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A MULTI-OPERANT ANALYSIS OF NEGATIVE PUNISHMENT:
DIRECT AND SYSTEMIC EFFECTS

A Thesis Presented

By

WILLIAM MICHAEL TYSON

Submitted to the Graduate School of the
University of Massachusetts in partial fulfillment
of the requirements for the degree of

Master of Science

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Psychology

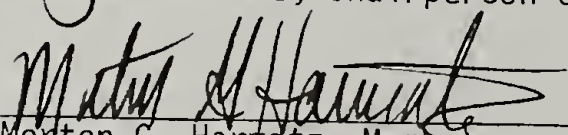
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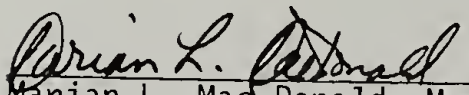
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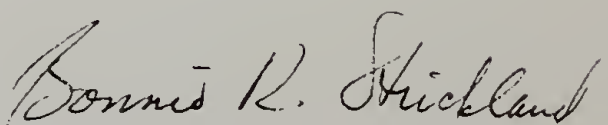
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C H A P T E R I

INTRODUCTION

Despite the fact that applied behavior analysis is generally committed to changing behavior by the construction and expansion of response repertoires through the use of positive reinforcement (Goldiamond, 1974) there are occasions upon which it is desirable to reduce the rate of a specific response. Occasions on which response reduction is ethically justifiable are those in which a specific response (a) is dangerous to self or others; (b) is socially unacceptable; or (c) impedes the acquisition of more productive behavior. Additionally, it is recommended that rate reduction techniques only be used when (a) constructional methods have failed or are inappropriate, or (b) when an immediate reduction is necessary for one of the above listed reasons (see Sulzer-Azaroff and Mayer, 1977, for detailed guidelines on choosing and applying response reduction strategies; see Stolz, 1978; and Goldiamond, 1974, for thorough discussions of the ethical, legal and constitutional issues involved).

The process in which we observe response rate reduction has been technically defined as punishment, and a number of procedures are available for this task. Use of these procedures is ethically and legally restricted as (a) there is a good deal of confusion, both scientific and technical, regarding their implementation and effectiveness; and (b) there is much popular sentiment against the use of these

procedures in western culture.

In its vernacular English usage, punishment refers to the occasion on which something bad happens, usually because of some transgression against either God, society or one's parents. In this usage punishment is painful, either physically or emotionally, and in its most extreme form, capital punishment, it is fatal. In its less extreme forms societal punishment has taken such forms as public whipping, incarceration, shunning and monetary retribution (fine). Parental punishment has taken forms such as spanking, grounding, withdrawal of affection, and loss of allowance or privilege. In this usage punishment is seen only as retribution to the transgressor. Neither the transgression itself nor the effect on future transgressions are included in this definition, although they may be seen as related.

The technical understanding of punishment in behavior analysis has a quite different flavor. Punishment is defined as a functional relationship within which a given response occurs less frequently when that response is reliably followed by the presentation or termination of a specified consequent event (Catania, 1968, 1979). This differs from the vernacular usage in that both the response (transgression) and the subsequent effect on rate must be specified.

Procedurally, there are two parameters which define the nature of behavior analytic paradigms:

1. The direction of the change from baseline rate of response. (Reinforcement describes an increase in rate; punishment describes a decrease in rate.)
2. The effect of the response on the consequent event. (The

presentation of a consequent event is described as a positive relationship, the termination of the consequent event is described as a negative relationship (Catania, 1968, 1979; Rachlin, 1976).)

Thus, we may easily distinguish two types of punishment: (a) positive punishment, where a specific response produces the occurrence of a consequent, and (b) negative punishment, where a specific response produces the termination (nonoccurrence) of a specified consequent event.

Positive punishment is often referred to simply as "punishment" and negative punishment is also known as "omission." Some of the confusion regarding punishment techniques may arise from the fact that the consequent event in positive punishment is an event of the type specified by the vernacular usage of the term punishment. Referring to the process simply as "punishment" may facilitate this confusion. In this paper the two processes, and the procedures which follow from them, will be specified using the terms positive and negative punishment, as above defined.

Notice that when the response rate increases, these definitions serve as definitions of positive and negative reinforcement. In behavior analysis, procedures are defined by their effect on response rate and not by any intrinsic quality of the consequent event. Consequent events are defined as "reinforcers" or "punishers" on the basis of their effect on the response rate of a specific organism. As this effect must always be empirically determined, the definitions and procedural specifications must remain, in their technically pure usage, as generic as is possible within our language system.

The Language of Punishment

It may be useful to explore some of the ways in which we verbally behave with regards to response rate reduction and propose some modifications to that verbal behavior. The proposed experiment is designed to test the effectiveness of these modifications when actually applied to behavior, in this case the behavior of white rats.

In behavior analysis, and psychology generally, our common language must also serve as our technical calculus, and we are wise to continually be aware of the biases and assumptions implicit in our use of that language (Hineline, 1980).

This digression as to the various meanings of punishment is meant to point out the arbitrary nature of these definitions. It can be argued that many of the current ethical, scientific, and technical ambiguities surrounding punishment are a function of differences in verbal behavior regarding the issues. There is evidence to suggest that the way in which we think about events is bound up in the way in which we verbally describe events and indeed with the very words and grammatical structures with which we organize events (Hineline, 1980; Whorf, 1951).

Aversive Control

The term aversive control refers to the procedures of positive punishment and negative reinforcement. In the paradigmatic cases, these procedures involve a response produced aversive stimulus and response terminated aversive stimulus, respectively. While the

"aversiveness" of the stimulus would usually be determined by the effect on response rate--decrease and increase, respectively--electrical shock, the most commonly used aversive stimulus in experimental settings, is generally found to have "aversive" effects (Hutchinson, 1977).

Aversive control techniques have been found to induce side-effects which validate alarm over their use in clinical and applied settings. The delivery of shock has been determined to reliably induce and maintain behavior patterns--termed "adjunctive" behavior--to which it has no direct contingent relationship. The response patterns most often studied have been those of aggression (Hutchinson, 1977), which is reliably induced after the delivery of shock (Ulrich & Azrin, 1962; Azrin, Hutchinson & Hake, 1963). Shock-induced aggressive responding is a stable effect and can itself reinforce instrumental responses that produce the opportunity for attack (Azrin, Hutchinson & McLaughlin, 1965). There is further evidence to suggest that shock will induce a variety of other adjunctive responses such as biting, eating of inanimate objects (pica) and polydipsia--the consumption of abnormally large amounts of liquid (Hutchinson, 1977).

Early in the history of operant conditioning, Skinner proposed that aversive techniques were not an effective method of behavior control, in that they produced "emotional" side effects. Furthermore, aversive stimuli tended to suppress responses other than the target response, as stimuli associated with aversive events come to have a generalized disruptive effect on behavior (Estes & Skinner, 1941; also, see Skinner, 1953, for a more detailed theoretical discussion of

problems with aversive control). Other side effects included the tendency, implicit in negative reinforcement, for organisms to escape or avoid situations in which aversive stimulation was or had been present. As a further complication, the experimenter or therapist could not always control the nature of the escape or avoidance behavior (Hineline, 1977).

Azrin and his colleagues (Azrin, Holz & Hake, 1963; Hake & Azrin, 1965; Herman & Azrin, 1964; Azrin, 1960) conducted a series of experiments in which the parameters of positive punishment were systematically investigated and a set of guidelines developed for the application of those procedures (reviewed in Azrin & Holz, 1966). Their claim was that positive punishment could be effectively used to reduce response rate while at the same time minimizing unwanted side effects. There was little formal study made at that time of aggressive and emotional side effects. The studies focused on (a) recovery of response rate when punishment was discontinued and (b) development of tolerance for shock (Azrin & Holz, 1966). An interesting finding here is that when given a choice between two responses each producing an identical rate of reinforcement (cigarettes), but where one of the two additionally produces the concurrent delivery of a punisher--in this case, white noise--institutionalized psychotics very rapidly and completely ceased the punished response and increased the unpunished response (Herman & Azrin, 1967). This leads to one of the guidelines that is of most relevance to this discussion: that is, that response rate may be decreased much more effectively if an alternative response is concurrently reinforced (Azrin & Holz, 1966).

Alternatives to Aversive Control

Given the empirical findings and the social climate regarding positive punishment it is not surprising that its use is severely restricted. One might conclude that aversive control techniques have more of a potential for harm, whether unintentional or malicious, than for benefit. A great deal of care and training is required to administer positive punishment effectively, let alone ethically, and abuses abound (Goldiamond, 1974). It is quite easy to see how one could, in attempting to reduce the rate of one response, induce other aggressive, emotional or pathological responses. These induced responses might themselves become the targets of punishment procedures which might or might not be effective (Hutchinson, 1977). One might predict a rapid escalation to a situation entirely defined by aversive contingencies. This phenomenon is often described in communication and family system analyses (Watslawick, Beavins & Jackson, 1967) and is alluded to by Azrin and Holz (1966), warning that "punishment reinforces the punisher."

As this is the case, a number of techniques have been devised for response rate reduction which do not involve the presentation of painful stimulation. These are generally subsumed under the category of negative punishment: the reduction of response rate which results from response contingent termination or withdrawal of a reinforcer. Sulzer-Azaroff and Mayer (1977) list the following procedures:

1. Differential reinforcement of other behavior (DRO)--sometimes referred to as reinforcement of omission: In this procedure the

non-occurrence (or omission) of a response for a specified interval is reinforced. Theoretically, and intuitively, the organism is not actually doing nothing during this period of time, hence the notion of "reinforcing 'other' behavior" (Ferster & Skinner, 1957).

2. Reinforcement of alternative responses (Alt-R): A special case of DRO where a specified "other" response is reinforced and reinforcement is withheld contingent on the emission of the response to be reduced.

3. Timeout from positive reinforcement (Timeout): Contingent withdrawal of the opportunity to respond for reinforcers; or removal of the organism from the situation where reinforcement may be obtained.

4. Response cost: Contingent increase in the number of responses or conditioned reinforcers which are required to produce primary reinforcers (Weiner, 1962); or, the contingent taking away (or fining) of conditioned reinforcers which has the effect of increasing the number of responses required to produce primary reinforcers.

Sulzer-Azaroff and Mayer (1977) consider the Alt-R procedure to be the most advisable because the emphasis is on the construction and expansion of adaptive repertoires via positive reinforcement, with little or no attention directed at the undesirable response. DRO is similar with the exception that there is no systematic repertoire construction. Response cost and Timeout are seen as less constructional in that the focus of attention is on the undesirable response, reinforcers are taken away and there is no direct repertoire building.

Zeiler (1976) found that DRO was effective in suppressing baseline responding. Skinner (1938) had hinted at this direction by

finding that delay of reinforcement attenuated responding, suggesting that by systematically delaying reinforcers one adventitiously reinforced other responses. He also found that one could reinforce the omission of a response (non-responding) producing the paradoxical "high rate of non-response."

Smith and Clarke (1972) investigated DRO, using a "food avoidance" paradigm modeled on Sidman's (1953) "shock avoidance" paradigm and found that the effect on response rate was equal to but opposite in direction from negative reinforcement. This establishes DRO as consistent with the parameters of negative punishment and incidentally suggests that we might consider negative reinforcement as the "differential punishment of other behavior." Donahoe (1977) has suggested that in either case these procedures may be regarded as variants along a dimension of reinforcement and punishment rather than as independent processes.

Timeout has compared well with positive punishment in terms of its effect in reducing response rate (McMillan, 1967). Further studies suggest that suppression by timeout varies as a function of intensity and frequency, paralleling positive punishment (Thomas, 1968). On the basis of this latter finding Thomas (1968) concluded that timeout was an aversive event.

Ferster (1957) found that response rate could be suppressed when non-responding resulted in the termination of a pre-timeout stimulus, suggesting that the reduction in rate "avoided" the timeout stimulus. Holz and Azrin (1963) found that timeout paralleled positive punishment in that more rapid suppression was obtained in humans when

an unpunished response was made available.

Baer (1971) found that children reduced the rate of a peanut-reinforced bar-press when the response produced a two-second interruption of a television cartoon. No recovery was found when the contingency was removed. Children would also learn a response which would avoid cartoon interruption (Baer, 1960). Baron and Kaufman (1966) obtained a high rate of responding to avoid timeout from monetary reinforcement.

Weiner (1962) suggested that there is some cost in all responses, and investigated the effect of different costs on the same reinforcer. He found that increasing cost, which decreases reinforcer density, does attenuate responding. He further suggested (1963) that response cost was a component of all aversive control procedures. He found that subjects would work to avoid increased response cost, and that further when an increased cost was attached to the avoidance responses themselves, this responding was attenuated.

Boren and Coleman (1970) while investigating the effects of various operant procedures on the behavior of delinquent soldiers found that response cost procedures induced aggressive behavior. The soldiers on the ward refused to attend a class, for which they would receive tokens, because of a cost imposed on lateness. Attendance dropped below baseline and the cost contingency was dropped. Doty, McInnis and Paul (1974) had a similar problem with chronic mental patients refusing to pay fines. Their quite brilliant solution was to reinforce fine paying by making the opportunity to exchange tokens for back-up reinforcers contingent on paying some tokens toward their fines,

and additionally forgiving percentages of the fines contingent upon prompt payment. This is an interesting combination of response cost and Alt-R.

Understanding Negative Punishment

One might speculate that negative punishment techniques are a form of aversive control, yet there is a good deal of evidence that these procedures do not always produce the side effects characteristic of aversive control (Sulzer-Azaroff & Mayer, 1977). We might then speculate that the degree of aversiveness is defined by parameters other than the procedures themselves. Positive reinforcement may be applied in such a way as to constitute coercion (Sulzer-Azaroff & Mayer, 1977) and "three days in the hole" can be considered an extreme form of timeout (Hineline, 1980). Conversely, there is evidence that positive punishment does not necessarily produce undesirable side-effects (Azrin & Holz, 1966) and even that responses may be reinforced by contingent shock under some conditions (Ayllon & Azrin, 1966).

In the coercion example, one might say that the procedure is no longer positive reinforcement, and that the organism is no longer responding to gain the reinforcer, but rather to avoid the deprivation condition. In this case the procedure constitutes negative reinforcement, an aversive control procedure.

Beyond Arbitrary Procedural Specifications

In the simplest operant reinforcement paradigm we can see a number of process relationships occurring simultaneously. The

procedural distinctions emerge in this view to be a function of what aspect of the environment controls the experimenter's verbal behavior rather than of the environmental conditions themselves. Let us use the simple example of a rat, food deprived to 80% of free-feeding weight, lever pressing under a continuous reinforcement schedule. This procedure is commonly defined as positive reinforcement. Other possible interpretations are:

1. negative reinforcement: the rat responds to terminate the physiological sensation of hunger.

2. positive punishment: responses which do not produce food are punished by hunger sensations.

3. negative punishment: food is withheld following responses other than the bar-press.

Notice that this analysis is only possible if we expand our frame of reference to include responses and consequents not generally specified, controlled or measured in the simple operant paradigm.

