Associations of phenylthiocarbamide tasting to alcohol problems and family history of alcoholism differ by gender

Kimberly A. Driscoll\textsuperscript{a}, Marisol Perez\textsuperscript{b}, Kelly C. Cukrowicz\textsuperscript{a}, Melanie Butler\textsuperscript{a}, Thomas E. Joiner Jr.\textsuperscript{a,*}

\textsuperscript{a} Department of Psychology, Florida State University, Tallahassee, FL, 32306-1270, USA
\textsuperscript{b} Department of Psychology, Texas A and M University, College Station, TX, 77843-4235, USA

Received 10 June 2004; received in revised form 21 December 2004; accepted 15 July 2005

Abstract

Past research associating phenylthiocarbamide/propylthiouracil (PTC/PROP) taste status with alcoholism has produced equivocal results. Some have found higher proportions of nontasters among those with a family history of alcoholism than controls, whereas others have not. The purpose of this study was to investigate the relationship between PTC taste status, alcohol problems, and family history of alcoholism. A total of 244 undergraduate students participated in this study, with a gender distribution of 75\% female and 25\% male. We found support for our hypothesis that male supertasters would report fewer problems with alcohol and a less significant family history of alcoholism. Interestingly, we also found that female supertasters had a greater family history of alcoholism and more current problems associated with alcohol use. Implications for the genetic link between PTC taste status and alcoholism are discussed.

\textcopyright{} 2005 Elsevier Ireland Ltd. All rights reserved.

Keywords: PTC; Taste status; Alcoholism; Family history of alcohol; Gender

1. Introduction

Abundant research indicates that there is a heritable component to alcoholism. For example, Schuckit (1994) found that 50\% of those who sought treatment for alcoholism had at least one close relative who was also alcoholic. Furthermore, children of alcoholics are more likely to become alcoholic than children of non-alcoholics (Cotton, 1979). In addition, adoptees who had one alcoholic biological parent were more likely to become alcoholic than adoptees with no alcoholic biological parents (Cadoret et al., 1980).

Some research suggests that the genetic contribution to alcoholism is higher in men than in women. Zuckerman (1999) reviewed the concordance rates of alcoholism in twin studies. He found that for identical male twins the rates ranged from 68 to 76\%, and for
identical female twins the rates ranged from 32 to 47% (see also Stabenau, 1990). Walters (2002) performed a meta-analysis on 50 family, twin, and adoption studies and found that the heritability of alcohol misuse was stronger in males than in females. In sum, research suggests that there is a heritable component to alcoholism and that the heritability is stronger for men than for women.

Fox (1932) discovered that the ability to taste phenylthiocarbamide (PTC) was heritable and followed an incompletely dominant pattern (Bartoshuk, 2000; Fischer et al., 1961). Subsequent research has demonstrated that there are three groups, distinguishable on the basis of taste reactions to PTC: non-tasters, who do not taste or 6-n-propylthiouracil (PROP), supertasters who perceive PTC/PROP to be extremely bitter, and a group in the middle, tasters, who can detect PTC/PROP but do not perceive it to be extremely bitter (Bartoshuk, 1993). Non-tasters have been found to have fewer taste buds than tasters, and tasters, fewer than supertasters (Bartoshuk et al., 1994).

Since Fox’s discovery, research has focused on determining whether PTC or PROP (PTC’s chemical relative) serve as a genetic marker for an array of behavioral phenomena, including psychopathology. Previous research found fewer supertasters among participants with a family history of depression than among those without a family history of depression (Joiner and Perez, 2004). Another study found more supertasters among participants with a family history of anxiety (Walker, 2002).

