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# SOME EFFECTS OF PUNISHMENT UPON UNPUNISHED RESPONDING[1]

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Animals permitted free access to a running wheel and drinking tube increased the amount of running when drinking was punished with electric shock. Additional experiments demonstrated that the simple presence or absence of a drinking tube (or running wheel) was a sufficient condition to observe a decrease or an increase in the alternative response. A quantitative analysis of these interactions observed between the incompatible running and drinking responses suggested that each response occupied a constant proportion of the time available for it. These results question an interpretation of the increase in unpunished alternative responding based upon its avoidance properties.

In a recent analysis of punishment methodology and theory (Dunham, 1971), a multiple response baseline procedure for studying the properties of punishment was outlined. With this procedure, two or more unconstrained incompatible behaviors are observed before and after the introduction of a punishment contingency for one of the responses in the organism's multiple response repertoire. When using this procedure, it is possible to observe the effects of the punishment operation upon both punished and unpunished behaviors.

In several experiments that have employed variations on the multiple response procedure (*cf.* Dunham, Mariner, and Adams, 1969; Munavi, 1970; Dunham, 1971), two properties of the response-contingent shock procedure have been observed: (a) the punished response is suppressed; and (b) of more interest, one of the unpunished alternative responses increases in probability.

The phenomenon of interest in the present series of experiments was the increase in unpunished responding that has been observed in the context of the multiple response baseline procedure. Dunham (1971) suggested that this increase in unpunished responding is avoidance motivated. If, for example, a situation is arranged where a rat spends a large proportion of an experimental session running in a wheel and drinking from a tube, the introduction of a response-contingent electric shock for drinking will automatically define an avoidance contingency for all other unpunished behaviors in the rat's repertoire, including the running behavior. Specifically, the more time the rat spends running, the fewer the shocks received during the session and the longer the "safe" interval between the shocks. The existence of this implicit avoidance contingency for all responses other than the punished response requires one to consider the possibility that an increase in the probability of any unpunished response is avoidance motivated.

There is, however, an alternative to the avoidance interpretation of the increase in unpunished responding observed during response-contingent punishment. If one again considers a hypothetical multiple response baseline consisting of unconstrained running and drinking behaviors, it is conceivable that there is an interaction between these two response states before the punishment contingency is introduced. Each response in the repertoire could, for example, have an inhibitory effect upon the other. Under such conditions, removing the opportunity for running would be a sufficient condition for the observation of an increase in drinking, or *vice versa.* According to such an interpretation, the basis for predicting the effects of punishment upon unpunished responding is not the implicit

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avoidance contingency enjoyed by unpunished responses, but the interactions that potentially take place between unconstrained baseline responses.

The first experiment in the series was designed, quite simply, to extend the generality of the phenomenon under examination to yet another multiple response situation. Subsequent experiments utilized this situation to examine some of the implications of the notion that interactions between baseline responses can account for the increment in unpunished behavior during punishment.

## EXPERIMENT 1

### Method

*Subjects*

Four experimentally naive male albino rats, weighing 250 to 300 g at the beginning of the experiment, were obtained from the Holtzman Co., Madison, Wisconsin.

*Apparatus*

A single modified Wahman activity wheel was housed in a ventilated, sound-insulated chamber, which was located in a room adjacent to the relay control equipment. The normal hardware cloth floor of the wheel was replaced with 3-mm stainless steel bars spaced 0.5 in. (1.2 cm) apart around the circumference of the wheel. The grid bars were connected to a Grason-Stadler E1064B shock generator via a commutator arrangement mounted on the shaft of the wheel. In all experiments using shock, a 0.3-mA., 0.5-sec signal was employed. The shock was not scrambled.

A drinking tube was made available through a hole 0.5 in. (1.2 cm) in diameter located 2.5 in. (6.2 cm) above the "floor" of the wheel. The frictional torque of the modified wheel was set at 24 mm/gs. (*cf.* Lacey, 1944).

