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Pleasantness of a Sweet Taste during Hunger and Satiety: Effects of Gender and "Sweet Tooth"

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Hungry or sated adult female ($N=29$) and male subjects ($N=28$), classified according to whether they had eaten or not within 2 h, rated four concentrations of sucrose in a lime drink for their sweetness intensity and pleasantness. Subjects also rated their attitude towards sweets in general (self-reported sweet tooth). Female subjects rated the solutions as less pleasant when tasted soon after a meal. Male subjects showed a non-significant trend in the same direction. Female subjects also rated the solutions as more intense than the male subjects did. Moreover, subjects who reported having a "sweet tooth" (regardless of gender) showed a significant alliesthesia effect (i.e., enhancement of pleasantness of sweet tastes by hunger), whereas those with "no sweet tooth" did not. We conclude that both gender and the degree of individual "sweet tooth" influence alliesthesia.

Introduction

It is a familiar experience that foods do not taste as pleasant after a substantial meal as they do after a prolonged fast. This effect of physiological state related to energy on the hedonic ratings of sweet foods and drinks was called *alliesthesia* by Cabanac (1971), from two Greek words meaning "another taste". The effect has been replicated several times (Cabanac, 1971; Cabanac & Fantino, 1977; Cabanac, 1979; Fantino, 1984; Looy & Weingarten, 1991). Laboratory animals show comparable effects in their electrophysiological responses as well as in behavioral affective reactions to the hedonic properties of food (Rolls *et al.*, 1986; Cabanac & Lafrance, 1990; Berridge, 1991).

However, little is known about how alliesthesia might be modulated by such characteristics as gender or individual differences in personal liking for sweetness. Looy & Weingarten (1991) have made some progress in this regard by showing that the subject's "liking" of sweet tastes affects alliesthesia, in that only subjects whose pleasantness ratings were negatively correlated with sweetness intensity showed alliesthesia. Other studies have shown that men and women differ in their hedonic ratings of identical taste stimuli (Enns *et al.*, 1979; Conner & Booth, 1988) and in their cravings for certain foods (Weingarten & Eston, 1991). These findings suggest that gender might have effects on the modulation of palatability by hunger.

In this study we examined how the gender of a subject is related to the alliesthesia difference and to hedonic and intensity judgments of a sweet lime drink. Additionally,

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we investigated how these measures are influenced by the "sweet tooth" of the person, as defined either by a self-report measure or by actual pleasantness ratings for sweet lime drinks.

Hunger and satiety states were distinguished operationally by asking whether the subjects had or had not eaten within the 2 h preceding the test. For most subjects, the answer to this question reflected whether they had eaten at all that day, since the test was usually administered in the morning.

METHODS

Subjects

Twenty-nine female (mean age = 23·3, $SD = 6·5$) and 28 male subjects (mean age = 23·1, $SD = 6·9$) participated on a voluntary basis. All were students or staff of the University of Michigan.

Procedure

The subjects were asked to rinse their mouths with a small amount of tap water prior to testing and between each lime drink. They were then asked to sip and swallow a small amount (approximately 2·5 ml each) of four solutions of a commercial fruit drink (lime Kool Aid). Lime drinks were identical except in sucrose concentration. The four solutions were presented in a different order for each subject. However, since there are 24 permutations of four different items, in five cases a particular order was used with two subjects instead of only one subject. Each solution contained a constant amount of Kool Aid brand drink powder (0·24% w/v; 11·25 g) in 475 ml of tap water, together with varying amounts of sucrose: 4·5% (21 g of sucrose), 9% (42 g), 18% (84 g) and 36% (168 g). Subjects were not allowed to see the bottles containing the solutions and the drinks were presented in opaque plastic cups in order to reduce visual cues about the viscosity differences of the four solutions. Color was equated by adding appropriate amounts of green food coloring to each solution in the bottles. Immediately after sipping each solution, the subjects were asked to judge first the intensity of the solution, from 1 = least intense to 9 = most intense and then the pleasantness of the solution from −4 = extremely unpleasant to +4 = extremely pleasant, with a zero value as indifferent. The scales were presented visually on paper and the subjects were asked to mark the selected value with a pen.