Several studies have linked taste status to alcohol-related variables – unsurprising given the heritable components to both alcoholism and PTC/PROP taste status, as well as the fact that alcohol is an oral irritant. However, the literature in this area has had mixed findings. Smith (1972) assessed PTC taste status among alcoholics, drug addicts, and matched controls, and found no differences in taste status among the groups. Reid and colleagues (1968) also failed to find a significant association between PTC taste status and alcoholism among controls and patients with cirrhosis of the liver. Swinson (1973) found no difference between alcoholics and controls on PTC taste status. Kranzler and colleagues (1998) found no difference on PROP taste status between participants who had a paternal history of alcoholism only, a maternal history of alcoholism only, a bilineal history of alcoholism, and no family history of alcoholism. In contrast, several studies have found higher rates of non-tasters among alcoholics than among controls. For example, Peeples (1962; as cited by Swinson, 1983, and Pelchat and Danowski, 1992) found higher rates of PTC non-tasters among alcoholics than controls. Spiegel (1972, as cited by Swinson, 1983) obtained this same result, using PROP instead of PTC, among a sample of alcoholics and controls. More recently, Pelchat and Danowski (1992) found that being an alcoholic did not predict higher rates of non-taster status, but having a family history of alcoholism did predict higher rates of non-taster status of PROP. DiCarlo and Powers (1998) also found that participants with a family history of alcoholism were more likely to be non-tasters of PROP than were controls. In sum, more research is needed in this area to help clarify the mixed findings.

The purpose of this study was to investigate the relationship between PTC taste status, alcohol problems, and family history of alcoholism, in the context of the differing genetic contribution to alcohol problems for men and women. More specifically, we were interested in determining how PTC taste status related to participants’ current alcohol problems and their family history of alcoholism, and whether these relationships differed by gender.

1.1. Hypotheses

1. Consistent with past research, it is hypothesized that there will be more supertasters among women than men. In a review of the literature, past research has shown that significantly more females are classified as supertasters than males (Bartoshuk et al., 1994). Sex differences have also been found in taste anatomy, where women tend to have more fungiform papillae and more taste buds than men (Bartoshuk et al., 1994).

2. Consistent with past research, men will have higher alcoholism scores than women. Past research has shown that alcohol abuse and dependence are more prevalent in males than in females, with a male-to-female ratio of 5:1 (American Psychiatric Association, 1994). Among college students, male undergraduates report drinking more frequently and
more heavily than female undergraduates (White et al., 2003).

3. Supertasters will have less family history of alcoholism and higher alcoholism scores compared with all others, and this may be particularly true for men. It is generally hypothesized that supertasters are less susceptible to alcoholism because they experience more burn from oral irritants, including alcohol (Bartoshuk et al., 1994); thus they may be “protected” from alcohol problems. And, it has been hypothesized that nontasters are more susceptible to alcohol problems because of decreased sensitivity to bitter tastes. Because the genetic contribution to alcohol problems is substantially higher in men, we hypothesized that men who were classified as supertasters would report fewer problems with alcohol and a less significant family history of alcoholism than others; regarding women, we made no strong predictions.

2. Method

2.1. Participants

A total of 244 undergraduate students (mean age = 20.9; S.D. = 2.07) participated in this study. Students were recruited from undergraduate psychology courses and were given several extra credit points for participating. Two students declined to participate and one participant did not complete the protocol. Reflecting the greater participation of women in psychology courses, 75% of the participants were female and 25% were male. The self-reported ethnic composition of the sample was 69.7% Caucasian, 13.5% Hispanic, 10.7% African–American, 1.2% Asian, and 4.9% Other.

2.2. Materials and procedure

After providing written consent, participants completed a questionnaire designed to gather simple demographic information (e.g., sex, age, ethnicity) and a questionnaire regarding family history of alcoholism. More specifically, they were asked the following questions: “How many biological siblings do you have?” and “Of your first-degree biological relatives [your biological parents and your biological siblings], how many have clear alcohol problems or have been treated for alcoholism?” This brief approach to assessment of family history has been validated in past work (Joiner et al., 2002, 2003). The percentage of first-degree relatives who had been diagnosed with or treated for alcoholism was calculated for this sample and the average was 0.10 (S.D. = 0.17).