*Procedure*

The animals were adapted to the laboratory for two weeks before being placed on a 23.5-hr water deprivation schedule for 10 days. Three daily sessions were next conducted to adapt the animals to the running wheel and drinking tube arrangement. The animals were, when necessary, given some extra training to help them find the drinking tube during these initial sessions. Phase 1 of the experiment consisted of 30-min sessions conducted five days per week during which the animal had free access to both running wheel and drinking tube. During baseline sessions, the only water permitted was available during the experimental sessions. Animals had free access to food in the home cages and on the two days per week when the animals were not run, they were permitted 30-min access to water in the home cages.

The running and drinking responses were measured in terms of their durations. Appropriate circuitry divided the entire session into 2-sec intervals and scanned each interval to determine if an instance of either response occurred during that interval. An instance of running was defined as a 90-degree revolution of the wheel, and an instance of drinking was defined as a single lap on the tube. These data were converted to a probability measure by dividing the number of intervals in which a response occurred by the total number possible in the session. (*cf.* Premack, 1965).

After 20 days of Phase 1 baseline training, Phase 2 punishment sessions were instituted. The procedure was identical to that employed in Phase 1 with two major differences: (a) each lick on the tube produced a shock; and (b) the animal was permitted 30-min access to water in the home cage 1 hr after the session to prevent a confounding of change in water intake with the introduction of the punishment contingency. Phase 2 punishment training continued for 28 days. It might be noted that attempts to punish the running response in pilot experimentation met with failure. Shocks did not seem to get through to the animal in a state of running with the necessary reliability. Hence, the present experiment limited punishment operations to the drinking response.

### Results and Discussion

Illness necessitated the removal of one rat from the experiment during baseline sessions. The data from the remaining three rats are presented in Figure 1. These data illustrate the two properties of response-contingent punishment that have been consistently observed in other experiments using a multiple response procedure: (a) the punished response is suppressed; and (b), the unpunished alternative increases in probability to levels that exceed the baseline probability of that response. The

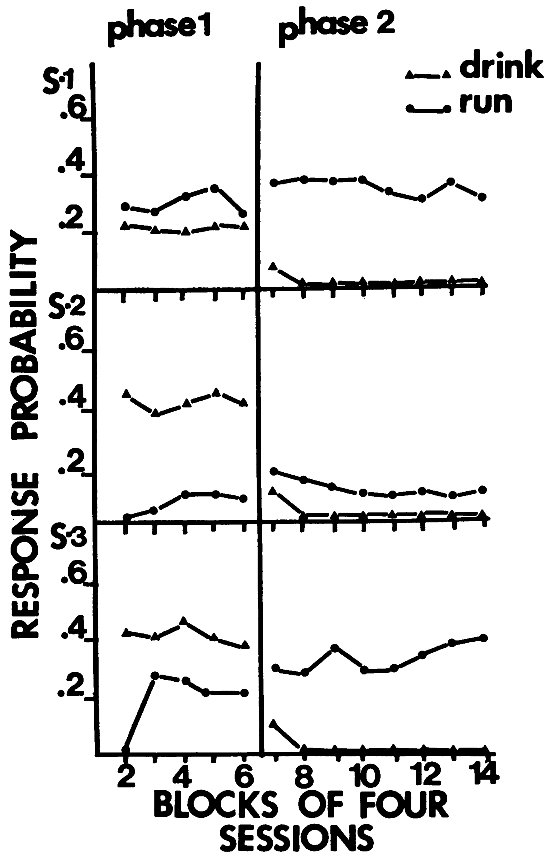


Fig. 1. Probability of running and drinking during Phase 1 (baseline) and Phase 2 (punishment) for the three rats in Experiment 1.

increase in running observed in the present experiment was maintained for the duration of the experiment (*i.e.,* 48 days).

