**CHANGES IN A MULTIPLE-RESPONSE REPERTOIRE
DURING RESPONSE-CONTINGENT PUNISHMENT AND
RESPONSE RESTRICTION:
SEQUENTIAL RELATIONSHIPS**

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A multiple-response baseline of four activities was established using gerbils as subjects. When one of the baseline responses was punished (Experiment 1) or restricted (Experiments 2 and 3), only the most probable of the alternative baseline responses increased. The response most likely to follow the punished or restricted responses during baseline sessions was also suppressed during subsequent punishment or response-restriction treatment.

Key words: multiple responses, response probability, response sequences, punishment, response restriction, gerbils

Given access to a relatively constant environment for a fixed period of time each day, most organisms will eventually develop a stable repertoire of responses for dealing with that environment. Once this response repertoire has stabilized, it is possible to introduce constraints into the situation and observe the manner in which the organism adapts the response repertoire to the constraints.

Experimental procedures which approximate the above-described conditions have been called multiple-response baseline procedures (Dunham, 1971, 1977), and there is a developing interest in using the multiple-response paradigm to analyze adaptations to various constraints introduced into the ongoing "stream of behavior" (cf. Bernstein, 1973; Dunham, 1971; Rachlin & Burkhard, 1978; Stadon, 1979).

In our laboratory, we have concentrated primarily on an analysis of various punishment operations using multiple-response baseline procedures, and two consistent generalizations have emerged from our research thus far. First, and not surprising, is the generalization that the introduction of response-contingent electric shock will suppress the referent (punished) response. Second, and more interesting, is the generalization that the most probable

of the unpunished alternative responses will increase in probability during punishment sessions whereas other unpunished alternatives maintain their baseline levels. These have been called the "punishment rule" and the "implicit avoidance rule" respectively, and these rules have consistently predicted the manner in which organisms will adapt a multiple-response repertoire to response-contingent punishment in situations we have studied thus far (Dunham, 1971, 1972, 1977, 1978).

In our most recent experiments (Dunham, 1978), some additional changes in behavior were observed that could not be subsumed by these two rules. In these experiments, we measured the amount of time gerbils spent in four different activities during daily experimental sessions. The activities were eating, digging, running, and paper shredding. After the multiple-response baseline was established, the eating response was punished. During subsequent punishment sessions, the gerbils adapted the response repertoire in the manner predicted by our two rules. Eating was suppressed, and the most probable unpunished alternative, running, increased in probability during punishment sessions. In addition, however, we observed that another unpunished alternative, digging, did not maintain its baseline level but declined during the punishment sessions. This latter result is obviously not subsumed by either the "punishment rule" or the "implicit avoidance rule," and an adequate analysis of the organism's adaptation to the punishment operation should also be able to specify

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the conditions under which a particular unpunished alternative will decline in probability during punishment sessions.

EXPERIMENT 1

In the various multiple-response baselines we have studied to date, we have assumed that the baseline responses are mutually exclusive and independent. In retrospect, it is perhaps more reasonable to suspect that sequential relationships between certain responses will develop during baseline observations of some response repertoires. In such cases, one might also suspect that these sequential relationships will interact in predictable ways with the punishment contingency. For example, in our most recent experiments (Dunham, 1978), the decline in the unpunished digging response when eating was punished would make sense if a sequential dependency between eating and digging existed during baseline sessions prior to punishment (i.e., a response sequentially dependent upon the punished response will also be suppressed).

The basic purpose of the first experiment in this series was to extend our analysis of the properties of response-contingent punishment to another combination of four responses and determine: (a) if sequential relationships do develop between certain responses during the baseline phase; and (b) if these sequential relationships are systematically related to the adjustments in unpunished responding during punishment sessions.

METHOD

Subjects

Four mature male Mongolian gerbils (*Meriones unguiculatus*) between 70 and 80 g were obtained from Tumblebrook Farm, Brant Lake, New York to serve as subjects. The animals were housed throughout the experiment in individual cages.