Participants also completed the Michigan Alcoholism Screening Test – Short Version (SMAST; Selzer et al., 1975). The SMAST is composed of 13 questions related to alcohol use and the consequences of alcohol use in which the participant endorses either “Yes” or “No.” Higher scores are suggestive of greater alcohol-related problems. The SMAST has been reasonably well validated as a measure of alcoholism (Selzer et al., 1975; Harburg et al., 1988). The SMAST has yielded adequate reliability estimates, with a mean coefficient alpha of 0.93 for combined samples of alcoholics and nonalcoholics (Selzer et al., 1975). Internal consistency for this sample was lower (i.e., 0.73), but adequate. The mean SMAST score for the participants in this study was 3.29 (S.D. = 1.17). In addition to examining continuous SMAST scores, we examined a dichotomized variable that was coded as follows: 1 = SMAST score was between 0 and 5; 2 = SMAST score was 6 or above. These cutoff scores were determined based on previous published work on the psychometric properties of the SMAST (Fleming and Barry, 1988), and on the SMAST distribution in this sample (6 or above represents >1 S.D. over the SMAST mean).

Following completion of the questionnaires, participants were administered a 3.80 cm by 1.43 cm piece of commercially prepared paper treated with PTC (obtained from the Carolina Biological Supply Company, Burlington, North Carolina). Participants were asked if they had smoked or ingested anything in the hour prior to the taste test; if they had, the test was delayed for an hour. Participants rinsed their mouth with water, and were instructed to moisten their tongue with saliva and to place the paper in the middle of their tongue. After 5 s, they were instructed to expectorate the PTC paper. They then indicated if they detected no taste or if they detected bitterness, and if the latter, they rated the intensity of the bitterness on a scale of 1–9, with 1 corresponding to “very mildly bitter” and 9 corresponding to “among the most bitter things I have ever tasted.” If the participants did not taste any
bitterness, they provided a rating of 0. This approach is similar to past work (Drewnowski et al., 2001; Frank and Korchmar, 1985). However, to test the reliability of the filter papers, the same procedure was administered to 48 participants who had not participated in the original study. They were given papers that were ordered from the Carolina Biological Company several months after this study was completed to maximize the probability that the papers would be different from the original batch that was used. Participants provided their ratings of bitterness and then 5 weeks later provided a second set of ratings. The test-retest coefficient was 0.90 ($P < 0.01$).

A recent study by Zhao and colleagues (2003) affirmed this result. They compared PROP filter papers to a three-solution method (3 concentrations of PROP and 3 concentrations of NaCl) and found them to be reliable in classifying taste status. Moreover, to validate the cutoff scores used in our study to assign taste status (described below), a $k$ means cluster analysis was performed on the bitterness scale. This analysis yielded three clusters with center means at 0, 4, and 8. Cluster membership almost perfectly correlated with our previous assignment of people to the categories of nontaster, taster, and supertaster ($r = 0.95, P < 0.01$). Overall, then, although the use of PTC paper to distinguish taste status for across-group comparisons has been criticized by some (Bartoshuk et al., 2002), data support this approach.

On the bitterness scale (range 0–9), participants who endorsed a 7 or higher were classified as supertasters ($n = 85$, mean rating 8.04, S.D. = 0.88), those who endorsed below a 7 were classified as tasters ($n = 76$; mean rating = 3.36, S.D. = 1.50), and those who endorsed a 0 were classified as a nontaster ($n = 83$). For information with regards to taste status by gender, refer to Table 1. After the completion of the questionnaires and taste test, all participants were debriefed and given their research credit.

### 3. Results

Before the analyses, all variables were examined for accuracy of data entry, missing values, and fit with distributional assumptions. There were no univariate or multivariate outliers among the variables. Descriptive statistics including means and standard deviations for the variables are presented in Table 2.

Hypothesis 1 – A chi-square was computed to test the hypothesis that women would have higher rates of supertaster status than men. Over 39% of women were supertasters, compared with over 21% of men, a significant difference (chi-square [df=1] = 6.55).

