Ethanol consumption of rats in individual, group, and colonial housing conditions

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Rats were housed in individual cages, in a group cage, or in a naturalistic colonial habitat, and given access to food, water, 10% ethanol, and 10% ethanol in a sweetened saline solution. Rats housed in the colony ingested significantly less total ethanol than either group or individually caged rats. When the flavored ethanol solution was removed, total ethanol intakes of all groups decreased and did not differ significantly. The data indicate that the stimuli of the colonial situation act to decrease ethanol intake when a palatable ethanol solution is available.

The consumption of and preference for ethanol by infrahuman species have been extensively studied and reviewed (Eriksson, 1969; Lester, 1966; Lester & Freed, 1973; Mardones, 1960; Mello, 1973, 1976; Myers, 1966; Myers & Veale, 1972; Richter, 1957; Wallgren & Barry, 1970; Wise, 1975). These reports have typically been undertaken to provide information ultimately useful for understanding and acting on alcohol use, abuse, and alcoholism in humans.

Any comparative model construed as a "miniature representation" of human behavior and physiology should provide a reasonable analogy to the ordinary conditions of human performance (Lester & Freed, 1973). However, most studies of infrahuman ethanol consumption examine the intake of ethanol by isolated subjects living in small, standard housing cages. In many experiments, in addition to being isolated, the animals are deprived of food and/or water.

A number of current theories of the determinants of human ethanol consumption stress possible social and cultural factors (Barry, 1968; Noble, 1978; Wallgren & Barry, 1970). Therefore, factors thought to have an important governing role in human alcohol use are necessarily excluded from consideration when individual caging of animals is employed. Although a number of studies have examined ethanol consumption of animals in cages of varying degrees of grouping (Brown, 1968; Deatherage, 1972; Hannon & Donlon-Bantz, 1975, 1976; Heminway & Furumoto, 1972; Parker & Radow,

1974; Rodgers & Thiessen, 1964; Slighter, 1970; Thiessen & Rodgers, 1965; Wilson, 1969), apparently there have been few studies of animal ethanol consumption in naturalistic habitats which mimic normal ecological and social variables of the species investigated. An analysis that allows for natural environmental and social interactions might better approximate the conditions of human ethanol consumption. In addition, a more naturalistic setting for the analysis of consummatory behavior of infrahuman subjects would eliminate factors such as isolation and deprivation, both of which have been closely associated with stress as indexed by pituitary-adrenal activation and gastric ulceration (Hatch, Wiberg, Balazs, & Grice, 1963; Lovely, Pagano, & Paolino, 1972; Paré & Temple, 1973). Such variables may elevate or depress spontaneous consumption of water and/or ethanol.

In the following experiment, consumption of water, ethanol, and flavored ethanol by rats housed in a naturalistic colony was studied and compared to that of individually and group-housed rats. The purpose of the present report was to examine differences in ethanol consumption and preference by rats under different housing conditions.

METHOD

Subjects

The subjects were nine male and nine female experimentally naive rats of Long-Evans descent (outbred, Charles River Crl:COBS[LE]BR), approximately 2 months of age at the beginning of the experiment.

Apparatus

The subjects were housed in one of the three following conditions: (1) Individual cage: Six subjects (three males and three females) were individually housed in stainless steel, wire-

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Figure 1. A schematic of the colonial habitat for Group C.

mesh individual home cages, 20 cm L $\times$ 25 cm W $\times$ 19 cm H. (2) Group cage: Six subjects (three males and three females) were group housed in a single stainless steel group cage, 33 cm L $\times$ 55 cm W $\times$ 35 cm H. (3) Colony: Six subjects (three males and three females) were group housed in a large, enclosed wooden colony, 245 cm L $\times$ 245 cm W $\times$ 94 cm H. The colony was filled to 55 cm with dirt, and rocks and tree segments were distributed throughout. The top of the colony was constructed of wire-mesh, allowing for observation of consumption and social interactions. This apparatus is schematically depicted in Figure 1.

