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Shock-avoidance and shock-escape drinking in rats: Rate of licking*

M. L. J. CRAWFORD

Baylor College of Medicine
and The University of Texas Graduate School of Biomedical Sciences
Houston, Tex. 77025

The drinking rates in rats were measured by interresponse times for licking under shock-avoidance or shock-escape contingent licking conditions. Interresponse times were quite comparable under either set of shock-contingent drinking conditions with the modal interlick interval approximately 145 msec. Well-established principles of behavior maintained on fixed ratio schedules would predict such results.

Stellar & Hill (1952) and Corbit & Luschei (1969) have described the invariant nature of the rate of drinking for water in the water-deprived rat and where the solution being consumed incident to the licking could be considered to be preferred or aversive in taste stimulation. The interresponse lick rate (IRT) did not change, even though hours of water deprivation and wide saccharin concentrations produced predictable changes in the volumes of solution ingested within a short test period, the volume of solution ingested being a function of the time spent in drinking.

Data reported here support the conclusions of the above researchers by extending the boundary conditions under which the drinking behavior is stable in that the consequence of the licking behavior may be (1) the avoidance of shock to the feet, (2) the escape from a repeated shock to the feet, and/or (3) the avoidance of, or escape from, a discriminative stimulus (SD) that has been associated with the occurrence of shock for a large number of trials.

METHOD

Data were collected for periods up to 20 months from six rats, albino and hooded,

of both sexes.

An experimental cage was provided with a drinking tube, accessible to the rat through a hole in the cage wall at one end. The tube permitted the rat's tongue to complete an electrical contact with the sensing apparatus only through the drinking solution. Such contacts between the drinking tube and the grid floor of the cage were detected by a Grason-Stadler Drinkometer. The floor was electrically common to the lick detection system and to a scrambled shock source (SDS) through a relay bank that prevented shock delivery to the rat's tongue. The experimental cage was enclosed in a large ventilated sound-attenuated chamber having an overhead 25-W house lamp that served as a discriminative stimulus (SDL) and was controlled remotely. A digital logic system controlled program requirements and supplied classified lick responses, relative to the SD, to the input of a TMC Computer of Average Transients (C.A.T. 1000) for histogramming of interlick intervals (IRTS). Cumulative records were also taken.

PROCEDURE

The rats were initially deprived of water for 23 h and given 1 h training with the termination of the house light contingent upon licking on a CRF schedule. After three to four such sessions, shock was introduced and increased in intensity until

avoidance motor response of the rat was obvious to the E. Shock duration was 0.5 sec and did not occur when the light was off. During subsequent training sessions the Ss were not under deprivation, always having food and water freely available in the home cage.

The rat was removed from the home cage, weighed, and placed in the experimental chamber with the house light (SDL) off. For a variable period up to 30 min, the chamber remained dark, and any drinking was recorded. At the end of this period, the SDL came on and remained on for 20 sec, unless the rat emitted up to nine licks on the drinking tube, turning off the light. The light remained off for 30 sec and the cycle was repeated, unless the S emitted four licks during this period, which kept the light turned off. However, if the FR9 ratio was not met within the first 20 sec following onset of the light, a brief (0.5-sec) shock was delivered to the feet, recurring every 6 sec, while the light remained on. To escape the recurrent shock, the rat had to emit 20 licks, after which the cyclic shock and light-on period terminated and the entire cycle was repeated after a 30-sec interval. Therefore, the schedule was a FR4 FR9 FR20 sequential schedule. Time-out periods of 15-20 min, where the house light was off and no shocks occurred, followed 20- to 30-min sessions where avoidance of shock was contingent upon licking. The logic system separated the licking responses, and counters tallied those responses occurring (1) during light off, (2) light on but before first shock, (3) after first shock, (4) total responses. Responses within these separated response classes were measured for interresponse times (IRTs).

At the end of the experimental session, the amount of liquid consumed during the session was measured. The present data, collected from six rats, were obtained where the rat licked solutions of either 10% or 20% ethanol in a commercially available breakfast drink (Tang; 70 g/500 cc solution).

RESULTS

As the rate of drinking was quite comparable for all six Ss (modal response 140 ± 10 msec under all conditions), data from only two Ss are presented in Fig. 1. Figure 1A demonstrates the degree of discrimination of the SDL and SDS in that the rat emitted no responses in the 20-min period prior to the occurrence of the first SDL and SDS sequence. After a brief "warm-up" the efficiency in terminating the SDL and consequently avoiding the SDS became very high. During the two long "runs" of licking in the first segment of the session, 200 IRTs were

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Fig. 1. Cumulative records and interresponse time histograms (IRTs) for licking during drinking by the rat. (A) IRTs for first histogram from the "runs" of the first segment; second histogram of IRTs from licks during SDL. (B) First IRT histogram from first segment terminating SDL; second IRT histogram from licks following SDS.

histogrammed, showing a modal value of approximately 140 msec and suggesting a skewing of the distribution in the positive direction, as would be expected. After the end of the shock-contingent drinking period (no SDL or SDS) no responses occurred until the first two shocks of the subsequent shock-contingent drinking period. Again, during this period, 200 IRTs of only the responses required to terminate the SDL on the FR9 schedule were histogrammed. The modal IRT was about 140 msec, or not apparently different from the distribution of IRTs taken from relatively long bursts of licking in the absence of the SDL.

Figure 1B, taken from another well-trained rat, demonstrates the comparable stability of the licking IRT for responses terminating the SDL, as

compared with an equal number of measured IRTs of responses required on the FR20 component to escape the cyclic SDS. Again the modal response was about 140 msec and did not differ between the two classes of response. This record contrasts with the record of the drinking pattern seen in Fig. 1A in that the rat, although on ad lib food and water for several months, demonstrated an initial drinking burst when first placed in the experimental chamber. As the solution being consumed incidental to this response was a 20% ethanol solution, the rat exhibited considerable locomotor ataxia in the latter portion of the session, yet the IRT for licking was apparently not altered. The efficiency of the response during this latter period was lowered in that the rat took more shocks.

DISCUSSION

The modal IRT values for licking rates in the rats of the present study were quite comparable with the data presented by Corbit & Luschei (1969), being about 140 msec in duration. However, the shape of the histogram distribution tended to be positively skewed, suggesting that possibly the modal IRT reflects approach of a maximal response rate—a conclusion compatible with failure to obtain a significant and sustained increase in licking rate (Hulse, 1967). The approach of a maximal rate of licking in the process of drinking by the rat could be predicted from well-established principles governing behaviors developed and maintained by ratio schedules of reinforcement (Ferster & Skinner, 1957). Fixed-ratio (FR)-maintained behaviors become highly repetitive, with high rates, as functions of the time on the schedule and the number of reinforced responses. For instance, examination of the record of pecking by a pigeon after many hours on a FR schedule reveals a high rate of response quite comparable in form to drinking records from the rat (Ferster & Skinner, 1957, p. 50). As the nature of the response places a major site of reinforcement effect on the effector organ, the delay between the response and reinforcement are minimized. Insofar as temporal separation of response and reinforcement is significant in determining the upper limit on response rate, licking behavior on a FR1 schedule would be expected to exhibit very high rates after extensive training. Undoubtedly, the rat comes to the experimental chamber having had an enormous number of reinforced lick responses since weaning, and it would hardly seem surprising then that the rate of licking appears undisturbed by the relatively minor and transient experimental manipulations of hours of deprivation, concentrations of saccharin, etc. Comparatively, running rates of pecking by the well-trained pigeon, on a FR schedule, do not change significantly with wide experimental changes in body weight (Ferster & Skinner, 1957, p. 77).

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