Hypothesis 2 – T-tests were computed to test the prediction that men would endorse higher alcoholism scores and family history of alcoholism than women. In this sample, men did not report significantly higher alcoholism scores or higher proportions of family history of alcoholism than women ($t$’s [242] < 1.15, $P$=ns).

Hypothesis 3 – A two-way (supertasters vs. others, and men vs. women) MANOVA, with proportion of family reported to have alcohol problems and dichotomized SMAST scores as dependent variables\(^1\), revealed a significant multivariate effect for the interaction between taste status and sex ($F$ [2, 239] = 3.55, $P < 0.05$). The multivariate main effects were both non-significant ($F$ [2, 239] < 1.71, $P$=ns). At the univariate level, the interaction was significant regarding the family history variable ($F$ [1, 240] = 5.50, $P < 0.05$), and represented a non-significant trend regarding the SMAST variable ($F$ [1, 240] = 3.13, $P$=0.078).

The means in Table 2 show the form of the interaction regarding the two dependent variables, family history and SMAST. As expected, among men who were supertasters, the proportion of first-degree biological relatives with alcohol problems was extremely low (very close to zero), whereas the proportion was substantially higher among others (proportion=0.11). A similar pattern emerged among

### Table 1

<table>
<thead>
<tr>
<th>Taste status by gender</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supertasters</td>
<td>$n = 13$</td>
<td>$n = 72$</td>
</tr>
<tr>
<td>Nontasters and tasters</td>
<td>$n = 48$</td>
<td>$n = 111$</td>
</tr>
</tbody>
</table>

Note: Over 39% of women were supertasters, compared with over 21% of men; chi-square = 6.55, $df=1$.

\(^1\) Analyses using the SMAST as a continuous variable were similar to the analyses in which the SMAST was used as a dichotomous variable. This procedure is resilient as with dichotomous dependent variables and chi-square analyses on the dichotomous SMAST variable led to highly similar findings and conclusions.
men regarding the SMAST – all male supertasters, without exception, scored below 6 on the SMAST, whereas among other men, over 10% exceeded the SMAST cut-off score used in this study (a cut-off score corresponding to substantial alcohol problems). Interestingly, the results for women displayed a quite different pattern. Women supertasters tended to report slightly higher family history rates and SMAST alcohol problems than other women.

Given that some criticize the classification of taste status by the use of filter paper, the data were reanalyzed using the bitterness scale as a continuous scale. Hierarchical regression equations were computed to address this issue. In the first regression equation, the proportion of family members reported to have alcohol problems was entered as the dependent variable, the bitterness scale and gender were entered as the independent variables in step 1, and their interaction was entered as an independent variable in step 1. Similar analyses were conducted with the SMAST as the dependent variable, in both continuous and categorical forms. Across analyses, results were identical to those reported above with regard to magnitude, direction, and significance of results, and with regard to inferences drawn therefrom.

### 4. Discussion

Consistent with the literature and our hypotheses, more women were classified as supertasters than men. In this sample, men endorsed no more alcohol problems or no greater family history of alcohol problems than women. Most interestingly, a significant association between taste status and alcohol problems was found for men – those who were supertasters had lower proportions of family history of alcoholism and fewer current alcohol problems. Unexpectedly, a nonsignificant trend emerged for women, such that supertasters had a greater family history of alcoholism and more current problems associated with alcohol use than others.

As mentioned previously, the literature on PTC/PROP taste status and alcoholism has produced mixed findings. The significant association between taste status and alcoholism among men is consistent with some of the earlier PTC/PROP taste status and alcoholism studies (Pelchat and Danowski, 1992; DiCarlo and Powers, 1998). In addition, this study lends support, among men, to the theory that supertasters are less susceptible to alcoholism because they experience more burn from oral irritants, including alcohol, and nontasters are more susceptible to alcohol problems because of decreased sensitivity to bitter tastes (Bartoshuk et al., 1994).

