WATER-DEPRIVATION-PRODUCED SIGN REVERSAL OF A CONDITIONED REINFORCER BASED UPON DRY FOOD¹

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Much of the research in the area of conditioned reinforcers has focused on such problems as strength of the reinforcer as related to the parameters of the conditioning situation, their functional significance in behavior chains, and their relationship to deprivation operations. The experiment to be reported in this paper properly falls into the class of experiments dealing with deprivation operations: it demonstrates that a positive conditioned reinforcer established and maintained by means of appropriate correlation with dry-food reinforcement can function as a negative reinforcer when the organism is water-deprived.

The experiment is divided into two parts: the first describes the effect of water deprivation on the frequency of subject-produced time outs (TO's) from dry-food-reinforced ratio behavior; the second part identifies the behavioral mechanism (S^r sign reversal) responsible for the observed effect.

SUBJECTS AND APPARATUS

The subjects (Ss) were four experimentally naive, male, hooded rats from the colony maintained by the Walter Reed Army Institute of Research. At 5 months of age their weights were slowly reduced to about 60% of the stabilized values determined by a 60-day, free-feeding schedule.

The experimental chamber was a standard, commercially available (Foringer & Co., Inc.) rat box with two modified telegraph key levers on the front wall. Above either lever was a small stimulus light. A pellet hopper was mounted at the same level as, and equidistant between, the levers. A force of about 15 grams was required to actuate the levers after an excursion of 4 millimeters. Actuation of either lever produced a sharp feedback click from a relay mounted in the box. The box was isolated in a white noise-filled, soundproofed room. The programming of the experiment and the recording of data were accomplished through the use of the usual automatic equipment.

PROCEDURE

Part I

Preliminary Training. Following magazine training and CRF in which the Ss were required to alternate levers for successive dry-food reinforcements (0.045-gram pellets, The J. P. Noyes Company), each rat was trained to stable performance in the two-lever situation. Throughout the procedure to be described, both levers were always available to S. One lever, the food lever, was always immediately beneath the stimulus light that was not illuminated, while the other lever, the TO lever, was always beneath the stimulus light that was illuminated.

The food lever was on a fixed-ratio (FR) schedule of reinforcement. The values of the ratio for the several rats were: Rat 1, FR 25; Rat 2, FR 20; Rat 3, FR 10; Rat 4, FR 25.

¹An earlier experiment somewhat similar to and suggesting the present research was performed by the senior author while on the faculty of the University of Maryland. That research was supported wholly by a grant from the General Research Board of the University of Maryland.

For all *Ss*, a single response made at any time (except during TO) on the TO lever produced a 5-minute TO. During a TO, (a) the houselight was illuminated and a 1000-cycle-per-second tone was present in the box; and (b) responses on either lever produced only the feedback click.

At the end of the 5-minute TO, the "food-available" condition (time in or TI) was automatically reinstated and remained in effect until *S* produced another TO. During TI, there was no tone in the box, and the houselight was extinguished; the only source of illumination was the stimulus light over the TO lever.

Daily sessions with the two-lever procedure were terminated at 50 reinforcements or 2 hours, whichever came first. The left-right positions of the TO and food levers were varied nonsystematically from session to session, and water was never available in the box.

The Experimental Variable. After about 1000 reinforcements on the above procedure, the water-deprivation variable was introduced. Each rat was subjected to total water deprivation on seven separate occasions, but no more frequently than once per week. Each subjection was for a 3-day period, during which daily sessions were run exactly as described above.

Part II

Rats 1 and 4 were utilized in the extension of the experiment. Rat 2 was used for other purposes, and Rat 3 died soon after the second part of the experiment was begun.

Except for the fact that the food lever was always on the right, the two rats were treated in sufficiently different fashion as to make separate presentation advisable.

Rat 1. Rat 1 was continued on the original procedure, including periodic subjection to water deprivation. However, the response requirement on the TO lever to produce a TO was changed to FR 10. After five 3-day water-deprivation periods, the contingency on the TO lever was changed to extinction, i.e., TO's could no longer be produced.