We may now construe the simple operant experiment as a concurrent choice experiment where only one response is monitored by the experimenter (Herrnstein, 1970; see also deVilliers, 1977, for a review of the choice and matching literature). Choice experiments have shown that subjects will match their responding, in two-response situations, proportionally to the relative density of reinforcement available to each response (deVilliers, 1977). In the case of the simple operant paradigm, the organism has a choice between the experimenter-chosen response and any other responses available within the situation. In this case the relative density of reinforcers especially available for

the experimenter-chosen response approaches 1.0 compared to the relative density available to the other responses (technically speaking, all other responses are on extinction, as no reinforcers will be delivered except on the occasion of the experimenter-chosen response). We expect that the rate of the experimenter-chosen response (R_1) will increase and that the rate of other responses (R_0) will decrease. Quantitative statements of this relationship can be derived from relative response rate and time allocation (deVilliers, 1977). Thus when the consequences of R_1 are for some reason withdrawn, as in extinction or negative punishment, or when R_1 is positively punished we expect the R_0 frequency to increase as the time which was allocated for R_1 is now available to R_0 . We saw in the Herman & Azrin study (1964) that punishment by white noise suppressed responding on one key while enhancing responding on an alternative key, even though the probability of reinforcement was equal on the keys.

A number of investigators have found that punishment facilitates unpunished responding when there is no programmed reinforcement of the unpunished responses (Brethower & Reynolds, 1962; Dunham, 1972; Dunham, Mariner & Adams, 1969). A possible explanation for this is provided by the choice and matching accounts of behavior (deVilliers, 1977). We saw that when the simple operant experiment was construed as a choice experiment, R_0 was being punished when R_1 was being reinforced; conversely, we can say that if R_1 is punished by shock then R_0 is being reinforced by the absence of shock. Reductions of shock density have been shown to reinforce responses which postpone or entirely avoid shock (Herrnstein & Hineline, 1966). As this is the case we might

expect that absence of shock would reinforce responding when the alternative is some density of shock. There remains the conceptual problem of how the absence of an event can affect responding. This may be addressed by pointing out that this absence is a contingent absence. The organism's history in that situation is one of a given shock density. The alternative responses are followed by shock. The absence of shock reinforces because that absence occurs in the context of an otherwise shock-dense environment.

In our present case R_0 does not actually reduce shock frequency from the experimenter's point of view, yet from the rat's point of view, when R_0 is emitted--and R_1 is not--the emission of R_0 is reliably followed by a shock free environment. While the experimenter knows that R_0 does not directly produce the shock-free environment, the fact is that as long as the rat emits R_0 , and not R_1 , no shock will occur. That the relationship in this case is not direct is beside the point.

Premack showed that when the opportunity to engage in a response with a high probability of occurrence was made contingent on the emission of a response with a lower probability of occurrence, the lower-probability response would increase in rate (Premack, 1959, 1962). Donahoe (1977) has extended this to account for relative discrepancies between environments in general such that quantitative predictions may be made of the direction of changes in rate. From this it is possible to predict choice on the basis of relative discrepancies between instrumental and contingent response probabilities.

We may, if we wish, consider consequent events as relative points on a single dimension. The reinforcing effect of any given

consequent event (R_c/S_c) is then defined by the discrepancy between its probability of occurrence and the baseline probability of the instrumental response (R_1).

In this case we define the consequent event in terms of not only the environmental stimulus (S_c) but by the response (R_c) for which S_c provides the opportunity (Premack, 1959). In the case of food, $p(R_c/S_c)$ is the probability of eating given that food is presented, so that this event is defined by two parameters: (a) the probability of the occurrence of S_c , and (b) the deprivation state of the organism, $p(R_c)$.

Thus, when we calculate the discrepancy-- $p(R_c/S_c) - p(R_1)$ --and when the discrepancy is positive, that is, when $p(R_c/S_c)$ is greater than $p(R_1)$, we may predict that the contingency will be reinforcing, and further that given two consequent events the one with the greater positive discrepancy will be preferred (Donahoe, 1977).

In the case of negative discrepancies, that is, when $p(R_c/S_c)$ is less than the $p(R_1)$, the greater discrepancy will be the most punishing. Thus, given a choice between two outcomes, a greater and a lesser density of shock, responses which produce the lesser density should tend to occur more frequently and responses which produce the higher density should occur less frequently. Given a choice between a negatively discrepant outcome and a positively discrepant outcome, the choice should be for the positively discrepant outcome.

Notice especially that in all cases the baseline probability of the instrumental response is our reference point and reinforcing and punishing may only be defined relative to this reference point.

Paradoxically, we get a reduced rate of response when the response produces no consequent event if the alternative is food (extinction), and a high rate of response when the response produces no consequent event if the alternative is shock (avoidance) (see Donahoe, in press, for a more complete presentation of the relational principle of reinforcement and its application to choice and matching behavior).

Negative punishment of R_1 can be seen as the positive reinforcement of R_0 , depending on the frame of reference one chooses to adopt. This, it may be seen, is not a fundamentally different process from positive punishment. In both positive and negative punishment a negatively discrepant outcome is made contingent on R_1 while concurrently a positively discrepant outcome is contingent on R_0 . The outcomes involved in negative punishment may be qualitatively different from those of positive punishment, but quantitatively the relative discrepancies and the effect on responding are similar in degree.

Defining Aversiveness

Thus, we may not easily define aversiveness in terms of procedural specifications or in terms of inherent quality of outcome. We require a method of assessing aversiveness which is procedurally independent. Further, we need a measure of aversiveness which reflects the organism's, rather than the experimenter/therapist's, point of view. In simple discrimination experiments it is often difficult to assess the aspect of the environment which antecedently controls responding (Ray & Sidman, 1970) so it is highly unlikely that in complex contingency situations, such as applied settings, we may be able to reliably

discriminate the aspects of the environment which consequently control responding. We have seen that all contingencies contain an aversive component: the question must remain as to whether this component is the salient condition for the organism under study. In order to ascertain this we require independent measures.

Assessing Aversiveness

Skinner (1938) defined aversive conditions as those which produced "emotional" behavior, or maintained avoidance responding. Escape and avoidance paradigms have been successfully used as a measure of aversiveness (Keller & Schoenfeld, 1950) but "emotional behavior" has not ever been well enough defined to serve as a reliable indicator.

Using the escape criterion, certain components of positive reinforcement paradigms have been assessed as aversive by the finding that, during those components, responses were reliably made which produced a timeout from the positive reinforcement schedule (Azrin, 1961; Brown & Flory, 1972). Paradoxically, avoidance of timeout itself has been shown to maintain responding (Baron & Kaufman, 1966; Kaufman & Baron, 1966; Holz, Azrin & Ayllon, 1963).

Leitenberg (1965) criticized these findings on the basis that traditional methods employed to assess the aversive properties of electric shock don't necessarily demonstrate that timeout is aversive, in that these procedures inadvertently increase the density of reinforcers available to the organism. As such it is not clear that avoidance of the aversive properties of timeout is maintaining responding, or simply that responding produces an environment in which more food is available.

Kaufman and Baron (1968) and Thomas (1968) controlled for reinforcer density and obtained suppression, but neither directly addressed the question of avoidance as a definer of aversiveness. Timeout was defined as aversive simply because it suppressed responding. These results are not definitive.

Another characteristic of aversive control is the induction of the aggressive and other adjunctive responses previously described. These responses seem to be reflexive (Ulrich & Azrin, 1962) and not controlled by identified contingencies (Hineline, 1977; Hutchinson, 1977). Azrin, Hutchinson, and Hake (1966) point out that these aggressive patterns can be distinguished from the food-conditioned responses described by Reynolds, Catania, and Skinner (1963) and further suggest that they may be used as a method for evaluating the aversiveness of procedures other than those involving shock. Introduction of an extinction condition, following periods of continuous reinforcement, was found to induce attack in much the same form as shock (Azrin, Hutchinson & Hake, 1966) leading to the conclusion that introduction of an extinction condition was an aversive event. This attack period followed about the same temporal parameters as the extinction burst--high rates of response following introduction of extinction conditions--and parallels the bursts of responses observed after shock in avoidance paradigms (Hineline, 1977). These avoidance bursts have similarly been found to parallel bursts of aggression or attack of inanimate objects when the opportunity is present (Hineline, 1977; Hutchinson, 1977).

Aggression has also been observed in long fixed interval

(Richards & Rilling, 1977) and fixed ratio (Cherek & Pickens, 1970) schedules of positive reinforcement. These aggressive responses reliably occur immediately after reinforcer delivery--at the bottom of the scallop or at the step characteristic of fixed-interval and fixed-ratio schedules, respectively--when reinforcer probability approaches zero (extinction) (Christian, Schaeffer & King, 1976).

Paralleling the investigations of aggression produced by shock, extinction and reinforcement schedules, is the investigation of schedule-induced polydipsia first reported by Falk (1961). Most research done with reinforcement schedules have used polydipsia as the measure of interest, but the findings have been similar to those of shock and aggression (Christian, Schaeffer & King, 1976). It is believed that the functional properties of all schedule-induced behavior are identical regardless of the particular response induced, the specific response seeming to be a function of whatever opportunities are available (i.e., if water is available, polydipsia occurs; if another animal is present, aggression occurs). Response patterns, which have been either schedule or shock induced, include paper shredding, air licking, pica (eating non-food material), locomotor activity, nitrogen licking, non-contingent bar-pressing, alcohol ingestion (with and without Kool-aid) and copulation in animals (Christian, Schaeffer & King, 1966), as well as pacing and drinking in psychotic adults (Kachanoff, Leveille, McLelland & Wagner, 1973) and smoking in normal adults--induced in a cognitive task (Wallace & Singer, 1976), and has been suggested to include coffee drinking, loquaciousness, and other "nervous habits" (Falk, 1977). Wheel running was originally proposed as fitting

the model of what we now call schedule induced behavior (SIB) by Skinner and Morse (1957), who called the phenomenon "concurrent behavior." Recently Staddon (1977) has questioned this, arguing that wheel running cannot be considered as schedule induced behavior, as it freely and reliably occurs, regardless of the contingencies or lack thereof, in so many situations.

The characteristics of schedule-induced behavior patterns are: (a) they are elicited after the infrequent delivery of a reinforcing stimulus to a deprived organism, or immediately following an aversive stimulus, rather than maintained by contingent consequents; (b) they occur in ritualistic, compulsive patterns; (c) the intensity of the induced response varies as a function of some dimension of the aversiveness of the stimulus (response requirement for reinforcement and deprivation level or shock intensity, frequency, and/or duration); and (d) the opportunity to emit these responses is reinforcing in that the organism will learn other responses in order to emit them, but they are often self-punitive or self-injurious (i.e., drinking to a bloated state) (Christian, Schaffer & King, 1976, p. 80).

Falk (1977) has discussed the functional role that schedule induced behavior (SIB) plays, by comparing SIB with displacement in phylogenic development, and has concluded that SIB plays a role in stabilizing behavior within a situation from which escape is impractical or impossible. The arousal is seen to mobilize the organism to emit pre-selected responses which will allow continued functioning in a hostile or unpredictable environment. (See Christian, Schaeffer & King, 1976; as well as Falk, 1977, for complete discussion of the

various attempts to explain these phenomena.)

It is interesting to speculate that behavior patterns such as nicotine, alcohol, and caffeine addiction as well as overeating and self-stimulation, which have been resistant to modification by contingent-consequence approaches, may be resistant owing to misconstruing of their nature and function. What is not interesting but alarming is that in using some behavior modification techniques we run the risk of inadvertantly inducing and maintaining side effects which are more undesirable and unmodifiable than the responses we originally were attempting to control. Adjunctive and induced behavior patterns have received very little attention in the behavior modification and applied behavior analysis literature (Foster, 1978). This, despite the call by Willems (1974) that behavior analysis pay attention to the "ecological" effects of behavioral applications, and Baer's (1974) agreement that a methodology for assessing those effects was necessary and should be developed.

An ecological approach would include the concurrent analysis of multiple behaviors in a given setting. This tactic would allow the behavior analyst to immediately modify procedures which produced undesirable disruptions of concurrently occurring behavior.

Such an approach however, presupposes a conceptual framework for analyzing these "adjunctive effects." This would include a systematic documentation of the form of these "ecological" effects. As of this writing we have only crude indicators and no fine-grained analyses of complex behavior interactions.

It is also not possible, at this time, to state categorically

that schedule induced behavior is a consistent and reliable indicator of the organism's assessment of environmental conditions. It would seem that a systematic analysis of subjective assessment and experience can and ought to be developed and these patterns of behavior documented. An understanding of individual experience is certainly within the scope of radical behaviorism (Day, 1969).

While it is beyond the scope of this project to attempt such a task, we can look at some procedures currently in use simply to see if different rates or patterns of adjunctive behavior are induced. This project, then, is an attempt to document the proposal for such a systematic account, as briefly described earlier, as plausible and advisable.

The Present Experiment

The present experiment is designed to examine some commonly used negative punishment procedures along the dimension of aversiveness, here defined as the relative induction of adjunctive behavior. Negative punishment has not been as intensively researched as other operant paradigms, largely as a result of confounds and complications of the single operant methodology (Catania, 1968).

This experiment will employ a free-operant chamber with multiple-operant capacities similar to those described in Dunham (1972) and Christian, Schaeffer and King (1976). The chamber will contain a retractable press-lever, drinking tube, running wheel, and bite-lever (a device which will record bites, but not other manipulations), as well as a food magazine.

Running in the wheel will serve as the target response. Wheel-running is a non-zero baseline response; that is, it occurs at a high stable rate without experimenter contrived reinforcers. This response was chosen in order to more closely approximate the situation, often encountered in applied settings, where one is called upon to reduce the rate of a response whose origin and maintenance conditions are unspecified or unknown.

An additional reason for using a non-zero baseline response is to avoid the confounding effect of withdrawing a reinforcer which has previously been used to maintain a response (Catania, 1968).

The contingent event, or reinforcer, will be the opportunity to obtain food by pressing the lever. Pellets will be available on specified variable-interval schedules and the experimental manipulations change the food densities available to the rat. These changes will be accompanied by tone onset and offset.

Drinking from the drinking tube and biting the bite lever will not be directly manipulated. The rats will have free access to these two responses in all conditions. It is expected that the target response will be suppressed equally in all experimental conditions, and our interest is in differences in the induction of adjunctive responding (in this case, drinking and biting).

The Experimental Conditions

Two negative punishment paradigms will be used as experimental conditions. These can loosely be called "timeout from positive reinforcement" and "response cost."

1. Timeout from positive reinforcement: In this condition withdrawal of the opportunity to obtain food by lever-pressing (retraction of the press lever) will be contingent on a given number of wheel revolutions. The opportunity to respond to food will be returned after a pre-set interval in which no revolutions have occurred.