After all the four solutions had been tasted, subjects were asked the following questions: (a) when did you have your last meal?; (b) how much of a "sweet tooth" do you think you have (4 = a lot; 3 = moderate; 2 = a little bit; 1 = none)? If the subject asked what was meant by "sweet tooth", he/she was told: "Do you like sweet foods more than other foods?". Subjects who had eaten their last meal less than 2 h prior to testing were assigned to the Sated Group (females: mean of minutes = 54·4, SE = 14·9; males: mean = 55·0, SE = 13·5), whereas subjects who had their last meal more than 2 h prior to testing were assigned to the Hungry Group (females: mean = 297·3, SE = 73·2; males: mean = 435·0, SE = 124·8). A Wilcoxon's rank-sum test showed that the hungry and sated groups differed significantly in reported time since last meal ($W_s = 137$, $N_1 = 16$, $N_2 = 17$, $p < 0·001$).

Data Analysis

An analysis of variance was performed on the intensity ratings, with gender, satiety state and order of solutions as between-subjects factors and concentration of sucrose as within-subjects factor. For the purpose of analysing the effect of stimulus order on intensity ratings, the actual sequence of solutions was reduced from 24 to 10 levels by grouping together subjects who were tested with orders having a similar "weight": the weight of an order was determined by assigning values from 1 to 4 to each solution (4 to the highest concentration and 1 to the lowest) and to the position from first to last (4 to the first and 1 to the last) and by multiplying these two numbers together; the sum of each of the four values so obtained yielded an "order score" (varying from 20 to 30) for each subject that was used to assign the subjects to ten groups. A four-factor analysis of variance was performed on the pleasantness ratings with gender, satiety state and order of solutions as between-subjects factors and concentration of sucrose as the within-subjects factor. Order of solution was assigned by the same procedure as for the analysis of intensity ratings. However, this factor did not reach statistical significance for pleasantness ratings, $F(9,26) = 0{\cdot}98$, n.s., and so it was deleted from all subsequent analyses.

RESULTS

Intensity Ratings

The subjects' evaluations of sweetness intensity (Figure 1) increased systematically with sucrose concentration, $F(3,78 = 147{\cdot}6$, $p < 0{\cdot}01$. All solutions differed significantly from each other (Dunn's multiple comparison tests, df = 55, $p < 0{\cdot}01$). However, women tended to describe the solutions on average as sweeter (mean = 5·84,

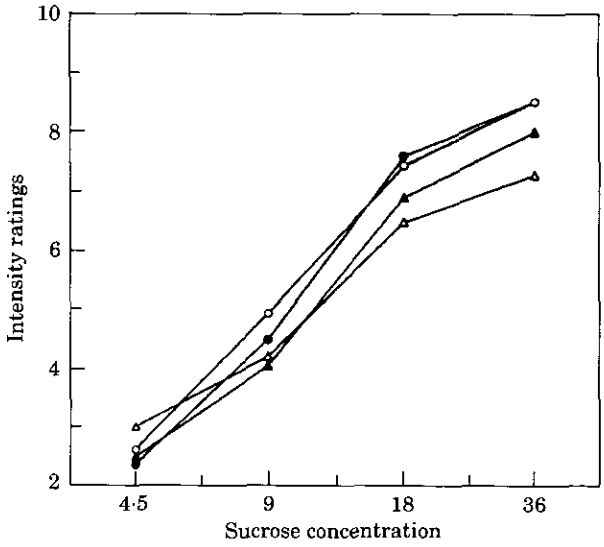

FIGURE 1. Mean intensity ratings of females and males in each satiety group for each sucrose concentration. ●, sated females; ○, hungry females; ▲, sated males; △, hungry males.

$SE = 0{\cdot}25$) than men did (mean = 5·33, $SE = 0{\cdot}24$). A significant gender by concentration interaction (Figure 1) indicated that this gender difference was most pronounced for the two highest concentrations (18 and 36%).

Order of presentation of solutions had a significant effect on intensity ratings, $F(9,78) = 2{\cdot}59$, $p < 0{\cdot}05$. It appeared that ratings were suppressed if higher concentrations were given first. This might be due to a range-bias effect (Conner *et al.*, 1987), in which ratings of low concentrations would be lower if the initial rating was of a high concentration.