Apparatus

The apparatus was a wooden chamber 43 cm wide by 30 cm deep by 28 cm high. The grid floor, constructed of 3-mm stainless steel rods spaced 1 cm apart, permitted the delivery of scrambled electric shock from a Grason-Stadler Model 700 shock generator. The front wall of the chamber was made of Plexiglas for observation purposes and also served as a door.

Centered on this wall was a food bin, which permitted continuous access to sunflower seeds through a 2 by 4 cm opening in the wall. The rear wall of the chamber permitted access to the lower half of a small activity wheel with an 11-cm radius mounted on a Wahmann activity-wheel hub. The running surface of the wheel was lined with fine-grit sand paper to facilitate traction. An open rectangular box (13 by 30 by 11 cm) was affixed to one side wall of the chamber. The box was filled to a depth of 5 cm with washed builder's sand. A translucent Plexiglas ceiling with a 7.5-W white bulb above it illuminated the chamber during experimental sessions.

The entire chamber was enclosed in a large sound-insulated box with a Plexiglas window for observation and a fan to provide a masking noise and ventilation. An observer was seated in the dark outside this box and provided with a key board for recording the frequency and duration of the various activities. Devices for recording these data were located in an adjacent room.

Procedure

Upon arrival, the animals were maintained in the laboratory in continuous light with ad lib. access to laboratory chow and water for two weeks. During the second week of adaptation, daily food intake was monitored, and for five days prior to the start of the experimental procedure, each gerbil was restricted to 80% of its normal ad lib. food intake.

Following five days on this deprivation schedule, the animals were given daily 20-min baseline sessions in the multiple-response chamber for a period of 12 consecutive days. During each session, each animal had free access to an unlimited supply of sunflower seeds, the running wheel, and the box of sand. An observer recorded the amount of time spent at each of these three activities and the amount of time spent in grooming activities.

Following these 12 baseline sessions, two of the subjects were exposed to a punishment contingency whereby a scrambled .5-mA .5-sec electric shock was delivered via the grid floor simultaneous with the onset of the eating response. The shock was continued at 2-sec intervals if the animal persisted in making the eating response after the initial shock. This punishment procedure continued for 10 consecutive 20-min daily sessions. The other two

animals served as between-subject controls for which baseline conditions were maintained during this second phase of the procedure. Finally, three recovery sessions were conducted in which the shock contingency was eliminated and baseline conditions were in effect for all animals.

Throughout the experiment the four activities of interest were operationally defined as follows: (1) grooming was defined as cleaning or rubbing the fur on any part of the body with stereotyped licking and/or paw movements; (2) the onset and offset of running behavior were defined as the initiation and termination of continuous wheel rotation (this does not include minor rocking movements sometimes observed); (3) the onset and offset of eating behavior were defined as the initiation of oral contact with the food and the termination of chewing movements (note that the animals usually consumed several seeds with each approach to the food hopper, defining "bouts" of eating without a measurable interval between successive seeds); and (4) the onset and offset of digging in the dirt were defined simply as the entry and departure from the sand box (a variety of different

movements were actually observed while the animals were in the sand with digging and scratching movements most frequent).

It should also be noted that records were kept of the number of sunflower seeds consumed during each daily session. During punishment training when eating was suppressed, each animal was given its average baseline ration of sunflower seeds in a supplemental home cage feeding one hour after the daily experimental session. Hence, the introduction of the punishment contingency was not confounded with an increase in deprivation levels during punishment sessions.

RESULTS AND DISCUSSION

Looking first at the response-duration measure, the results obtained with all four subjects during baseline, punishment, and recovery phases of the procedure are illustrated in Figure 1.

During the baseline phase, the running response was universally preferred over the other three activities by all four subjects. Running was followed in order by digging, eating, and grooming. The one exception to this typical response hierarchy was a reversal in the order

Fig. 1. Response durations for four subjects in Experiment 1 during each of the three phases of the procedure. Baseline and punishment data are averaged over the last six sessions of each phase, and recovery data are averaged over the three recovery sessions conducted. The range of response durations is presented as an index of variability for each response.

of eating and digging responses observed in the hierarchy of S-3.