2. Response-cost: In this condition an increased cost, in responses, of gaining a food reinforcer will be contingent on a given number of wheel revolutions. Wheel revolutions will be followed by the onset of a tone that is correlated with a no-food condition. At this point, completion of a fixed ratio of lever presses will terminate the tone and reinstate the normal schedule of reinforcement. This approximates the effect of being fined a token (thus requiring the completion of the response requirement for earning another token) or of simply being required to do extra work for the same primary reinforcer. This procedure most closely approximates the technique of "contingent effort" (Luce, Christian, Lipsker & Hall, 1981).

In baseline conditions there will be free access to the wheel and the lever will be programmed with the same variable interval schedule for food as in the timeout and response-cost condition. Dependent measures will be (a) length of time to suppression of the wheel-running and (b) changes in rate and distribution of induced behavior (drinking and biting). These will be compared across experimental conditions and to baseline conditions, allowing an assessment of (a) the effectiveness of the procedure in suppressing the target response and (b) the desirability of the procedure in terms of the production of unwanted side effects (adjunctive behavior).

Notice that in each of these experimental conditions two parameters are defined: these are (a) the criterion for withdrawal of the opportunity to obtain reinforcers (negative punishment) and (b) the criterion for the reinstatement of the opportunity to obtain reinforcers (positive reinforcement). By establishing these procedures within a multiple-operant methodology it becomes clear that these two procedures constitute different versions of differential reinforcement of other behavior (DRO). As such, one might conclude that the differences between the two are procedural and do not necessarily constitute different processes. One might also suggest that DRO be considered the general model of negative punishment.

Thus, the critical difference between the two experimental procedures lies in the criteria for reintroduction of reinforcement. In the timeout condition reinforcement is contingent only on the omission of the wheel running response (Skinner, 1938). In the response cost condition a specific "other" response is reinforced, that being lever pressing. This is analogous to the previously mentioned Alt-R procedures (Sulzer-Azaroff & Mayer, 1977). In this latter condition lever pressing, already reinforced by food, is additionally reinforced by termination of the tone and no-food condition, and reinstatement of the normal schedule of reinforcement. In either condition we are reinforcing "other" behavior, the relevant difference is whether or not we are specifying the "other" response to be reinforced.

There is also a difference in the two procedures along the dimension of response dependence. In the "response cost" condition, positive reinforcement--the reintroduction of the normal food

reinforcement schedule--is contingent not only on omission of wheel-running (a non-response) but additionally on the completion of a lever-press ratio. Thus punishment and reinforcement are response dependent. In the "timeout" condition only punishment is response dependent as the reintroduction of reinforcement depends only on the omission of wheel-running and not directly on whatever else the organism may be doing. There is speculation that this dimension of direct control of the environment may be a salient feature by which organisms discriminate control as aversive, and perhaps define such concepts as freedom (Skinner, 1953). It is my contention that the two dimensions of response-dependence/independence and explicit/accidental reinforcement of alternative responses are, at least in these procedures, operationally identical.

It would be consistent with the radical behavioral approach to social issues to find that questions of freedom and the like could be seen as embedded in the design of environmental controls. While this type of speculation goes beyond the data, and certainly beyond the scope of this experiment, the results of this experiment could indicate that at least the experience of aversiveness is related to questions of design, and this would imply some guidelines for workers in the applied field.

C H A P T E R I I

METHOD

Subjects

Six male, albino rats (R1, T4, T6, R8, T9, R10) of the Sprague-Dawley strain, obtained from Charles River Breeding Labs, served as subjects in this experiment. These experimentally naive rats were approximately 75 days old at the beginning of the experiment. The subjects were maintained at 80 percent of their free-feeding weight. They were housed individually under a constant 12 hour light-12 hour dark cycle, with free access to tap water.

Apparatus

Sessions were conducted in two free-operant chambers especially constructed for this experiment. Each unit consisted of an area 41cm in width, 13cm in height and 16cm in depth. The two end walls were made of plexiglass 18cm in width and 15.5cm in height. The manipulanda were mounted on a sheet metal wall measuring 41cm in width and 13cm in height, with a lip at the bottom which protruded 2.5cm into the chamber at a height of 2.5cm from the floor. The fourth side consisted of a frame measuring 41cm in width and 38cm in height which housed a Wahmann running wheel measuring 11cm in width and 35cm in diameter. The entrance to the wheel was an inverted semi-circular space measuring 29cm in width and 7cm in height at midpoint, matching the bottom section of

the running wheel. A plexiglass roof, measuring 42cm in width and 15cm in depth, was attached by hinges to the running wheel frame. This entire unit was mounted, with braces on the plexiglass sidewalls, to a plywood base. A floor of wire mesh was suspended approximately 2.5cm above the plywood base and ran the length of the chamber.

A retractable lever was mounted in the sheet metal wall 6.5cm from the right plexiglass wall and 6cm above the mesh floor with the lever, 5cm in width and 1cm thick, extending 2.8cm into the chamber when extended and flush to the sheet metal wall when retracted. A downward force of 0.15N on the lever was required to operate the micro-switch. A drinking tube was mounted behind the sheet metal wall with the tip of the tube fitting into a hole 1cm in diameter drilled in a plexiglass plate, itself mounted 0.2cm behind the sheet metal. A 1.3cm diameter hole was drilled in the sheet metal 5cm to the left of the lever and 5.4cm above the mesh floor through which the rats could lick the drinking tube.

A magazine for the delivery of food pellets was mounted on the sheet metal wall 3.5cm to the left of the drinking tube hole and 2.5cm above the mesh floor. The opening for the magazine was 4.7cm square. Standard 0.045g food pellets obtained from the P. J. Noyes Company served as reinforcers. A bite-lever (two strips of metal spring-mounted such that pressing the two strips together operates a micro-switch) was mounted 7.7cm from the left plexiglass wall and 5.5cm from the mesh floor. The metal strips were approximately 0.15cm thick and 2cm wide and extended 3.1cm into the chamber. These were covered with masking tape to provide novel stimulation. Switch closure required a

force of .25N. At rest, the lever was parallel to the mesh floor, but could swivel up or down approximately 2cm. Moving the lever up or down could not operate the microswitch.

The drinking tube was attached to a Grayson-Stadler drinkometer for recording the licking frequency. Two magnets were mounted at each pole of the running wheel which operated a proximity switch mounted on the frame. These gave a count of each half-revolution of the wheel. The wheel hub turned a gear which revolved against a ratchet, allowing the wheel to turn in only one direction.

The experimental chambers were enclosed by sound and light attenuating shells measuring 75cm in width and in height and 60cm in depth. A 15w, 110v AC refrigerator bulb was mounted at the midpoint of the ceiling of each attenuating shell, serving as houselight. Small exhaust fans were mounted in the rear of the attenuating shells. These served both to ventilate the chambers and to provide approximately 70dB masking noise. A speaker mounted on the rear wall of the shell directly behind the running-wheel provided approximately 80dB of white noise. This was programmed such that there was a 0.05sec break in the white noise at the rate of twice per second.

Programming was accomplished by standard electro-mechanical equipment located in an adjacent room. Session lengths were set by a pre-determining counter operated by a one-per-second pulse-stream generator. Responses were recorded by a bank of counters and transferred to data sheets after each session.

Procedure

Following deprivation to 80 percent of free-feeding weight, all animals were introduced to the chambers for the purpose of habituation and magazine-training. These sessions lasted about twenty minutes per day during which time food pellets were delivered on a variable-time, 45-second (VT-45") schedule. Animals were allowed free access to the running wheels and the drinking tube. The levers remained retracted during these sessions. Habituation was continued for approximately one week, by which time the animals were reliably responding to the sound of the feeder operating and running in the wheel. The animals were shaped to the drinking tube by extending the tube 1cm into the chamber and gradually withdrawing it to its final position flush with the plexiglass plate, approximately 0.2cm behind the sheet metal wall. On the sixth day of these sessions, the levers were extended and the lever-pressing response was shaped. This was accomplished by the method of successive approximations. Once an animal had pressed the lever, further presses were reinforced on a continuous reinforcement schedule. On day seven, the schedule was faded until the terminal Variable-Interval, 45-second (VI-45") schedule was obtained. The animals were then continued on this schedule for two additional days. At this time the experiment was begun.

The Experiment

Each animal was exposed to a variable blackout period immediately prior to and following the sessions. A single push-button

simultaneously began the sessions in both chambers. This same switch operated the houselight and turned on all programming equipment simultaneous with the start of a 3000 second (fifty minute) count-down. When this count-down was completed the programming equipment, data counters, and the houselights were simultaneously turned off. The rats were then returned to their home cages and given an auxiliary feeding of Purina rat chow. Experimental sessions were routinely held between 3:30 and 6:30 A.M. (± 30 minutes). The rats were run in the same sequence and in the same chambers throughout the experiment. Light-dark cycles in the home cages were scheduled such that the dark cycle began at approximately 7:00 A.M. Rats being nocturnal, the sessions were held at the beginning of their active period (equivalent to "first thing in the morning" for humans).

Pellet delivery was programmed by tape readers employing identical tapes for each chamber. Operation of the tape-reader caused the reader to stop (lockup) until a lever-press was emitted. A lever-press during lockup operated the pellet dispenser and restarted the tape reader. All lever-presses made when the reader was not in lockup, even if it was stopped, had no effect.

The Experimental Conditions

During Baseline (A1), free access was allowed to the running-wheel, drinking tube, and bite-bar. Lever presses were reinforced on a VI-45" schedule.

Following this A1 phase the animals were exposed to one of the two experimental phases, either response-cost (RC) or timeout (T0).

The animals were assigned by coin flip to one of the two sequences, either RC-T0 or T0-RC. The animals receiving RC first are designated by the letter R (R1, R8, R10) and the animals receiving T0 first are designated by the letter T (T4, T6, T9).

In the T0 experimental phase, six half-revolutions of the wheel operated a clock set at forty-five seconds. Simultaneous with the clock operating, the lever was retracted and the tape-reader stopped. Subsequent running at the same criterion of six half revolutions caused the clock to reset to forty-five seconds. After the forty-five seconds had elapsed with no wheel running, the clock operated a relay which extended the lever and re-started the tape-reader.

In the first experimental session the animals were exposed to successively increasing timeout durations beginning with five seconds, increasing to 25 seconds, and finally to the terminal duration of 45 seconds. By the third session all three animals were receiving forty-five second timeout durations.

In the RC experimental phase, six half-revolutions of the wheel opened a circuit to a pre-determining counter set at 25 responses. Simultaneous with this the tape-reader stopped and white noise was turned on within the chamber. Subsequent running at the same criterion of six half-revolutions caused the PD counter to reset to 25 responses. After the emission of twenty-five lever presses with no wheel runs (count-out) the PD counter operated a relay which offset the white noise and restarted the tape-reader. In the first experimental session the rats were exposed to successively increasing response cost requirements beginning with 5 lever-presses and increasing by increments of

five lever-presses to terminal criterion of 25 lever-presses. By the third session, all animals were receiving response cost of twenty-five lever-presses.

In both conditions pellets were available on a VI-45" schedule except when the punishment period was in effect. The animals could maintain a pellet rate (maximum = 67 pellets per session) and an average inter-pellet interval (minimum = 45 seconds) identical to baseline only by suppressing running to less than six half-revolutions (criterion for punishment being six half-revolutions). In neither condition could the animal accumulate either time or responses if running intervened. The requirements were either 45secs or twenty-five lever-presses from the last half-revolution. They could, however, accumulate half-revolutions, hence the number of half-revolutions necessary at any given time to enter punishment was variable. The experimental conditions provided an interruption to the normal reinforcement schedule such that no pellets became available for the period of time the animal spent running plus either 45 seconds in T0 or the amount of time required to emit 25 lever-presses in RC. At the offset of the punishment condition the normal Inter-Pellet-Interval (IPI) would be reintroduced. Thus, entering punishment did not allow the animal to escape from the longer IPIs programmed on the VI schedule.

Following the punishment phase the animals were returned to the VI-45" baseline schedule (A2), during which there were again no programmed contingencies on wheel-running. An additional control phase followed. This employed a VI-60" schedule to control for effects due simply to the reduction in pellet rate which the animals experienced

during punishment. This phase was identical to the baseline phases (A1 and A2) with the exception of reinforcer density available to lever-presses (maximum pellets per session = 50; minimum average IPI = 60"). Isolation of experimental effects due to the contingencies alone could be accomplished by providing baseline rates at the reduced pellet density.

Following the VI-60" phase, each animal received the punishment treatment which it had not received in the first punishment phase. Thus, three animals received T0 followed by RC, and three received RC followed by T0. This controlled for sequence and carryover effects from one treatment to the subsequent treatment. At this time procedures identical to those previously described were followed.

This phase was followed by a return to baseline (VI-45") conditions. This phase (A3) was terminated when relative stability was obtained. For five of the animals this condition was continued for eight days. For one animal (T9) this condition was extended to 15 days.

Data Collection

During baseline phases and the VI-60" phase, lever-presses, one-half revolutions of the wheel, licks on the drinking tube, bites on the bite bar, as well as the number of pellets earned were counted. During punishment phases additional counts were made of lever-presses, half-wheel turns, licks and bites emitted while the animal was actually being punished. A count was also made of the total number of seconds spent in punishment. When the first punishment phase was begun, a

decision was made to record bouts of running. This was accomplished during experimental conditions by counting the number of times that the timer in the T0 condition or the pre-determining counter in the RC condition reinstituted normal conditions. During baseline and VI-60" phases entry to the wheel started a clock which clocked out at 30 seconds. If the rat ran again within 30 seconds the clock was reset. Thus, a bout of running was defined as 6 or more half-revolutions of the wheel occurring more than 30 seconds following the most recent run. Observations at this time indicated that if the rat were to leave the wheel and then re-enter, it usually did so within 20 seconds. If the rat did not run again within approximately 20 seconds it would usually not run again for a minimum of 120-150 seconds. The thirty second criterion was chosen to take this factor into account and also to provide a rough average between the timeout interval of 45 seconds and the modal time of 15 to 20 seconds required to emit the 25 responses necessary to terminate response cost.

The entry rate provides a more sensitive measure of the effect of the T0 and RC procedures on running. Both the timeout and response-cost contingency are only contacted when the animal has discontinued running. The 45-second T0 interval would only be contacted when the animal left the wheel. The direct contingency (absence of the lever) would be identical whether the rat emitted 10 half-revolutions or 100 half-revolutions. Similarly, in the RC condition the animal would be required to emit 25 lever-presses regardless of the running rate during the bout. The stopping of the tape-reader during the time that the animal is actually running is a much less direct effect. Thus, we

might wish to construe the entry rate as a more precise measure of the running frequency and the revolution rate as a measure of the intensity of the running response. Henceforth these will be referred to as frequency and rate, respectively. This distinction was not discovered until the beginning of the first punishment phase, and at that time there was no way to reconstruct the entry rate for the first baseline.