Throughout the experiment, all subjects had continuous access to food (Purina Rat Chow) and an ad-lib choice of water and one or both of two 10% ethanol solutions, the specific choice varying with the particular phase of the study. Fluids were presented in drinking tubes fitted with valveless stainless steel spouts. The available fluids were as follows: (1) H₂O—tap water; (2) ETOH—a volumetric (v/v) solution of 10% ethanol (from U.S.P. 95%) in tap water; (3) SGNE—a previously described (Kulkosky, 1978, 1979) solution of .125% sodium saccharin, 3.0% glucose, 1.0% sodium chloride, and 10% v/v ethanol in tap water.

Subjects in the individual cages (Group IC) received fluids in three bottles placed along the front wall of the individual home cage. Each bottle was separated by 3 cm. Subjects in the group cage (Group GC) received fluids in three bottles, two placed along the front wall and a third placed on the left wall of the group cage. Each bottle was separated by 20 cm. Subjects in the colony (Group C) received fluids in three bottles placed in the center of the front, left, and right walls of the colony. Each bottle was separated by approximately 173 cm. In all conditions, the spouts protruded approximately 3 cm into the living chamber.

Food was scattered about the floor along the front wall of the living space. All subjects were maintained under 12:12 L:D lighting cycle at an ambient temperature of 21°–27°C.

Procedure

Phase I: Adaptation—Upon receipt in the laboratory, the subjects were assigned randomly to one of three conditions and placed in the appropriate living space. During this phase (25 days), subjects in all conditions had continuous access to H₂O in all three drinking locations. **Phase II: H₂O vs. ETOH vs. SGNE**—On Days 1–16, all subjects had continuous access to three different fluids, H₂O, ETOH, and SGNE. The relative positions of each of these fluids at the three drinking locations was determined randomly for each of the 16 days of this phase, with the randomization of positions constant for all groups. **Phase III: H₂O vs. ETOH**—On Days 17–21, all subjects had continuous access to two different fluids, H₂O and ETOH. SGNE was removed during this phase. The positions of each of the two solutions in the three drinking locations were determined randomly for each of the 5 days of this phase. The randomization of positions was constant for all three groups.

Throughout all phases of the experiment, the bottles were weighed daily and cleaned every 2nd day. Fresh fluids were prepared and presented every 2nd day.

Data were analyzed with one-way analysis of variance with $p < .05$ as significant.

RESULTS

The data of one Group IC subject were discarded from analysis because of excessive spillage. All analyses are based on Ns of 5 (Group IC), 6 (Group GC), and 6 (Group C).

Phase I

During the initial 25-day adaptation phase, mean daily water intakes of Groups IC, GC, and C were 33.0, 29.9, and 29.5 ml, respectively. The groups did not differ significantly in the amount of water consumed during this phase ($F = 2.14$, $df = 2,72$, $p > .05$).

Phase II

The mean percent of total fluid intake of ETOH for each group during the subsequent 16-day period of Phase II is shown in Figure 2. The three groups showed a small, but significant, difference in percent of total fluid intake as ETOH ($F = 9.5$, $df = 2,45$, $p < .05$). Subjects in the group cage (Group GC) drank a significantly smaller percentage of ETOH (mean = 5.4%) than Group IC (mean = 11.8%) ($F = 18.2$, $df = 1,45$, $p < .05$) and Group C (mean = 9.7%) ($F = 8.3$, $df = 1,45$, $p < .05$). The intakes of Groups IC and C did not differ significantly ($F = 1.9$, $df = 1,45$, $p > .05$).