Consider next the changes in the response hierarchies of the two subjects (S-1 and S-3) during the punishment phase of the procedure. The changes in the response repertoire of S-1 essentially replicate those observed in our previous research with a similar response repertoire (Dunham, 1978). Specifically, the eating response was suppressed, and the most probable unpunished alternative, running, increased in probability. As such, these two changes add further support to the previously described punishment and implicit avoidance generalizations. Note also that the digging response declined in probability during punishment, whereas grooming remained essentially at baseline level.

The punishment contingency produced a very different reorganization of the response hierarchy in S-3. Eating was completely suppressed, whereas the most probable unpunished alternative, running, declined slightly in probability. In this animal, unpunished digging increased, whereas grooming was maintained at baseline level.

The seemingly inconsistent adjustments to punishment across these two different subjects are particularly interesting if one examines next the data presented in Table 1. These data,

which are averaged over the last three sessions of the baseline phase, are an index for each subject of the degree to which any one response in the repertoire is sequentially dependent upon any of the other three activities during baseline sessions. The rows of the matrix are labeled as preceding activities, whereas the columns are labeled as following activities in the pair sequences. Given, for example, that a bout of digging has just occurred in S-1, the probability is .19 that it will be followed by a bout of running. The diagonal of the matrix defines the probability that successive bouts of the same response will be observed. For measurement purposes, a minimum pause of two seconds was required to define an interval between successive bouts of any particular activity, and as the data indicated, successive bouts of running were frequently observed using this definition.

Of primary interest in the present context are the sequential relationships that exist between eating, the baseline response to be punished, and the other three responses. The data from three of the subjects (S-1, S-2, and S-4) indicate that the response most likely to follow eating is the digging response. Note, however, that S-3 deviates from this pattern in that the running response is most likely to follow eating in this subject. These data provide some support for the notion that a response that is sequentially dependent upon the punished response during baseline will also be suppressed during subsequent punishment sessions. Hence, with S-1, both eating and the sequentially dependent digging response were suppressed; and with S-3, both eating and the sequentially dependent running response were suppressed.

The two between-subject control animals (S-2 and S-4) were not punished during Phase 2 of the procedure, and they essentially maintained their baseline levels of performance throughout the second phase of the procedure. Hence, the changes observed in both the punished and unpunished responses with S-1 and S-3 cannot be explained simply as a shift in baseline performance produced by additional exposure to the experimental procedure. Recovery data obtained on S-1 and S-3 indicated that the previously punished eating response remained completely suppressed, and the changes in unpunished alternative responses persisted throughout these three recovery ses-

Table 1

Sequential dependencies between all possible combinations of the four responses observed during baseline sessions. Based upon average for last three baseline sessions.

Subjects	Digging	Running	Eating	Grooming
S-1				
Digging	.00	.19	.38	.38
Running	.02	.70	.03	.24
Eating	.32	.03	.48	.16
Grooming	.07	.63	.08	.22
S-2				
Digging	.03	.46	.43	.06
Running	.12	.64	.11	.10
Eating	.94	.04	.02	.00
Grooming	.04	.54	.14	.27
S-3				
Digging	.04	.48	.17	.30
Running	.14	.63	.13	.08
Eating	.05	.27	.67	.01
Grooming	.00	.63	.26	.10
S-4				
Digging	.04	.29	.39	.21
Running	.05	.76	.06	.13
Eating	.72	.12	.12	.04
Grooming	.09	.50	.12	.28

sions. Logistical problems in the laboratory forced us to terminate the recovery phase after three sessions.

Taken together these data support the notions outlined earlier. Sequential dependencies between a punished response and other responses in the repertoire during baseline sessions interact in a predictable fashion with subsequent punishment operations. These changes would appear to require an elaboration of the existing punishment and implicit avoidance rules to include the sequential dependency factor.

EXPERIMENT 2

The data from the preceding experiment suggest the following extension of the rules necessary to predict the effects of response-contingent punishment upon a multiple-response repertoire: (a) a punishment rule that states that the punished response will be suppressed; (b) an implicit avoidance rule that states that the most probable unpunished alternative will increase in probability during punishment training; and (c) a sequential dependency rule that states that responses sequentially dependent upon the punished response during baseline sessions will also be suppressed by the punishment operation. The data also suggest that the sequential dependency rule takes priority over the implicit avoidance rule when the two are in conflict as was the case with S-3 in the preceding experiment (i.e., the most probable unpunished alternative, running, was also sequentially dependent upon the punished response).