In addition to these raw measures, the average number of licks per pellet and lever-presses were calculated for each session. The measures of interest reported in this study are absolute frequency of licks (licks), absolute frequency of one-half revolutions (wheel-runs or runs), absolute frequency of presses on the lever (lever-presses or presses), absolute frequency of pellets (pellets). Additional measures were the average frequency of licks per pellet (licks/pellet), the average frequency of lever-presses per pellet (lever/pellet), the frequency of running bouts as previously defined (wheel-entry) and the mean rate of running for each entry (wheel-rate). Means for each condition were calculated on each measure based on the last eight sessions of each condition. The Absolute Mean Ratio or Kappa (K) was calculated for each mean. This measure of dispersion was chosen as it is independent of the mean and the scale, allowing comparisons of variability to be made between measures of different types. K may also be graphically represented, allowing both statistical and graphic utility (Johnston & Pennypacker, 1981).

CHAPTER III

RESULTS

Due to the complexity of these results, the following format will be used. First, general patterns of responding will be described, followed by a description of the effects of the experimental procedures in suppressing the rate of wheel-running and wheel-entry. The three rats in each sequence will be described separately. Next, the effect of the procedures on the adjunctive responses will be presented, followed by a description of some incidental findings. Each major section will be followed by a summary of the findings. A detailed presentation is necessary owing to the high degree of individual difference in response to the two experimental procedures. Perhaps the most salient result of this experiment is the complex variation within, and interaction between, response systems that is revealed when multiple-operant methods are employed.

In reading the graphs, please note that both the degree of difference between phases as well as the dispersion around a particular mean are represented by the ratio obtained by dividing the higher figure by the lower (degree of difference) or by calculating the absolute-mean-ratio (K), respectively. All graphs have been prepared on semi-logarithmic paper to preserve the ratio character of the data, and to allow comparisons regardless of frequency. Thus a ratio of two to one would be represented identically to a ratio of 1000 to 500.

If this ratio is the degree of difference it may be represented as a numeral 2 alongside the line joining the two data points. If it is an absolute mean ratio it will be represented as a vertical bar around the mean measuring the distance from one to two on the log-scale (Johnston & Pennypacker, 1981).

General Response Patterns

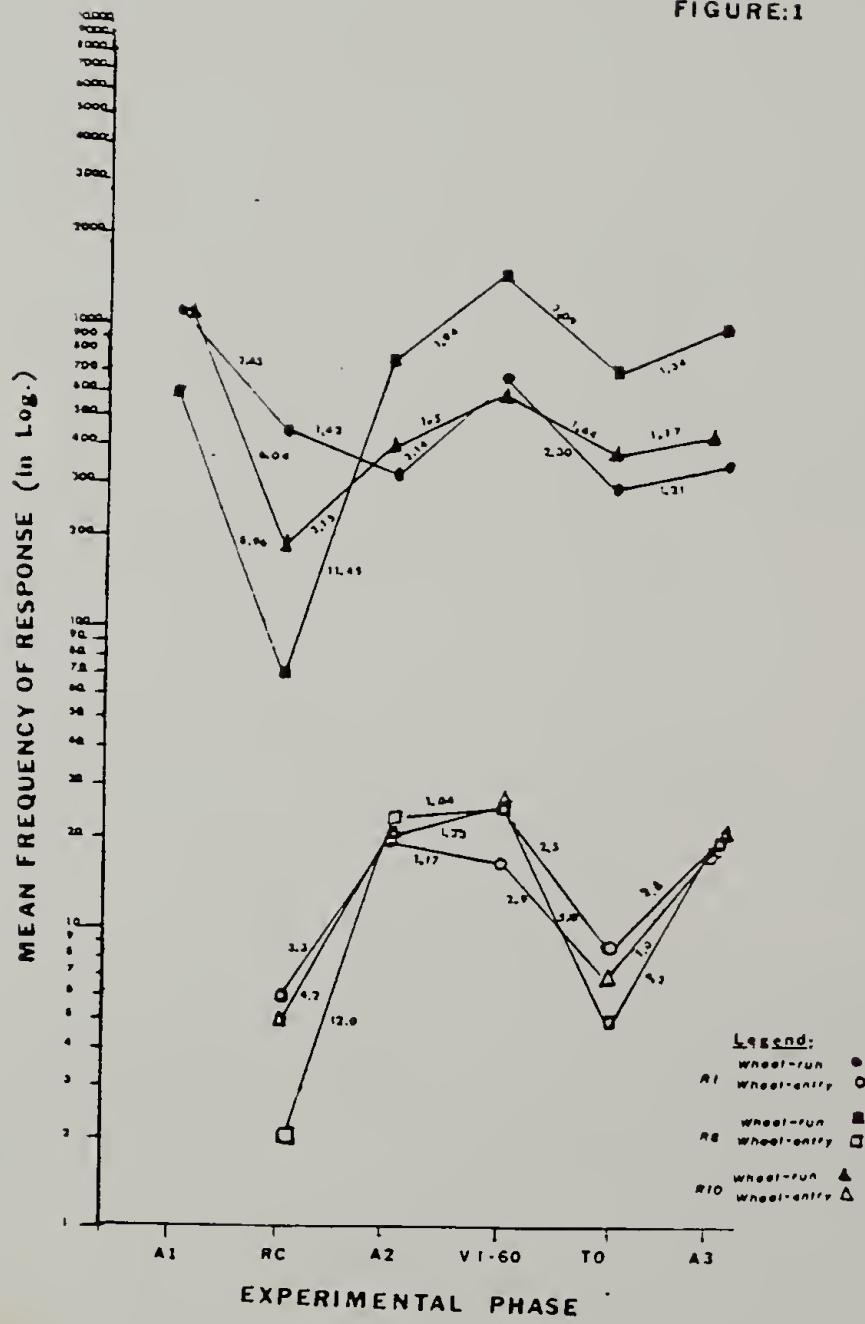
All six animals quickly established similar patterns of responding during the baseline phase. They would press the lever until a pellet was obtained. On eating the pellet, they would lick the drinking tube at a remarkably stable rate, emitting approximately the same number of licks after each pellet. They would then return to the lever, pressing it a few times. If another pellet was not obtained, they would run in the wheel for a few revolutions, intermittently jumping out to give the lever a press. When a pellet was delivered they would eat and drink, only returning to the wheel during the longer IPIs. Despite the inter-subject variation on the various responses and the overall pellet rates, this pattern was strikingly similar in all animals.

Punishment Effects on Wheel Running

Figure 1 shows the mean frequency of half-revolutions (rate) of the wheel and of entries to the wheel (frequency) for the three animals in the R sequence (RC first). The rates of half-revolutions were suppressed substantially for all three animals during the RC phase. In the A2 phase two of the animals (R1 & R10) continued to run below

Figure 1. The mean rate of wheel-running and entries by experimental phase for the subjects receiving response-cost first.

FIGURE:1



the A1 rate and one animal (R8) exceeded his A1 running rate. One animal (R1) showed further suppression during A2 than was obtained during the RC phase. During the VI-60" baseline phase all three animals showed substantial increases over the rates obtained in A2. This condition provided an overall pellet rate equated with that obtained in the punishment phases.

There is a reduction in the T0 phase in the running rates for all three animals. These can be seen to be approximately equal to the increases obtained during the VI-60" phase. The T0 rates can therefore be seen to be approximately equivalent to those obtained in the A2 phase, using the VI-60" rate as a reference point. There is little evidence for any suppression by the timeout contingency beyond that provided by the change in reinforcer rate.

During A3 there was some increase in the rate of wheel-running, but these differed only minimally from the rates obtained during T0 and A2. An inspection of the individual graphs for each animal (see Figs. 2, 3, 4) shows that these means and their dispersions overlapped substantially.

Returning to Figure 1, entries were reduced during RC for all animals. Raw session data for each animal are presented in Figure 5 (R1), Figure 6 (R8), and Figure 7 (R10). Inspection of the raw session data shows a systematic suppression of the entry rate in the first few days of RC. We may infer from this that the entry rate during A1 was approximately that of the first few days of RC and that there is a suppression of entries initiated during the RC phase. Returning again to Figure 1, recovery ratios in A2 are substantial for all animals. In

Figure 2. The mean rate, by condition, of lever-pressing, running, licks per pellet, pellets and wheel-entries for R1.

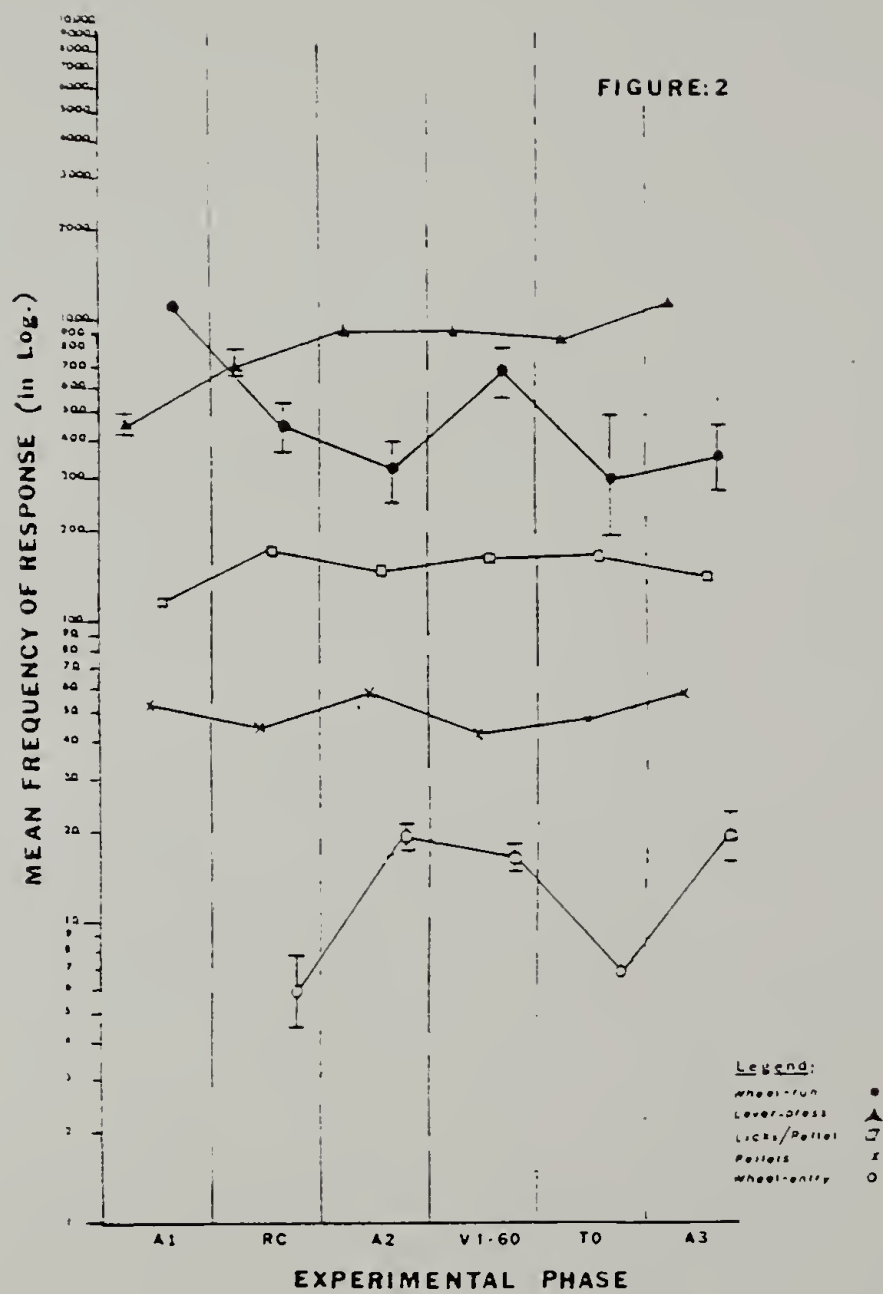


Figure 3. The mean rate, by condition, of lever-pressing, running, licks per pellet, pellets and wheel-entries for R8.

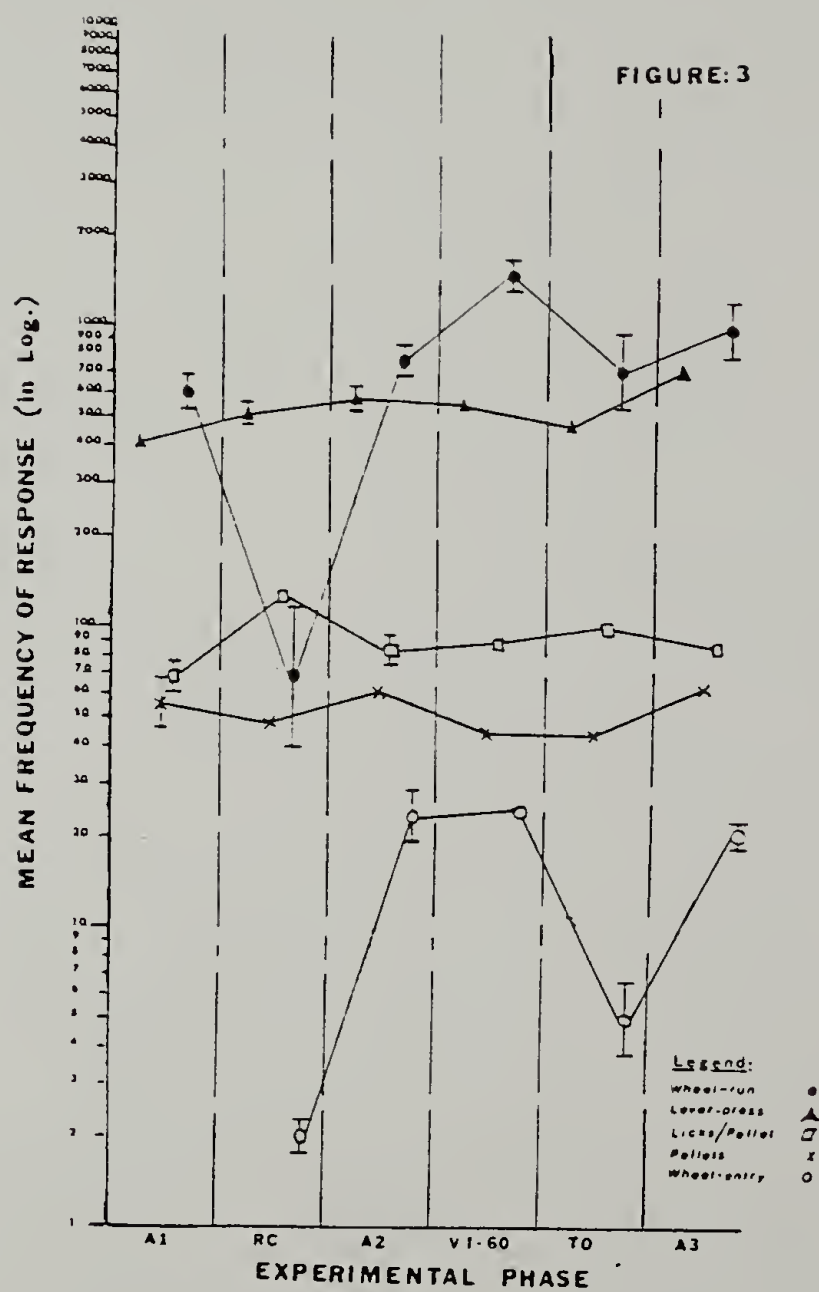


Figure 4. The mean rate, by condition, of lever-pressing, running, licks per pellet, pellets and wheel-entries for R10.

