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Satiety-dependent microbehavior in water ingestion by the rat: The effects of salt and water preloads on response duration

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Rats were maintained on a 23½-h water-deprivation schedule and trained in either CRF operant responding or free drinking. A disruption of the intrasessional relation between response rate and duration opposite to that noted earlier with alcohol (Crow, Westveer, & Kass, 1976) was seen in the case of osmotically induced thirst. The results are discussed as they related to gastric distention hypotheses of the satiation of thirst.

Response duration in operant responding decreases in both mean and variance with continued reinforcement of rate contingencies, and increases in mean and variance in extinction (Hurwitz, 1954; Millenson & Hurwitz, 1961; Schwartz & Williams, 1972). Hurwitz (1954) noted that response duration increases "with extended rewarded practise," an effect he attributed to either fatigue or a reduction in motivation.

In free-drinking behavior, response duration of licking (on-off time) has been studied as a "microbehavioral" aspect of the water ingestive act. The intrasessional lick time was found to decrease for nutritive solutions (Allison & Castellan, 1970; Hulse, 1967) and for water in thirsty animals (Crow, Westveer, & Kass, 1976). A fatigue explanation was advanced for this effect by Hulse (1967).

That these effects reflect some aspect of satiety as opposed to fatigue is supported by several observations. Ratio schedules of reinforcement produce a greater number of responses, but a lower response duration, than CRF reinforcement schedules, and the points of inflection of the curves for barpressing and licking within a 30-min drinking session are similar, although the energy required is different (Crow, Edelbrock, & Martin, 1975; Crow, Westveer, & Kass, 1976). The fact that ordinarily response rate and duration are correlated, but that under certain conditions the measures may not be related (Millenson, Hurwitz, & Nixon, 1961), appears contrary to a simple fatigue effect.

If these microbehavioral changes in drinking reflect satiation, a possible contributing factor may well be gastric distention (Engstrom & Deaux, 1974; O'Kelly, 1954). In order to explore this possibility, the present study was designed to observe such microbehavior after preloads equal in volume, but differing in their capacity to quench thirst.

This study was presented at the meeting of the Psychonomic Society, St. Louis, November 1976.

METHOD

Subjects

Subjects were six male and six female albino rats from the colony at Western Washington State College. The animals ranged in weight from 187 to 313 g.

Apparatus

The apparatus was described elsewhere (Crow, Westveer, & Kass, 1976). It consisted of two water-delivery operant chambers and two free-drinking chambers equipped to measure both number and duration of responses.

Loads

The loading procedure was taken from that of O'Kelly, Crow, Tapp, and Hatton (1966) in which tap water or sodium chloride solutions (percent weight/volume) were intubated into the stomach under light ether anesthesia. All load volumes were 2% of the body weight in cubic centimeters.

Procedure

All animals were adapted to a 23½-h water-deprivation schedule, with food available ad lib, and trained to a stable level of performance. Six of the 12 animals were assigned to the operant boxes and 6 to the drinking boxes throughout the study. After a stable response level had been attained, an ether control day was administered to all animals. The ether control consisted of light anesthetization and the insertion of the stomach tube without loading. The ether control day and each of 3 subsequent load days were separated by 6 intervening days of normal runs (operant or drinking box), such that all animals received water, 2%-NaCl, or 4%-NaCl loads accounting for order. A postsession period of free access to water was given after the 4% loading. Measures were made throughout of the number of responses and average response duration at Minutes 2, 6, 14, and 30 of the daily sessions.

RESULTS

Two analyses of variance were carried out. For the macrobehavior (number of responses either lick or barpress), a 2 by 3 by 4 design of a between (barpress vs licking) and two within variables (water, 2% NaCl, or 4% NaCl; and 2-, 6-, 14-, 30-min segments of the session) was used. A similar 2 by 3 by 4 ANOVA was carried out for the microbehavior (lick duration), with