Males were significantly affected by order of presentation of the solutions, $F(9,13) = 2{\cdot}83$, $p < 0{\cdot}05$, whereas females were not, $F(9,13) = 2{\cdot}585$, n.s. Moreover, hungry male subjects tended to rate the 4% concentration as sweeter and the 36% as less sweet than the sated male subjects did, $F(3,39) = 4{\cdot}10$, $p < 0{\cdot}01$.

Pleasantness Ratings

When genders were combined together, pleasantness ratings were higher if subjects reported that they had not recently eaten than if they were recently fed.

Solutions were rated negatively overall (mean = −0·42, $SE = 0{\cdot}21$) by subjects who had their meal within 2 h of testing and positively by subjects who had their meal more than 2 h before testing (mean = 0·15, $SE = 0{\cdot}21$), $F(1,26) = 6{\cdot}47$, $p < 0{\cdot}05$. Evaluations varied significantly with concentration, $F(3,78) = 9{\cdot}50$, $p < 0{\cdot}01$; the average pleasantness rating exhibited a maximum at 9% (which corresponded closely to the amount of sucrose recommended by the Kool Aid manufacturer).

The pleasantness ratings of different concentrations were influenced by gender of the rater, $F(3,78) = 2{\cdot}78$, $p < 0{\cdot}05$. Women (sated and hungry) assigned a positive hedonic rating only to the 9% solution and assigned negative ratings to the lowest (4·5%) and highest (36%) concentrations (Figure 2). Males (sated and hungry)

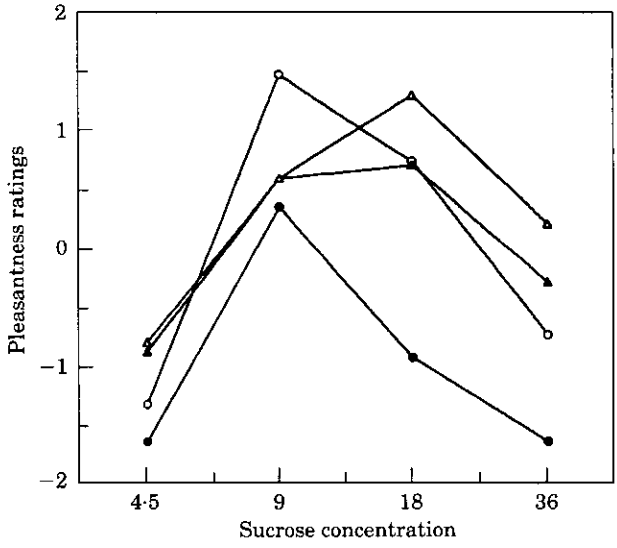

FIGURE 2. Mean pleasantness intensity ratings of females and males in each satiety group for each sucrose concentration. ●, sated females; ○, hungry females; ▲, sated males; △, hungry males.

instead assigned positive hedonic ratings to both intermediate solutions (9 and 18%) and rated the two extreme solutions less negatively than women did.

The general tendency of males to assign higher hedonic ratings than females was also reflected in a significant main effect of gender, $F(1,26) = 6{\cdot}44$, $p < 0{\cdot}05$.

To explore the influence of gender on alliesthesia, each gender was analysed separately. As shown in Figure 2, the Sated Group in both genders exhibited lower pleasantness ratings of solutions than the Hungry Group. However, this effect reached statistical significance only for female subjects, $F(1,81) = 5{\cdot}429$, $p = 0{\cdot}028$. Males as a group did not show significant alliesthesia, $F(1,79) = 0{\cdot}33$, n.s.

Analyses of variance were also performed on each satiety state separately. Whereas the Hungry Group did not show a significant gender difference in hedonic ratings (women: mean $= 0{\cdot}03$, $SE = 0{\cdot}29$; men: mean $= 0{\cdot}33$, $SE = 0{\cdot}30$), in the Sated Group the two genders differed significantly (women: mean $= -0{\cdot}96$, $SE = 0{\cdot}30$; men: mean $= 0{\cdot}029$, $SE = 0{\cdot}27$; $F(1,15) = 8{\cdot}133$, $p < 0{\cdot}01$), the women showing an average negative rating for the lime drink.

