 4,674 (43.6%)			<.001
Non-user	1203 (40.4)	835 (49.2)	
Exclusive snus user	631 (21.2)	124 (7.3)	
Exclusive smoker	211 (7.1)	398 (23.5)	
Dual user	932 (31.3)	340 (20.0)	

[a] Based on sandwich variance estimate accounting for correlation between twin pairs.

[b] Age at first use was missing for 186 men and 171 women. For dual users, this is age at first use of the first tobacco product tried.

sample increases the likelihood of Type I error, one member from each complete twin pair was excluded from all remaining analyses through simple random sampling (n = 2,302). A reliability analysis was performed using the excluded twin to verify the findings.

Finally, in order to evaluate subgroups of initial reactions with regard to risk of becoming a user and to better understand how combinations of initial reactions influence use, binary recursive partitioning (BRP) was applied using the RPART routines (Therneau & Atkinson, 1997). BRP is a nonparametric classification tree method that predicts an outcome variable by partitioning the data into subgroups in a recursive manner. The sample is initially split into two subgroups, called nodes, by finding the predictor variable and its cutpoint that maximize the difference between groups with respect to the response variable. The difference between groups is defined using the Gini criterion, an impurity function that has a low value when a split discriminates well between classes of the response variable. This process is repeated for each resulting node until the split produces subgroups that do not differ significantly on the outcome or until group sizes are too small to further split, resulting in a terminal node.

The method next chooses the "best" tree as the pruned-down tree that yields the most accurate predictions based on cross-validation. The RPART routine automatically performs a 10-fold cross-validation, in which the full sample is randomly divided into 10 subsamples. The tree is generated with 90% of the full sample, and the remaining 10% of the sample is used as a validation dataset. This procedure is repeated 10 times. The results of cross-validation are used to choose the smallest tree with validation error within one standard deviation of the lowest validation error (Breiman, Friedman, Olshen, & Stone, 1984). Since BRP does not employ significance tests, results are interpreted with regard to relationships among variables that are predictive of the outcome of interest.

In contrast to logistic regression, BRP is able to handle missing predictor values automatically through the use of surrogate splits. The use of surrogate splits is only possible when at least one of the predictor variables is non-missing, hence participants missing all initial reactions were excluded from these analyses. To examine whether those missing all initial reactions differed from the participants included in the study, we compared the tobacco use characteristics of the two populations. Participants missing all initial reactions did not differ by age at baseline (p = .300) but were more likely to be women (p < .001). Among women, EC who were missing all initial reactions were more likely to be cigarette users (p = .029) and EC+S who were missing all initial reactions were more likely to be exclusive cigarette users and less likely to be dual users (p < .001). Among men, EC+S who were missing all initial reactions were more likely to be exclusive cigarette users (p < .001).

Merkle and Shaffer (2010) compared the predictive accuracy of BRP with that of regression and found that while regression had better predictive accuracy when a linear relationship truly existed, the difference was small at larger sample sizes (i.e., $N \geq 1,000$). Furthermore, when a linear relationship did not hold, the predictive accuracy of BRP was much better than that of regression, a difference that increased with sample size. Therefore, with the very large sample size in the present study, we should expect similar if not better predictive accuracy from BRP when compared with a more standard regression approach.

All analyses were conducted using SAS version 9.2 (SAS Institute, Cary, NC, 2010) and R version 2.12.0 (R Development Core Team, 2010). Any p < .05 was considered statistically significant. Given the known differences in tobacco use between men and women, all analyses were stratified by sex.

Results

Participant Characteristics
Half of the analytic sample was women and the average age at interview was 34 years for both men and women. Table 1

Table 2. Initial Reactions to Cigarettes by Type of User and Sex for 3,387 Participants From STAGE Who Experimented With Only Cigarettes (EC)