The mean percent of total fluid intake of SGNE for each group during Phase II is shown in Figure 3. The three groups differed significantly in percent of total fluid intake as SGNE ($F = 55.0$, $df = 2,45$, $p < .05$). Subjects housed in the colony (Group C) drank a significantly smaller percentage of SGNE, flavored ethanol (mean = 31.1%) than Group IC (mean = 51.3%) ($F = 69.2$, $df = 1,45$, $p < .05$) and Group GC (mean = 54.6%) ($F = 93.8$, $df = 1,45$, $p < .05$). The SGNE intakes

Figure 2. Mean percentage of total fluid intake of ETOH, 10% ethanol, for Groups IC (individually caged), GC (group caged), and C during Phase II and Phase III.

of Group IC and Group GC did not differ significantly ($F = 1.86$, $df = 1,45$, $p > .05$).

The mean percent of total fluid intake of H_2O for each of the three groups is shown in Figure 4. The three groups differed significantly in the percent of total fluid intake as H_2O ($F = 34.1$, $df = 2,45$, $p < .05$). Group C subjects drank a significantly greater percent of H_2O (mean = 59.2%) than Group IC (mean = 37.2%) ($F = 57.4$, $df = 1,45$, $p < .05$) and Group GC (mean = 39.9%) ($F = 43.9$, $df = 1,45$, $p < .05$). The H_2O intakes of Groups IC and GC did not differ significantly ($F = 0.9$, $df = 1,45$, $p > .05$).

Figure 3. Mean percentage of total fluid intake of SGNE, 10% ethanol in saccharin + glucose + NaCl vehicle, for Groups IC, GC, and C during Phase II.

Figure 4. Mean percentage of total fluid intake of H_2O for Groups IC, GC, and C during Phase II and Phase III.

Table 1
Mean Absolute Fluid Intake (ml) for ETOH, SGNE, H_2O , and Mean Total Fluid Intake (ml) for Groups IC, GC, and C over the Three Phases of the Experiment.

Group	Phase I			Phase II		Phase III		
	H_2O	ETOH	SGNE	H_2O	T	ETOH	H_2O	T
IC	33.0	4.7	20.2	14.8	39.7	7.4	26.7	34.1
GC	29.9	2.5	24.1	17.7	44.2	4.0	35.5	39.5
C	29.5	4.3	13.5	26.1	43.9	6.6	37.6	44.2

Phase III

The mean percent of total fluid intake of ETOH and H_2O for each of the three groups during Phase III (Days 17-21) is shown in Figures 2 and 4. Following the removal of SGNE at the beginning of Phase III, consumption of ETOH and H_2O by all groups increased. Although consumption of both fluids increased above levels consumed in Phase II, H_2O was greatly and consistently preferred to ETOH for all groups.

The mean percent of total fluid intake of ETOH was significantly different for the three groups of rats ($F = 7.4$, $df = 2,12$, $p < .05$). Subjects housed in individual cages (Group IC) drank a significantly larger percent (mean = 21.8%) than Group GC (mean = 10.0%) ($F = 14.7$, $df = 1,12$, $p < .05$), but did not differ significantly from Group C (mean = 15.2%) ($F = 4.6$, $df = 1,12$, $p > .05$). The ETOH intakes of Groups GC and C did not differ significantly ($F = 2.9$, $df = 1,12$, $p > .05$).

The mean grams of total ethanol intake (TEI, weight of absolute ethanol from ETOH + SGNE) for Phase II was 2.0, 2.1, and 1.4 g/rat for Groups IC, GC, and C, respectively. The groups differed significantly in TEI during this period (Days 1-16) ($F = 16.9$, $df = 2,45$, $p < .05$). Group C, colony-housed rats, drank significantly less total ethanol than Group IC ($F = 19.6$, $df = 1,45$, $p < .05$) and Group GC ($F = 30.0$, $df = 1,45$, $p < .05$), but TEI for Groups IC and GC did not differ significantly ($F = 1.1$, $df = 1,45$, $p > .05$).

The mean TEI for Phase III was .6, .34, and .52 g/rat for Groups IC, GC, and C, respectively. There were no significant differences in total grams of ethanol consumed per rat among any of the three groups across Phase III ($F = 3.3$, $df = 2,12$, $p > .05$).