## EXPERIMENT 2

The result of interest in the first experiment was the demonstration of another instance in which an unpunished response increases in probability during punishment training. The question of interest in the remaining experiments was whether this increase in running is avoidance motivated, as suggested by Dunham (1971), or if it can be considered a release from a mutually inhibitory interaction between running and drinking during baseline sessions. Experiment 2 was designed to examine two implications of the latter notion. If drinking inhibits running (and *vice versa*) during baseline sessions; (a) simply removing the opportunity to drink from the baseline conditions should be a sufficient condition to observe an increase in the probability of running; and (b), removing the opportunity to run from the baseline conditions should be a sufficient condition to observe an increase in the probability of drinking.

### METHOD

*Subjects and Apparatus*

Four naive albino rats of the same sex, strain, weight, *etc.* as used in Experiment 1 served. The apparatus was identical to that described in the first experiment with the exceptions noted below.

Phase 1 of the procedure consisted of baseline training with free access to the running wheel and drinking tube during the half-hour daily sessions. After initial adaptation to the apparatus, 24 days of training were conducted. In Phase 2, the animals were randomly assigned to one of two conditions. Rats 1 and 2 were no longer permitted access to the drinking tube during the experimental sessions. The tube was removed from the chamber and the only access to water was in the home cage during a 30-min period each day. Rats 3 and 4 were no longer permitted access to the running wheel during daily sessions. This was accomplished by applying a mechanical brake to the wheel for the duration of the sessions. Phase 2 continued for 48 days.

### RESULTS AND DISCUSSION

The results of both phases of the experiment for all four rats are presented in Figure 2. They reveal that the removal of one response from a two-response baseline is a sufficient condition for the observation of an increase in the alternative response. In Rats 1 and 2, the removal of the drinking tube was a sufficient condition for the observation of an increase in running. Similarly, in Rats 3 and 4, the braking of the running wheel produced an increase in drinking behavior. These increases were maintained for the duration of the experiment.

The increase in drinking produced by the removal of running, and vice versa, was somewhat surprising in view of the data seen in phase 1 of Figure 2. These two responses did not fill the experimental time during the baseline sessions. Hence, there was time during baseline sessions to drink more or run more if the animals were so disposed. It would thus

