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Longitudinal Changes in Sweet Preferences in Humans

J. A. DESOR[1]

Technical Center, General Foods Corporation, White Plains, NY 10625

AND GARY K. BEAUCHAMP

Monell Chemical Senses Center and Department of Animal Biology
School of Veterinary Medicine University of Pennsylvania, Philadelphia, PA 19104

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DESOR, J. A. AND G. K. BEAUCHAMP. *Longitudinal changes in sweet preferences in humans.* PHYSIOL BEHAV 39(5) 639–641, 1987.—Preferences for the taste of sucrose were measured in 44 humans when they were 11–15 years of age and again in the same individuals 9–10 years later when they were 19–25 years of age. Preferred level of sweet decreased over the intervening years. This suggests that in humans, as in rats, heightened preferences for sweet observed in the young decline with age.

Taste preference Sweet Human developmental

IT has been shown that 9- to 15-year-old humans demonstrate preferences for higher levels of sweet than do adults [6]. The effect was replicated in a study comparing adolescents below the age of 16 with those over 16 years [11]. The cause of this age difference is not clear.

One possibility is that successive generations are acquiring preferences for higher levels of sweet, perhaps because of greater exposure to it. Preferences for sweet can be modified by experience under laboratory conditions [14]. If the age difference is due to this mechanism, then higher preferences will appear in the adult population as younger generations age.

Alternatively, individuals may change as they age, showing heightened preferences during growth years and reduced preferences as adults. Such longitudinal changes occur in rats. Preferences for both sucrose-containing diets [12,16] and sucrose solutions in rats fed standard chow diets [3] decline as animals mature. This reduction in preference occurs in rats given early experience with sweet as well as those without such experience [16], although it was not seen in rats fed diets high in fat [3]. If a similar developmental mechanism underlies the age difference in humans, then longitudinal changes will be observed, and successive generations of adults should exhibit relatively constant preferences for sweet.

The purpose of the present study is to test between these alternative hypotheses by testing for longitudinal changes in human preferences for sweet.

METHOD

Subjects

The subjects were 44 humans who had been subjects in an earlier study testing for sweet preferences [6]. Their ages ranged from 11 to 15 years (mean=13.2) when first tested in 1973 and from 19 to 25 years (mean=21.8) in the present experiment, conducted in 1982–1983. There were 16 males and 28 females; 18 were Black and 26 were Caucasian. The subjects were selected from a list generated during a Philadelphia twin study previously conducted at the Krogman Growth Center at the University of Pennsylvania. The names were kindly provided by Dr. Soloman Katz of the University of Pennsylvania.

Stimuli

The stimuli were sucrose solutions in concentrations of 0.075, 0.150, 0.300, and 0.600 M. The solutions were made with reagent grade sucrose and deionized water.

Procedure

The subjects were tested using a procedure identical to that used in the earlier study [6]. Each was presented with four cups containing 30 ml samples of the sucrose solutions at room temperature. The subject tasted the four solutions without swallowing them and then ranked them in order of most to least preferred. The subject rinsed his mouth thor-

[1]Requests for reprints should be addressed to J. A. Desor, Technical Center, General Foods Corp., 250 North St., White Plains, NY 10625.

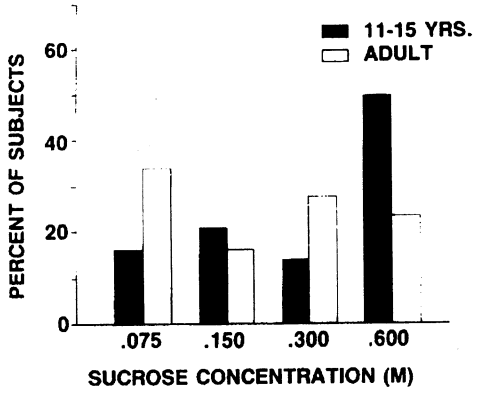

FIG. 1. Percentages of subjects selecting each concentration of sucrose as their most preferred when they were 11–15 years old and when they were adults.

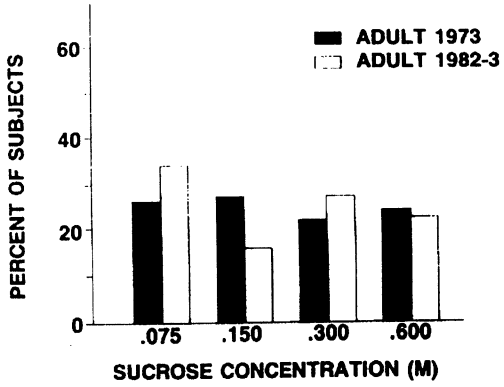

FIG. 2. Percentages of subjects selecting each concentration as their most preferred for adults tested in 1973 and adults tested in 1982–1983 who became adults since 1973.

oughly before the test and could rinse as he wanted thereafter. Presentation order was balanced across subjects.