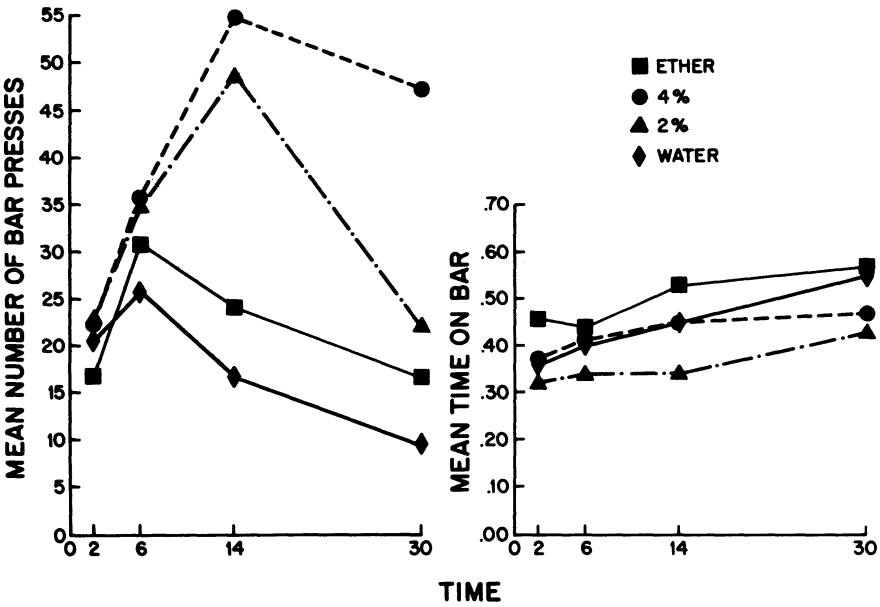

Figure 1. Macrobehavioral changes (left) and microbehavioral changes (right) of operant CRF responding as a function of preloads of water or sodium chloride solutions.

the exception that the within-sessions time data (that is the 2-, 6-, 14-, and 30-min averages of response duration) for the lick duration were entered in a reverse order. This was done to ease interpretation of the interaction, as previous data have demonstrated increasing barpress duration and decreasing lick time within the session (Crow, Westveer, & Kass, 1976).

For the macrobehavioral data there was a significant main effect of barpressing vs licking ($F = 162.4$, $df = 1/10$), a significant load effect ($F = 44.5$, $df = 2/20$), a significant within-sessions effect ($F = 9.76$, $df = 3/30$), a significant interaction of Barpress by Lick Responses by Load ($F = 39.7$, $df = 2/20$), a significant Barpress by Lick by Within-Sessions Time interaction ($F = 9.0$, $df = 3/30$), and a significant triple order interaction ($F = 8.7$, $df = 6/60$).

For the microbehavioral data there was a significant task effect (barpress vs lick durations, $F = 85.0$, $df = 1/10$), a nonsignificant load effect ($F = 2.4$, $df = 2/20$), a significant satiety effect (increased barpress time, decreased lick time over the session, $F = 11.3$, $df = 3/30$), and no significant interaction at the 5% confidence level.

The data for macro- and microbehavior are presented in Figures 1 and 2. It can be seen that, while the macrobehavior was influenced by the loads, the microbehavior was not. The ether control data (not included in the analysis) are shown for comparison.

DISCUSSION

If the microbehavioral changes over the course of the drinking session reflect a gastric distention satiety process, one would not expect equal volumes of preloaded solutions to affect the changes. This should be the case even though the preload solutions differentially affected the rate of response over the course of the session. It appears that some kind of inhibitory mechanism, reflected by response duration, is at work which increases in intensity as the session concludes and that this mechanism is separate from a facilitatory mechanism of some kind which is capable of overriding the inhibitory effect or mechanism.

The data appear in keeping with earlier postulations of a satiety mechanism separate from a correctional mechanism in thirst (O'Kelly, 1963), and consistent with the notion that gastric distention may constitute an important cut-off cue in the 23½-h water-deprivation schedule (Engstrom & Deaux, 1974; O'Kelly et al., 1958).

As the general question of the continuity of the satiation process has been an issue (Allison & Castellan, 1970), and with the suggestion by Morgan (1974) that satiation may be more closely related to an extinction phenomena than to drive reduction, relevant aspects of the present data should be discussed. Figure 3 shows the response duration changes within the 30-min drinking session of a nontreated group of rats under a 23½-h water-deprivation schedule. These data differ from that reported earlier (Crow, Westveer, & Kass, 1976) in that log intervals of measurement were used rather than the previous 5-min segments. The 5-min data result in a continuity of barpressing duration change, but within the first 6-min there is a sudden change in duration, a change masked by the 5-min measures. Figure 1 shows this change for the ether control group, but not for the groups receiving stomach loads, which show a continuous change. There is a significant difference in barpressing duration at Minute 2 between the load groups and the ether group shown in Figure 1 ($p < .05$). An early cut-off mechanism within the first 6 min for barpressing is suggested, and this is obviously inconsistent with a continuity hypothesis.