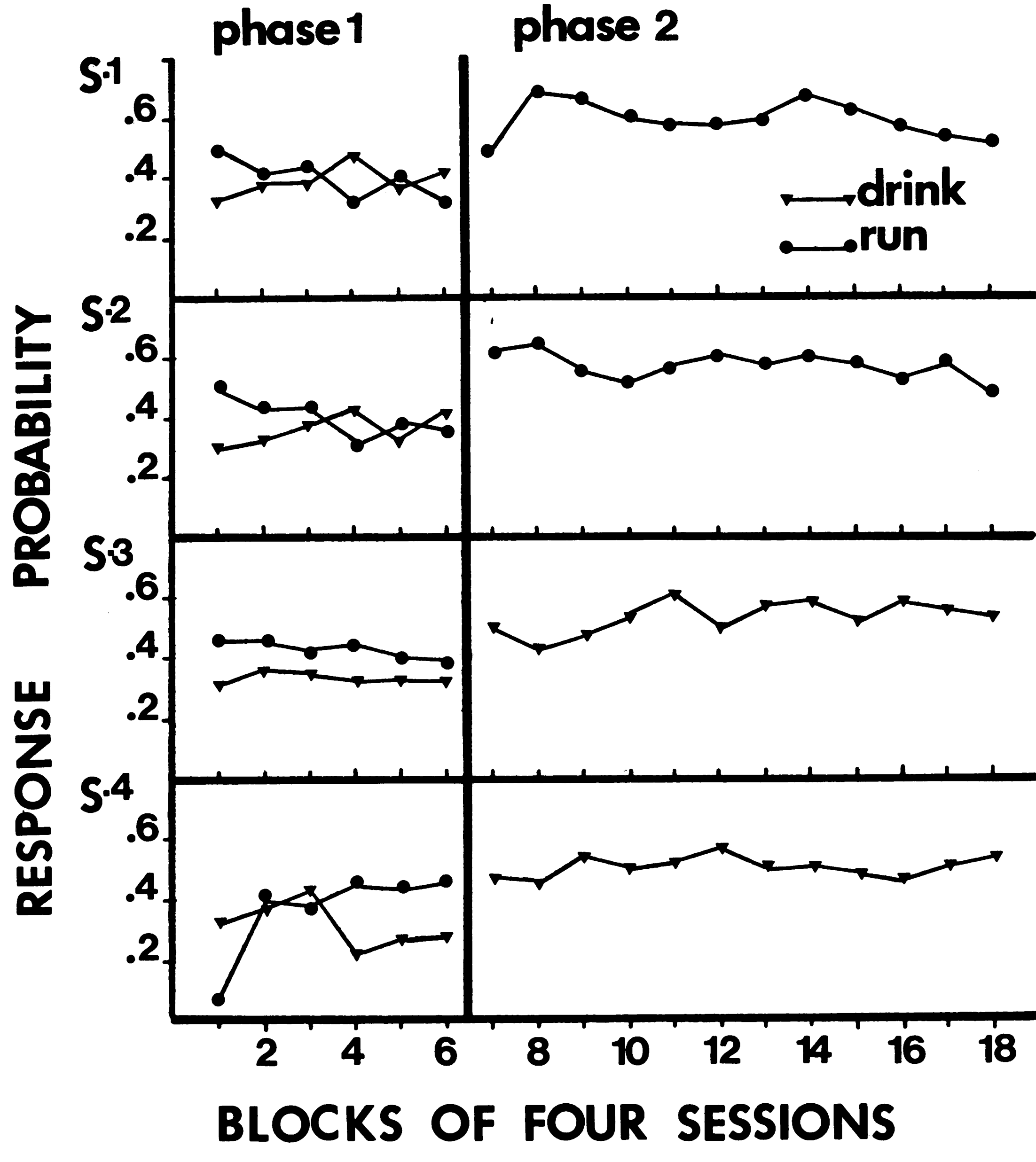


Fig. 2. Probability of running and drinking during Phase 1 (baseline) and Phase 2 (one response removed) for the four rats in Experiment 2.

appear that the probability of a particular response is relative to its context, *i.e.,* the presence or absence of other responses.

## EXPERIMENT 3

Although the data in Experiment 2 support the notion that the increase in unpunished behavior observed in Experiment 1 can be explained in terms of an interaction between baseline behaviors, they do not eliminate the possibility that the increase in unpunished responding is avoidance motivated. In defense of the avoidance interpretation, it can be suggested that the removal of the drinking tube or the braking of the running wheel is an aversive operation with properties qualitatively similar to those of the electric shock used in the first experiment. With this assumption, the increase in drinking while the wheel was braked could easily be viewed as an attempt to avoid the aversive properties of the braked wheel, and *vice versa*. Hence, the avoidance interpretation of the increase in unpunished responding is still feasible, albeit somewhat strained.

The third experiment in the series was designed to examine two additional implications of the notion that running and drinking have a mutually inhibitory effect upon each other during baseline sessions, and to demonstrate that the increase in unpunished behavior observed in Experiment 1 does not require us to invoke an explanatory avoidance mechanism. First, the mutually inhibitory effects of these two behaviors would be directly demonstrated if the addition of a running wheel to the single response baseline of drinking reduced the probability of drinking and *vice versa*. Second, there would be no need to consider an avoidance mechanism if the subsequent removal of the running wheel produced an increase in the probability of drinking that did not exceed the initial baseline probability of drinking in the absence of the wheel, and *vice versa*. Alternatively, an increase in drinking to levels that exceed its initial single response baseline probability would require reference to some additional source of motivation (*i.e.*, an avoidance mechanism). The same, of course, is true with reference to the running response as measured in the presence and absence of the drinking tube.