"Sweet Tooth" Ratings

There were no significant differences between the two genders in self-reported sweet tooth (females: mean $= 2{\cdot}28$, $SE = 0{\cdot}18$; males: mean $= 2{\cdot}04$, $SE = 0{\cdot}17$). Also, gender did not interact significantly with satiety state in determining reports of sweet tooth. However, the simple effect of satiety state approached significance, $F(1,52) = 3{\cdot}62$, $p < 0{\cdot}10$. Subjects who had eaten a meal within 2 h before testing tended to give higher sweet tooth ratings (mean $= 2{\cdot}34$, $SE = 0{\cdot}16$) than subjects who had eaten their last meal earlier (mean $= 1{\cdot}92$, $SE = 0{\cdot}18$).

"Sweet Tooth Groups" and Alliesthesia

The 41 subjects who chose a value from 2 to 4 on the "sweet tooth" score were categorized as reporting a sweet tooth and not the 16 subjects who chose the score of 1. A separate analysis of variance with gender, satiety state and concentration as factors was performed for each group. Subjects who reported a sweet tooth showed significant alliesthesia, hunger/satiety $F(1,36) = 5{\cdot}36$, $p < 0{\cdot}05$, whereas the others did not, $F(1,12) = 0{\cdot}50$, n.s. Moreover, in the latter group, the effect of concentration on pleasantness ratings also failed to reach significance, $F(3,36) = 2{\cdot}47$, $p < 0{\cdot}10$, whereas in the subjects with sweet tooth the effect of concentration on pleasantness ratings was highly significant, $F(3,108) = 6{\cdot}311$, $p < 0{\cdot}01$.

Since men and women did not differ overall in "sweet tooth" ratings, and since an analysis of variance in pleasantness ratings showed that sweet tooth and gender did not interact, $F(1,65) = 0{\cdot}01$, n.s., we concluded that the effect of sweet tooth on alliesthesia is independent of gender and that it does not arise from a gender difference in levels of sweet tooth.

Relationship of "Sweet Tooth" to Hedonic Ratings

Several analyses were performed to determine whether self-reported sweet tooth values were correlated with average hedonic ratings of the solutions.

Initially, we evaluated the relationship of sweet tooth score to hedonic ratings of each individual solution. When compared to the ratings for the 9% solution, the

correlation ($r = 0{\cdot}223$) approached significance, $F(1,54) = 2{\cdot}83$, $p < 0{\cdot}10$. Self-report of sweet tooth, in other words, seem to predict hedonic ratings of the intermediate and most liked concentration. Self-reports of sweet tooth did not correlate significantly with individual pleasantness ratings for the 18% solution ($r = 0{\cdot}015$) and 36% solution ($r = 0{\cdot}048$), which were the two sweetest solutions used in the study.

Looy & Weingarten (1991) divided subjects into "likers" and "dislikers" (the former showing a positive slope of the regression line of the hedonic response over increasing concentrations and the latter a negative slope) and found that the effect of satiety on pleasantness was strongest for dislikers. We also attempted to evaluate the relationship of sweet tooth to the profile of hedonic ratings. Subjects were grouped as "likers" if their pleasantness rating of the 36% concentration was higher than that of the 18%. Subjects who showed the reverse relationship between these ratings were grouped as dislikers, and those who showed the same rating for both concentrations were excluded from further analyses.

Separate analyses of variance were performed on likers and dislikers, with gender, satiety state and concentration as factors. The effect of satiety state reached significance, $F(1,36) = 8{\cdot}68$, $p < 0{\cdot}05$, only for the "dislikers" (sated subjects evaluated the solutions more negatively than the hungry subjects) and not for the "likers", $F(1,10) = 0{\cdot}008$, n.s., as reported by Looy & Weingarten (1991).

When these groups were further divided by gender (male likers: $N = 7$; male dislikers: $N = 20$; female likers: $N = 7$; female dislikers: $N = 19$), the effect of satiety state was significant only in the female dislikers, $F(1,18) = 9{\cdot}64$, $p < 0{\cdot}01$.

