Pharmacology Biochemistry and Behavior, Vol. 65, No. 3, pp. 357–362, 2000

0091-3057/00/$–see front matter

PII S0091-3057(99)00222-1

Differences in the Consumption of Ethanol and Flavored Solutions in Three Strains of Rats

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Received 4 December 1998; Revised 24 May 1999; Accepted 4 June 1999

GOODWIN, F. L. W., N. BERGERON AND Z. AMIT. *Differences in the consumption of ethanol and flavored solutions in three strains of rats.* PHARMACOL BIOCHEM BEHAV **65**(3) 357–362, 2000.—Several studies have shown a correlation between ethanol consumption and the intake of flavored solutions in rats, particularly sweet solutions. This observation, however, has not been shown in all strains of rats. The present study examined whether the intake of ethanol and that of flavored solutions would be related in Lewis (LEW), Wistar (WIS), and Wistar Kyoto (WKY) rats. During phase I, all rats were presented with water and a flavored solution following a continuous access paradigm as developed by Overstreet et al.: quinine (0.25% wt/vol), saccharin (0.1% wt/vol), ethanol (ETOH) (10% vol/vol), and saccharin-quinine (SQ) solutions (0.4% wt/vol–0.04% wt/vol). During phase II, fluid presentations were reduced to a 10-min limited access schedule and were presented in the same order. Results showed strain differences in intake and preference for ETOH and SQ during both phases, but not in quinine or saccharin intake. ETOH and saccharin intake were only correlated in the LEW strain during limited access drinking, while ETOH and SQ intake were correlated in the LEW strain as well as when all strains were collapsed during continuous drinking. These findings suggested that any association between ETOH and sweet intake may not be generalizable to all rat strains. The animals used in this study may have differed in taste sensitivity, as low ETOH-consuming LEW rats were sensitive to the bitter taste of quinine alone, as well as when mixed with saccharin. Sensitivity to bitter tastes may be an important predictor of low ETOH consumption and/or preference. These data provide further evidence for the role of taste factors in the mediation of voluntary ETOH consumption in rats. © 2000 Elsevier Science Inc.

Ethanol Saccharin Quinine Lewis Wistar Kyoto

PATTERNS of alcohol consumption vary widely across the human population (1); however, it is not uncommon for individuals to develop specific preferences for particular alcoholic beverages. In animal studies as well, research is beginning to suggest that taste factors may also play an important role in the development of drinking patterns. Moreover, research now suggests that patterns of ethanol (ETOH) consumption may be genetically related to similar patterns of consumption of nonpharmacological beverages, particularly sweet solutions [e.g., (3, 13)]. There are several lines of evidence suggesting that there may be a relationship between the intake of and/or preferences for flavored solutions and ETOH. Intake of bitter and sweet solutions was found to be related to subsequent ETOH consumption in nonselected albino rats (6). Subsequent studies indicated that genetic factors may underlie specific taste preferences, in that rats selectively bred for high ETOH intake were found to drink more of a sweet solution than rats bred for low ETOH intake [e.g., (13): Preferring (P) and Nonpreferring (NP) rats, (15): Alcohol Accepting and Alcohol Nonaccepting rats, (16): P and NP female rats]. However, this association between ETOH and sweet solution intake was also obtained in nonselected rat strains [e.g., (13): Fawn-Hooded, Maudsley Nonreactive, Maudsley Reactive rats], suggesting that intake of sweetened solutions may be a general predictor for subsequent ETOH intake common to all rodent strains. Also, it has been shown that the predictive relationship between ETOH and sweet intake was also reciprocal, as level of saccharin intake predicted subsequent levels of ETOH consumption in Wistar rats (4).

In addressing the question of what commonality could exist between ETOH and sweet solutions, the answer does not appear to be taste. It has been shown that rats generalize the taste of ETOH solutions to mixtures of sweet and bitter solutions, and not to solutions of sweet flavors alone (7,8,10,11). These data suggested that ETOH and sweet–bitter mixtures have similar gustatory properties. Hence, the findings of simi-

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lar responses to ETOH and sweet solutions are difficult to interpret. Also of interest was a study demonstrating important discrepancies in the responses to ETOH and sweet solutions by selectively bred P and NP rats (16). There were great differences in the magnitude of intake of the two solutions, where the sweet solutions were consumed in very high quantities compared to the ETOH solutions (16). Moreover, the differences among the strains in ETOH consumption did not parallel the pattern of intake of the sweet solutions: preference for ETOH among the strains ranged from low to high; however, all animals displayed high preferences for the sweetened solutions, with some simply having higher preferences that others (16). Thus, as more research of this nature accumulates, it seems difficult to claim an "equivalence" between ETOH and exclusively sweet solutions.