	Men (n = 836)				Women (n = 2,551)			
	Non-user	Smoker	Chi-square	p value[a]	Non-user	Smoker	Chi-square	p value[a]
Pleasant sensations			21.94	<.001			34.06	<.001
None	398 (82.9)	212 (68.6)			1067 (81.3)	735 (71.1)		
Any	82 (17.1)	97 (31.4)			245 (18.7)	299 (28.9)		
Relaxation			12.78	<.001			43.31	<.001
None	376 (81.9)	214 (70.9)			1065 (82.9)	718 (71.4)		
Any	83 (18.1)	88 (29.1)			219 (17.1)	287 (28.6)		
Pleasurable buzz			49.62	<.001			87.62	<.001
None	404 (85.2)	205 (63.7)			1100 (84.2)	725 (67.9)		
Any	70 (14.8)	117 (36.3)			206 (15.8)	342 (32.1)		
Dizziness			40.71	<.001			175.13	<.001
None	239 (50.5)	91 (27.9)			560 (43.0)	197 (17.9)		
Any	234 (49.5)	235 (72.1)			741 (57.0)	905 (82.1)		
Unpleasant sensations			2.29	.131			0.03	.871
None	165 (34.4)	124 (39.7)			440 (33.6)	356 (33.9)		
Any	314 (65.6)	188 (60.3)			870 (66.4)	694 (66.1)		
Nausea			0.03	.857			3.36	.067
None	247 (51.7)	169 (52.3)			658 (50.5)	510 (46.7)		
Any	231 (48.3)	154 (47.7)			646 (49.5)	582 (53.3)		
Coughing			2.88	.090			0.34	.559
None	114 (23.7)	93 (29.1)			335 (25.3)	280 (26.3)		
Any	367 (76.3)	227 (70.9)			991 (74.7)	784 (73.7)		
Difficulty inhaling			10.85	<.001			9.29	.002
None	301 (64.7)	228 (76.0)			772 (61.3)	674 (67.5)		
Any	164 (35.3)	72 (24.0)			488 (38.7)	325 (32.5)		

Note. Numbers for each initial reaction do not sum to the same value due to missing data. Sample size of 3,387 for EC after randomly excluding one member from each twin pair.

[a] From Chi-square test.

presents smoking-related characteristics of the study population by sex. Among those who experimented with only cigarettes (EC), more women than men became smokers ($p = .019$) and the average age at first use of cigarettes was slightly younger for women than men (15.1 vs. 15.6 years, $p < .001$). In contrast, among those who experimented with only snus (ES), nearly 80% of men and over 50% of women became snus users ($p < .001$), and the average age at first snus use was younger for men than women (16.1 vs. 20.3 years, $p < .001$). Among those who experimented with both products in their lifetime (EC+S), over 20% of women and less than 10% of men adopted exclusive cigarette use, while the reverse was true for exclusive snus use. The proportion of men who became dual users was higher than for women (31.3% vs. 20.0%, respectively). Notably, the age at first tobacco use was younger for those who tried both cigarettes and snus than for those who tried either product exclusively and was younger for men than women (13.9 vs. 14.5 years, $p < .001$).

Initial Reactions to Tobacco

Table 2 presents univariate associations between initial reactions and future smoking among EC. Compared with non-users, those who became smokers experienced higher prevalence of pleasant sensations, relaxation, pleasurable buzz and dizziness, but a lower prevalence of difficulty inhaling (all $p < .001$). Unpleasant sensations, nausea, and coughing were not associated with becoming a smoker. Similar patterns were observed

for men and women. The most common reaction experienced by smokers was dizziness (72.1% for men, 82.1% for women).

Table 3 presents univariate associations between initial reactions and future snus use among ES. Compared with non-users, those who became snus users experienced higher prevalence of relaxation and pleasurable buzz (all $p < .001$ for both men and women). Men who became snus users experienced higher prevalence of dizziness ($p = .004$), whereas women who became snus users experienced lower prevalence of dizziness ($p = .031$) compared with non-users of the same sex. Compared with non-users, women who became snus users also experienced higher prevalence of pleasant sensations ($p < .001$) and lower prevalence of unpleasant sensations ($p = .014$) and nausea ($p = .021$).

Results of analyses using the Chi-square test to compare across the four categories of EC+S ("non-user of both," "exclusive smoker," "exclusive snus user," and "dual user") indicate the prevalence of every initial reaction differed by type of user (all $p < .001$) (data not shown). For men and women, future use of either tobacco product was associated with a favorable initial reaction to that product. Those who became exclusive smokers experienced higher prevalence of favorable reactions to cigarettes, but not snus, and vice versa. Those who became regular dual users experienced higher prevalence of pleasant sensations, relaxation, pleasurable buzz and dizziness, and lower prevalence of unpleasant sensations and nausea, in response to both cigarettes and snus.