These effects on alliesthesia of the relative pleasantnesses of strongly sweet drinks were significant only for groups of likers and dislikers divided on the basis of their ratings to the two highest concentrations (18 and 32%). If lower concentrations were used to divide subjects, this effect on alliesthesia disappeared, unlike the results reported by Looy & Weingarten (1991). This difference in results perhaps relates to the fact that they used pure sucrose solutions rather than a fruit-flavored drink.

"Likers" and "dislikers" did not differ in self-reported sweet tooth ratings, $F(2,51) = 0{\cdot}19$, n.s.

Discussion

Our finding of a gender difference in average hedonic ratings of sweetness is consistent with previous studies which showed that men give higher pleasantness ratings to sweet tastes than women do (Enns *et al.*, 1978) or maximally prefer a more highly sweetened drink (Conner & Booth, 1988). Male subjects as a group valued the lime drinks overall more positively. In particular, they rated the 18% solution on average as positively as the 9% solution, whereas only the 9% solution (i.e., the commercially recommended concentration) was rated positively on average by female subjects.

The major finding of this study is that gender influenced alliesthesia. In particular, women showed numerically and statistically greater alliesthesia than men.

Men and women also differed in their overall hedonic ratings only when sated and not when hungry. This might reflect an influence of cognitive factors on hedonic ratings. Women in western culture are more concerned with weight than men and therefore more "conflicted" in their attitudes about food (Wooley & Wooley, 1983). Weingarten & Elston (1991), for example, have shown that in a large group of young

adults, females tended to assign greater negative effect to indulgence of sweet cravings than men did. It is possible that such influences on appraisals of sweet foods are stronger during satiety. A second possibility is that men's hedonic ratings are biased to a greater degree by a stable interpretation of their own preferences (e.g., "I enjoy fruit drinks; so I must like this"). This might mask hedonic decrements after satiety, while women's hedonic ratings more accurately reflected situational hedonic assessment, without this bias. The present results do not allow us to infer the relative importance of cultural and physiological factors in the gender difference observed.

Self-reported sweet tooth was not strongly predictive of individual differences in hedonic ratings. However, only subjects with a sweet tooth showed significant alliesthesia. Since the two genders did not differ in self-reported sweet tooth, and gender and sweet-tooth factors did not interact in pleasantness ratings, it seems clear that gender effects and sweet-tooth effects on alliesthesia are independent of each other. Additionally, the tendency of satiety states to affect sweet-tooth ratings suggests that self-reported sweet tooth could be under the influence of the temporary physiological state of the person instead of being exclusively based upon the memory of past experiences with sweet drinks.

We essentially replicated Looy & Weingarten's findings (1991) that only "dislikers" (i.e., in their study, subjects with a negative hedonic slope over increasing sucrose concentrations) tended to show alliesthesia. In this study, a significant effect of satiety on pleasantness was found only for the subjects who gave lower pleasantness ratings to the 36% than they did to the 18% sucrose drink. However, gender seems to be an important factor, since again only females exhibited the effect.

One interesting aspect of our findings is that men and women not only differ in hedonic ratings but also in their sweetness intensity ratings of the same solutions. Do women assign lower hedonic ratings for a given concentration than men because they perceive sweet substances to be more intense? If that were the case, the preferred sweetness for women would be at lower concentrations. However, Figure 2 shows that the two genders' hedonic response curves are not simply shifted relative to each other. Women as a group seem to have a narrow preference for 9% solutions. In Booth's terms (1990), they might have a steeper "preference peak" than men. There were, in fact, more women (26/29) who showed a preference peak, as opposed to a linear or flat hedonic profile, than there were men (16/28).

The relationship between intensity and hedonic ratings may be explained better by the inverse hypothesis that hedonic reactions influence the way in which a subject describes the intensity of a solution. That is, an unpleasantly strong sweet taste may be more likely to be described as extremely intense. A narrow and symmetrical preference peak in women relative to a wider hedonic curve for men is consistent with the idea that cognitive factors related to gender might change together the ways in which a subject discriminates both taste intensity and pleasantness.

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