To address this limitation, Goodwin and Amit (3) investigated the relationship between the consumption of ETOH and a sweetened solution based on previous research that attempted to match the tastes of ETOH to bittersweet mixtures (7,9,10,11). The results, however, indicated a negative relationship between the levels of intake of the two solutions in two of the three strains used (Lewis and Wistar Kyoto strains, and not in the Wistar strain), giving rise to the suggestion that the putative association between ETOH and sweetened solutions as reported across seven other strains of rats (13) may not be generalized to all rat strains.

The present study was designed to clarify the source of these discrepant reports by examining the relationship between ETOH and sweet consumption again, but in the strains used by Goodwin and Amit (3) and using the procedure and solutions of Overstreet et al. (12). In addition, the bittersweet solution used by Goodwin and Amit (3) was incorporated at the end of the experiment, and the procedure itself was run under a continuous as well as a limited access drinking paradigm. It was hypothesized that if there is a generalized association between ETOH and sweet intake in all rodent strains, then ETOH intake should be directly related to the intake of the sweetened solutions in all three strains of rats used in the present study.

METHOD

Subjects

Subjects for Phase I (continuous fluid access) were 10 male rats of the inbred Lewis strain (LEW), 10 male rats of the outbred Wistar strain (WIS), and 10 male rats of the inbred Wistar–Kyoto strain (WKY) (Charles River, Canada). The animals weighed approximately 115–212 g (LEW), 225–235 g (WIS), and 227–260 g (WKY) at the start of the experiment. Subjects for Phase II (limited fluid access) were 8 of the 10 male LEW rats used in Phase I, 8 of the 10 male WIS rats used in Phase I, and 8 of the 10 WKY male rats used in Phase I (Charles River, Canada). These animals now weighed approximately 295–370 g (LEW), 470–560 g (WIS), and 450–520 g (WKY) at the start of Phase II. All animals were housed individually in stainless steel cages, in a temperature and humidity controlled room. Animals were maintained in a 12 L:12 D cycle, with lights on at 0800 h and lights off at 2000 h. During Phase I, drinking fluids were presented in two glass Richter-type tubes on the front of the cages. The position of the tubes was altered daily so as to avoid side preference. During Phase II, drinking fluids were presented in plastic tubes with steel ball-bearing spouts mounted on the front of the cage. Standard rat chow (Agway) and water were available ad lib.

Procedure

Phase I: continuous fluid access. Following a 3-week acclimatization period to the animal colony facilities, all rats were presented with a choice between tap water in one Richter tube and a flavored solution in the other tube. These fluids were available for 23 h every day (1 h was taken for measuring and weighing). These solutions were presented in the following order: 0.25% (wt/vol) quinine for 4 days, 0.1% (wt/vol) saccharin for 4 days, 10% (vol/vol) ETOH for 20 days, and 0.4% (wt/vol) saccharin–0.04% (wt/vol) quinine solution (SQ) for 16 days. The volume of fluids consumed was measured daily, and body weights were recorded every 3 days.

Phase II: limited fluid access. Following a 3-week washout period, rats were exposed to a limited access (LA) drinking schedule. Fluids were delivered to the rats in plastic tubes with steel ball-bearing spouts. They were provided with access to a 0.1% saccharin solution during a daily 2-h session for 1 week. Access to the saccharin solution was then further reduced to a daily 1-h session for 1 week, followed by a daily 1/2 h session for 1 week, and finally to a daily 10-min session for 1 week. At this time, LA training was established, and fluid presentations began. Solutions were presented in the following order: 0.25% (wt/vol) quinine for 4 days, 0.1% (wt/vol) saccharin for 10 days, 10% (vol/vol) ETOH for 20 days, and 0.4% (wt/vol) saccharin–0.047% (wt/vol) quinine solution (SQ) for 16 days. The solutions were available for 10 min per day. The volume of fluid consumed was measured daily, and body weights were recorded every 3 days.