Rat 4. Although the original daily running procedure continued in effect, subjection to water deprivation was discontinued. Instead, (a) an attempt was made to simulate the effects of water deprivation by feeding Rat 4 large quantities of dry food; and (b) the requirement on the TO lever to produce a TO was changed to FR 10.

Since no significant results were realized in the attempt to simulate water deprivation, the procedure was abandoned. Rat 4 was then subjected to two 3-day water-deprivation periods, and its TO behavior with the FR 10 requirement on the TO lever was examined.

RESULTS AND DISCUSSION

Part I

The major behavioral effects of water deprivation are shown in Fig. 1 and 2. Figure 1 presents the median number of TO's taken by the four *Ss* during the several days of water deprivation (1, 2, 3 on abscissa), including the session before (SB) and the first session after its termination (SA). The points at O are for all other nonwater-deprived days. Figure 2 shows the relative median FR running rate on the food lever for the SB through SA sessions. Running time was computed by subtracting TO, eating, and pause-after-reinforcement times from session length. The medians are expressed relative to (i.e., divided by) the median running rates for the O sessions of Fig. 1.

Note the following:

1. In Fig. 1, Rats 1 and 3 show the greatest TO frequency on the third thirst (equals water deprivation) day. In Fig. 2, the same animals show the greatest single

rate drop from the second to the third thurst session. Both effects occur irrespective of food-lever position.

2. In Fig. 1, Rat 2 shows a peak in TO frequency on the second thurst day. In Fig. 2, it shows the greatest single rate drop from the first to the second thurst session. Both effects occur irrespective of food-lever position.

3. The data of Rat 4 are more complicated in that the shapes of its TO and rate functions depend on food-lever position. With the food lever on the left, its functions are similar to those of Rats 1 and 3; with the food lever on the right, its functions are similar to those of Rat 2.

The above observations imply a relationship between the two sets of functions shown in Fig. 1 and 2. Whereas it may *not* be concluded that where running rate is lowest, TO frequency is greatest (Rat 2 and "food lever: right" for Rat 4), it may be concluded that TO frequency is greatest in that session showing the greatest drop in running rate relative to the session before.

The experimental procedure described above is fundamentally that of a discrimination experiment in which a behavior is "favorably" (in terms of reinforcement return for time

Figure 1. Median TO frequency plotted against the type of experimental session. On the abscissa: 1, 2, 3 refer to the 3 days of water deprivation; SB is the session before a 3-day thirst period; SA is the first session after its termination, and O represents all other (nonwater-deprived) sessions.

and effort) reinforced in the presence of one stimulus complex (TI) and not reinforced in the presence of another (TO). General knowledge about this experimental paradigm and the one referred to as "chaining" indicates that the positive stimulus (TI complex) becomes not only a discriminative stimulus for the reinforced behavior but also takes on positive-reinforcement properties. A behavior which eliminates such a stimulus and re-

Figure 2. Relative median running rate on the food lever plotted against the type of experimental session. Median running rates are relative to (i.e., divided by) median running rates for O-type sessions of Fig. 1. The abscissa is the same as that of Fig. 1.

places it with a TO is weakened, since the removal of a positive reinforcer constitutes negative reinforcement.

It was found that water deprivation increased the frequency of TO's.² The problem remains to ascertain whether the increase was due to a reversal from positive to negative in reinforcement sign of the TI stimulus, so that its removal constituted positive reinforce-

²Kendler (1951, 1952, 1954) studied the effect of water deprivation after dry-food reinforcement in a series of three maze studies. The design of those experiments permits no inferences with regard to the problem studied in this paper. Kendler's general conclusions, however, are supported by the results of the present research.

ment, or whether the increase was due to some other factor. It was shown, for example, that rate on the food lever declined with increasing water deprivation. The reduction in the probability of a response to the food lever implies necessarily an increase in the probabilities of other behaviors, most of which are not under experimental control or observation. Could the increase in activity on the TO lever have resulted as an expression of this mechanism without a reversal in the reinforcement sign of the TI stimulus? If it can be shown that a change in the requirement on the TO lever to produce a TO modifies behavior on that lever in accordance with some known properties of positive reinforcement (here, the removal of a negative reinforcer), then the reversal can be inferred. The results of the second part of the experiment are relevant to this point.