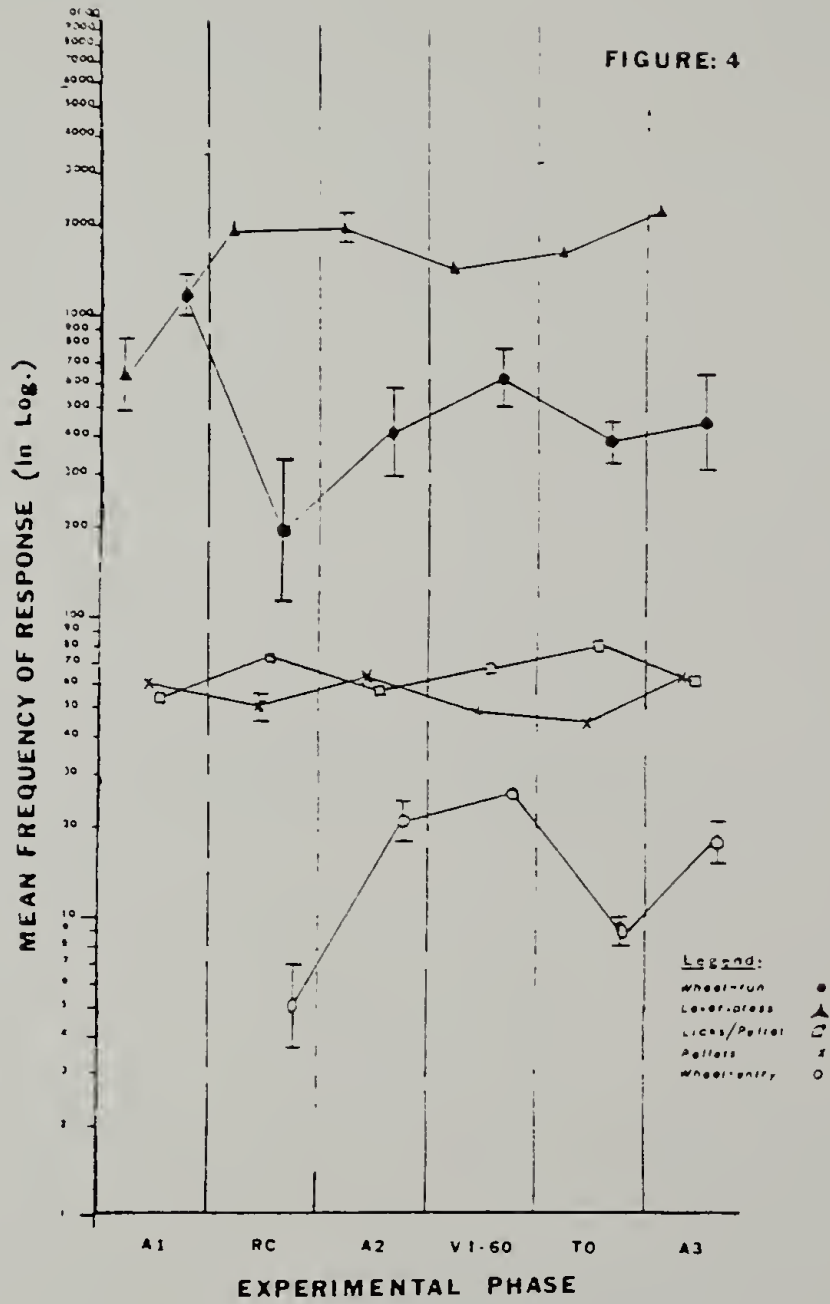


Figure 5. The rate of responding on all measured responses by session for R1.

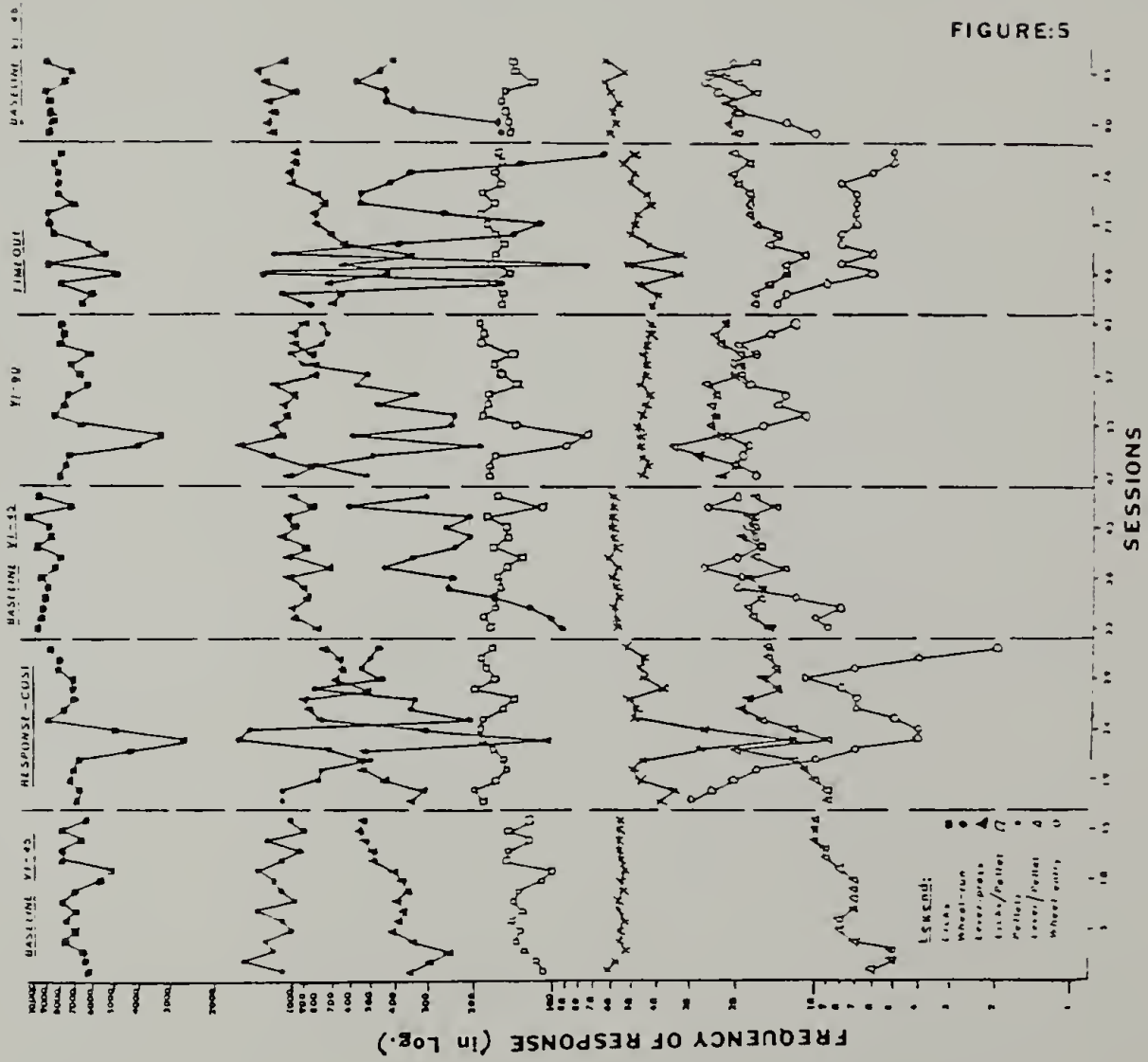


Figure 6. The rate of responding on all measured responses by session for R8.

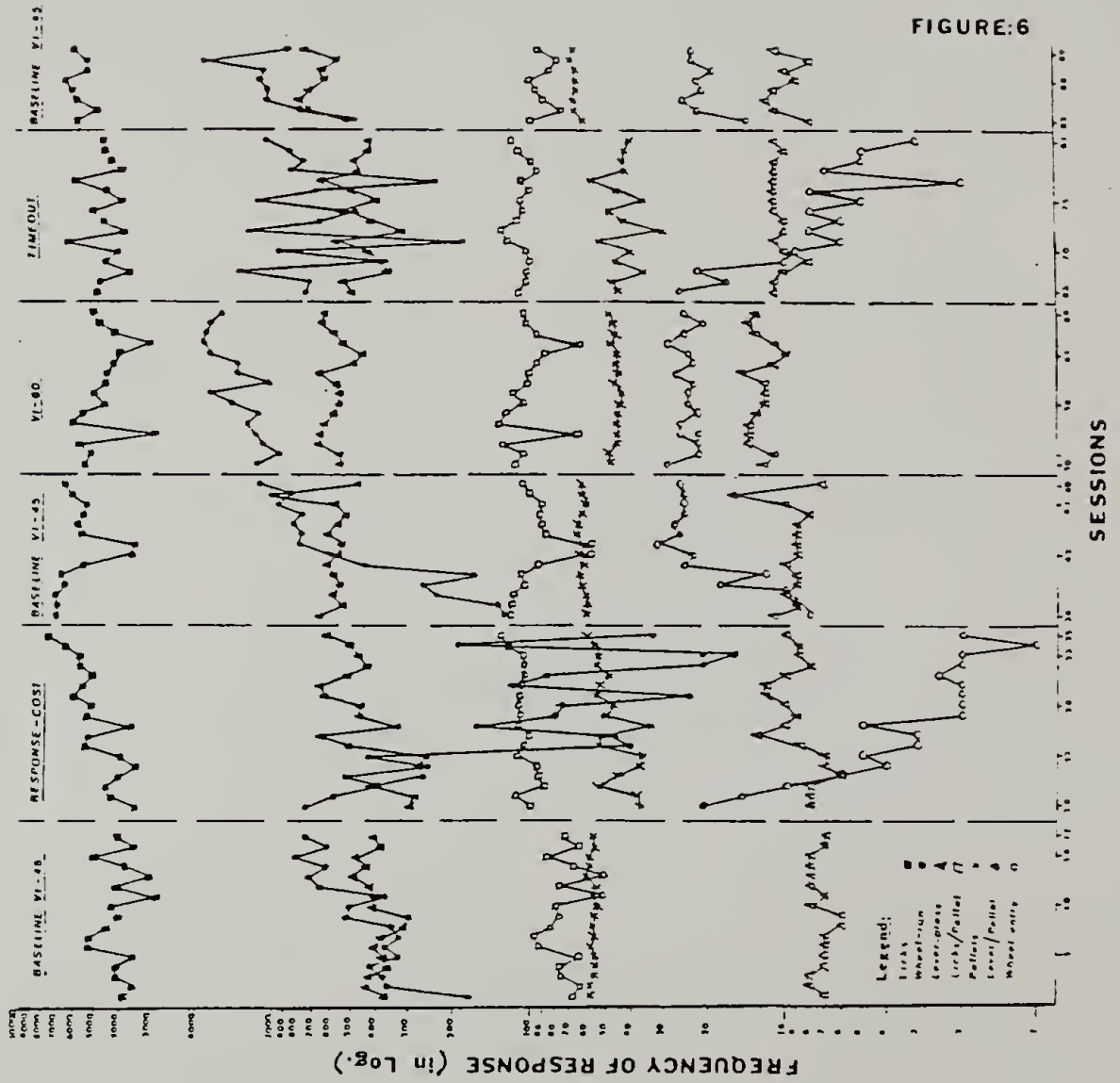
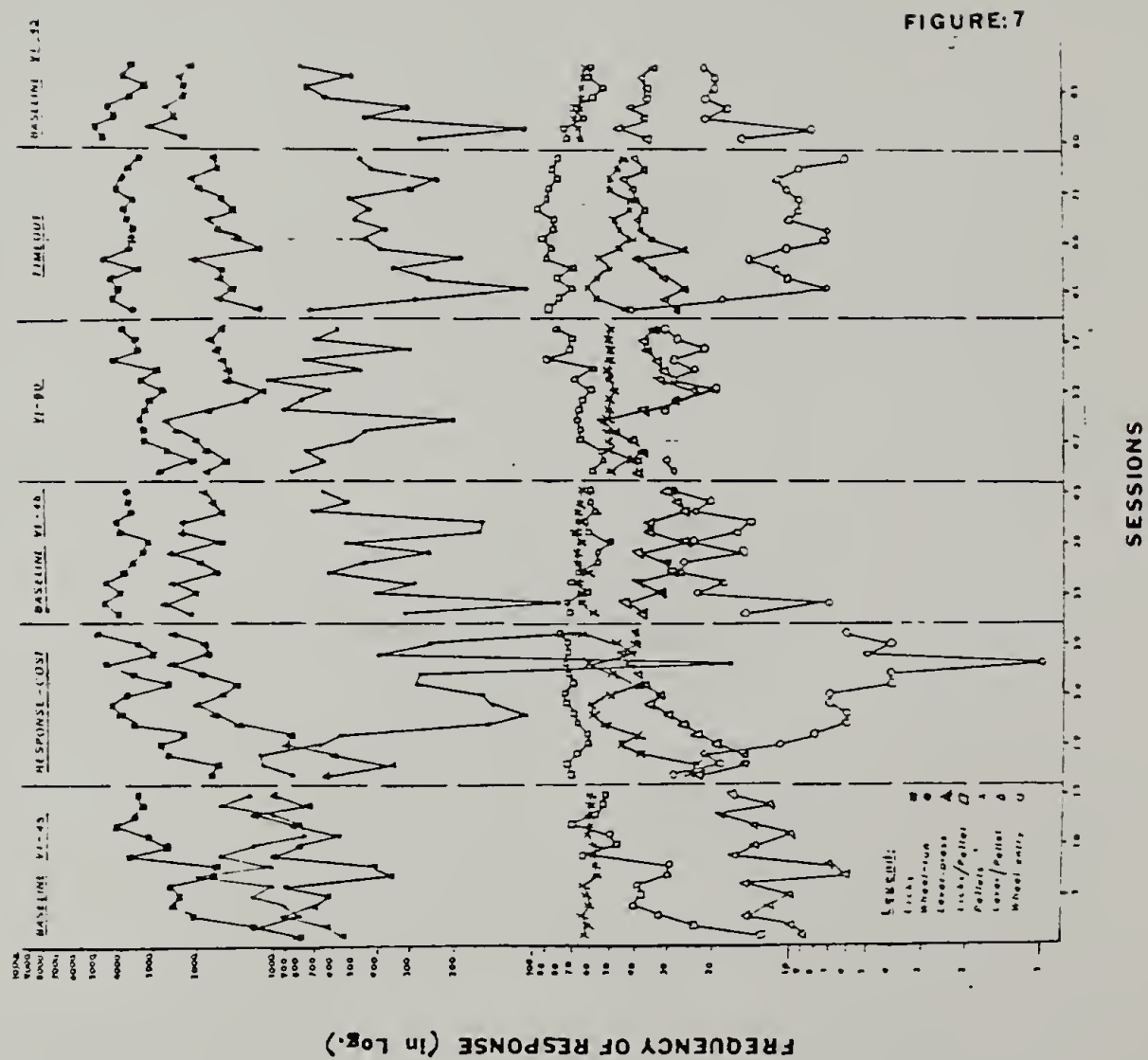


Figure 7. The rate of responding on all measured responses by session for R10.



the VI-60" phase there is a minimal increase in entries for two of the animals and a minimal decrease in one (R1).