Table 3. Initial Reactions to Snus by Type of User and Sex for 1,383 Participants From STAGE Who Experimented With Only Snus (ES)

	Men (n = 1,054)				Women (n = 329)			
	Non-user	Snus user	Chi-square	p value[a]	Non-user	Snus user	Chi-square	p value[a]
Pleasant sensations			2.25	.134			26.86	<.001
None	141 (64.7)	469 (59.1)			108 (71.1)	70 (42.2)		
Any	77 (35.3)	325 (40.9)			44 (28.9)	96 (57.8)		
Relaxation			3.85	.050			24.00	<.001
None	137 (64.9)	444 (57.4)			111 (73.5)	75 (46.3)		
Any	74 (35.1)	329 (42.6)			40 (26.5)	87 (53.7)		
Pleasurable buzz			18.95	<.001			21.23	<.001
None	144 (67.6)	405 (50.9)			104 (67.5)	69 (41.8)		
Any	69 (32.4)	391 (49.1)			50 (32.5)	96 (58.2)		
Dizziness			8.09	.004			4.63	.031
None	41 (18.9)	93 (11.6)			35 (22.9)	57 (33.7)		
Any	176 (81.1)	712 (88.4)			118 (77.1)	112 (66.3)		
Unpleasant sensations			1.13	.287			6.08	.014
None	76 (34.7)	248 (30.9)			60 (39.0)	88 (52.7)		
Any	143 (65.3)	554 (69.1)			94 (61.0)	79 (47.3)		
Nausea			0.38	.540			5.33	.021
None	78 (35.5)	272 (33.3)			60 (39.0)	87 (51.8)		
Any	142 (64.5)	546 (66.7)			94 (61.0)	81 (48.2)		

Note. Numbers for each initial reaction do not sum to the same value due to missing data. Sample size of 1,383 for ES after randomly excluding one member from each twin pair.

[a] From Chi-square test.

Positive reactions (including pleasant sensations, relaxation, and pleasurable buzz) were more common among ES than EC, occurring among 40%–57% of ES men and women and only 31%–36% of EC men and women. Dizziness was experienced by a majority of participants, with 59% of EC men and 69% of EC women and 87% of ES men and 71% of ES women experiencing at least mild dizziness. Among men, ES experienced significantly more dizziness ($p < .001$) and nausea ($p < .001$) than EC. Finally, ES experienced significantly more unpleasant sensations than EC (male $p = .032$, female $p < .001$).

Binary Recursive Partitioning Results

Figure 1 presents classification trees for initial reactions to cigarettes predictive of becoming a smoker among EC. Despite the significant association between several initial reactions and regular smoking in univariate analysis, BRP identified only buzz as predictive of being a smoker among men. Men were predicted to be smokers with a probability of .63 if they experienced any buzz when they first tried cigarettes. BRP identified two reactions as predictive of being a smoker among women, dizziness and difficulty inhaling. Women were predicted to be smokers with a probability of .60 if they experienced any dizziness and no difficulty inhaling when they first tried cigarettes. Women who experienced no dizziness at first use had a predicted probability of only .28 for being a smoker.

Classification trees among ES were more complex, as shown in Figure 2. Notably, no split significantly improved the ability to discriminate between snus users and non-users among men. This result was not surprising given that nearly all men who experimented with snus became regular snus users (79%). BRP identified pleasant sensations, age at first snus use, and relaxation as predictive of snus use among women. Women were predicted to be snus users with a probability of .68 if they experienced any pleasant sensations, with a probability of .78 if they experienced no pleasant sensations but were older than 26 at first use and with a probability of .61 if they were 26 or younger at first use and experienced no pleasant sensations and any relaxation.