RESULTS

The most preferred concentrations selected here were compared to the most preferred concentrations of these subjects when they were tested earlier. The distribution of recent first choices was tested for goodness of fit using the earlier frequencies as expected values.

The level of sucrose selected as most preferred decreased between adolescence and adulthood, $\chi^2(3)=22.13$, $p<0.05$. The percentages of subjects selecting each concentration as their most preferred in adolescence and later in adulthood are given in Fig. 1. When 11–15 years of age, half these subjects selected the highest concentration as their most preferred. As adults, these same subjects distributed their preferences almost evenly over the four levels of sweetness tested. On an individual basis, 24 (54%) decreased the concentration selected as most preferred, 6 (14%) increased it, and 14 (32%) selected the same concentration.

The 44 subjects retested here were representative of the 618 adolescents tested in the original study. The percentages of young subjects selecting each concentration as most preferred, low to high, were 15, 14, 21, and 50% in the sample of 618 [6] and 16, 20, 14, and 50% in the subset retested here. The distributions do not differ, $\chi^2(3)=2.40$, $p<0.5$.

The preferences expressed by these subjects as adults are very similar to those observed among the 140 adults in the earlier study. The percentages of adults selecting each concentration as their most preferred for those tested as adults in 1973 [6] and for those tested more recently, and now adults, are given in Fig. 2. The distributions do not differ, $\chi^2(3)=2.95$, $p<0.5$.

No sex or race differences were observed in this sample of 44, although both were found in the larger sample of adolescents from which this group was drawn [10]. There was a small test-retest correlation between individual's first choices on the two tests, $\rho=0.33$, n=44, $p<0.05$.

The data were also analyzed using a composite preference index based on ranks of all four samples as used in one report of the earlier work [10]. The results were the same as reported above for first-choice data.

DISCUSSION

The results support the hypothesis that in humans, individuals reduce their preferred level of sweet as they mature. They do not support the hypothesis that successive generations are acquiring increasingly stronger preferences for sweet. Not only did individual preferences decline, but this more recent generation of adults demonstrated no evidence of a stronger preference for sweet than the earlier generation of adults. That this longitudinal effect is similar to that observed in rats suggests that it is a developmental effect characteristic of these, and perhaps other, mammalian species.

The maturational effect observed here may be due to physiological, behavioral, and/or cultural factors. One hypothesis is that higher caloric needs of young, growing animals are expressed as preferences for higher levels of sweet. While there is some evidence that short-term hunger can affect preference for sweet [4], overall caloric need, per se, does not consistently affect it in this direction. Neither obese humans [9] nor malnourished infants [15] demonstrate heightened preferences for sweet.

Further, naturally occurring foods that are conspicuously sweet, some ripe fruits and vegetables, are not the most calorically dense food available to an omnivore. If an innate preference subject to maturational changes has evolved to serve energy needs, it is more likely to be for fat rather than sweet. That obese adults have heightened preferences for fat, not sweet [9], is consistent with this notion.

An alternative hypothesis is that the increased sweet preference among growing animals correlates with increased requirements for nutrients such as some vitamins and minerals obtainable from fruits and vegetables. There is little evidence that there is a series of specific appetites, one for each vitamin and mineral. However, there would be no need for such an array of specific appetites to have evolved if the general preference for sweet supports adequate intake of several of these materials. It might be argued that without a preference for sweet, humans would be primarily fat-seeking and thus, largely carnivorous. The preference for sweet expands the species' use of available nutritional resources.

An immediate physiological factor that may mediate the maturational change in preferred level of sweet is hormonal status. Sex hormones affect responses to sweet [8, 13, 17],

but these do not easily explain a general preference shift in both sexes. Hormones controlling growth common to both sexes are a more likely possibility.

Behavioral and/or cultural factors can account for the age effect in humans. However, both are unlikely explanations for the age effect in rats. The relevant learning mechanisms are unlikely to operate in individually housed animals reared on a single food, conditions under which the effect has been observed [16].

The preference for sweet is clearly innate in humans, evident soon after birth and before postnatal learning could occur [7]. It may be modulated by experience, although the nature of experimental and dietary factors are not clear [1, 2, 5]. It appears that superimposed on this innate preference is a maturational change that occurs in mid- to late adolescence. This maturational effect results in a shift toward a reduced preference for sweet.