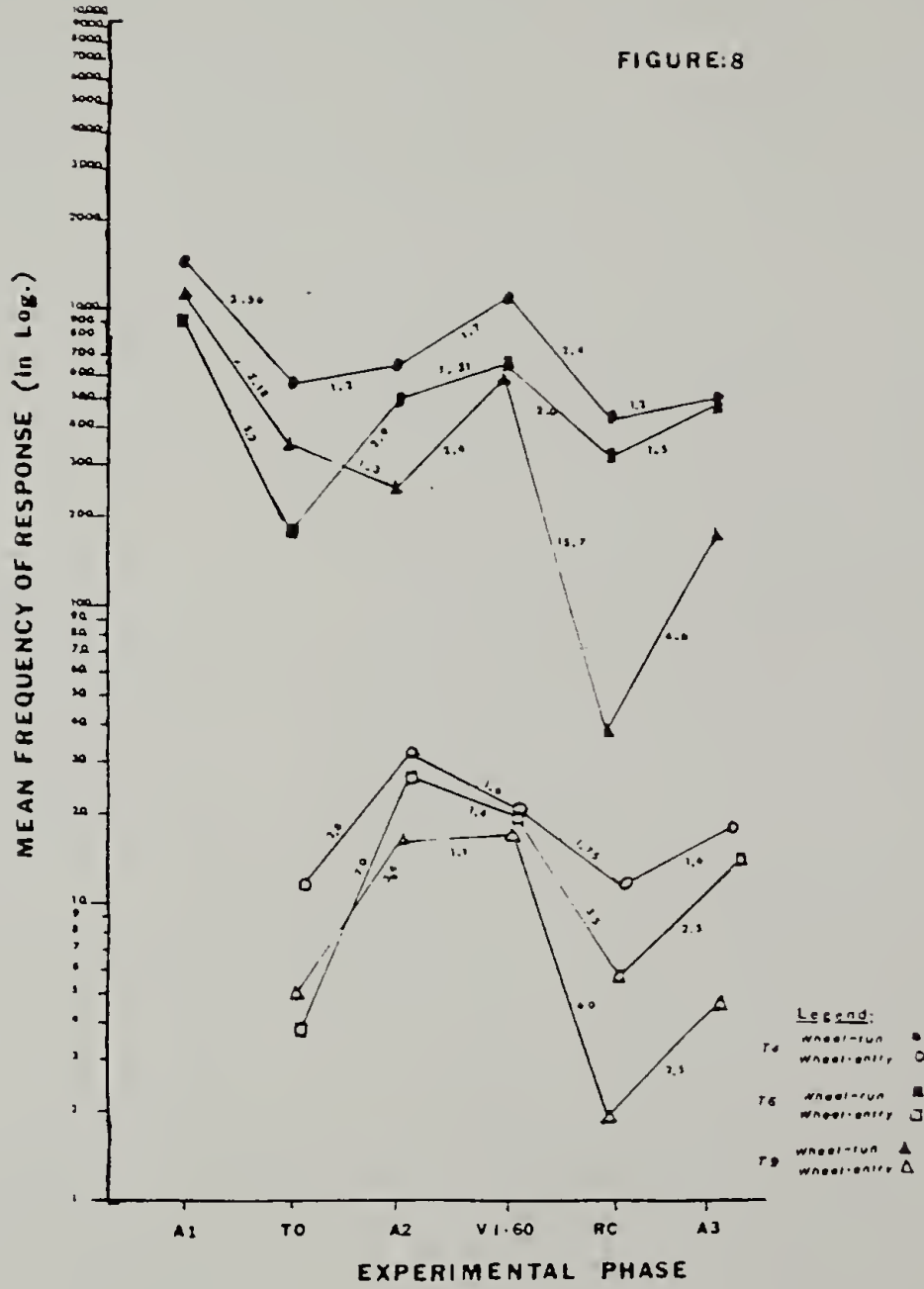
There is a substantial reduction in the rate of entries during T0, although not as great as during RC for R8 and R10. Inspection of Figures 3 and 4 shows no overlap in the dispersion around these means. Inspection of Figure 2 shows the mean entry rates for T0 and RC to be within the same range. Recovered rate of entry during A3 is equivalent to the rates obtained in A2. The obtained ratios are approximately equivalent to those obtained during suppression by T0.

Effect on Wheel Running: Timeout-Response Cost Sequence

Figure 8 shows the mean rate of half-revolutions and wheel-entries for animals in the T sequence. An inspection of Figure 8 shows the rate of half-revolutions for all three animals to be substantially suppressed during the T0 phase. T4 showed minimal recovery (ratio = 1.2) and an inspection of Figure 9 shows substantial overlap in running rate during the A2 and T0 phases. T6 recovered substantially and Figure 10 shows no overlap in the dispersion around these means. T9 suppressed half-revolutions in A2 below the rate obtained in T0 and Figure 11 shows no overlap in these dispersions.

All animals evidenced an increase in wheel-running in VI-60" above the rates obtained in T0 and, with the possible exception of T6, the rate was also appreciably higher than observed during A2. T4 (see Figure 9) and T9 (see Figure 11) clearly have elevated rates during the VI-60" phase.

Figure 8. The mean rate of wheel-running and entries by experimental phase for the subjects receiving timeout first.



Following VI-60" there was decreased running for all animals in the RC phase. For T9 this was most dramatic, falling clearly below the other means (see Figure 11). T4's rate during RC was well below the adjacent VI-60" mean and the A2 distribution and is also below, with slight overlap, the T0 distribution. An examination of the individual session data for T4 (see Figure 12) suggests that running did suppress more in RC than in T0. T4 showed approximately the same degree of recovery following RC as he had following T0. The rate of running was slightly less following RC than following T0. T6, however, obtained a higher mean rate of running in RC than in T0. Although an examination of Figure 10 shows a high degree of overlap, an inspection of the raw session data (Figure 13) suggests more suppression in T0 than in RC.

Returning to Figure 8, the rates of wheel-entry are now considered. The rates of wheel-entry showed equal suppression in both T0 and RC for T4. T6 evidenced slightly less entries in T0 than in RC, although there is a good deal of overlap in the distributions (see Figure 10). An inspection of the data from individual sessions (Figure 13) shows that there were fewer entries during T0. Alternatively, T9's entry rate during RC was clearly less than in T0. T4 and T6 both showed decreases in entries during the VI-60" phase as compared to the adjacent A2 phase. These were not as great as the suppression during the experimental phases, yet there was a clear change, not evidenced in the other four animals, due apparently to the reduction in food density alone.

In A3 all three animals recovered rates of entry lower than

Figure 9. The mean rate, by condition, of lever-pressing, running, licks per pellet, pellets and wheel-entries for T4.

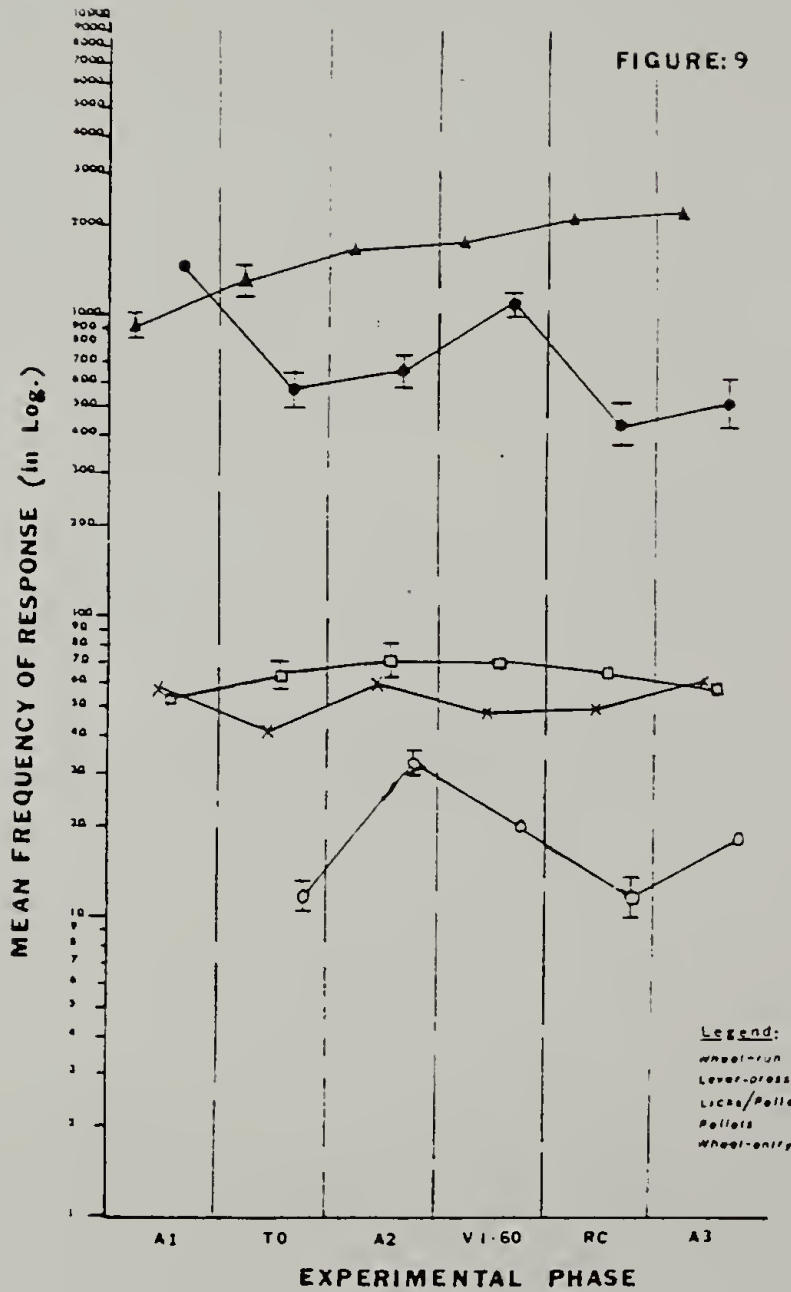


Figure 10. The mean rate, by condition, of lever-pressing, running, licks per pellet, pellets and wheel-entries for T6.

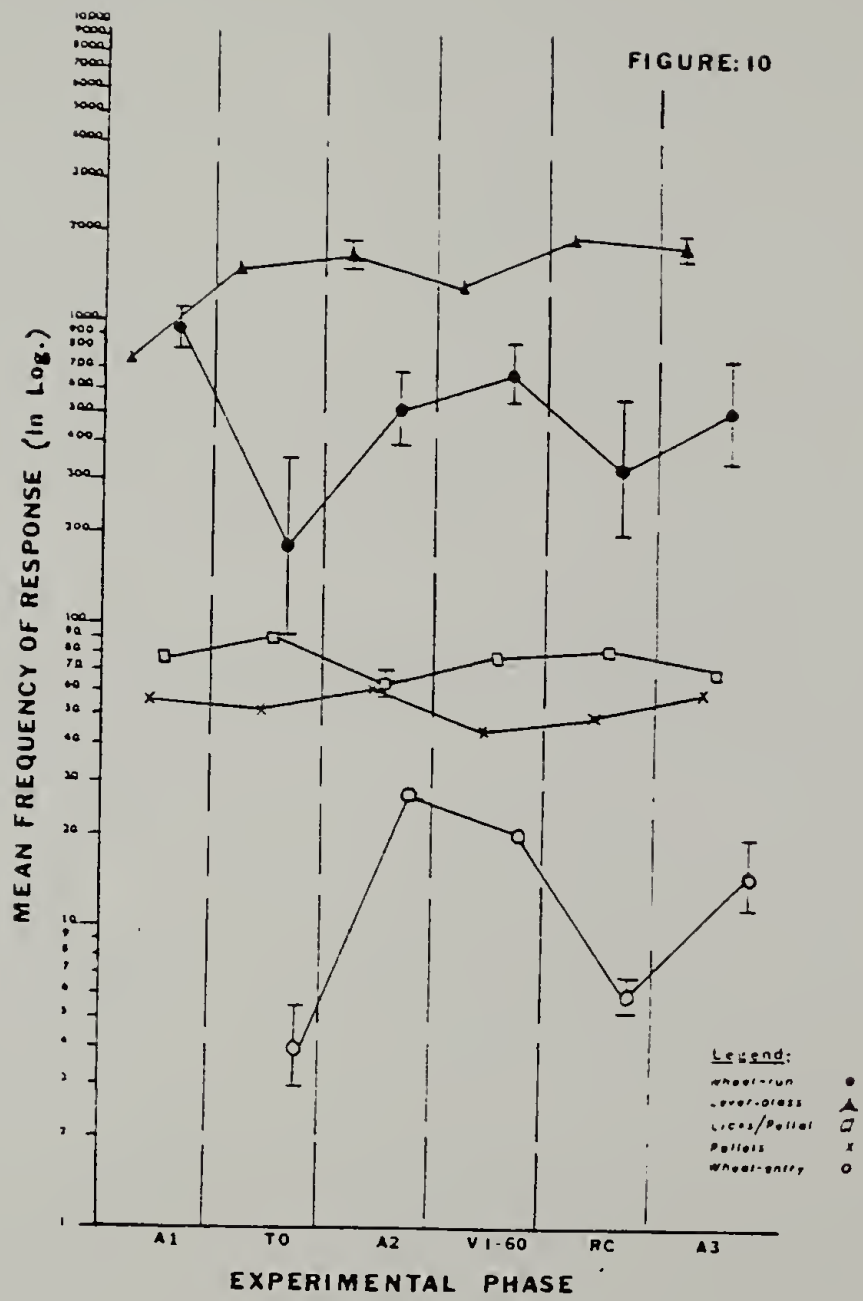


Figure 11. The mean rate, by condition, of lever-pressing, running, licks per pellet, pellets and wheel-entries for T9.