There could be several different explanations for the gender difference that emerged in the association between PTC taste status and alcoholism. First, previous research has indicated that a greater genetic contribution to alcohol problems may exist for men than for women; thus, PTC status may have a decreased association with alcohol problems for women. In addition, the general prevalence rate of alcohol problems is significantly lower for women than men (although the main effect did not reach statistical significance in this undergraduate sample). Our female participants might also have had a family history of depression that could be influencing our results. DiCarlo and Powers (1998) studied participants who had a pure family history of alcoholism, a family history of depression and alcoholism, and no family history of psychopathology. They found that those with a family history of alcoholism tended to have greater proportions of non-tasters, and those with a family history of depression and alcoholism tended to have greater proportions of supertasters. Interestingly, their group with family history of depression and alcoholism consisted almost entirely of females, roughly consistent with research demonstrating that among alcoholic women, depression precedes alcoholism in two-thirds of the cases (Zuckerman, 1999). Thus, it is possible that our finding among women that supertasters had more alcohol problems and a

---

### Table 2

<table>
<thead>
<tr>
<th></th>
<th>Proportion of family with alcohol problems</th>
<th>SMAST score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (S.D.)</td>
<td>M (S.D.)</td>
</tr>
<tr>
<td>Supertaster</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>0.00 (0.05)</td>
<td>1.00 (0.06)</td>
</tr>
<tr>
<td>Females</td>
<td>0.12 (0.02)</td>
<td>1.06 (0.03)</td>
</tr>
<tr>
<td>Nontasters/tasters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>0.11 (0.03)</td>
<td>1.10 (0.03)</td>
</tr>
<tr>
<td>Females</td>
<td>0.08 (0.02)</td>
<td>1.03 (0.02)</td>
</tr>
</tbody>
</table>
stronger family history of alcoholism could be influenced by a family history of depression. Replicating this study with the inclusion of family history of depression as a variable would be an interesting avenue for future research.

There are several limitations to this study that should be considered when interpreting the results. First, it had an unequal number of male and female participants (75% female, 25% male); a greater number of male participants would have improved the study. Another limitation of the study is the comparatively young age of participants, since only those with early onset alcoholism are likely to be included (although those with a family history of alcoholism tend to have an earlier age of onset). In addition, college samples tend to have a greater proportion of binge drinking as well as participants with fewer experiences with alcohol (and thus fewer chances to have experienced problems with alcohol use). Third, the SMAST was the only measure of current alcohol problems. In addition, family history of alcohol problems was assessed by asking the participants to report these problems for first-degree relatives. Though this approach is defensible, other measures and semi-structured interviews would have enhanced assessment of these variables. Finally, there was no control substance used (such as NaCl) to measure how bitter the PTC really was for each participant, though it should be noted that our classification scheme appeared to operate well, and Zhao et al. (2003) found that NaCl only helped in distinguishing the borderline cases for taste status, which only occurred approximately 7% of the time in their sample.

There are several implications of this study. First, it is the second study to find a significant association between PTC taste status and alcoholism; all other studies that have found a significant association used PROP. Second, the results indicate that a genetic association may exist between PTC taste status and alcoholism in men; additional studies should be conducted to determine the nature of any genetic mechanism. These results are consistent with Pelchat and Danowski’s (1992) suggestion that alcoholism and PTC taste status are influenced by a genetic mechanism, resulting in an inability to taste PTC that is associated with greater palatability of alcoholic beverages for the novice user. This study also supports the hypothesis that there are genetic differences by gender in alcohol problems. This may indicate that the “burn” effect of alcohol experienced by men may differ for females. Future research should focus on the relationship between taste status, alcoholism, and sex to determine if the genetic basis of supertaster status helps to explain the differential prevalence rates of alcoholism in men and women. Additional studies should be conducted to replicate these results, addressing the design limitations of this study.

References


Bartoshuk, L.M., Duffy, V.B., Fast, K., Green, B.G., Prutkin, J., Snyder, D.J., 2002. Labeled scales (e.g., category, Likert, VAS) and invalid across-group comparisons: what we have learned from genetic variation in taste. Food Quality and Preference 14, 125–138.


