A SOURCE OF ERROR IN ESTIMATING THE NUMBER OF REINFORCEMENTS IN A LEVER PRESSING APPARATUS¹

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While recording the cumulative-response frequencies during conditioning trials of 10 rats in a lever-pressing apparatus, it was found that between the 40th and 100th response the curve suddenly accelerated, and then was followed presently by a period of nonresponding. As a result, the curve takes on the character of an extinction curve which typically alternates between periods of high responding and no responding (4). Since the arrowed section in our figure exceeds a rate of response commensurate with intervening eating activity, either the food dispenser broke down during this period of time or the *S* was engaging in response bursts on the lever without picking up its food in the trough. In either case, estimation of the "number-of-reinforcements" parameter would be confounded. This experiment was an attempt to locate the source of trouble.

METHOD

Subjects

Five 3-month-old male hooded rats (litter mates) were selected from the closed colony maintained by the Department of Psychology.

Apparatus

Each *S* was given six trials in a lever-pressing apparatus. The apparatus consisted of a 12-inch-square box, a food dispenser which delivered 0.04-gram pellets into a recessed food trough, and a lever mounted 2 1/2 inches above floor level. The lever responded to a pressure of 5 grams, measured 1 inch square, and was placed 5 inches to the right of the food trough. When the lever was pressed, a buzzer placed at the rear of the apparatus sounded for as long as the lever was held down. The food trough was shielded by a light plexiglas door which had to be

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nuzzled open before a food pellet which was dispensed into the trough could be obtained. Lever and food-trough responses were recorded on a cumulative kymograph and a three-channel pen recorder. The apparatus was housed in a sound-insulated chamber, the top of which consisted of heavy, double plate glass. This allowed E to inspect the food dispenser and trough. Between the fine wire-mesh lid of the apparatus and the glass top of the chamber, a light was fixed to prevent S from looking at E. The experimental room itself was kept in complete darkness during the experiment.

Habituation

Two weeks before the start of the experiment, Ss were placed on a 22-hour fasting schedule. Water was constantly available. Ss were weighed and handled daily.

Conditioning Trials

Conditioning trials were divided into two phases. In Phase I, Ss were conditioned to open the trough door and retrieve food pellets. This phase lasted for 2 days. On the first day, five pellets were placed into the trough. The trough door was wedged open by E. On the second day, S was placed into the apparatus and given pellets whenever it opened the trough door after E had sounded a buzzer (0.5 second). The resulting reinforcement schedule may be described as aperiodic. Thirty pellets were given during this session.

Phase II consisted of three sessions. During this phase, food delivery was contingent upon S's pressing the lever. The buzzer sounded for as long as the lever was held down. The first session terminated after 30 pellets were obtained; the second session, given on the following day, ended after the 90th pellet had been obtained; the final session, given on the third day of Phase II, ended with the 150th pellet.

RESULTS AND DISCUSSION

The pattern of behavior systematically reinforced in the present experiment involves moving towards the lever, pressing the lever (L), moving towards the food trough, opening the trough (T), retrieving the pellet, and eating. A response burst is defined as a series of identical responses occurring rapidly in succession in the sequence. According to our analysis of the tapes, all Ss engaged in lever response-bursts. However, for purposes of the present analysis, only lever bursts involving more than 3 responses have been isolated. The reason for this restriction is as follows: bursts of fewer than 3 responses occur primarily during the initial conditioning trial, between the 1st and 30th reinforcement. Thereafter, the probability of making more than one lever response in succession is very low, and seldom involves more than two successive responses.

The results of our analysis are entered in Table 1. Column A gives the ordinal number of reinforcements prior to the response burst. Column B gives the number of lever-pressing responses making up the response burst. This number excludes the last lever response before the next trough response.

It will be seen that the median number of lever responses is 15, with a range of 13 - 23. Such response bursts tend to take place between the 53rd and 118th reinforcement.

Table 1*

Sessions					
I 1 - 30		II 31 - 90		III 91 - 150	Total No. Lever Responses (L)
Reinforcements					
S	A B	A B	A B		Probability, $p(L/T)$, Trial 110 - 150
1	- -	- -	94 14	186	0.77
2	- -	64 15	- -	185	0.81
3	- -	- -	103 23	172	0.73
4	- -	- -	118 16	198	0.68
5	- -	53 13	- -	181	0.79

* The frequency of response during a lever response-burst is given in column B; column A gives the ordinal number of the first response in the burst.

The total number of lever responses recorded for all three conditioning trials is given in the fourth column, while the fifth column gives the values of $p(L/T)$, the probability of a lever response given a trough response, as calculated over the final 40 reinforcements. A corresponding analysis of $p(T/L)$, that is, the probability of a trough response given a lever response was not undertaken for the present experiment, since, as already mentioned, the probability $p(L/L)$ is very low. A more recent experiment by J. B. Appel and the writer, furthermore, shows that $p(T/L) \rightarrow 1$ after as few as 25 reinforcements.

Thus, the values in column 5 indicate that the optimal response pattern in this situation, namely, shuttling between lever and trough (and vice versa) without engaging in supernumerary responses, has become firmly established.

The results show that the number of lever responses during conditioning sessions exceed the number of reinforcements by as much as 30 %. Consequently, if number of lever responses is used for determining the number-of-reinforcements parameter and, possibly, for relating it to such a dependent variable as number of responses to extinction within a criterion period, a serious source of error may arise (1, 2). Again, referring to the study by Appel and Hurwitz, we were able to show that if S_s are first trough-trained without an S^D , the number of lever responses during Phase II may exceed the number of reinforcements over the first 30 reinforced trials by 80 - 300 %.

Three conditions contribute to this discrepancy between the number of lever responses and reinforcements: first, during initial lever-training trials there is a tendency to repeat the lever response. This tendency is reduced by associating an S^D with the lever which, during Phase I, has become conditioned to trough-approach responses. Second, during a session, S engages in incomplete, abortive lever responses which go unreinforced. The immediate effect of nonreinforcement is to return to the lever and respond more forcefully as well as repetitively (3, 7). Finally, the major contribution to the difference between the number of responses

and the number of reinforcements arises from the response-burst tendencies reported in this paper.

Food hoarding should be ruled out as a possible explanation. Although our initial observations of the response-burst phenomenon occurred in an apparatus which permitted hoarding, i. e., where as many pellets were delivered as S made lever responses, the present apparatus avoided this pitfall.

SUMMARY

Five male hooded rats were trained in a lever-pressing apparatus, food serving as reinforcement. Following two trough-training sessions, each S was given three lever-pressing training sessions, a total of 150 reinforcements being given. A continuous record of lever and trough responses was obtained and subsequently analyzed. This showed that the probability of a lever response following a trough response, i. e., $p(L/T)$, as calculated over the final 40 reinforcements, ranges between 0.69 and 0.81. Furthermore, the probability is high that between the 50th and 110th lever response S engages in a response burst on the lever. This response burst accounts for a considerable proportion of the difference between the total number of lever responses reinforced and the number of reinforcements obtained.

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