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10: Title: USA: Children who love sweets more likely to become alcohol dependent (19 November 2003)
Author: Laurance J
Citation: news.independent, 15 November 2003
A new study, due to be published in the November issue of Alcoholism: Clinical and Experimental Research, suggests that having a sweet tooth as a youngster, makes you much more likely to develop alcoholism as an adult. The study, carried out by researchers from the Mount Sinai School of Medicine led by Dr Alexei Kampov-Polevoy, suggests that there is a genetic link between sugar and alcohol. Dr Kampov-Polevoy said that the link between sugar and alcohol was likely to a result of a genetic abnormality in then brain. He went on, "Pleasurable reactions to both alcohol and sweet substances are regulated by the same mechanism, namely the brain's opioid system". The study concluded that by saying that researchers believed that children of alcoholics (coa) have a genetic abnormality in the brain opioid system, which leads to an increased sensitivity to the rewarding effects of alcohol. (CBA Summary)

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Original title: Children who love sweets more likely to be alcoholics

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Family History of Alcoholism and Response to Sweets

Alexey B. Kampov-Polevoy, James C. Garbutt, and Elena Khalitov

Background: The relationship between a hedonic response to sweet tastes and a propensity to excessive alcohol drinking is supported by both animal and human studies. This study was designed to test the hypothesis that the genetic risk for alcoholism as measured by a paternal history of alcoholism in young social drinkers is associated with sweet-liking, defined as rating the strongest offered sucrose solution (i.e., 0.83 M) as the most palatable during the standard sweet test.

Methods: Participants were 163 subjects (39% male) without a lifetime history of alcohol or drug abuse or dependence. Eighty-one subjects had a paternal history of alcoholism (FH^+), and 82 did not (FH^-). Each subject rated a series of sucrose solutions for intensity of sweetness and palatability. Subjects were categorized as sweet-likers if they rated the highest sucrose concentration as the most pleasurable.

Results: The estimated odds of being a sweet-liker were 2.5 times higher for FH^+ than for FH^- subjects. FH^+ subjects disliked the tastes of the two weakest offered sucrose concentrations (0.05 and 0.10 M), whereas FH^- subjects reported these tastes to be neutral.

Conclusions: The results of this study support the hypothesis that sweet-liking is associated with a genetic vulnerability to alcoholism.

Key Words: Sweet Taste, Alcoholism, Genetic Marker.

TWIN AND ADOPTION studies provide strong evidence that genetic influences are important in the etiology of alcoholism (heritability estimates of 40–60%; e.g., Prescott et al., 1999). The search for phenotypical markers of the risk for alcoholism has led to the identification of several biological variables, including reduced behavioral responses to alcohol (Schuckit and Gold, 1988) and a reduced P3 component of event-related brain potential [for review, see Begleiter and Porjesz (1999)]. However, despite extensive investigation in this field, health professionals do not have a straightforward test to gauge the risk of developing alcoholism, indicating that further research in this area is needed.

Research of the past two decades strongly indicates an association between avidity to consume sweet substances and excessive alcohol intake [for review, see Kampov-Polevoy et al. (1999)], which may be at least partially determined by genetic mechanisms (Bachmanov et al., 1996, 2003; Overstreet et al., 1993; Stewart et al., 1994, 1997). Compared with alcohol-avoiding animals, alcohol-preferring animals (i.e., mice, rats, and monkeys) consumed larger amounts of sweet solutions (Bell et al., 1994; Forgie et al., 1988; Gahtan et al., 1996; Gosnell and Krahn, 1992; Higley and Bennett, 1999; Kampov-Polevoy et al., 1990, 1994, 1995; Koros et al., 1998; Overstreet et al., 1993, 1997; Ramirez and Sprott, 1978; Sinclair et al., 1992), had impaired control over consumption of sweet solutions (Kampov-Polevoy et al., 1990, 1994, 1995; Koros et al., 1998; Overstreet et al., 1997), and preferred more concentrated sweet solutions (Sinclair et al., 1992).

