

RAPID COMMUNICATION

Fat-Preferring Rats Consume More Alcohol Than Carbohydrate-Preferring Rats

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KRAHN, D. D. AND B. A. GOSNELL. *Fat-preferring rats consume more alcohol than carbohydrate-preferring rats*. ALCOHOL 8(4) 313–316, 1991.—Rats with a genetic preference for alcohol (ETOH) have been found to consume more dietary fat than ETOH nonpreferring rats. We therefore hypothesized that rats selected on the basis of fat and carbohydrate (CHO) preferences would differ in ETOH intake. Patterns of macronutrient self-selection were determined by allowing rats to select diets from separate sources of CHO, fat and protein. Subsequently, CHO- and fat-preferring groups were formed. All rats were then returned to a lab chow diet and trained to drink ETOH (4–12%) during one hour of access per day. Food restriction was used only in the first three weeks of the procedure. On the final drinking sessions, water and ETOH were alternated on a daily basis. Fat-preferring rats consumed significantly more ETOH than water; CHO-preferring rats consumed approximately equal amounts of ETOH and water. Furthermore, fat-preferring rats consumed more ETOH than CHO-preferring rats. This study suggests that there may be a common mechanism underlying diet preference and oral intake of ETOH.

Alcohol	Fat-preferring rats	Carbohydrate-preferring rats	Macronutrient preference	Oral drug intake
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THE availability of alternative reinforcers in the environment may influence drug self-administration in rats. One aspect of the reinforcing value of food is fat content. When given a choice between foods differing in fat content, rats generally prefer the foods containing the most fat (18). This appears to be related to preferences for the taste and texture of high fat diets and not simply due to increased caloric density (18). However, the degree of preference (as measured by amount of food intake) when high and low fat diets are available simultaneously varies greatly among different strains of rat (16). Previous studies by our group show that intakes of fat in macronutrient self-selection paradigms vary widely between individuals of the same rat strain (Sprague-Dawley) (6). This variability in intake of a high fat diet across and within strains is consistent with the hypothesis that these diet preferences are genetically determined.

The development of the AA and ANA rat lines was made possible by the wide range in the genetically determined preference for alcohol which was observed among outbred rats (3). It is of interest that AA rats (i.e., rats with a high preference for the reinforcing or rewarding aspects of alcohol) have higher fat intakes (presumably indicative of higher fat preferences) in diet self-selection situations than do ANA rats (4). When alcohol is made available to AA rats in a diet self-selection paradigm after a period when the only available fluid had been water, alcohol intake and changes in fat intakes in self-selection paradigms are significantly and positively correlated in AA rats ($r = .73$). Changes

in carbohydrate intake are significantly negatively correlated with alcohol intake in this strain (5). Thus, there is a positive relationship between the preference for the alcohol (i.e., a drug), and the high-fat diet (i.e., a food) in a population of rats selected on the basis of preference for alcohol. In a related line of investigation, Pekkanen and Eriksson (15) found that rats fed a high fat diet (65% of energy as fat; 30% protein; 5% carbohydrate) drank more alcohol than rats fed a control diet (15% fat; 30% protein; 55% carbohydrate). Conceivably, this effect of diet in a nonchoice situation could have been due to effects of fat on alcohol absorption. However, it is not known whether animals selected on the basis of fat preference also have a high preference of alcohol or other drugs. We hypothesized that Sprague-Dawley rats identified as fat-preferrers in a dietary self-selection paradigm would drink more alcohol than rats identified as carbohydrate preferrers.

METHOD

Subjects were selected from a group of 31 male Sprague-Dawley rats previously tested for feeding and diet selection responses to morphine (0–10 mg/kg). All rats received identical treatment in the study of response to morphine and their diet selection responses before and after the morphine protocol did not differ. All rats were individually housed, maintained on a 7 a.m.–7 p.m. light, 7 p.m.–7 a.m. dark cycle, and maintained

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TABLE 1
COMPOSITION OF DIETS USED TO DETERMINE DIET PREFERENCES

	Diet		
	Carbohydrate	Fat	Protein
Corn Starch	57.7	—	—
Dextrin	28.8	—	—
Sucrose	9.6	—	—
Casein*	—	—	105.0
DL-Methionine	—	—	1.6
Vegetable Shortening	—	40.6	—
Safflower Oil	—	2.1	—
AIN-76A Vitamin Mix†	1.0	1.0	1.0
AIN-76 Mineral Mix†	3.5	3.5	3.5
Choline Chloride	0.2	0.2	0.2
Cellulose (Alphacel)	5.0	5.0	5.0
Weight (g)	105.8	52.4	116.3
Total Energy (kcal)‡	390	390	387
Energy Density (kcal/g)	3.69	7.44	3.33

All components are expressed as weight (grams).

*Assuming a protein content of 90%.

†The vitamin and mineral mixes contain 97 and 12% sucrose, respectively.

