Variability in the burst lick rate of albino rats as a function of sex, time of day, and exposure to the test situation

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Burst lick rate was measured in 16 adult albino rats deprived of water for 23 h. Females licked faster than did males, and the mean lick rates of both sexes increased from Day 1 to Day 6 of the experiment. Both sexes licked faster at night than during the day, but this difference was statistically significant only for females. Results are viewed as challenging the hypothesized invariance of mammalian lick rates.

The hypothesized invariance of burst lick rate in mammals has remained relatively unchallenged since Stellar & Hill (1952) first established this generalization by stating that. regardless of deprivation level or phase of the test session. "the rat laps water at the rate of six to seven tongue laps per second or it does not drink at all [p. 98]." Davis & Keehn (1959) declared that the rat's lick rate was constant across various solutions of saline, sucrose, and saccharin: and Schaeffer & Premack (1961) claimed that no differences in lick rate were found when weanling rats of both sexes were compared to adult rats. It should be noted that none of these often-cited studies reported statistical tests.

The initial challenge to the invariance hypothesis came from a Japenese investigator. In an apparently little-read study, Imada (1964) found a statistically significant interaction between deprivation level and session phase. in which 24-h-deprived rats licked faster at the beginning of the test session than did 6-h-deprived rats. but this difference was nonexistent later in the session. Imada's challenge to the invariance hypothesis is supported by the work of Allison (1968). who found statistically significant individual differences in the licking rates of adult rats.

Subsequently. Allison & Castellan (1970) defined procedures for a microanalysis of licking behavior in which the mean duration of individual licks within bursts (on-off time) and the mean duration between individual licks within bursts (off-on time) are examined. They reported that scores for rats obtained by these microanalyses differed significantly for nutritive and nonnutritive solutions.

In the usual "free-drinking" situation. licks on a tube opening produce liquid directly. Hulse has criticized the invariance hypothesis using a procedure in which discrete drops of liquid are pumped through the tube opening. With this procedure. lick rate varies significantly as a function of the reinforcement schedule and the test session phase (Hulse. 1967).

Cone. Cone. Golden. & Sanders (1973) recently

reported that both sex and circadian cycle phase significantly affect burst lick rate in the Virginia opossum. Since all opossums were run at both times of day investigated. it was possible to control statistically for individual differences within sexes for both the circadian cycle phase factor and the repeated days factor. A more direct challenge to the invariance hypothesis could be made if significant differences in lick rate were obtained with a design that did not permit statistical removal of within-Ss variability across critical test conditions. To meet this criterion. the present experiment was designed. using randomized groups of both sexes. Albino rats served as Ss. since the majority of the statements concerning lick rate invariance are based upon rat data.

METHOD

Subjects

The Ss were eight male and eight female albino rats obtained from Charles River Breeding Laboratories. All were 220 days old at the start of the experiment. Each was housed individually in a colony room maintained at $21°-23°C$ and 38% humidity under an LD 12:12 lighting cycle (lights on: 0600-1800 h. DST).

Apparatus

A 1.5-cm-diam hole. 4.5 cm from the floor of a 37 x 30 x 28 cm cage. provided access to a standard water bottle drinking spout. Licks on a 2.5-mm-diam hole in the spout tip operated an electronic drinkometer circuit modified from Zucker (1969. p. 127). This test cage was housed in a ventilated. sound-treated chamber. containing a $7^1{}_2$-W houselight. which delivered 1.5 fc at the grid floor of the cage for both day and night test sessions. White noise from an amplified Grason-Stadler 455C white-noise generator was presented at 78 dB (SPL). Temperature was maintained at $22°-24°C$.

All licks were recorded both on electromechanical counters and on a BRS Foringer POC-112. which was operated by programming equipment to record burst duration. responses per burst, interburst interval. and extraneous (nonburst) responses.

Procedure

Four males and four females were assigned randomly to a morning group (0900-1200 h). and the remaining Ss were assigned to an evening group (2100-2400 h). Water deprivation was maintained at 23 h for all Ss. and test sessions lasted 30 min.

On the day before data collection was begun. each S was placed in the apparatus with the water bottle spout protruding at least .5 cm into the cage. As soon as S had begun licking. the spout was retracted 3 mm behind the inside face of the front wall. where it remained for the rest of the study. Each S was allowed 20 min in the apparatus on this familiarization day.