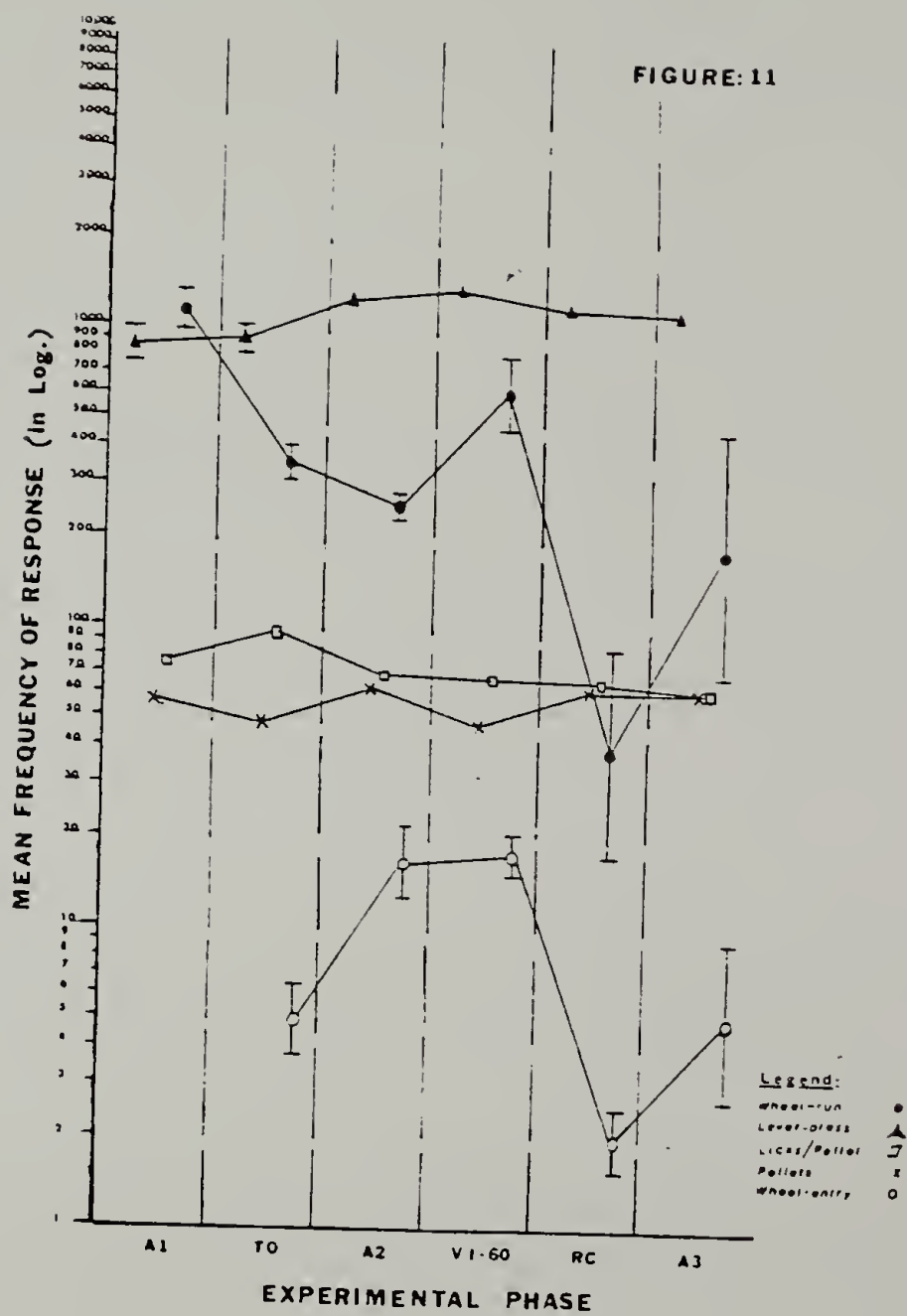


Figure 12. The rate of responding on all measured responses by session for T4.

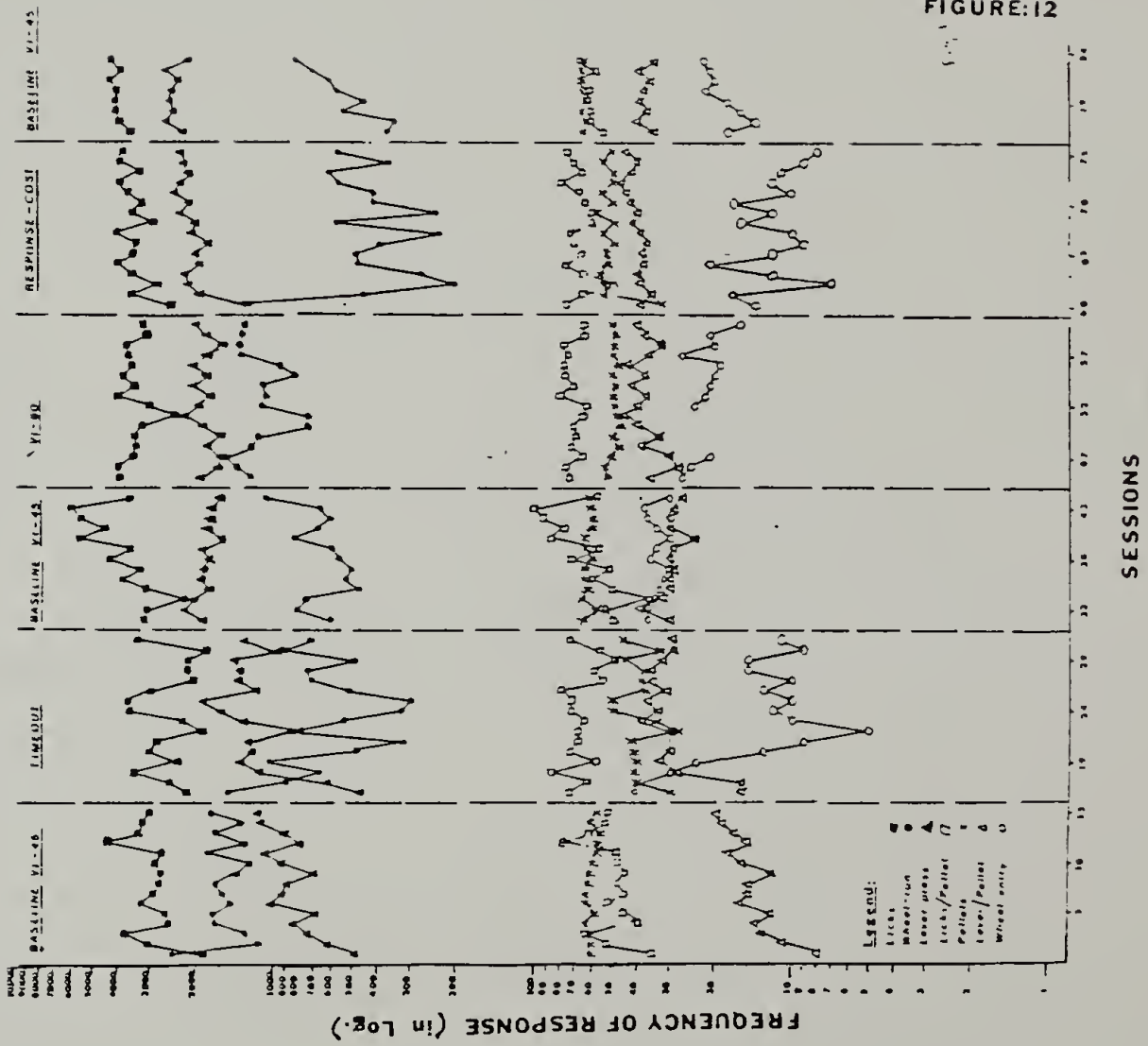


Figure 13. The rate of responding on all measured responses by session for T6.

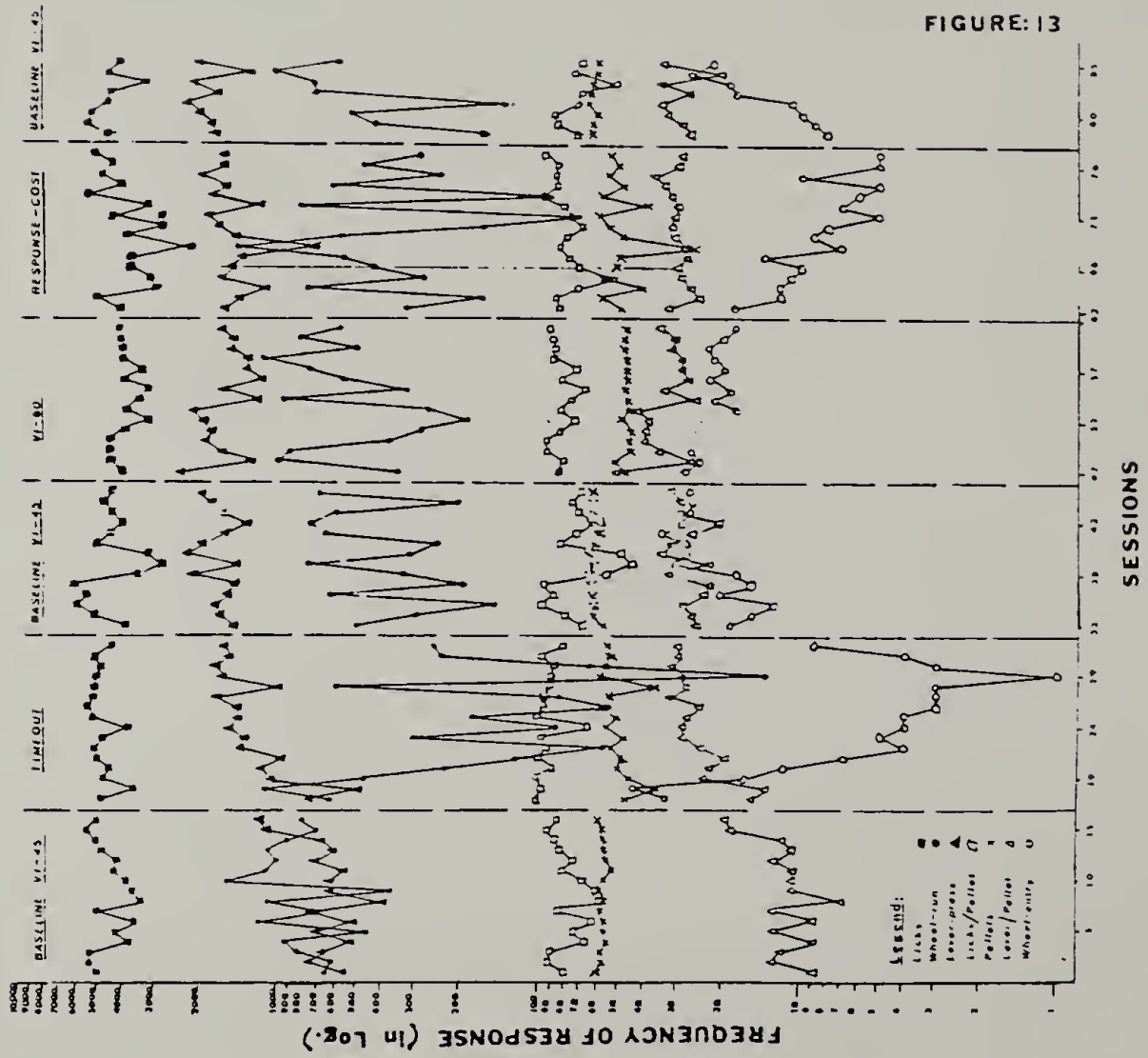
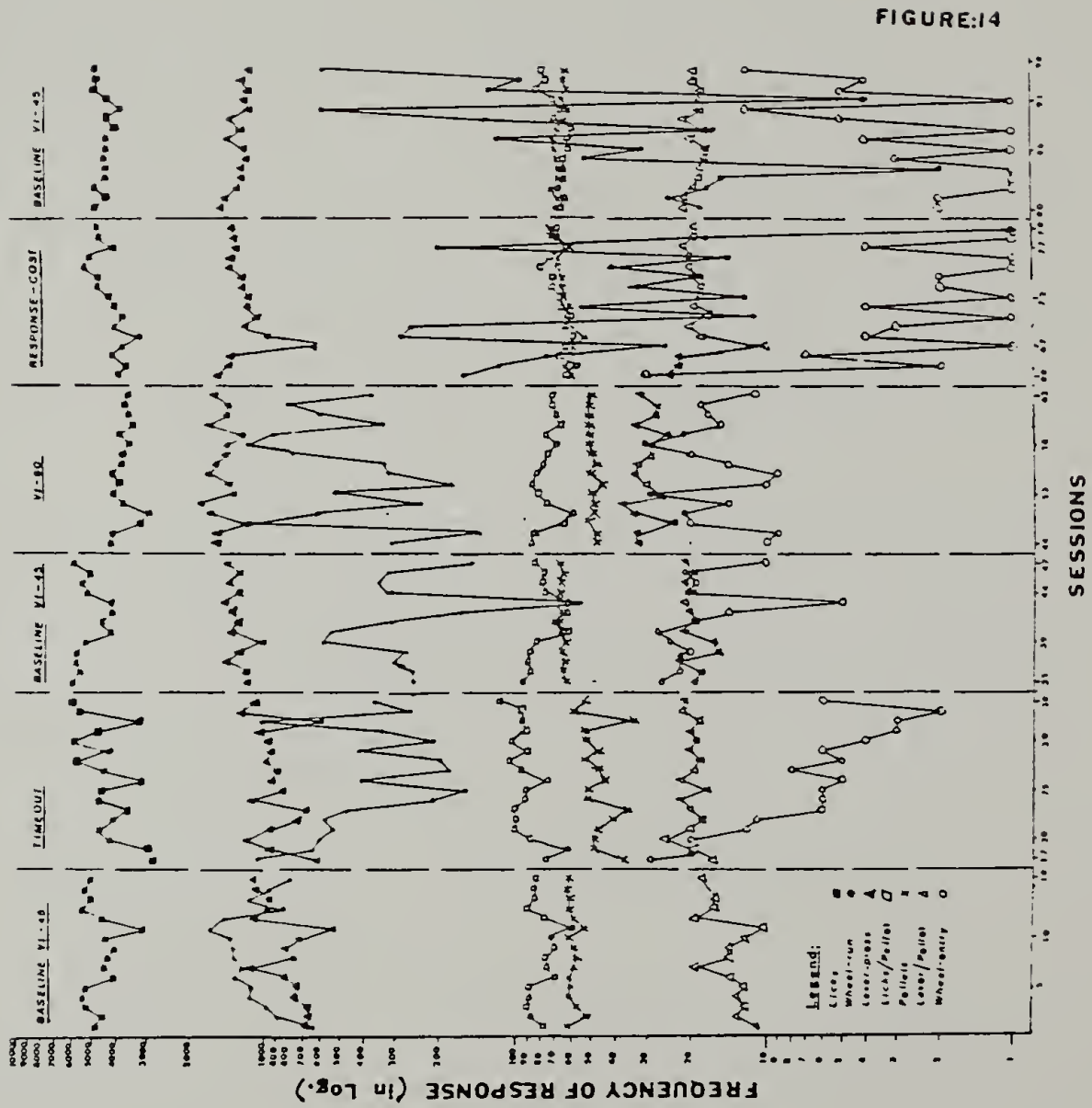


Figure 14. The rate of responding on all measured responses by session for T9.



those observed in A2 despite the variable degrees of suppression produced by the experimental procedures. An inspection of the raw session data shows that T6 (Figure 13) began to recover higher entry rates during A3 but these still were not as high as during A2 (following T0) and the rate of increase is much slower. T9 (Figure 14) shows very little recovery until well into the extended period of the A3 phase and even then the recovery is quite low.

Disruption of Running Rates

An inspection of the raw session data (Figures 5, 6, 7 and 12, 13, 14) suggests that one of the major effects of the experimental contingencies was to disrupt the stability of wheel-running. This is shown in Figures 2, 3, 4 and 9, 10, 11 by comparing the degree of variability represented by the absolute mean ratios for wheel-running during the experimental phases to the A1 baseline; also by comparing the variability of both wheel and entry rate to that obtained in the other responses.