‡Based on energy values of 4, 9 and 4 kcal/g for carbohydrate, fat and protein.

on a dietary self-selection regimen in which carbohydrate, fat and protein were available in separate jars attached to the floor of each cage. Compositions of the diets are shown in Table 1. After 26 days on this regimen (2 days after the final morphine trial), diet preferences were determined by measuring intake of the macronutrients daily for 2 consecutive days. Based on these results, two groups ($n=8$) were selected: a fat-preferring group (FP) and a carbohydrate-preferring group (CP). Average daily intakes of the fat, carbohydrate and protein were 54 ± 4 , 24 ± 2 and 18 ± 2 kcal, respectively, for the FP group, and 9 ± 1 , 60 ± 3 and 19 ± 2 kcal, respectively, for the CP group. Fat and carbohydrate intakes for the two groups were significantly different ($p < 0.01$, 2-tailed, t -test). After these determinations, all rats were placed on a standard lab chow diet. Five days later, alcohol intake was determined with procedures adapted from those of Stewart and Grupp (19). Rats were food deprived overnight, and each morning at 8 a.m. were transferred to individual drinking cages, which contained several pellets of lab chow. At the time of first placement into these cages, a 25 ml buret containing a 4% alcohol solution (v/v) was also attached to each cage. One hour later, rats were returned to their home cages, where food was available for an additional 3 hours. Alcohol solution remaining in the buret was determined to the nearest 0.1 ml. Water was always available in the home cages. At 1-week intervals, the alcohol concentration available in the drinking cages was increased from 4 to 8 to 12%. After 7 sessions with 12% alcohol, food deprivation was discontinued, and food was no longer available in the drinking cages. Thus, food was available ad lib except during the daily test sessions. For 22 additional days, rats were given daily 1-h opportunities to drink 12% ethanol. On the following 2 days, only water was presented in the daily sessions. On the next 6 days, water and 8% alcohol were alternated daily as the only available fluid in the session. For each rat, intakes were averaged for the final 3 water sessions and the final three 8% alcohol sessions. These averages were compared with repeated measures t -tests.

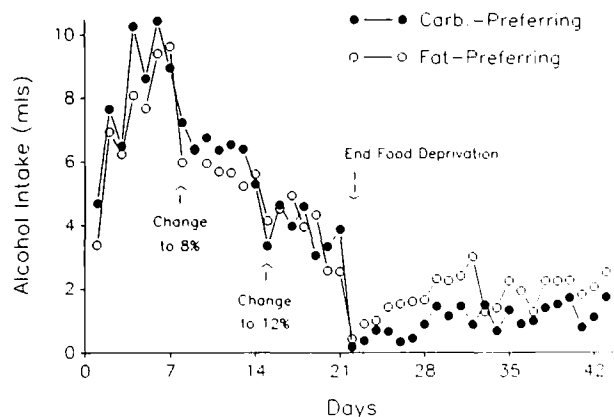


FIG. 1. Mean alcohol intake (1 h) by carbohydrate-preferring and fat-preferring rats. The initial concentration was 4%; this was increased to 8% on Day 8 and to 12% on Day 15. Intake was relatively high because rats were on a schedule in which food was available for only 4 h/day, and alcohol was presented during the first hour of food access. After Day 22, when the deprivation regimen ended, the intake of fat-preferring rats was generally higher than that of carbohydrate-preferring rats.

RESULTS

Amounts of alcohol consumed daily by the two groups are shown in Fig. 1. When nondeprived (beginning Day 22), fat-preferring rats consumed more alcohol than carbohydrate-preferring rats at nearly every opportunity over approximately 3 weeks of repeated exposures to alcohol. This pattern was not apparent during the training period, when animals had access to food only 4 hours per day. When the intake of 8% alcohol during the last three alcohol sessions was compared to the intake of water during the last three water sessions, repeated measures t -tests indicated that fat-preferring rats consumed significantly more alcohol than water [$t(7) = 3.58$, $p < 0.01$]; carbohydrate-preferring rats consumed approximately equal volumes of water and alcohol [$t(7) = 0.76$, NS] (Fig. 2). Furthermore, fat-preferring rats consumed more alcohol than carbohydrate-preferring rats [$t(14) = 2.44$, $p < 0.05$] (Fig. 2). On the final test day, the body weights of the two groups were not significantly different (514 ± 13 g for fat-preferring rats; 505 ± 11 g for carbohydrate-preferring rats).