### Method

*Subjects and Apparatus*

Four experimentally naive rats of the same age, sex, and strain as used in the previous experiments were used; the apparatus was also identical to that used in previous experiments.

*Procedure*

All details of the procedure were identical to those in the previous experiment with the exceptions noted below. Phase 1 of training consisted of 30-min sessions in which Rats 1 and 2 were permitted free access to the drinking tube while the running wheel was braked. Rats 3 and 4 were permitted free access to the running wheel while the drinking tube was retracted. All rats were run on a 23.5-hr water deprivation schedule during this phase of the experiment.

Phase 2 of training was identical for all four rats. Daily 30-min sessions were conducted in which free access to both running wheel and drinking tube were permitted. Phase 3 of training returned to the single-response baseline condition of phase 1. Rats 1 and 2 were permitted access only to the drinking tube; and Rats 3 and 4 were permitted access only to the running wheel.

### Results and Discussion

The results for all four rats in all three phases of the experiment are presented in Figure 3.

The results reveal that the presence or absence of a response during the free-access sessions is a sufficient condition for the observation of a decrease or an increase in the probability of the alternative response respectively.

Two points need emphasis. First, the simple addition of the running wheel to a baseline of drinking behavior reduces the probability of drinking and *vice versa*. This is a direct empirical demonstration of the mutually inhibitory effects that these two responses have upon each other in this situation. Second, when the brake is applied to the wheel in Phase 3, the increase in drinking does not exceed the baseline probability of drinking alone, as observed in Phase 1 of the experiment. The same result is observed in the case of running in the presence and absence of drinking. As was the case in the preceding two experiments, the animal does not fill experimental time with running and drinking when the two are concurrently available.

The data presented in Figure 3 support the notion that there is a mutually inhibitory interaction between free-access running and drinking and that the increase in one behavior when the other is removed does not require reference to an avoidance mechanism. The remaining response simply seeks a baseline level that it would have exhibited in the absence of the inhibitory effects of the other response.

## GENERAL DISCUSSION

The data presented in these three experiments have several implications for the multiple-response baseline analysis of punishment

