Satiety-dependent microbehaviors in water ingestion by the rat: The effects of alcohol on response duration

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Under a 23.5-h water deprivation schedule, response durations of licking behavior and barpressing were observed to parallel response rate during the course of the 30-min drinking session. The microbehavioral, but not macrobehavioral, indexes of satiety were eliminated by alcohol (1 g/kg). Results are discussed as they relate to O'Kelly's regulatory model of water balance.

Satiety functions, serving to terminate corrective motor activity, are essential processes in water regulation, and a major problem in this area has been the identification of mechanisms inhibiting ingestion in advance of tissue rehydration (O'Kelly, 1963). Indexes of these pre-absorptive satiety mechanisms include both macro- and microbehavioral events. For the former case, using a standard 23.5-h deprivation schedule, volume of intake in free access situations and operant response characteristics have been used (O'Kelly, 1954; Ridgley, O'Kelly, & Falk, 1957). Both intake and response rate often parallel stomach clearance (Engstrom & Deaux, 1974; O'Kelly, Falk, & Flint, 1958). For the latter case, microbehavioral aspects of licking behavior including rate (Stellar & Hill, 1952), licking burst duration, licking pause duration, within burst lick duration, and within burst pause duration have been studied for both nonnutritive and nutritive fluids (Allison & Castellon, 1970; Hulse, 1967). The former authors report that, taken as a whole, their data support a continuous or gradual model of satiety as opposed to a discontinuous or stepwise process.

Although a negative water balance may result from alcohol (Beard & Knott, 1971), an initial depression in water ingestive behaviors may occur. Alcohol depression of response duration of barpressing in rats was reported earlier (Crow, Edelbrock, & Martin, 1975), but evidence was presented suggesting that behavioral adjustments may be made to prolonged or repeated debilitation through alcohol. Moderate (12%) but not large (24%) concentrations of alcohol may be tolerated by rats, but only with repeated experience (Crow, 1970).

Several questions arise from these studies: (1) Since neither of the previously mentioned microanalyses of licking considered water intake, but rather saccharin or nutritive fluids, what are the microbehavioral characteristics of thirst satiety in the standard 23.5-h water deprivation schedule? (2) What is the relation, if any, of satiety-dependent microbehaviors involved in licking to the more macrobehavioral aspects of barpressing

for water reinforcement? (3) Would a central nervous depressant, such as alcohol, affect differentially the *micro* as opposed to the *macro* behavioral aspects of drinking? (4) Do microbehavioral aspects of water ingestion provide the same information about satiety processes as such macrobehavioral indexes as number of licks or number of barpresses? The present study was designed to observe and compare the number of responses and response duration in the course of thirst satiety of the free access and barpressing situation both with and without prior alcohol treatment.

METHOD

Subjects

Twenty-four male rats, approximately 90-150 days of age, were used. All animals were taken from a colony of a basic Long-Evans strain maintained at Western Washington State College and were naive to the experimental situation.

Apparatus

The leverpressing apparatus consisted of two water-delivery-type Grason-Stadler units in conjunction with Cramer digital counters and Grason-Stadler (.1-sec) running time meters. Interession intervals were timed by means of a stopwatch. The free access apparatus was made up of a compartment (18 x 18 x 24 cm) equipped with a 100-ml eudiometer drinking tube fitted with a stainless steel spout positioned 7.5 mm from the cage wall and 8.5 cm above the cage floor. Access to the tube from the cage was through a square aperture which was 10 x 10 mm. A Grason-Stadler drinkometer with the counters and running time meters above were used to assess number of licks and average duration of licking behavior.

Dosages

Ethanol was administered intraperitoneally from a 24% solution of 95% alcohol in an amount which was 1 g/kg and was given 10 min prior to the test session.

Procedure

All animals were adapted to and maintained on a 23.5-h water deprivation schedule throughout the experiment. Food was available ad lib except for the ½-h drinking period. In the case of leverpressing, the animals (N = 12) were trained to a stable level of continuous reinforcement performance in terms of number of presses and total duration of lever depression at 5-min intervals during the course of the 30-min drinking session.

Figure 1. Cumulative number of responses and cumulative response duration in a 30-min continuously reinforced operant situation. Alcohol dosage was 1 g/kg (see text).

Half of the animals were injected with alcohol 10 min prior to the daily session on alternate days, such that a total of six repeated alcohol treatments were carried out (over 12 days). Previous data (Crow, Edelbrock, & Martin, 1975) failed to show placebo effects on time on bar or number of responses, thus the control animals were not saline injected on test days.

In the case of free access to water during the 30-min drinking session, a procedure similar to that of the barpressing phase was carried out, with the exception that log intersession intervals were used (2, 6, 14, 30 min). Such intervals assured data points for all animals. There were 12 animals, 6 of which were controls.