Data Analysis

Daily fluid consumption data (ml) for water and the flavored solution were converted into: intake of the flavored solution (g/kg for ETOH and ml/kg for all other solutions), preference for the flavored solution as a percentage of total fluid consumed (%), and total fluid consumption (ml/kg). All intake measures had to be corrected for body weight at the time of measurement because of within-strain as well as between-strain variations in body size (see Analysis of Body Weights, Results section). For each flavored solution, the mean consumption of the last 4 days of presentation were used for statistical analysis (phase). Separate one-way analyses of variance with repeated measures were conducted on the variables of intake, preference, and total fluid consumption for each flavored fluid during Phase I and II. Results were reported concurrently for each flavored fluid. Post hoc Tukey tests ($p < 0.05$) were performed where appropriate for pairwise comparisons.

The mean intakes of the four solutions were further compared using rank-ordered Spearman correlation coefficients in the following groupings: within each strain separately, collapsed across all strains, comparing high ETOH-drinking WIS vs. low ETOH-drinking LEW, and comparing high ETOH-drinking WIS vs. low ETOH-drinking WKY. These correlations were conducted separately for Phases I and II.

RESULTS

Quinine

During the continuous fluid presentations, there were no significant differences among LEW, WIS, and WKY rats in mean quinine intake, $F(2, 27) = 0.37$ (see Table 1). There were also no differences among the strains in their preferences for the quinine solution, $F(2, 27) = 0.47$ (see Table 2). Intake of the quinine solution for all animals was low, as evi-

TABLE 1

MEAN FLUID INTAKE FOR ALL STRAINS DURING PHASE I: 24-HOUR FLUID ACCESS

	Fluids			
Strain	Quinine (ml/kg)	Saccharin (ml/kg)	Ethanol (g/kg)	Saccharin-Quinine (ml/kg)
Lewis	6.9 (1.0)	155.6 (23.2)	0.6 (0.1)	5.4 (0.6)
Wistar	5.0 (0.6)	204.5 (12.5)	2.6 (0.1)	11.7 (1.2)
Wistar–Kyoto	6.1 (0.8)	144.1 (12.9)	0.9 (0.1)	8.1 (0.7)

The values not enclosed in parenthesis represent mean intake for the final 4 days of fluid presentation. Values enclosed in parentheses represent mean square errors (SE).

denced by their small intake values relating to their total fluid consumption, as well as by their low preference ratios. Analysis of total fluid consumption during Phase I revealed no differences among the strains, $F(2, 27) = 1.06$ (see Table 3).

Quinine intake during limited access presentations also did not differentiate the strains, $F(2, 21) = 0.05$ (see Table 4).

Saccharin

All animals drank large quantities of the saccharin solution during the continuous access phase (see Table 1). Analysis revealed no overall significant differences in intake among LEW, WIS, and WKY strains, $F(2, 27) = 1.17$. However, a significant strain × days interaction, $F(6, 81) = 2.85$, $p < 0.05$, indicated that LEW and WKY strains initiated consumption at a significantly lower level than WIS rats ($p < 0.05$) (90.8 and 131.3 ml/kg vs. 239.8 ml/kg, respectively), and that LEW rats increased their saccharin over the four presentation days (from 90.8–199.5 ml/kg) to match that of WIS rats (182.2 ml/kg) ($p < 0.01$). Preference for the saccharin solution relative to water was also very high for all animals (see Table 2). Analysis revealed no significant differences among the strains, $F(2, 27) = 0.83$. There were also no overall strain differences in total fluid intake, $F(2, 27) = 1.13$ (see Table 3).

Saccharin intake during limited access presentations did not differentiate the strains, $F(2, 21) = 2.51$ (see Table 4).