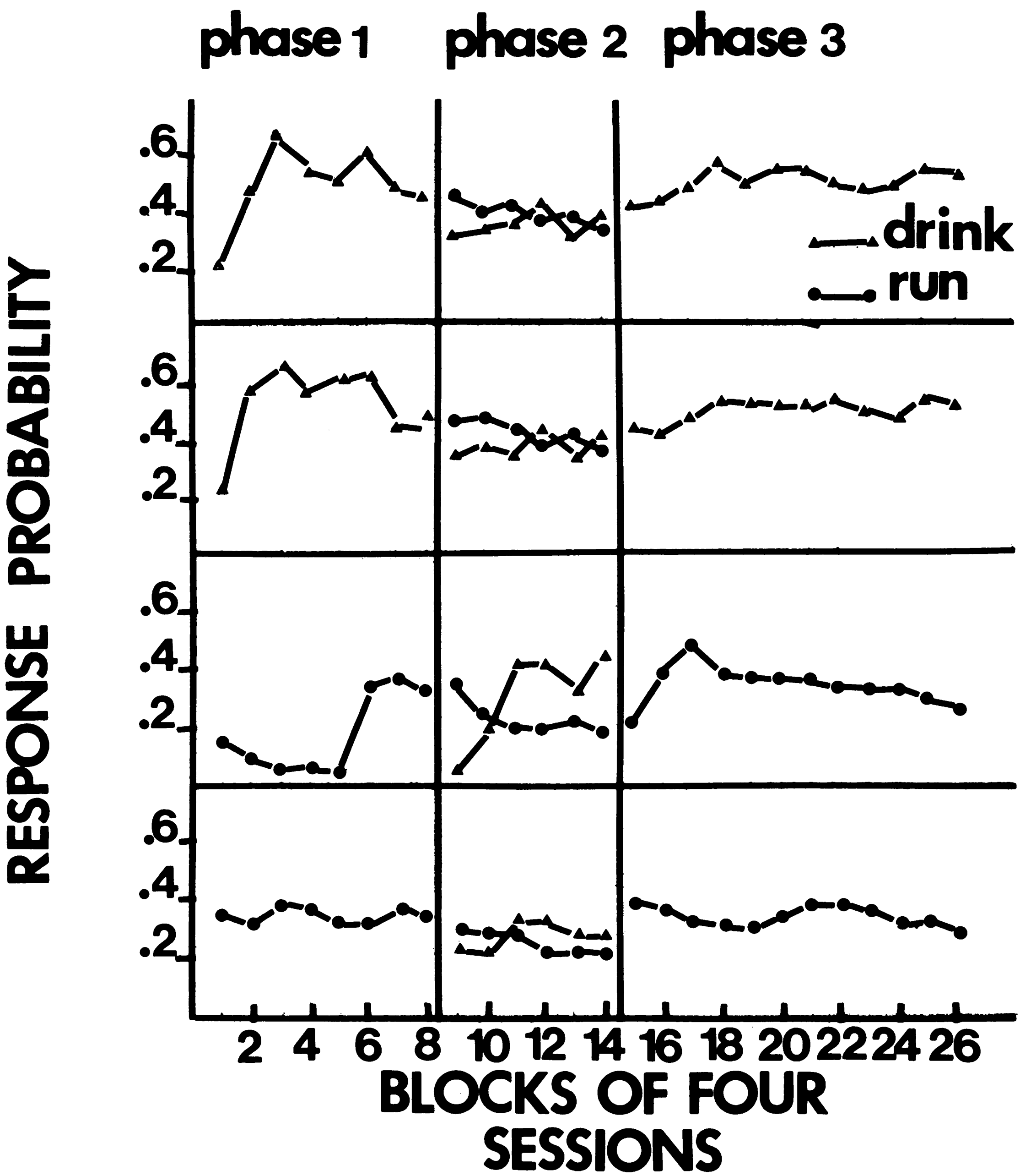


Fig. 3. Probability of running and drinking during Phase 1 (single response baseline), Phase 2 (concurrent response baseline) and Phase 3 (one response removed) for the four rats in Experiment 3.

outlined in an earlier paper (Dunham, 1971). Perhaps the major implication is that the data question the necessity of invoking an avoidance mechanism to explain the increase in unpunished responding observed during response-contingent punishment. In the case of running and drinking behavior, it is apparent that the simple presence or absence of one response in the baseline condition is a sufficient condition to observe a decrement or increment, respectively, in the alternative behavior. As a result, the punishment contingency (or the implicit avoidance contingency it defines) is not a necessary condition to observe the increase in an alternative response.

Although the phrase "mutually inhibitory" has been used in a descriptive sense to discuss the interactions observed between running and drinking behavior in these experiments, the data obtained are consistent with a more general motivational model recently elaborated by Staddon and Simmelhag (1971). They suggest that the organism will allocate its time in a manner that maintains a balance between a number of "competing tendencies to action". If, at any time, one behavior is constrained in some manner, they suggest that the organism will fill the time available by sampling from some alternative behavior that they call an *interim activity* (p. 13).

Whether one accounts for the increase in an alternative behavior in terms of implicit avoidance contingencies, mutual inhibitory states, or interim activities, it is somewhat surprising to observe in the case of running and drinking that the amount of increase observed in one response when the other is eliminated follows a rather precise quantitative rule. A post-hoc analysis of the data obtained in the three experiments suggests that: *given two incompatible behaviors, each behavior will occupy a constant proportion of the time available to it*[2]. If, for example, with running and drinking concurrently available, the rat spends 10% of its time running and 20% of its time drinking, it is obvious that it spends one-eighth of the time available for running in the state of running. If the drinking tube is removed from the situation, the above rule predicts that it will increase running by one-eighth of the additional time made available by the absence of the drinking tube. The actual increase in running (or drinking) observed in the present experiments and the increase predicted by the constant proportion rule are presented in Table 1. As is obvious from the data, the rule fits the data very well.