RESULTS

For the leverpressing data, cumulative number of responses and cumulative time on bar in seconds were noted for each succeeding 5-min segment during the 30-min session for the terminal alcohol treatment day. The data are presented in Figure 1. Cumulative number of responses and cumulative time per response for the six 5-min periods for the 30-min session were subjected to separate analyses of variance. That is, an alcohol/no-alcohol between- and a within-session time design was used. In the case of the number of responses, there was no significant alcohol effect ($F = .008$, $df = 1/10$), a significant within (time) effect ($F = 29.02$, $df = 5/50$), and no significant interaction ($F = .497$, $df = 5/50$). In the case of time on bar, there was a significant alcohol effect ($F = 10.45$, $df = 1/10$), a significant within (time) effect ($F = 2.89$, $df = 5/50$), and a significant interaction ($F = 2.98$, $df = 5/50$).

Thus alcohol, after repeated dosages, did not depress the number of responses but did elevate the response duration. Consequently, the average time on bar did not increase over the course of the session for the alcohol group, but did for the sober group. A comparison of the overall variance within the session for each animal yields a mean value of .076 msec for the alcohol group and .620 msec for the sober group. This mean difference in individual variance of barpressing duration across the session is significantly different by Mann-Whitney

U-test at the 5% confidence level. Note that these data represent the effects on drinking behavior after repeated alcohol treatments. Initial effects of alcohol were either a complete cessation of drinking or a depression of number of responses as well as an elevation of response time.

Figure 2 shows the licking data in the free access situation. The number of responses (licks) and total duration of tongue contact or on-off time (time on tube) were noted (noncumulatively) for the succeeding time periods (2, 6, 14, and 30 min) throughout the 30-min session. These data for the terminal treatment day were subjected to 2 by 4 analyses of variance. For the number of responses, there was no significant alcohol effect ($F = 1.28$, $df = 1/10$), a significant within (time) effect ($F = 5.01$, $df = 3/30$), and no significant interaction ($F = .14$, $df = 3/30$). For the time-on-tube data, there was no significant alcohol effect ($F = .35$, $df = 1/10$), a significant within (time) effect ($F = 45.35$, $df = 3/30$), and a significant interaction ($F = 4.94$, $df = 3/30$). Thus, a decrease in time on tube accompanied satiety, and this change was affected by alcohol. Variance scores, similar to those computed for time on bar, showed that the individual variance of time on tube was lower for the alcohol group (mean variance .005 msec) than for the sober group (mean variance .025 msec). This mean difference was significant at the 5% confidence level by Mann-Whitney U-test.

DISCUSSION

That the duration of tongue contact (time on tube) decreased continuously as a function of rehydration supports the assumption that such microbehavioral events are reflective of, and may be used to assess certain aspects of, the satiety process. The data for water in the present study closely resemble the on-off durations for the rat's licking of nutritive solutions reported by Allison and Castellan (1970). That such a change was

Figure 2. Number of licks and lick duration in the 30-min free access drinking situation. Alcohol dosage was 1 g/kg (see text).

not found previously for the drinking of saccharin solutions (Hulse, 1967) has been attributed to a different underlying satiety mechanism (Allison & Castellan, 1970).

The continuously reinforced barpressing for water under the standard 23.5-h deprivation schedule yielded macrobehavioral data (number and rate of response) which closely approximate earlier reports (Ridgley, O'Kelly, & Falk, 1957). The changes in barpressing duration (time on bar) with satiation appear to represent still another microbehavioral analog of the satiety process. That the response duration increased over the course of the session would seem to support a fatigue hypothesis of barpressing analogous to that hypothesis of changes in microbehaviors proposed by Hulse (1967). The fact, however, that rats are able to maintain very low response times over a much greater number of responses with fixed-ratio schedules (Crow, Edelbrock, & Martin, 1975) would argue against the fatigue hypothesis. The time-on-bar changes appear to correspond to those changes in cumulative number of responses as satiety ensues, and these latter macrobehavioral changes have been shown to correspond in turn with stomach clearance (Engstrom & Deaux, 1974; O'Kelly, Falk, & Flint, 1958). That the macrobehaviors in the alcohol groups did indeed reflect satiety rather than ascending and descending limbs of intoxication is supported by the lack of a significant difference from the control groups and by the reinstatement of fluid balance by way of the water reinforced operant.

The independence (as well as interdependence) of the correctional, satiety, and orientational mechanisms proposed by O'Kelly (1963) appear particularly relevant here, especially in terms of a distinction between the complex orientational operations, on the one hand, and the rather specific correctional behavior, on the other. If alcohol acts more directly upon such correctional processes (e.g., motor impairment), orientational

mechanisms may compensate for such altered function after repeated intoxication. Evidence of such neural compensation for prolonged alcohol-induced behavioral impairment was reported earlier in connection with the ethanol metabolism inhibitor, pyrazole (Crow, Edelbrock, & Martin, 1975).

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