RESULTS

Rate of licking was computed for each burst (10 or more licks with no interlick interval greater than 1 sec). and unweighted mean burst rates were computed for each of the six sessions for each S.

When these data were treated as a 2 (sex) by 2 (time of day) by 6 (sessions) ANOVA (Winer. 1962. p. 337).

all main effects yielded significant F ratios. Time of day was significant (F = 13.42, df = 1/12, p < .005), with lick rate faster at night ($\overline{X}$ = 6.31) than during the day ($\overline{X}$ = 5.85). Sex was a significant determiner of lick rate variance (F = 29.44, df = 1/12, p < .001), with female lick rate ($\overline{X}$ = 6.41) higher than male ($\overline{X}$ = 5.75). However, sex interacted significantly with time of day (F = 4.66, df = 1/12, p < .05). Planned orthogonal comparisons (Edwards, 1968, p. 139) indicated that the nocturnal lick rate of males ($\overline{X}$ = 5.84) was not significantly faster than their diurnal rate ($\overline{X}$ = 5.66). By contrast, the nocturnal lick rate of females ($\overline{X}$ = 6.78) was significantly faster (F = 58.66, df = 1/12, p < .001) than their diurnal rate ($\overline{X}$ = 6.04).

For both sexes, at both times of day, lick rate showed a significant increase from Day 1 to Day 6 (F = 9.67, df = 5/60, p < .001): Day 1 $\overline{X}$ = 5.52, Day 6 $\overline{X}$ = 6.38. None of the interactions of sex and time of day with sessions was found to vary from the expected value for F under the respective null hypotheses.

DISCUSSION

An examination of the daily scores of individual Ss makes it easy to understand why previous researchers have concluded that momentary lick rate is invariant for the rat. In the absence of statistical tests permitting the rejection of such a null hypothesis, it is intuitively appealing to accept as invariant a mammalian behavior which occurs at a rate of 5-7 times/sec.

Adherents to the invariance hypothesis might well choose to ignore Hulse's (1967) findings, because the procedure for delivering the fluid differs from "true" free-drinking. The microanalysis of Allison & Castellan (1970) might also be discounted, since the micromeasures are extrapolated ones and do not necessarily mean that the traditional licks/sec measure during bursts of licking varies with experimental treatment. While the Cone et al (1973) study used a traditional free-drinking method, its findings could be discounted on the possibility that the opossum is a unique species.

The present findings, however, cannot be so easily ignored. The procedure is directly comparable to those usually employed for measuring burst lick rate under free-drinking conditions, and the S studied is the ever-popular white rat.

Female rats were found to lick faster than male rats, an effect which may be explained by Davenport's (1961) finding of a negative correlation between burst lick rate and tongue size. In the present study, female Ss ($\overline{X}$ weight = 318 g) were clearly smaller than male Ss ($\overline{X}$ weight = 426 g).

Although both sexes licked faster at night than during the day, this difference was statistically significant only for females. While no explanation of this sex difference is being offered, it can be stated that these day-night differences were consistent from day to day, thus arguing against a confounding of circadian cycle effects in the females with estrous cycle effects. It is also interesting to note that Balagura & Devenport (1970) obtained

significant Sex by Time of Day effects in the postoperative feeding patterns of VMH-lesioned rats.

After 6 days of testing, both sexes averaged 6.38 licks/sec as compared with 5.52 licks/sec on Day 1, a significant increase in mean lick rate of .86 licks/sec. The only other free-drinking study to report an increase in lick rate across test sessions was done by Keehn & Arnold (1960). No statistical tests were reported, but it was stated that mean lick rates for adult male and female rats increased from 7.03 licks/sec during Days 1-5 of the experiment to 7.52 licks/sec after a month of testing. The relatively smaller rate increase obtained by these workers may be due to a ceiling effect generated by the higher initial rates of their Ss. These higher initial rates may, in turn, be associated with the larger drinking tube aperture (4 mm vs 2.5 mm) and/or the shorter test session (5 min vs 30 min).

At the very least, the present study has shown that the burst lick rate of adult albino rats in a free-drinking situation varies as a function of sex, time of day of testing, and length of exposure to the testing situation. Together with several studies cited earlier, the present findings question the long-standing generalization that mammalian lick rates are invariant.

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