Two questions were of primary interest in this second experiment. First, the changes in the response repertoire observed in the first experiment are subject to a number of interpretations which are based upon assumptions about the unique properties of electric shock as an aversive stimulus. For example, it has traditionally been very popular to suggest that the motivational state associated with painful stimulation will selectively inhibit particular activities and selectively facilitate others (e.g., Bindra, 1974; Dickinson & Pearce, 1977; Konorski, 1967).

In this second experiment we wanted to determine if we could produce the same changes in behavior by simply removing food from the experimental environment instead of

introducing response-contingent electric shock. If the removal of food produces the same results as those obtained with the punishment procedure, interpretations based upon the unique properties of the shock stimulus would be questioned. Second, we were also interested in whether or not the sequential dependency rule that emerged from the rather sparse data of the first experiment would continue to predict the unique individual adjustments in the response repertoires of additional subjects in this second experiment.

Subjects and Apparatus

Four Mongolian gerbils of the same age, sex, and weight as used in the first experiment served. The apparatus was identical in all respects to that used in the first experiment.

Procedure

Adaptation and deprivation procedures for all four subjects were identical to those used in Experiment 1. After the adaptation phase, all four subjects went through a three-stage procedure consisting of baseline observations, a treatment phase in which food was removed from the environment, and a recovery phase in which the baseline conditions were reinstated. The baseline phase consisted of 12 consecutive daily 20-min sessions during which an observer recorded the amount of time spent running, digging, eating, and grooming as defined in the previous experiment. Following these 12 sessions, the sunflower seeds were removed from the food bin for a period of 12 consecutive daily sessions. One hour after each experimental session, the animals were given the average number of seeds that they had consumed during baseline sessions in their home cage. Finally, the sunflower seeds were returned to the experimental environment for six consecutive days of recovery. All other details of the procedure were identical to those used in Experiment 1.

RESULTS AND DISCUSSION

The duration data for all four subjects during all three phases of the procedure are presented in Figure 2.

During the baseline phase all four of the subjects revealed essentially identical response hierarchies in which the most probable response, running, was followed in order by digging, eating, and grooming. S-3 was a mi-

Fig. 2. Response durations for the four subjects in Experiment 2 during each of the three phases of the procedure. Baseline and restriction data are arranged over last six sessions of each phase; the recovery data are averaged over six sessions. The range of response durations is presented as an index of variability for each response.

nor exception in which the order of eating and grooming was reversed.

During the second phase, when the opportunity to eat was eliminated, three of the subjects (S-2, S-3, and S-4) made essentially the same adjustments in their response repertoires. Specifically, the most probable alternative response, running, increased in probability during Phase 2 to levels that exceeded the baseline, whereas digging tended to decline to levels below its previous baseline. Grooming essentially maintained its low level of baseline performance.

The one subject (S-1) which deviated from this pattern of adjustment revealed a decrease in running and a slight increase in digging over sessions during Phase 2.

Looking next at the recovery data in Figure 2, it is interesting to note that all responses show a tendency to return to baseline levels except the one response that had increased during Phase 2. The increase in running produced in S-2, S-3, and S-4 actually continues to increase during the recovery phase.

Once again, the sequential dependency data presented in Table 2 provide a consistent account of what would appear to be inconsistent data across the subjects plotted in Figure 2.

Table 2
Sequential dependencies between all possible combinations of the four responses observed during baseline sessions. Based upon average for last three baseline sessions.