The same single reaction that predicted smoking among EC men (buzz) was identified for EC+S men who became dual users. Men were predicted to be dual users with a probability of .41 if they experienced any buzz when they first tried either tobacco product. The BRP tree for women identified buzz, pleasant sensations, and age at first use as predictive of dual use. Women were predicted to be dual users with a probability of .61 if they experienced no buzz when they first tried cigarettes and were older than 28 at first tobacco use, and with a probability of .39 if they experienced any buzz when they first tried cigarettes and any pleasant sensations when they first tried snus (data not shown).

All the preceding results were checked using the randomly excluded twin from each complete twin pair. As expected, the results of this reliability analysis confirmed all findings. In particular, the BRP trees were identical for both EC men and women. For EC men, the predicted probability of being a smoker if buzz was experienced at first use was .64 in the reliability analysis when compared with .63 in the primary analysis. For EC women, the predicted probability of being a smoker if any dizziness and no difficulty inhaling were experienced at first use was .58 in the reliability analysis when compared with .60 in the primary analysis. These differences of 2% or less in predicted probabilities indicate strong concordance among the primary analysis and the analysis utilizing the excluded twin. ES men
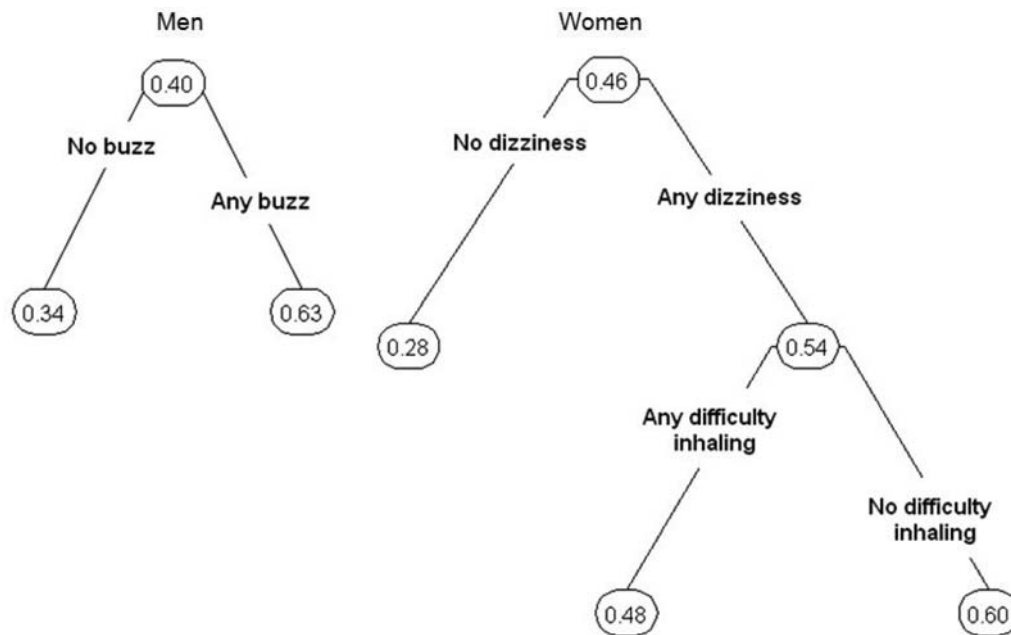
Figure 1. Classification tree for initial reactions to cigarettes predictive of becoming a smoker among men (left) and women (right). The value displayed is the predicted probability of being a smoker..

still had no tree and among ES women, pleasant sensations were still identified as the most important initial reaction for predicting snus use.

Discussion

Our findings suggest that those who progress to regular tobacco use may be more sensitive to the rewarding effects of nicotine. This sensitivity may be greater among those who try snus, as pleasant reactions were nearly twice as common among snus users as among cigarette smokers. Notably, we found a high prevalence of regular snus use regardless of initial reactions, especially among men. Our findings also highlight age at first snus use as a relevant predictor of future snus use among women, who had a higher predicted probability of being snus users if they experimented with snus as adults.