While the data in these three experiments appear to make it superfluous to refer to an avoidance mechanism to account for the increase in unpunished responding in this situation, two points should be made in defense of the initial avoidance interpretation of the phenomenon. First, to conclusively eliminate or to support the notion of an avoidance motivated increase in unpunished behavior

[2]The author is grateful to Charles Shimp for suggesting this quantitative analysis of the data obtained.

Table 1

Average Probability of a Response

| | *Observed* | *Predicted* |
|---|---|---|
| *Experiment I:* | | |
| Subject 1 | 0.35 | 0.34 |
| Subject 2 | 0.13 | 0.13 |
| Subject 3 | 0.35 | 0.34 |
| *Experiment II:* | | |
| Subject 1 | 0.63 | 0.66 |
| Subject 2 | 0.57 | 0.62 |
| Subject 3 | 0.50 | 0.51 |
| Subject 4 | 0.51 | 0.49 |
| *Experiment III:* | | |
| Subject 1 | 0.34 | 0.35 |
| Subject 2 | 0.50 | 0.55 |
| Subject 3 | 0.35 | 0.33 |
| Subject 4 | 0.34 | 0.35 |

it is necessary to develop a measure of avoidance motivation that is independent of the increase in unpunished behavior it seeks to explain. Then, and only then, can experiments be done to measure directly the degree to which the increase in unpunished responding is avoidance motivated and/or represents a release from the inhibitory effects of other behaviors in the multiple response baseline. Second, it is the case that response-contingent punishment will always define an implicit avoidance contingency for unpunished responses in the organism's response repertoire. The existence of this contingency requires one to consider in each case the possibility that an increase in unpunished responding does reflect the operation of an avoidance mechanism. It would, in fact, be somewhat surprising if such an implicit avoidance contingency was consistently found to be ineffective in view of the efficacy of explicitly arranged avoidance contingencies for arbitrary behaviors.

The data presented in these experiments also raise the question of appropriate control comparisons in the context of a multiple-response baseline analysis of behavior that was not considered when the procedure was initially outlined (*cf.* Dunham, 1971). If one considers only two response states, A and B, in the analysis, it is obvious from the running and drinking example that these response states can interact. Using the term inhibition in a purely descriptive sense, running and drinking were mutually inhibitory during free-access baseline conditions. Had there been a measure of grooming it is conceivable that there would be no interaction between grooming and the two other behaviors. Alternatively, the presence or absence of the drinking tube might have produced an increment and decrement in grooming probability. Obviously, the literature provides an excessive amount of knowledge about the interactions between some behaviors for some species (*e.g.*, eating and drinking, *cf.* McFarland, 1964), but little knowledge of the boundary conditions of such interactions in terms of types of behavior (*cf.* Premack, 1969) and types of interaction.

In view of potentially unlimited interactions between unconstrained behaviors, a change in probability of any one behavior should always be compared to the probability of that behavior in the presence and absence of each of the other responses in the baseline. Specifically, if we consider a baseline of grooming and running and find that the introduction of a drinking tube increases the probability of grooming and decreases the probability of running, the change in the probability of running should be compared to its probability in the presence and absence of each of the other responses. Only then will one know if it is necessary to consider the operation of some mechanism other than the interaction that takes place between unconstrained behaviors during baseline observations.

In summary, the present experiments question the necessity of the avoidance interpretation of the increase in unpunished responding observed in Experiment 1, and illustrate the need for control procedures that were not outlined in the initial discussion of the multiple response procedure (*cf.* Dunham, 1971).

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