Subjects	Digging	Running	Eating	Grooming
S-1				
Digging	.08	.52	.08	.28
Running	.11	.77	.05	.06
Eating	.37	.50	.00	.00
Grooming	.37	.62	.00	.00
S-2				
Digging	.04	.71	.17	.06
Running	.21	.64	.08	.04
Eating	1.00	.00	.00	.00
Grooming	.75	.25	.00	.00
S-3				
Digging	.00	.61	.16	.22
Running	.13	.83	.00	.00
Eating	.71	.28	.00	.00
Grooming	.60	.30	.00	.10
S-4				
Digging	.05	.68	.16	.10
Running	.19	.74	.00	.06
Eating	.88	.12	.00	.00
Grooming	.17	.66	.00	.17

Of primary interest are the data that reveal what the animals are doing immediately after a bout of eating during baseline sessions. For

Table 3

Rank-order comparison of the baseline sequential dependency between eating and digging, and the percent change in digging observed when eating is removed. Percentage measure based on average for last three baseline sessions and average for restriction phase.

Subject	Sequential Dependency	Percent Change in Digging
S-2	1.00	-26%
S-4	.88	-8%
S-3	.71	-2%
S-1	.37	+5%

three of the subjects (S-2, S-3, and S-4) the most probable response following a bout of eating is digging in the dirt, whereas for S-1, the most probable response following eating is running in the wheel. These data confirm the generality of the sequential dependency rule that emerged in Experiment 1. A response that is sequentially dependent upon eating during baseline sessions will be suppressed in subsequent sessions when the opportunity to eat is eliminated from the environment (regardless of the position that response holds in the baseline hierarchy).

The data presented in Table 3 provide further support for this sequential dependency rule. Subjects are rank-ordered according to the degree to which eating is followed by digging during baseline sessions and according to the extent to which a decline in digging is observed when eating is subsequently removed from the repertoire. Any nonparametric correlational statistic would yield a perfect correlation between these two sets of ordinal data.

It is also possible to ask whether or not the increase in running during Phase 2 is related to the sequential relationship between eating and running during baseline sessions. One might expect that an increase in running could be inhibited to the degree that a bout of running often followed eating during baseline. The data presented in Table 4 suggest that the stronger the sequential relationship between eating and running during baseline sessions, the smaller the increase observed in running when eating is subsequently removed from the repertoire. These data are not, however, as consistent as those in Table 3.

Taken together, then, these data do provide additional support for the notion that the sequential relationships which develop during baseline exert a systematic influence on subse-

Table 4

Rank-order comparison of baseline sequential dependency between eating and running, and percent change in running when eating is removed. Percentage measure based upon average for last three baseline sessions and average for restriction phase.

Subject	Sequential Dependency	Percent Change in Running
S-1	.50	-48%
S-3	.28	+14%
S-4	.12	+27%
S-2	0	+1%

quent reorganization of a response repertoire placed under constraint.

Finally, the results obtained with the response frequency measure (number of times each response is initiated) should be mentioned. Basically, the frequency measure permits the same conclusions as the response duration data presented in Figure 2 with the qualification that the changes observed with the frequency measure are less pronounced than those seen in Figure 2. This has been a typical result in previous experiments (cf. Dunham, 1978) and it indicates that the adjustments that the animal makes in its response repertoire represent increases or decreases in bout durations rather than frequency of initiation.

EXPERIMENT 3

The basic purpose of this third experiment was to further test some implications of the qualitative rules that emerged in the first two experiments. Specifically, the same four-response repertoire was established and, subsequently, the gerbils' access to the sand box was blocked in order to eliminate the digging response from the baseline repertoire. This operation raises a particularly interesting question when compared to the elimination of the eating response in previous experiments. Reference to Tables 1 and 2 indicates that the response most likely to follow digging during baseline observations in six of the eight gerbils was the running response. Since the running response is also the most probable response in the baseline repertoire, blocking the digging response pits the sequential dependency rule (predicts decline in the sequentially dependent running response) against the "implicit avoidance rule" (predicts increase in the most proba-

ble running response). Hence, the changes produced in the response repertoire by blocking the digging response should provide additional information about the generality of these two rules and the manner in which they interact when pitted against each other.

METHOD

Subjects, Apparatus, and Procedure

Four Mongolian gerbils of the same age, sex, and weight as used in the first two experiments served as subjects. Adaptation and deprivation procedures were identical to those used in the first two experiments. After the adaptation phase all four subjects went through a three-stage procedure consisting of baseline observations, a treatment phase in which a false wall was inserted into the chamber to block access to the sandbox, and a recovery phase in which all four baseline responses were again permitted.