Ethanol (ETOH)

Analysis of ETOH intake during Phase I revealed significant differences among LEW, WIS, and WKY rats, $F(2, 27) = 25.33$, $p < 0.0001$ (see Table 1). A Tukey test indicated that WIS rats consumed significantly more ETOH than LEW and WKY rats ($p < 0.01$), while LEW and WKY rats did not differ from each other. Preference ratios were also significantly different among the strains, $F(2, 27) = 20.00$, $p < 0.0001$ (see Table 2), whereby WIS rats displayed the highest preference for ETOH relative to LEW and WKY rats ($p < 0.01$). Analysis of total fluid consumption revealed no overall group differences, $F(2, 27) = 1.78$ (see Table 3). However, a significant strain × days interaction, $F(6, 81) = 2.56$, $p < 0.05$, indicated that both WIS and WKY rats decreased their total fluid intake over the 4 days (from 114.3 to 105 ml/kg, from 96.8 to 82.4 ml/kg, respectively) (both $p < 0.01$). This decrease pertained only to a decrease in water consumption as ETOH consumption remained unchanged.

ETOH intake during the limited access phase revealed no significant differences among the strains, $F(2, 21) = 0.50$ (see Table 4).

Saccharin–Quinine (SQ)

SQ intake during continuous access drinking water was not significantly different among LEW, WIS, and WKY rats, $F(2, 27) = 3.22$, $p = 0.056$ (see Table 1). There were, however, significant differences among the strains in the preference ratios for this solution, $F(2, 27) = 3.88$, $p < 0.05$ (see Table 2). The mean preference ratio for LEW rats was significantly lower than that of WKY rats ($p < 0.05$) WIS and WKY rats did not differ significantly from each other. There was also a significant difference between the strains in total fluid consumption, $F(2, 27) = 3.47$, $p < 0.05$ (see Table 3). LEW rats consumed more fluid as compared to WKY rats ($p < 0.05$). WKY and

TABLE 2

MEAN FLUID PREFERENCE FOR ALL STRAINS DURING PHASE I: 24-HOUR FLUID ACCESS

	Fluids			
Strain	Quinine (%)	Saccharin (%)	Ethanol (%)	Saccharin-Quinine (%)
Lewis	5.2 (0.8)	65.4 (6.3)	7.3 (0.6)	5.7 (0.5)
Wistar	4.0 (0.5)	81.5 (2.3)	31.0 (0.6)	12.2 (1.2)
Wistar–Kyoto	5.8 (0.8)	75.1 (2.4)	15.0 (1.6)	13.3 (0.7)

The values not enclosed in parentheses represent mean preference for the final 4 days of fluid presentation. Values enclosed in parentheses represent mean square errors (SE).

TABLE 3

MEAN TOTAL FLUID CONSUMPTION FOR ALL STRAINS DURING PHASE I: 24-HOUR FLUID ACCESS

	Fluids			
Strain	Quinine (ml/kg)	Saccharin (ml/kg)	Ethanol (ml/kg)	Saccharin-Quinine (ml/kg)
Lewis	131.1 (1.4)	204.3 (15.9)	108.9 (0.5)	103.0 (2.2)
Wistar	134.5 (3.4)	237.6 (15.2)	106.3 (2.7)	91.4 (0.9)
Wistar–Kyoto	109.1 (3.5)	186.2 (10.6)	84.7 (4.3)	72.6 (1.9)

The values not enclosed in parentheses represent mean total fluid consumption for the final 4 days of fluid presentation. Values enclosed in parentheses represent mean square errors (SE).

TABLE 4

MEAN FLUID INTAKE FOR ALL STRAINS DURING PHASE II: LIMITED FLUID ACCESS

	Fluids			
Strain	Quinine (ml/kg)	Saccharin (ml/kg)	Ethanol (g/kg)	Saccharin-Quinine (ml/kg)
Lewis	0.08 (0.08)	4.72 (0.45)	0.010 (0.003)	0.47 (0.23)
Wistar	0.11 (0.11)	5.19 (0.27)	0.023 (0.002)	0.32 (0.13)
Wistar–Kyoto	0.13 (0.07)	7.49 (0.95)	0.015 (0.001)	1.06 (0.17)

The values not enclosed in parentheses represent mean intake for the final 4 days of fluid presentation. Values enclosed in parentheses represent mean square errors (SE).

WIS rats did not differ in their consumption levels. These results seemed to indicate that water consumption in LEW rats was higher than for the other two strains, as their SQ preference was low but their total fluid intake was high.