Consistent with a continuity after the 6th min, and consistent with an extinction explanation of the latter part of the 30-min session, is an analysis of the variance of the barpressing duration as the session closes. The variance increases fivefold from .014 sec to .075 sec from the 6th to the 30th min in the data shown in Figure 3. This is in keeping with variance changes noted by Hurwitz (1954) for extinction data.

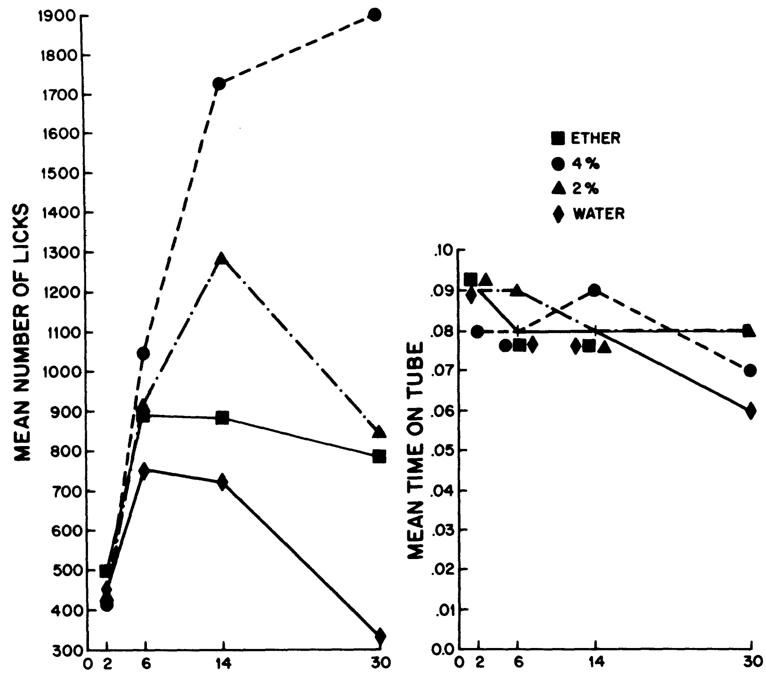

Figure 2. Macrobehavioral changes (left) and microbehavioral changes (right) of free drinking as a function of preloads of water or sodium chloride solutions.

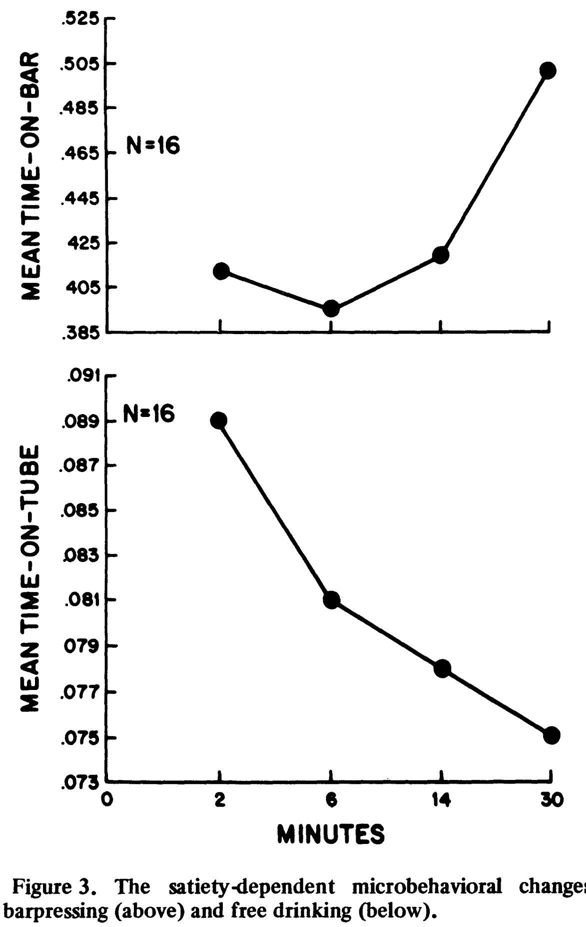

Figure 3. The satiety-dependent microbehavioral changes in barpressing (above) and free drinking (below).

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