RESULTS AND DISCUSSION

Consider first Table 5, which presents the sequential relationships that developed during the baseline observations of the four-response repertoire. Of primary interest in the present

context are those responses that are sequentially dependent upon the subsequently restricted digging response. In all four subjects, running is obviously the most likely event to follow a bout of digging during baseline sessions. As such, the sequential dependency rule that emerged from the data in the previous two experiments would predict a decline in the running response when digging is restricted.

Consider next the duration data for all four subjects during all three phases of the procedure presented in Figure 3. During the baseline phase, the hierarchy observed in previous experiments was basically replicated. Running was the most probable response followed in order by digging, eating, and grooming. One minor exception to this order was a reversal in the order of eating and digging in S-3. As such the "implicit avoidance rule" predicts an increase in the most probable alternative in the baseline hierarchy, the running response, when digging is restricted. The data during the restriction phase in Figure 3 reveal the outcome when these two predictive rules are in conflict. Three of the subjects (S-1, S-3, and S-4) made essentially the same adjustments in the response repertoire. The unre-

Fig. 3. Response durations for the four subjects in Experiment 3. Baseline and restriction data are averaged over last six sessions of each phase; the recovery data are averaged over six sessions. The range of response durations is presented as an index of variability for each response.

Table 5

Sequential dependencies between all possible combinations of the four responses during baseline sessions. Based upon average for last three baseline sessions.

Subjects	Digging	Running	Eating	Grooming
S-1				
Digging	.13	.52	.22	.13
Running	.18	.70	.02	.10
Eating	.59	.06	.35	.00
Grooming	.33	.48	.00	.19
S-2				
Digging	.09	.81	.11	.00
Running	.25	.64	.02	.10
Eating	.47	.00	.53	.00
Grooming	.25	.67	.08	.00
S-3				
Digging	.06	.69	.17	.08
Running	.14	.77	.01	.08
Eating	.40	.20	.40	.00
Grooming	.29	.59	.00	.12
S-4				
Digging	.07	.71	.18	.03
Running	.13	.86	.01	.01
Eating	.62	.08	.31	.00
Grooming	.90	.05	.00	.05

stricted running response increased to varying degrees, and the other two unrestricted responses maintained their baseline levels. S-2 deviated slightly from this pattern in that a relatively small increase in running and an increase in eating were observed. Although these data are generally consistent with the predictions of the "implicit avoidance rule," the data presented in Table 6 indicate that the sequential relationships observed during baseline also have the predicted effect upon running during the restriction phase. Specifically, the increase in running observed during the baseline phase is largest in those animals where the baseline sequential relationship between eating and running is smallest. As the data in Table 6 indicate, these two measures show a perfect inverse relationship on an ordinal scale of measurement.

Table 6

Rank-order comparison of baseline sequential dependency between digging and running, and the percent increase in running during restriction phase.

Subject	Sequential Dependency	Percent Increase in Running
S-2	.81	+4%
S-4	.71	+8%
S-3	.69	+25%
S-1	.52	+27%

To summarize briefly, the data obtained during the restriction phase are consonant with both of the rules which have operated in the previous experiments: (a) the most probable unrestricted alternative increases during restriction; and (b) sequential relationships observed during baseline will reduce the extent to which the response increases during restriction. When systematically pitted against each other, the data suggest that these two rules interact with predictable offsetting effects.

Finally, the recovery-phase data presented in Figure 3 indicate that running returns to its lower baseline level in all subjects except S-4 when the digging response is restored to the repertoire. There is also a rather consistent tendency for the eating response to increase during the recovery phase in three of the subjects (S-1, S-2, and S-3). The reasons for this latter change are not immediately obvious at this point.

GENERAL DISCUSSION

The general goal of this research program has been to analyze the effects of punishment in the context of a multiple-response repertoire. The data from the present experiments extend the analysis in two important ways. First, the data indicate that sequential dependencies between baseline activities interact in a systematic manner with subsequent punishment operations. Specifically, a baseline response which is sequentially dependent upon a response to be punished will also be suppressed during subsequent punishment sessions. We have referred to this phenomenon as the sequential dependency rule. Second, the present data indicate that the qualitative adjustments made in a multiple-response repertoire when a response is eliminated from that repertoire are essentially the same whether the response is eliminated by contingent electric shock or by simply removing the opportunity for the response to occur.