Mean absolute intakes of ETOH, SGNE, and H_2O as well as total fluid intake for each group across the three phases of the study are summarized in Table 1.

DISCUSSION

Given a three-bottle choice of water, 10% ethanol, and 10% ethanol in a sweetened and salty vehicle, rats housed in a naturalistic colonial environment ingested significantly lower percentages of the flavored ethanol solution and lower amounts of total ethanol than either

individually or group-caged rats. When the choice of flavored ethanol was removed, total ethanol intake for all groups greatly decreased, and did not differ significantly among the groups. These findings are consistent with the often-reported elevation of ethanol intake by the addition of sweeteners (Cullen et al., 1973; Eriksson, 1969; Geiger & Barker, 1976; Gilbert, 1974; Kulkosky, 1978, 1979; Myers & Tytell, 1972; Rodgers & McClearn, 1964; Samson & Falk, 1974) and reports of immediately lowered ethanol intake by rats after removal of sapid congeners (Cullen et al., 1973; Geiger & Barker, 1976; Kulkosky, 1979).

A crowding and isolation stress explanation of the finding of lowered total ethanol intake by rats in a colonial habitat is plausible. Rats in a colonial habitat have far greater floor area (10,004 cm²/rat) than either individually housed animals (500 cm²/rat) or group-housed animals (302.5 cm²/rat). The colonial rats also had the opportunity to expand the area per animal by burrowing. The area per rat in the colony greatly exceeds the areas per animal previously used in grouping studies (see Hannon & Donlon-Bantz, 1976). If stress acts to increase ethanol consumption (for reviews, see Lester, 1966; Lester & Freed, 1973; Myers, 1966; Myers & Veale, 1972; Wallgren & Barry, 1970), and isolation or crowding act as effective stressors (Brown, 1968; Deatherage, 1972; Fox, 1974; Hannon & Donlon-Bantz, 1975, 1976; Hatch et al., 1963; Heminway & Furumoto, 1972; Lovely et al., 1972; Parker & Radow, 1974; Rodgers & Thiessen, 1964; Thiessen, 1964; Thiessen & Rodgers, 1961, 1965; Welch, 1974), the data may be explained as a response to stress of increased intake of ethanol in the flavored solution. However, there were no significant differences in total ethanol intake among the groups when the choice of flavored ethanol was removed. The above explanation, therefore, can only be possible for ethanol consumption when maximized by the addition of sapid solutes so that resultant blood ethanol levels are sufficiently high to exert psychopharmacological effect (Kulkosky, 1979).

However, other explanations might also be compatible with the observed results. For example, taste preferences might conceivably be different in the colony because contact is permitted with soil, tree segments, rocks, etc. (e.g., geophagia was observed in the colony). Nevertheless, colony-housed rats showed a nearly exclusive preference for the ethanol-free saccharin + glucose + NaCl vehicle in two-bottle tests against water, which was nearly identical to that of individually housed rats (Kulkosky, 1979; Kulkosky, Zellner, Hyson, & Riley, Note 1). Thus, an explanation of the lowered flavored-ethanol intake as an effect of altered taste preferences in the colony for the sapid vehicle appears unlikely.

The action of social stimuli other than simple proximity might prove responsible for the relatively lower total ethanol intake in the colony. Adequate room for the establishment of territoriality and dominance

hierarchies or the formation of "local tradition" (Eibl-Eibesfeldt, 1970) of drinking might be cited as possible influences on flavored ethanol intake. More detailed study of social and environmental interactions in naturalistic colonies should further clarify the factors responsible for the relatively decreased total ethanol intake in a colonial habitat (Moran, 1975; Woods & Kenney, 1979).

In summary, when rats are offered a flavored ethanol solution, subjects housed in a naturalistic colonial habitat consume significantly less total ethanol than rats housed in individual or group cages. The data suggest that the stimuli of the colonial habitat act to decrease maximized ethanol intake.

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