Human studies have also found an association between hedonic (pleasurable) response to sweet solutions and alcohol dependence (Kampov-Polevoy et al., 1997) or cocaine dependence (Janowsky et al., 2003). Alcohol- and cocaine-dependent patients in these studies more often gave the highest pleasantness rating to the most concentrated sucrose solution (0.83 M) offered during the standard sweet test and were referred to as sweet-likers, whereas most of control subjects gave the highest pleasantness ratings to one of the lower sucrose concentrations (0.05, 0.10, 0.21, or 0.42 M) and were referred to as sweet-dislikers. Furthermore, data indicate that sweet-liking is associated with the genetic risk of alcoholism as estimated by a paternal history of alcoholism regardless of alcoholic status (Kampov-Polevoy et al., 2001). However, two other studies failed to replicate these results (Kranzler et al., 2001; Scinska et al., 2001). The difference in the results of these studies may be attributed to some methodological differences between the studies (e.g., different methods of evaluating the hedonic response to different sweet solutions or different criteria for determining sweet-liking sta-

From the Department of Psychiatry (ABK-P), Mount Sinai School of Medicine, New York, New York; Department of Psychiatry and Center for Alcohol Studies (JCG), University of North Carolina at Chapel Hill, Chapel Hill, North Carolina; and School of Statistics (EK), University of Minnesota, Minneapolis, Minnesota.

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Reprint requests: Alexey B. Kampov-Polevoy, MD, PhD, Department of Psychiatry, 536/OOMH, Bronx Veterans Affairs Medical Center, 130 W. Kingsbridge Rd., Bronx, NY 10468; Fax (718) 741-4709; E-mail: kampov@earthlink.net

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tus; see "Discussion"). The discrepancy between the results of these studies emphasizes the importance of methodological issues in determination of pleasurable response to sweet stimuli. Therefore, in this study we used the procedure that in the past was shown to have an adequate discriminatory power (Janowsky et al., 2003; Kampov-Polevoy et al., 1997, 2001).

This study was designed to test the hypothesis that the genetic risk of alcoholism, as measured by paternal history of alcoholism, is associated with the hedonic (pleasurable) response to sweets, as measured by the standard sweet test in individuals without a lifetime history of substance use disorders.

METHODS

Subject Recruitment

Most subjects were recruited via e-mail announcement from the office of the Vice Chancellor of Student Affairs to the students of the University of North Carolina at Chapel Hill (approximately 22,000 messages) containing the description of the study. Six thousand responses, including 2481 from subjects with alcoholism in the family, were received. To recruit 81 subjects with a positive (FH^+) and 82 subjects with negative (FH^-) paternal history of alcoholism who met the inclusion/exclusion criteria (i.e., age 18–25 years, no lifetime history of alcohol or drug abuse or dependence, and no current medical problems), we screened approximately 800 candidates.

After reviewing a complete description of the study, subjects were asked to give a written, informed consent. Then prospective subjects completed the Michigan Alcoholism Screening Test (Selzer, 1971) modified for the assessment of the alcohol-related behavior of the subject's biological father (FMAST; Levenson et al., 1987). Because the designation of risk for alcoholism is based on the subject's report of his or her father's drinking, the conservatively strict cutoff (FMAST score >9) was used to minimize false positives, as suggested by Levenson et al. (1987). Eighty five students designated as FH^+ subjects and 85 FH^- students were invited into the study.

Evaluation of personal psychiatric and substance abuse/dependence history was conducted with the Structured Clinical Interview for DSM-III-R (Spitzer et al., 1990). Quantitative assessment of subject's alcohol drinking and drug use was performed with a 90-day timeline follow-back (Sobell et al., 1988). During the interview, it was found that 7 of 170 subjects met DSM-III-R criteria for lifetime alcohol and/or drug abuse. These subjects were excluded from the study. Therefore, the final study group consisted of 163 subjects.

Sweet Test

The sweet test was conducted at least 1.5 hr after a meal and 1 hr after smoking or tooth brushing. Two milliliters of each of 5 concentrations of sucrose solution (0.05, 0.10, 0.21, 0.42, and 0.83 M) were presented 5 times in pseudorandom order, for a total of 25 samples. For comparison, Coca-Cola Classic (Coca-Cola Co., Atlanta, GA) is a 0.33 M sugar solution. Subjects were instructed to sip the solution, swish it around in their mouths, and spit it out. They were then asked to rate the solution, rinse their mouth with distilled water, and proceed to the next solution. To rate the sucrose solution sweet intensity, each subject was asked to rate "How sweet was the taste?" on a 200-mm analog scale. Each subject was then asked to rate each solution's pleasurableness, answering the question "How much do you like the taste?" with the same analog scale. The two poles of this analog scale were "dislike it very much" (scored as −100) and "like it very much" (scored as 100). The average rating of pleasurableness of each sucrose solution was calculated. Sweet-liking was defined as giving the highest pleasantness rating to the highest sucrose concentration (0.83 M), and sweet-disliking was defined as giving the highest pleasantness rating to one of the lower sucrose concentrations (0.05, 0.10, 0.21, or 0.42 M).