SQ intake during limited access presentations did differ significantly among the strains, $F(2, 21) = 4.32$, $p < 0.05$. Tukey's tests revealed that WKY rats consumed more than WIS rats ($p < 0.05$) and LEW rats did not differ from either strain (see Table 4).

Analysis of Body Weights

During the 24-h drinking phase, analysis of body weights indicated that there were significant differences among the three strains during each fluid phase: quinine phase $F(2, 27)$ 10.45, $p < 0.001$, saccharin phase $F(2, 27) = 15.61$, $p < 0.0001$, ETOH phase $F(2, 27) = 13.95$, $p < 0.001$, SQ phase $F(2, 27) = 29.86$, $p < 0.0001$. Specifically, WIS and WKY rats were significantly larger than LEW rats ($p < 0.01$), while WIS and WKY rats did not differ.

During limited access drinking, these group differences in weight persisted: quinine phase $F(2, 21) = 71.67$, $p < 0.0001$, saccharin phase $F(2, 21) = 66.99$, $p < 0.0001$, ETOH phase $F(2, 21) = 67.52$, $p < 0.0001$, SQ phase $F(2, 21) = 69.55$, $p < 0.0001$. LEW rats remained significantly smaller than both WIS and WKY rats throughout ($p < 0.01$), and mean weight for WKY rats fell below that of WIS rats only during the quinine and saccharin phases of ($p < 0.05$).

Correlational Analysis

In LEW rats, ETOH intake was correlated with both quinine and SQ intake during Phase 1, $r_s = +0.830$ and $+0.964$, respectively, ps < 0.01 (see Table 5). Quinine and SQ were also positively correlated in LEW rats, $r_s = +0.915$, $p < 0.01$. During limited access fluid presentations, only ETOH and saccharin intakes were correlated in the LEW strain, $r_s = +0.905$, $p < 0.01$ (see Table 6).

In both WIS and WKY strains, ETOH intake was not correlated with that of any other fluid during Phases I and II. However, in the WIS strain, saccharin and SQ intakes were correlated during continuous drinking, $r_s = +0.806$, $p < 0.01$ (see Table 5).

When the fluid intake data for Phase I from all animals was collapsed, ETOH intake was significantly correlated with that of SQ, $r_s = +0.660$, $p < 0.01$ (see Table 5). There were no significant correlations during Phase II drinking.

The combination of high ethanol-drinking and low ethanol-drinking groups also yielded significant fluid intake relationships. When WIS (high ETOH-drinking) and LEW (low ETOH-drinking) rats were combined, ETOH intake was correlated with SQ intake during 24-h access, $r_s = +0.762$, $p < 0.01$ (see Table 5), and with saccharin intake during limited-access drinking, $r_s = +0.544$, $p < 0.05$ (see Table 6). And subsequently, when WIS (high ETOH-drinking) and WKY (low ETOH-drinking) rats were considered together, only saccharin and SQ intakes were correlated during 24-h access, $r_s = +0.633$, $p < 0.01$ (see Table 5).

DISCUSSION

The hypothesis of a general association between the intake of ETOH and sweetened solutions was not supported by the findings of the present experiment. The results indicated significant strain differences in ETOH intake and preference among the Lewis, Wistar–Kyoto, and Wistar strains, but these were not paralleled by similar differences in intake or preference for the sweet, saccharin solution.

Saccharin and ETOH intakes were only correlated during limited access drinking in the Lewis strain as well as when the Lewis strain was combined with the high ETOH-drinking Wistar strain. Saccharin–quinine intake was related to ETOH intake only during the continuous drinking phase, also in Lewis rats as well as when they were combined with Wistar high-ETOH drinkers. These findings alone do not provide much confidence for any notion of consistent taste preferences and the prediction of ETOH intake. However, it must be noted that when all three strains were combined the only significant correlation to appear was that of ETOH intake with saccharin–quinine intake during the continuous drinking phase. As well, when the low ETOH-drinking Lewis strain was compared with the high ETOH-drinking Wistar strain, ETOH intake was found to be related to saccharin–quinine intake during Phase I, and to saccharin intake during Phase II. Therefore, the results of these correlated tests suggest that the relationship between ETOH and sweet intake may not be altogether specious, but may not be as clearly evident as was originally proposed.