Several implications of these data deserve further discussion. The first concerns the mechanism(s) that might be assumed to underlie the changes in unpunished behavior when one response is suppressed by response-contingent shock. The introduction of an electric shock into the response repertoire has a number of properties surplus to its most obvious effect of eliminating a response from the repertoire.

As noted earlier, there is a long-standing tradition that suggests that such aversive stimuli can selectively inhibit certain "appetitive" motivational states and selectively facilitate others or elicit responses which will selectively compete with other responses (cf. Dickinson & Pearce, 1977; Dunham, 1978). We have also argued (Dunham & Carr, 1976) that the introduction of shock into a multiple-response repertoire can define certain responses as "safe" activities depending upon the temporal patterning of the shocks. Indeed, our use of the term "implicit avoidance rule" in reference to the increase in the most probable unpunished response during punishment implies that this behavior is fear motivated and maintained as an avoidance response (Dunham & Carr, 1976).

It seems apparent that any or all of the above mechanisms could be tendered as explanations for the increases and decreases in certain behaviors that we have observed in previous punishment research. However, the fact that we have observed the same basic pattern of adjustment in Experiment 2 without the use of an aversive stimulus like electric shock directly questions such interpretations. For example, it is difficult to argue that the removal of sunflower seeds from the environment is a sufficient condition for the development of fear-motivated behavior or for the inhibition of selected "appetitive" responses. As such the label "implicit avoidance rule" that was developed in the context of our punishment procedures would seem to carry too much surplus meaning at this point. In future discussion, the label "hierarchical rule" will be used with reference to the prediction that the most probable unrestricted response in the baseline hierarchy will increase when one response is restricted. This label makes reference to the structural properties of the baseline response repertoire without implications for any particular motivational mechanism such as "fear conditioning."

A similar point can be made with respect to analyses of punishment based upon notions about the "functional relevance" of particular responses. These positions (e.g., Bolles, 1970; Herring, 1979; Walters & Glazer, 1971) argue that certain species-typical activities (e.g., defensive reactions) are refractory to the effects of punishment, whereas other activities are uniquely susceptible to manipulation as avoidance responses. When applied in the context

of multiple-response baseline procedures, these arguments imply that certain responses will not be suppressed by aversive stimulation, whereas others will be facilitated depending upon their category of "functional relevance." In addition to a number of metatheoretical problems that characterize this "functional relevance" hypothesis (cf. Dunham, 1977, 1979), the data from the present experiments suggest that the categories of functional relevance (e.g., defensive, consummatory, escape, etc.) might not be a particularly effective basis for predicting how a response repertoire will change when aversive stimulation is introduced. Our data suggest, alternatively, that a knowledge of structural factors such as the position of a response in the baseline hierarchy and/or sequential relationships between responses provide a more general predictive framework than a scheme based upon membership in particular functional categories of behavior.

Finally, the data from the second and third experiments suggest that it may be of considerable heuristic value to extend our analysis of punishment beyond its traditional conceptual framework of the fear conditioning literature. The fact that we have observed the same qualitative adjustments in the response repertoire whether we punished eating or simply removed food from the environment suggests that a fundamental property of punishment operations is to require that the organism undertake a major reorganization of its response repertoire. Hence, questions about the properties of response hierarchies (Dawkins, 1976), questions about response substitution rules (Rachlin & Burkhard, 1978; Staddon, 1979), and problems of time sharing (McFarland, 1976) seem to be at least as relevant as traditional theoretical questions about single-process and two-process fear conditioning in the context of these punishment phenomena (Dunham, 1971).

Although these data are somewhat limited in scope, they suggest that a systematic analysis of the structural characteristics of multiple response repertoires might lead to some new insights into the mechanisms which underlie an organism's adaptation to constraint's imposed on an ongoing response repertoire.

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