Table 1. Demographic Data and Data Reflecting Alcohol Intake for the FH^+ and FH^- Groups

Variable	FH^+ group (n = 81)	FH^- group (n = 82)	p Value
Age (years)	21.1 ± 0.4	23.0 ± 0.3	<0.0001[a]
Gender (% male)	33%	46%	0.09[b]
Ethnicity (% Caucasians)	80%	83%	0.7[b]
Drinking episodes per month	4.0 ± 0.4	4.2 ± 0.5	0.7[a]
Drinks per drinking episode	3.5 ± 0.3	2.9 ± 0.2	0.08[a]
Abstinence before the test (days)	6.1 ± 1.5[c]	7.6 ± 1.2[d]	0.8[a]
Smoking (cigarettes per day)	1.3 ± 0.4	0.5 ± 0.3	0.1[a]

p values represent either [a] two-sample t tests or [b] Pearson's χ^2 test for independence for a 2 × 2 contingency table.

[c] Nine subjects in this group abstained from alcohol for more than 3 months. Their data were not included in the analysis.

[d] Four subjects in this group abstained from alcohol for more than 3 months. Their data were not included in the analysis.

Statistical Analysis

Two-sample t tests and Pearson's χ^2 test of independence for a 2 × 2 contingency table were used to evaluate differences between the FH^+ and FH^- groups. The relationship between the hedonic (pleasurable) response to the sweet taste and a paternal history of alcoholism was studied by using the proportional odds logistic regression models (Agresti, 1996; McCullagh, 1980).

RESULTS

The study group consisted of 163 subjects [age, 22.1 ± 0.2 years (mean ± SEM); 39% men]; 81 subjects were designated as FH^+ (average FMAST score, 13.2 ± 0.5), and 82 subjects were designated as FH^- (average FMAST score, 0.8 ± 0.2). On average, subjects had 4.1 ± 0.3 drinking episodes per month, consuming 3.2 ± 0.2 standard drinks per episode. All subjects abstained from drinking alcohol for at least 24 hr (13 subjects reported abstinence exceeding 90 days; the average duration of abstinence for the rest of the group was 7.8 ± 0.9 days). Sixteen subjects (9.8%) reported smoking cigarettes (on average, these subjects smoked 9.3 ± 0.6 cigarettes per day). FH^+ subjects were slightly younger than FH^- subjects. Comparative demographic, data as well as data reflecting alcohol drinking and smoking for FH^+ and FH^- subjects, are presented in Table 1.

All tested subjects were able to effectively discriminate between different concentrations of sucrose, generating appropriate concentration-response curves. There was no significant difference in sweet taste intensity ratings between FH^+ and FH^- groups (data not shown). Most (53%) subjects in the total sample gave the highest pleasantness rating to the strongest offered sucrose solution (0.83 M) and were designated as sweet-likers according our classification. When FH^+ and FH^- subjects were compared, the proportion of sweet-liking subjects was higher in the FH^+ group (66%) compared with the FH^- group (42%; Pearson's χ^2 statistic p value for the test of independence in the 2 × 2 table = 0.002). When FH^+ and FH^- subjects were analyzed by gender, 45% of female FH^-

Table 2. Pleasurable Ratings for the Taste of Various Concentrations of Sucrose Solutions in FH^+ and FH^- Nonalcoholic Subjects

Sucrose concentration (M)	Pleasurable rating		
	FH^+ subjects	FH^- subjects	p Value
0.05	−25.0 ± 3.8	−6.4 ± 3.2	0.0002
0.10	−19.2 ± 3.4	−2.0 ± 3.0	0.0002
0.21	−0.04 ± 3.3	9.9 ± 3.0	0.027
0.42	31.9 ± 3.9	19.3 ± 4.3	0.032
0.83	32.3 ± 5.2	15.0 ± 5.5	0.024

A "0" score corresponds with "neither like nor dislike." A negative score (from 0 to −100) reflects a measure of dislike of a particular sucrose concentration. A positive score (from 0 to 100) reflects a measure of liking a particular sucrose concentration. p values represent two-sample t tests.

subjects were sweet-likers compared with 62% of female FH^+ subjects ($p = 0.19$; χ^2), and 39% of male FH^- subjects were sweet-likers compared with 67% of male FH^+ subjects ($p = 0.005$; χ^2).