The strains of rats used in the present study displayed differences in ETOH intake and preferences as did those in the study by Overstreet et al. (13). The present findings were also consistent with those of Goodwin and Amit (3) using the same strains, and therefore, provided further evidence for differences in ETOH intake and preference among Lewis, Wistar, and Wistar–Kyoto rats. None of the three strains differed in saccharin preference. All rats showed a high preference for the saccharin solution over water, a common finding

TABLE 5

SPEARMAN CORRELATION COEFFICIENTS FOR MEAN FLUID INTAKE IN DIFFERENT STRAINS/GROUPINGS DURING PHASE I: CONTINUOUS FLUID ACCESS

	Strain/Grouping					
Fluid Comparison	Lewis	Wistar	Wistar–Kyoto	All Rats	Lewis vs. Wistar	Wistar–Kyoto vs. Wistar
ETOH vs. Quin	0.830†	0.227	0.103	0.117	0.099	−0.011
ETOH vs. Sacc	−0.212	−0.079	−0.067	0.092	0.084	0.247
ETOH vs. SQ	0.964†	0.285	0.091	0.660†	0.762†	0.371
Sacc vs. SQ	−0.152	0.806†	0.321	0.322	0.323	0.633†
Sacc vs. Quin	0.127	0.018	0.139	0.072	0.050	0.043
Quin vs. SQ	0.915†	0.092	0.285	0.305	0.343	0.116

*$p < 0.05$; †$p < 0.01$.

TABLE 6

SPEARMAN CORRELATION COEFFICIENTS FOR MEAN FLUID INTAKE IN DIFFERENT STRAINS/GROUPINGS DURING PHASE II: LIMITED FLUID ACCESS

	Strain/Grouping					
Fluid Comparison	Lewis	Wistar	Wistar–Kyoto	All Rats	Lewis vs. Wistar	Wistar–Kyoto vs. Wistar
ETOH vs. Quin	−0.412	0.234	0.412	0.237	0.186	0.380
ETOH vs. Sacc	0.905†	0.357	−0.429	0.283	0.544*	−0.029
ETOH vs. SQ	−0.262	0.238	0.643	0.237	0.124	0.171
Sacc vs. SQ	−0.381	−0.095	0.167	0.169	−0.268	0.368
Sacc vs. Quin	−0.412	−0.514	−0.247	−0.311	−0.410	−0.345
Quin vs. SQ	0.412	0.156	0.247	0.193	0.220	0.091

*$p < 0.05$; †$p < 0.01$.

in many studies [e.g. (13, 15)]. Although Overstreet and his colleagues (13) had found a relationship between ETOH and sweet intake in seven different rat strains, this was not observed in the Lewis, Wistar, and Wistar–Kyoto strains. However, the response of Lewis, Wistar and Wistar–Kyoto rats to the saccharin solution suggested that it was not an appropriate comparison solution for ETOH, as the two fluids seem to have differing hedonic values, based on both intake and preference levels. In the present study, the saccharin solution was consumed in such great quantities as to inflate the daily fluid intake of the animals above levels observed during the other phases of the experiment. Thus, saccharin intake seems to distort the normal mechanism regulating fluid intake, which makes a comparison with ETOH intake difficult to justify and interpret. Interestingly, a subsequent study conducted by Overstreet and colleagues (5) using the original seven strains (13) found that both selected and nonselected ETOH preferring rat strains significantly inflated their daily total fluid intake almost twofold in the presence of a saccharin solution, while ETOH non-preferring strains did not. All strains were reported to show equivalently high preference ratios for the saccharin solution (5). The data suggested that it may not be the intake of or preference for a sweetened solution that differentiates strains but rather a fluid satiety mechanism.