Dizziness and pleasurable buzz were the strongest predictors of smoking in this study, consistent with prior reports. Haberstick et al. (2011) examined retrospective responses to the ESE among 2,482 young adult twins and found that individual differences in initial reactions to cigarettes are best explained by heritable and environmental influences on dizziness. The authors suggest that dizziness may represent the most genetically informative subjective experience and therefore could be used clinically to identify individuals at risk of regular use (Haberstick et al., 2011). In a study comparing retrospective responses to the ESE with prospective responses to a Nicotine Spray Effects questionnaire among 58 young adult non-smokers with modest lifetime exposure to cigarettes, Perkins, Lerman, Coddington, and Karelitz (2008) found that reporting dizziness on the ESE was associated with greater prospective ratings of "feel the effects" and "want more" when comparing nicotine spray to placebo. This may indicate that the ESE item of dizziness predicts greater sensitivity to the reinforcing effects of

nicotine (Perkins et al., 2008). Furthermore, the results of a factor analysis of reactions to initial cigarette use identified a "pleasant" dimension, an "unpleasant" dimension, and a "buzz" dimension that consisted of dizziness and pleasurable buzz. The "buzz" factor was significantly associated with increased odds of progressing to regular smoking, and this effect was especially strong among individuals who did not experience any pleasant reactions (Richardson et al., 2010). Finally, among 8,373 youths who ever smoked a whole cigarette, Hu, Davies, and Kandel (2006) found that dizziness was significantly associated with 18% increased odds of ever daily smoking after adjustment for important potential confounders such as depressive symptoms, self-esteem, and having friends who smoke.

To our knowledge, this is the first study to describe initial reactions to snus and their impact on future regular snus use. Our finding that 79% of men and 54% of women who exclusively tried snus became users is striking and suggests that, particularly for men, snus use is easily adopted after trying regardless of initial reactions. The tolerability of snus may be greater than cigarettes due to route of administration as nicotine is absorbed through the digestive system rather than inhaling, or to social acceptability as there is no secondhand smoke or public restrictions on its use. For women, it was notable that a later age at first snus use predicted future use. The reason for this is unclear but highlights that public health messages to dissuade snus use should target adults as well as adolescents.

The patterns of predictors identified for EC, ES and EC+S in men and women suggest that reactions differ by tobacco type. Our findings imply that it is not just reactions to nicotine that influence future use as reactions differ by route of administration. Snus appeared to be more tolerable and induced more favorable reactions than did cigarettes, and this was further supported by analyses conducted among dual users, which suggested future use of either tobacco product was associated with
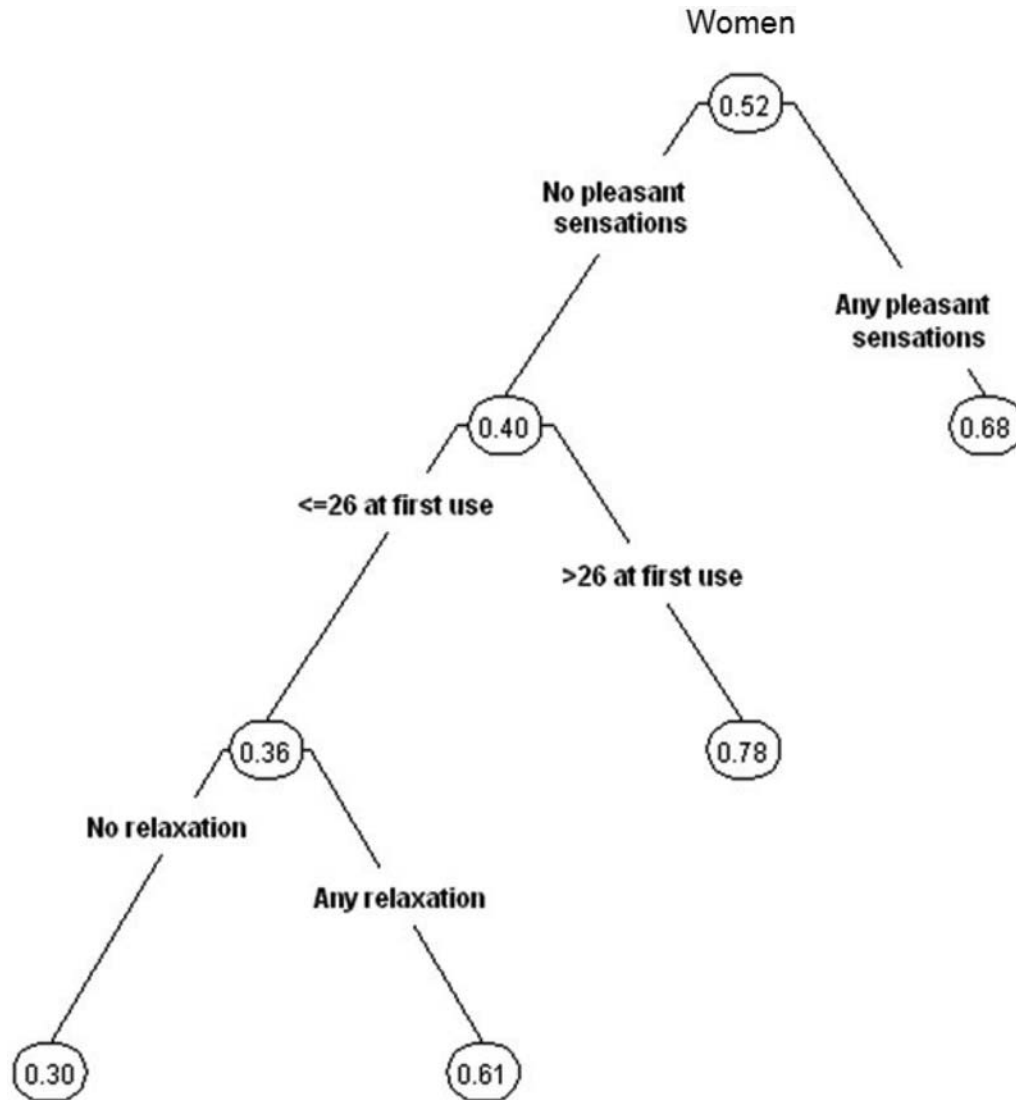
Figure 2. Classification tree for initial reactions to snus predictive of becoming a snus user among women. The value displayed is the predicted probability of snus use. No splits improved the classification for men who tried snus.