Further analysis with proportional odds logistic regression models for pleasurable response to the sweet taste (the response variable was represented with five categories corresponding to 0.05, 0.1, 0.21, 0.42, and 0.83 M concentrations of sucrose solution) and the FH categorical predictor showed that FH was a significant factor ($p = 0.003$). On average, the estimated odds of being a sweet-liker were 2.5 times higher for FH^+ than for FH^- subjects (95% confidence interval, 1.36–4.57). The addition of other predictors to the model (i.e., age, gender, number of drinking episodes per month, drinks per drinking episode, and number of cigarettes smoked per day) showed that these variables were not significant in predicting sweet-liking [i.e., when dropped from the model, the variable resulted in a nonsignificant change in deviance ($p > 0.05$)].

Comparison of the average pleasurable ratings of different sucrose solutions between FH^+ and FH^- groups showed that FH^- subjects considered the taste of low-sucrose concentrations (0.05 and 0.1 M) as neutral (a rating of 0 corresponds with "neither like nor dislike"), whereas FH^+ subjects gave low-sucrose concentrations a negative pleasurable rating, indicating that they disliked the taste (Table 2). Pleasurable ratings for the two strongest offered sweet solutions (0.42 and 0.83 M) were higher in the FH^+ group compared with the FH^- group, whereas the pleasurable ratings for the less-concentrated sucrose solutions (i.e., 0.05, 0.10, and 0.21 M) were lower in the FH^+ group compared with the FH^- group. Furthermore, there was a significant negative correlation of FMAST score (i.e., quantitative index of paternal alcohol-related behavior) with the pleasurable ratings for 0.05 M ($r = -0.25$; $p = 0.001$) and 0.1 M ($r = -0.26$; $p = 0.0008$) sucrose concentrations, but not with the pleasurable ratings for 0.21, 0.42, and 0.83 M sucrose solutions ($p > 0.05$).

DISCUSSION

This study extends previous research exploring the relationship between hedonic response to sweet taste and excessive alcohol intake. Since Ramirez and Sprott (1978) and Forgic et al. (1988) demonstrated a relationship between sweet intake and alcohol intake, a number of studies have confirmed these findings in mice (Bachmanov et al., 1996; Belknap et al., 1993), rats (Bell et al., 1994; Dess et al., 1998; Gahtan et al., 1996; Gosnell and Krahn, 1992; Kampov-Polevoy et al., 1990, 1994, 1995; Koros et al., 1998; Overstreet et al., 1993, 1997; Sinclair et al., 1992), and nonhuman primates (Higley and Bennett, 1999). There is evidence that the association between ethanol intake and consumption of sweets in animals might be genetic in origin [Bachmanov et al., 1996; Dess et al., 1998; Overstreet et al., 1993; Spanagel et al., 2002; Stewart et al., 1994, 1997; for review, see Bachmanov et al. (2003)].

In addition to a high intake of sweet solutions, rats genetically selected for high alcohol intake prefer stronger concentrations of sweets compared with alcohol-avoiding rats (Sinclair et al., 1992). Similar patterns of hedonic (pleasurable) responses to sweet tastes have been described in human subjects as well. For example, Thompson et al. (1976) showed that most individuals can be classified into one of two categories: sweet-likers, who report an increasing pleasurable response to increasing concentrations of sucrose across the range of 0.0 to 2.0 M, and sweet dislikers, who may show an increasing pleasurable response only up to a 0.2 M concentration and then show decreasing pleasurable responses as sucrose concentrations increase to more than 0.6 M. Similar patterns of the hedonic response to sweets were described in humans in a number of studies (Cabanac, 1979; Looy et al., 1992; Looy and Weingarten, 1991; Pangborn, 1970; Thompson et al., 1976).

Sweet-liking has been shown to be associated with excessive alcohol intake in humans, similar to animal findings reported by Sinclair et al. (1992). Our own study showed that the prevalence of sweet-liking was higher (65%) among alcoholics than among nonalcoholic control subjects (16%; $p = 0.0003$; Kampov-Polevoy et al., 1997). However, this study gave no indication whether sweet-liking reflects a genetic vulnerability to substance abuse and exists before the onset of the excessive drinking or is a result of a long history of heavy drinking and drug use, as suggested by Hirsch (1997).

The first evidence that sweet-liking is associated with a genetic vulnerability to alcoholism as measured by a paternal history of alcoholism came from a study of hedonic (pleasurable) response to sweet taste conducted in alcoholic patients and control subjects, the latter without a lifetime history of alcoholism or substance abuse or dependence (Kampov-Polevoy et al., 2001). This study showed that a paternal history of alcoholism contributes to the likelihood of being a sweet-liker independently of alcoholic status.