Saccharin–quinine intake was related to ETOH intake only in Lewis animals during Phase I. It is worth noting that this relationship occurred in the strain that consumed the least ETOH as well as the least saccharin–quinine. Thus saccharin–quinine and ETOH may be perceived by Lewis rats as having similar gustatory properties. This relationship also persisted when the Lewis rats were combined with the high ETOH-drinking Wistar rats. These findings are consistent with the work of Kiefer et al. (8,10) who reported that rats trained to avoid an ETOH solution generalized the aversion to sweet–bitter mixtures, and not to the individual flavors of sweet or bitter alone. But perhaps the most convincing evidence from the present study and support for Kiefer's theory was that when all three strains were combined, only the ETOH/saccharin–quinine relationship was significant. That this relationship was not observed in all three strains individually suggested that perhaps the saccharin–quinine solution was not the appropriate concentration of saccharin and quinine needed to equate with the gustatory properties of a 10% (vol/vol) ETOH solution. Aversion generalization studies commonly tested ETOH solutions of 3, 6, and 9% (vol/vol) against various saccharin–quinine mixtures, and so it is not yet known which concentrations of saccharin with quinine match 10% ETOH. Further investigations are needed to determine the equivalent "taste" to that of a 10% (vol/vol) ETOH solution as measured in the aversion generalization paradigm with various sweet–bitter mixtures. These investigations should be conducted separately for different rat strains, as there appears to be differences in taste responsivity.

It is of interest to note the other correlations in fluid preferences. For example, during continuous access drinking, ETOH intake in Lewis rats was also related to quinine intake, and saccharin–quinine intake was related to quinine intake. Therefore, Lewis rats treated the ETOH, saccharin–quinine and quinine solutions similarly by drinking very little amounts, perhaps reacting to the common underlying bitter taste in these three solutions. However, when the fluids were presented for a limited amount of time, only ETOH intake and saccharin intake were highly correlated in Lewis rats. Wistar rats, unlike Lewis rats, consumed large quantities of the ETOH solution, suggesting that ETOH was less aversive to them. Wistar rats seemed to be less sensitive to bitter taste, because their saccharin–quinine intake was correlated with saccharin intake during Phase I, suggesting that they may be responding to the sweet taste of the solutions. However, ETOH consumption was not related to consumption of saccharin or saccharin–quinine solutions, suggesting that their ETOH intake is guided by factors other than taste.

Although the Wistar–Kyoto strain did not display any correlations in the intake of any of the solutions, aside from when they were combined with high ETOH-drinking Wistar rats during Phase I drinking, they nevertheless detected flavor as they adjusted their fluid consumption according to the solutions presented. As their ETOH intake was so low [consistent with other reports; (14)] and unrelated to that of any other of the other solutions, it may have been mediated by a mechanism other than taste, such as pharmacological effects.

Several restrictions limit the generalizability of the present results. The purpose of the study was to replicate the methodology from Overstreet et al. (13). Therefore, while criticisms about paradigm are always warranted, one primary objective was to examine results in our strains using a previously developed paradigm. Due to the presentation sequence of fluids, there may have been an imposed order effect, thus limiting our confidence in general conclusions. It may be appropriate to apply a more randomized design of presentation in future studies. Also, these results were obtained with only one concentration per flavored solution. Although the results did not reproduce those from the Overstreet et al. (13) study using the same concentrations, the overall conclusions may have been different had several concentrations of each fluid been used. It is possible that relationships exist at other concentrations, and this study was not sensitive enough to bear these out.

With these restrictions in mind, the results of the present study challenge several popularly held notions. Of general interest, fluid intake patterns were not analogous across continuous and limited access drinking phases. This holds important repercussions when comparing research reports utilizing these two commonly employed drinking paradigm. Second, the correlations that were found in the present study differed across strains, suggesting that strain specificity may be an important factor. And finally, the notion of a general association between ETOH and sweet intake was challenged, as saccharin intake was only related to ETOH intake in one strain during limited access drinking. However, saccharin–quinine intake was related to ETOH intake when all three strains were collapsed. As differences in ETOH and saccharin–quinine intake were observed among the individual strains, it cannot be dismissed that their consumption was not in part mediated by differences in taste reactivity. Several studies have previously shown that the taste of ETOH plays an important role in limiting ETOH consumption in some rats [e.g., (2,9,12,17–19)]. Rats who consumed ETOH by intragastric self-infusion were found to consume significantly greater amounts of ETOH when compared to the oral route (2,17). Rats with gustatory cortex ablations, whose ability to taste was diminished, also consumed more ETOH than neurologically intact rats (9,12). Also, flavoring ETOH has been shown to increase ETOH consumption in rats and mice (18,19). Therefore, investigating differences in taste sensitivity, rather than taste preference, may help us understand and perhaps predict ETOH consumption in rodents.

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