a favorable initial reaction to that product. We acknowledge that unmeasured behavioral, social, and environmental factors play a role in adoption and may also be associated with initial reactions.

Strengths of this study include its population-based design, assessment of both cigarette and snus use patterns, and excellent statistical power. Applying BRP to these data was a novel and appropriate method to determine combinations of reactions that predict future use for several reasons. First, unlike logistic regression, only individuals missing all predictor values are excluded. This reduced the chance for selection bias to impact results. Second, the predictive power of BRP is superior to logistic regression, particularly in large sample sizes. Finally, BRP reveals combinations of reactions predicting future use, allowing for a more intuitive interpretation of the data. Admittedly, BRP is a hypothesis-generating approach and we regard our findings as preliminary.

Limitations are acknowledged. Participants missing all reaction data were excluded from this analysis, the majority of who were exclusive cigarette smokers. It is unclear how missing initial reaction data among exclusive smokers would impact our results; however, our findings are consistent with prior reports. All tobacco use data were obtained through retrospective self-report and use of either tobacco product at interview was not confirmed through biochemical testing. It is possible that recall bias and subject self-selection could have affected our findings. One might expect differential recall bias, with regular users recalling more pleasant initial reactions and non-users recalling more unpleasant initial reactions, which would result in exaggerated effect sizes. Positive associations between retrospective and prospective reports of initial reactions to cigarettes suggest that recall bias may be minimal in studies of small sample sizes (Perkins et al., 2008; Pomerleau et al., 2005). Because ability to detect subtle differences improves as sample size increases, and our study was substantially larger than prior reports, we

acknowledge our results may be more sensitive to recall bias. Future studies are needed to validate our results.

Our findings highlight the need for more research on the progression to regular snus use and dual use. Although the health ramifications of snus are less severe than for cigarettes, snus is still an addictive product that is associated with increased health risks compared with using no tobacco at all (Gartner, Hall, Chapman, & Freeman, 2007; Lee, 2011). Given the high rate of adoption of snus use observed in our study, future studies should determine the impact of snus marketing on awareness, attitudes and uptake in an effort to reduce tobacco consumption of all types among all age groups.

Funding

Declaration of Interests

None declared.

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