The present study provides additional support for the hypothesis of an association between sweet-liking and a paternal history of alcoholism in a sample of young individuals (men and women) without lifetime alcohol or drug abuse or dependence. This study provides the first evidence

that FH^+ subjects may dislike the taste of the weaker sucrose solutions (i.e., 0.05 and 0.10 M), whereas FH^- subjects consider the taste of these solutions as neutral. In this regard we should note that aversion to the sucrose taste, especially at the low concentrations, has been noted in rats after treatment with the opioid antagonist naltrexone (Ferraro et al., 2002). Therefore, aversion to the taste of low-sucrose concentrations may be associated with hypofunction of the brain opioid system. This finding, if confirmed, may provide a mechanistic explanation of why FH^+ subjects tend to give higher pleasurable ratings to more-concentrated sweet solutions.

Our findings of an association between a hedonic (pleasurable) response to a sweet taste and paternal history of alcoholism are at odds with the results of at least two published studies, and this requires comment. Kranzler et al. (2001) did not find any difference in the prevalence of sweet-likers between nonalcoholic FH^+ and FH^- groups. Seventy-seven percent of subjects in their sample were shown to be sweet-likers regardless of their FH status. Analyzing this study, we noted that although the same standard sweet test was used, sweet-liking and sweet-disliking status were defined differently. In our previous studies (Kampov-Polevoy et al., 1997, 2001) and in this study, sweet-liking was defined as liking the highest offered sucrose concentration (0.83 M). Kranzler et al. (2001) designated to the sweet-liking group subjects who gave higher pleasurable ratings to the tastes of 0.42 or 0.83 M sucrose solutions and designated to the sweet-disliking group subjects who gave higher pleasurable ratings to the tastes of 0.05 or 0.10 M sucrose solutions. Subjects who gave the highest pleasantness rating to the 0.21 M sucrose solution were excluded from their analyses. Inclusion of subjects who gave highest pleasurable rating to the taste of a 0.42 M sucrose solution (i.e., sweet-dislikers, according our classification) into the sweet-liking group and exclusion of subjects who gave the highest pleasurable rating to the taste of 0.21 M sucrose solution from the sample may explain the high prevalence of sweet-likers in the Kranzler et al. (2001) study. When results of the present study were recalculated by using the criteria suggested by Kranzler et al. (2001), no difference in the prevalence of sweet-liking was found between FH^+ and FH^- groups. The other difference in the Kranzler et al. (2001) study was that their subjects were older than ours (average age of 26 vs. 22 years, respectively). As Kranzler et al. noted, by excluding subjects with alcohol problems in this older group, they excluded subjects with early-onset alcoholism, arguably the most genetic form of alcoholism (Dawson, 2000).

The other study that failed to find a difference in hedonic responses to sweet taste between FH^+ and FH^- subjects was reported by Scinska et al. (2001). That study used a very different method of sweet testing that used only three sucrose concentrations (1, 10, and 30%; these concentrations correspond approximately to 0.03, 0.29, and 0.88 M sucrose solutions), which were tested with other solutions (e.g., quinine hydrochloride, citric acid, and sodium chloride). Most subjects in this study gave the highest pleasantness rating to the 0.88 M sucrose solution regardless of their FH status.

This methodology of evaluating hedonic responses to sweet taste has the following limitations. (1) Sweet solutions were presented intermittently with other solutions (e.g., quinine hydrochloride, citric acid, and sodium chloride). The presentation of qualitatively dissimilar taste substances (e.g., sucrose and quinine) may significantly interfere with the taste perception of these substances (Rankin and Marks, 1992) and, as a result, interfere with the hedonic response to these substances. (2) Unlike the standard sweet test, when subjects were instructed to swish sucrose solution around the mouth to allow it to contact with various taste receptors, in the Scinska at al. (2001) study, small amounts of various solutions were applied locally on the anterior tongue. (3) Each sucrose solution was offered to a subject only once. Therefore, during the first presentation of a tastant, the subject did not have a reference point. In our experience, the sweet-liking status determined on the basis of the first presentation of sucrose solutions is not always the same as the sweet-liking status determined on the basis of the average scores obtained after five presentations. For example, in our present study, a match between the first and average pleasantness ratings was noted in only 49% of subjects. (4) Only three sucrose solutions (0.03, 0.29, and 0.88 M) were offered to a subject. It should be noted that originally the term *sweet-liking* was proposed by Thompson et al. (1976) to describe subjects who, unlike the subjects designated as *sweet dislikers*, do not report a decrease in pleasurable response to the sweet taste of sucrose when its concentration exceeds 0.6 M (approximately 21% w/v). Scinska et al. (2001) used a much lower cutoff concentration of 10% (approximately 0.3 M) in their study, thus designating as sweet-likers at least some individuals who would be designated as sweet-dislikers in the standard sweet test used in our studies. This may explain the high prevalence of sweet-likers in both the FH^+ and FH^- groups in the Scinska et al. (2001) study. Therefore, the failure to detect the difference between these groups may be attributed to differences in methodology.