DISCUSSION

This study provides evidence that fat-preferring rats consume more alcohol than carbohydrate-preferring rats. These results complement those referred to above in that it is possible to predict not only that AA rats will prefer a higher fat/carbohydrate ratio in their diets than ANA rats, but also that rats which prefer diets with high fat/carbohydrate ratios will prefer alcohol more than rats which prefer diets with low fat/carbohydrate ratios. It is important to note that when these rats were tested for alcohol intake both groups were maintained on the same diet (i.e., lab chow). Thus, the observed differences in alcohol intake cannot be attributed to differences in the composition of the maintenance diet, but are more likely to be related to baseline differences in preference. However, lab chow is a low fat diet (carbohydrate, fat, and protein comprise approximately 59, 12, and 28% of total calories, respectively). Thus, lab chow closely approximates the diet chosen by carbohydrate-preferring rats and is much lower in fat than that self-selected by fat-preferring rats. It is possible, then, that the alcohol intake of fat-preferring rats

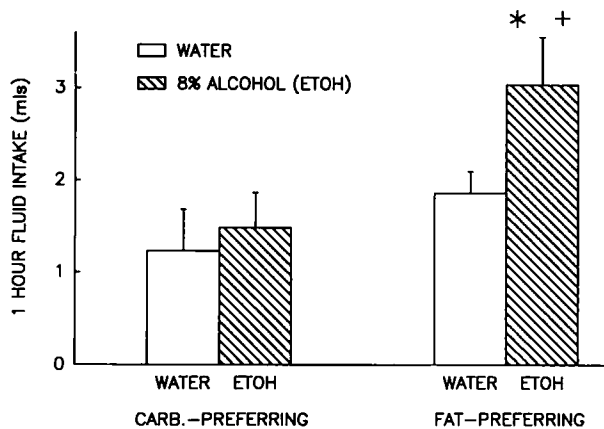


FIG. 2. Average intakes of water and 8% alcohol by rats classified as carbohydrate-preferring or fat-preferring. The means are the average of three 1-h sessions with each fluid for each rat. These data were collected on days 46–51 of the experiment (not included on Fig. 1). Fat-preferring rats consumed significantly more alcohol than water ($*p < 0.01$) and significantly more alcohol than carbohydrate-preferring rats ($+p < 0.05$).

exceeded that of the carbohydrate-preferring rats because the fat-preferring rats were drinking alcohol while deprived of a preferred ingestant and not because of the baseline difference in diet preferences. Increases in drug self-administration due to deprivation of a highly-preferred, sweet ingestant have been previously described (1). Likewise, it is possible that no difference in alcohol intake was observed during the training period because the restriction of food intake to four hours per day caused increased fat preferences, as had been demonstrated in experiments involving food deprivation (17), rendering the carbohydrate-preferring group more like the fat-preferring group.

One explanation for the present observations is that a common mechanism is involved in controlling the preferences for macronutrients and alcohol. However, the mechanism underlying the differences observed here is unknown and probably quite complex. It is possible that such factors as differential after-effects of food deprivation or morphine treatment on the fat- and carbohydrate-preferring groups as well as differences between groups in learning or differences between groups in response to handling-stress may play a role in this phenomenon. Further, as both food and alcohol are ingested orally, these findings may be related to differences in orosensory factors. Kampov-Polevy et al. reported higher intakes of both saccharin and quinine solu-

tions by alcohol-preferring rats (9).

The relationship between fat preference and drug intake does not appear to be limited to alcohol self-administration. Marks-Kaufmann and Lipeles demonstrated that only those rats which ate high amounts of fat in macronutrient self-selection paradigms (i.e., demonstrated high baseline preferences for fat) became oral consumers of morphine (12). As rats which demonstrate high baseline preferences (probably genetically determined) for fat showed higher levels of opiate self-administration, it is possible that responsiveness to palatability factors and responsiveness to the reinforcing aspects of drugs are controlled by similar neural mechanisms. The hypothesis that similar neural mechanisms control responsiveness to the reinforcing aspects of a variety of drugs and/or foods is also supported by the finding that rats which were selectively bred for high and low morphine drinking showed parallel high and low ethanol drinking (14). Innate preferences for fat also appear to influence the effects of opiate agonists on food intake, as the stimulation of fat intake by morphine is greatest in the subset of rats with high baseline preferences for fat (6). Thus, the effects of, as well as the preferences for, drugs may be influenced by baseline macronutrient preferences. It is important to note that the relationship between fat intake and drug intake may be revealed only when baseline macronutrient self-selection is determined prior to the introduction of alcohol. When fat emulsions (i.e., an alternate reinforcing or preferred substance) are provided as a third choice in the "two-bottle" paradigm, alcohol intake is decreased (10).

This alcohol-fat relationship may not be limited to rats, as two separate studies have shown that U.S. adults and Finnish men who were classified as high alcohol users were noted to eat more fat than those classified as low alcohol users (7,8). Furthermore, bulimics, who binge on high-fat, "forbidden" foods and report intense cravings for these foods probably as a result of self-deprivation (2), also have very high rates of alcohol and other substance abuse (13). Alcoholic women, in turn, have high rates of bulimic behavior (11). These clinical observations, combined with data from laboratory animals indicating that food deprivation increases fat preferences (17) as well as drug self-administration (1), are consistent with hypothesis that these preferences share some common mechanisms. Thus, characterization of the relationship between fat/carbohydrate preferences and drug self-administration may have important implications for understanding these human disorders.

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