Part II

Rat 1. Some relevant cumulative records for Rat 1 are shown in Fig. 3. All of the records in Fig. 3 are comparable in that they (a) were taken on the third day of 3-day thirst periods, and (b) represent 2-hour sessions. The cumulating pen marks responses on the food lever; "pips" indicate reinforcements, and the extensive offsets mark TO's. Responses on the TO lever are recorded by the event pen. Records A and B are from the last two 3-day thirst periods in the earlier part of the experiment. There is an occasional tendency to produce TO's with short bursts on the TO lever, such as at *b* in Record B. The tendency to burst might be comparable with the one observed by Sidman (1954) in a shock-avoidance situation. Note, however, the TO's produced by single responses at *a* in A and the occurrences of spaced responses as at *f* in B. The total response frequencies on the TO lever are 31 and 41 for A and B, respectively. (A burst at the beginning of Record A is omitted from the figure.) Record C depicts the effect of changing the requirement on the TO lever to FR 10. That record is from the fourth 3-day thirst period with the FR 10 requirement, and the increased output and marked tendency to burst such as at *c* are apparent. In Record C, the next to the last third-thirst-day session with the FR 10 requirement on the TO lever, 118 responses occurred on the TO lever. The final session produced 144 responses on the TO lever, but that record was smudged beyond presentation. Record D shows the initial effect of changing the TO lever contingency to extinction. A total of 242 TO lever responses occurred in the session of Record D. The increased output is not unlike the effect often obtained with the introduction of extinction after positive reinforcement. Record E is from the tenth 3-day thirst period with the extinction contingency on the TO lever. Total response output by this time has dropped to a steady value of about 65, approximately half the output under the TO lever requirement of FR 10, but, notably, about twice the previous output under FR 1. The effect seems due primarily to the continued occurrence of long bursts. Record F shows the second of the two 3-day thirst periods that terminated the experiment for Rat 4. Two TO's occurred at the beginning of the session, both produced by sharp bursts of responding (*d* and *g*, Record F). The tendency to burst is in marked contrast with the earlier TO-producing behavior of Rat 4, which differed from that shown for Rat 1 (Records A and B) in that Rat 4's third-thirst-day TO lever output per 2-hour session was about half that for Rat 1 (medians: Rat 1, 41 responses; Rat 4, 22 responses), with almost no tendency to burst.

The results obtained in the second part of the experiment with Rats 1 and 4 conform to expectations if one assumed that the TI stimulus complex functioned as a negative reinforcer when the rats were water-deprived.

Figure 3. Sample cumulative records. The cumulating pen marks responses on the food lever, and the event pen marks responses on the TO lever. The records have been artificially reset to the base line in order to conserve space. Records A, B, C, D, and E are for Rat 1 under several TO lever requirements. (See text.) Record F is for Rat 4 with FR 10 on the TO lever.

SUMMARY

Fixed-ratio behavior on one lever of a two-lever box was maintained by dry-food reinforcement. A single response on the second lever produced a 5-minute TO. The four rats were periodically subjected to three consecutive days of water deprivation, and it was found that this variable reduced running rate on the food lever and increased the frequency of TO's in such a fashion as to indicate that TO frequency due to water deprivation is greatest in that session showing the largest drop in running rate relative to the session before.

The question was raised as to whether the increased frequency of TO's was due to a reversal in sign of the reinforcing properties of the TI stimulus complex. In the second part of the experiment, the requirement on the TO lever to produce a TO was changed. It was found that when the requirement was raised, response frequency on that lever increased; when that lever was put on extinction, response output dropped after an initial, sudden increase such as is often noted with the onset of extinction after positive reinforcement. An attempt was made with one rat to simulate the effect of water deprivation with heavy feedings of dry food, but this attempt was unsuccessful.

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