Two other studies that used the same methodology as the one described by Scinska et al. (2001) failed to find differences in the prevalence of sweet-likers between alcohol-dependent and control subjects (Bogucka-Bonikowska et al., 2001) or between opiate-dependent and control subjects (Bogucka-Bonikowska et al., 2002). This is in contrast to the recent study by Janowsky et al. (2003), in which, with the standard sweet test, differences were found in the prevalence of sweet-likers between hospitalized cocaine addicts and matched control subjects. These contradictory findings support the idea that the choice of methodology is critical in the assessment of the pleasurable response to sweet taste.

The mechanism of the association between consumption of sweet substances and self-administration of drugs or

alcohol is not fully understood. It was suggested that the relatively high pleasurable rating for the taste of stronger concentrations of sweet solutions noted in alcoholics might result from a chemosensory adjustment of the olfactory system to excessive alcohol intake [for discussion, see Hirsch (1997)]. However, such a view is not consistent with the results of this study, in which young subjects with no lifetime history of alcohol abuse or dependence were enrolled.

A better understanding of an association between consumption of sweet substances and alcohol intake comes from the evidence indicating that the rewarding effect of both alcohol and sweet foods may be mediated by the same brain mechanisms. For example, different rewarding events, including feeding, alcohol intake, and self-administration of psychostimulants, are accompanied by the similar activation of the mesolimbic dopamine system [Hernandez and Hoebel, 1988; Lyness et al., 1979; for discussion, see Di Chiara et al. (1998)], suggesting that alcohol, stimulants, and sweets may share common dopaminergic mechanisms that mediate their hedonic effects. Another common mechanism that has been shown to mediate, at least in part, the hedonic response to both alcohol and sweet substances is the brain opioid system. For example, stimulation of μ-opioid receptors within the nucleus accumbens facilitates consumption of both saccharine solution and alcohol in nondeprived rats (Zhang and Kelley, 1997). Involvement of the brain opioid system in mediating the pleasurable effect of alcohol has been well documented [Froehlich and Wand, 1996; Froehlich et al., 1998; for review, see Froehlich and Li (1993, 1994)]. Furthermore, the highly heritable (Froehlich et al., 2000) β-endorphin response to alcohol was shown to be associated with a family history of alcoholism (Gianoulakis et al., 1989, 1996). Some authors suggested that activity of the brain opioid system may serve as a biomarker of genetic risk for alcoholism (Froehlich et al., 2000).

In this regard, it is of special interest that the brain opioid system also mediates the hedonic response to sweets. Eating a sweet diet has been found to induce alterations in the sensitivity, synaptic levels, and gene expression of opioid systems (Dum and Herz, 1984; Dum et al., 1983; Gianoulakis et al., 1990; Marks-Kaufman et al., 1989; Rudski et al., 1997; Shabir and Kirkham, 1999; Welch et al., 1996). Chronic exposure to saccharin leads to the development of tolerance to opioids (Lieblich et al., 1983) that may be detected in rats after 24 hr of ingestion of sweet solutions and that progressively increases over the next 5 weeks (Bergmann et al., 1985).

It is important for our study to note that the pleasantness of the sweet taste may reflect the activity of the brain opioid system. For example, animal studies using preference-aversion curves with different concentrations of saccharine demonstrated that activation of the brain opioid system with morphine shifts the curve to the left toward the preference for weaker saccharin solutions (Calcagnetti and Reid, 1983), whereas the opiate antagonist naloxone produces the opposite effect (Leventhal et al., 1995).

These data are consistent with the hypothesis that the offspring of alcoholics have a genetically determined defect of the activity of the brain opioid system that results in abnormal reinforcement after ingestion of alcohol—perhaps contributing to a predisposition to alcoholism. The same defect of the brain opioid system may also contribute to a higher hedonic (pleasurable) response to the taste of more concentrated sweet solutions because the taste of the weaker sweet solutions may be insufficient to produce a pleasurable reaction. This mechanism may explain why the hedonic (pleasurable) response to sweet taste has a predictive value regarding excessive alcohol intake.

In summary, the results of this study provide further support to the hypothesis that the pleasurable response to sweets is associated with a genetic vulnerability to alcoholism as measured by a paternal history of alcoholism. If confirmed by further investigations, these findings indicate that this trait may be considered as a potential phenotypic marker of genetic vulnerability to alcoholism.

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