Summary of Frequency and Rate of Running Results

All subjects showed decreased entries when either T0 or RC was imposed. Three animals showed greater suppression during the RC phase than during the T0 phase (T9, R8, R10). Two animals showed equal suppression during both phases (T4, R1), and one animal (T6) showed greater suppression in the T0 phase.

When RC preceded T0 equal recovery was observed for all animals

in the subsequent baseline phases, despite differences in suppression. When T0 preceded RC, less recovery was observed in the baseline phase following RC, again regardless of differences in suppression. These results (see Figure 15) suggest that RC produced differential effects in permanently suppressing frequency when it followed T0. T0, however, produced no differential effects when it followed RC in maintaining permanent reductions in frequency, regardless of which procedure produced greater suppression when it was actually imposed. All animals showed suppression of rate when the contingency was imposed and all but one animal showed permanent suppression of rate when the contingency was removed.

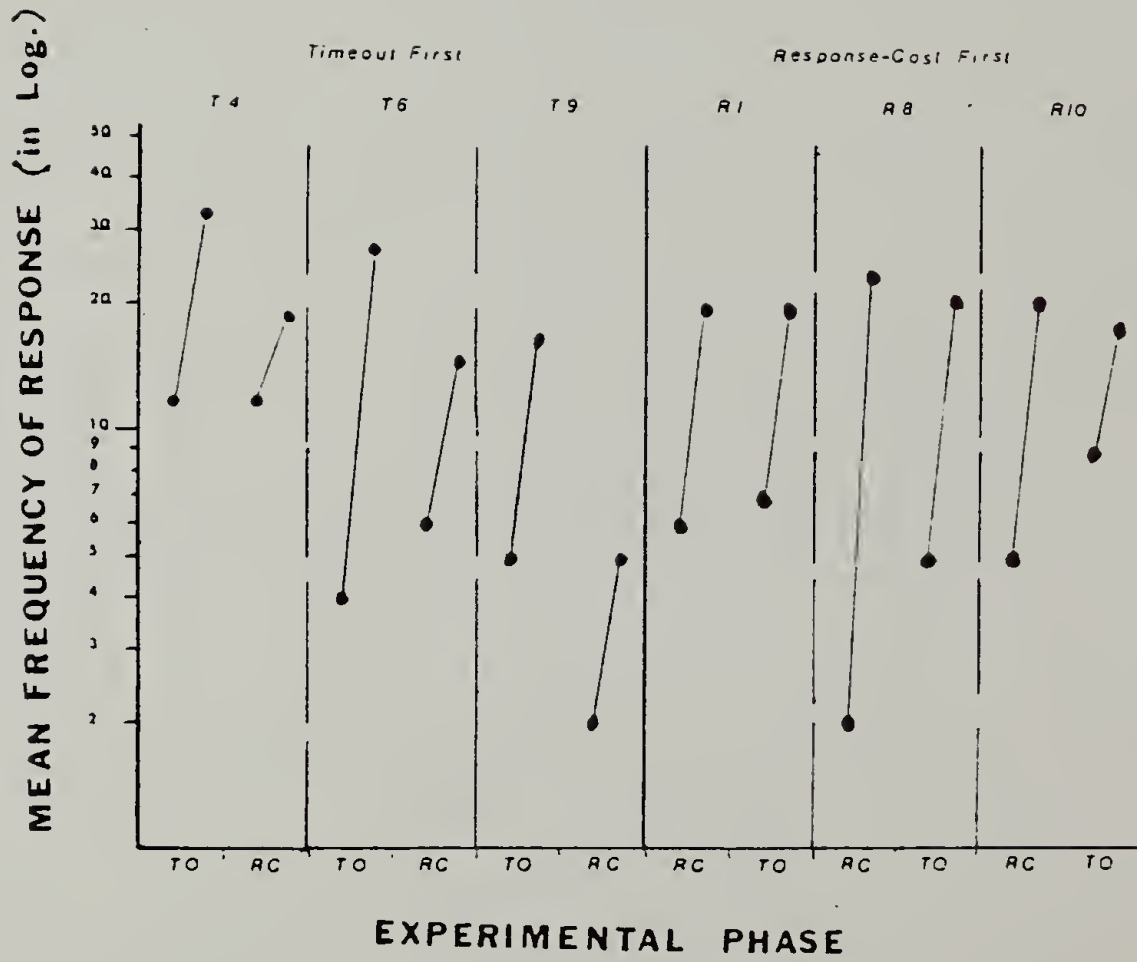
Four animals showed greater suppression of wheel rate during RC (T4, T9, R8, R10). One animal (R1) showed equal suppression and one animal (T6) showed greater suppression during T0. Two animals (T9, R1) suppressed wheel-rate in A2 when the contingency was no longer in effect, below the rate obtained in the first experimental phase. Only one animal (R8) recovered and exceeded, during A2, the rate of running observed during A1.

Adjunctive Effects

The negative punishment procedures imposed in this experiment directly affected entry rate and only indirectly affected the rate of half-revolutions. Entries can be construed as a measure of the frequency of wheel-running and half-revolutions (rate) may be better construed as a measure of "intensity." It may be argued that changes in rate, in this instance, are more likely an adjunctive effect given that

Figure 15. The rate of wheel-entry recovery for all subjects. Graph shows mean entry rate during each procedure and the baseline phase immediately following.

FIGURE:15



rate is not directly contacted by the contingency. It is more likely that these changes are induced or elicited as an indirect effect of the procedures.

The two adjunctive responses to be considered here are the rate of licking and the rate (intensity) of wheel-running. Biting did not occur frequently enough to be considered as a valid datum.

Figure 16 shows the mean frequency of licks per pellet, pellets per session, and mean half-revolutions per entry to the wheel for the final eight sessions of each phase for the animals in the R sequence. Figure 17 shows the same measures for the animals in the T sequence.

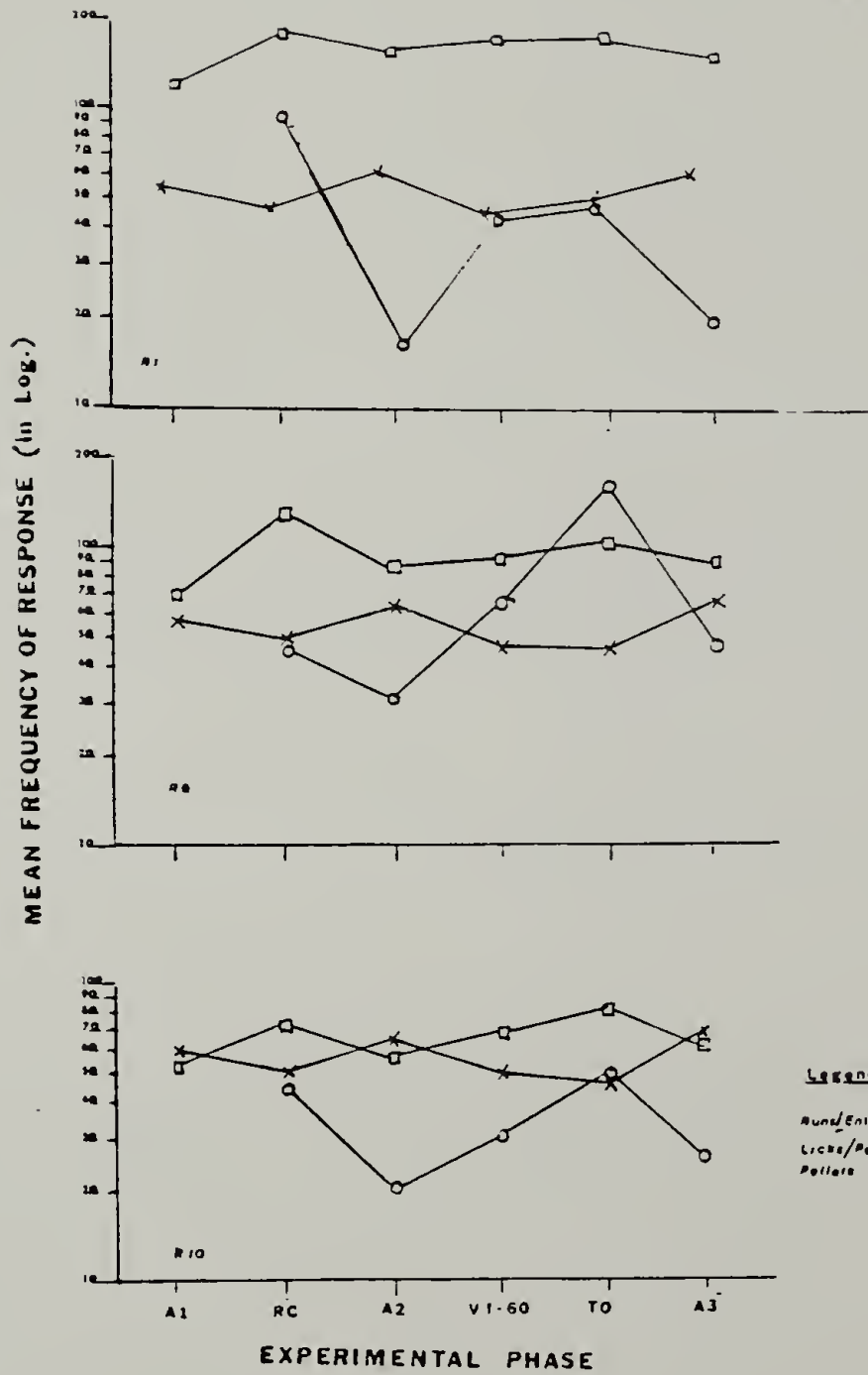
Generally, all animals showed some adjunctive effect when the contingencies were imposed. These were clearly changes in either the licking rate or the wheel-rate. To some degree these were affected by the overall pellet rate (note data from VI-60" phases), but there was also a substantial effect due to the contingencies alone. The animals varied greatly in terms of differential effects on each response, and by each procedure. As such, the two adjunctive measures will be considered separately and each animal's performance described.

Licking

The three R sequence animals evidenced an increase in licks per pellet during response cost as compared to the A1 baseline (see Figure 16). During A2, only R10 reduced licking to approximately A1 levels. The other two animals reduced to a point about halfway between their A1 and RC rates. For R1 this change is minimal. During the VI-60" phase, R1 and R8 showed minimal increases, while R10's rate increased

Figure 16. The mean rate of licks per pellet, pellets, and mean rate of running per entry for the subjects receiving response-cost first.

FIGURE:16



substantially.

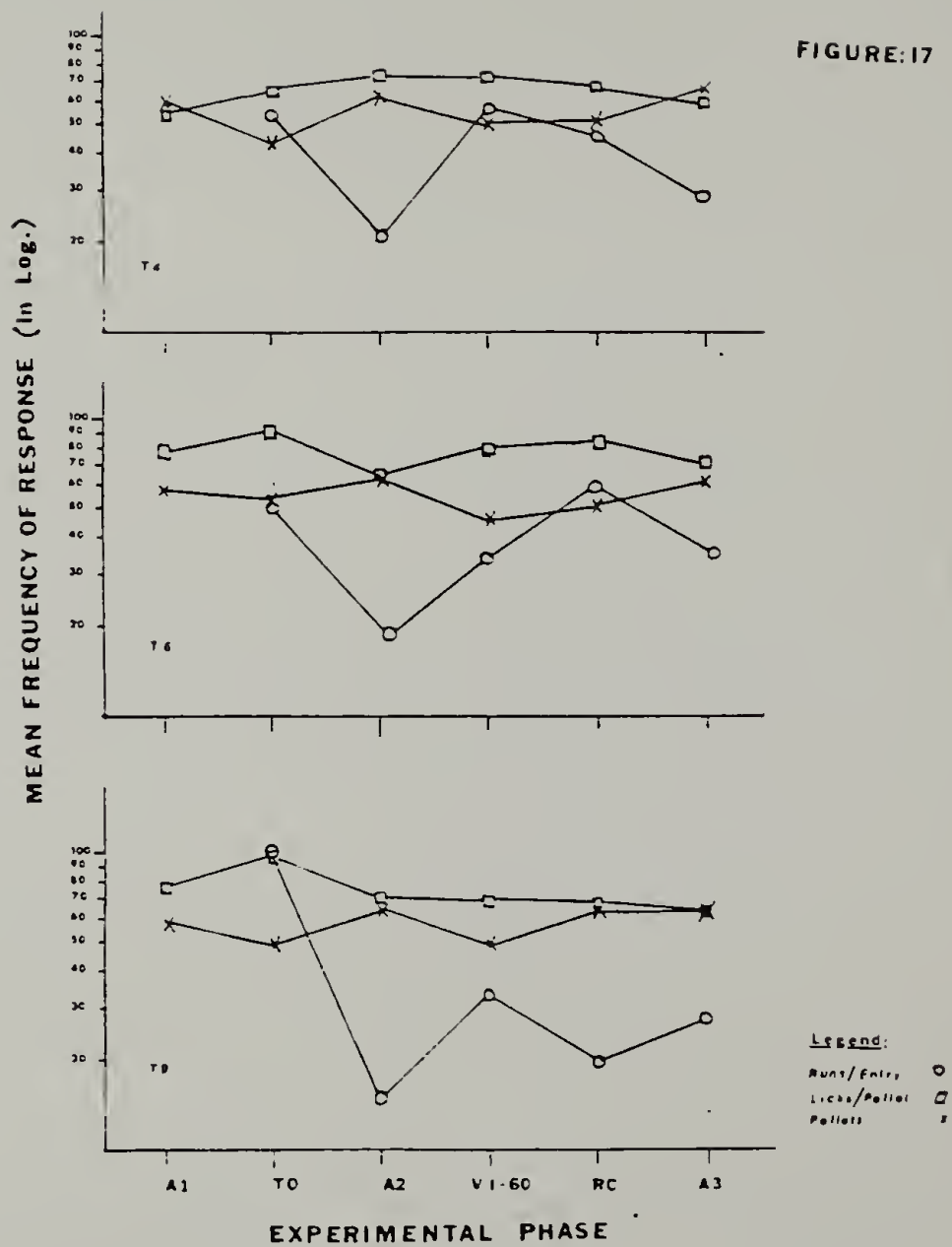
In the T0 phase, R1 and R8 again evidenced minimal increases. In the case of R1, VI-60" and T0 rates are approximately the same and only slightly higher than those in the A2 phase. T8 shows more differentiation from phase to phase, with the T0 rate slightly higher than the VI-60" rate, which is itself only slightly higher than the A2 rate. R10 shows the same pattern as R8, with the differences from condition to condition more pronounced. Additionally, R10's T0 rate of licking is higher than his RC rate. For R1, the lick rates during T0 and RC, as well as VI-60", are equal. R8's RC rate is higher than the T0 rate. All three animals show some reduction in licking rate during A3 but none return to the A1 rates.

All three animals in the T sequence showed an increase in licking rates during T0 (see Figure 17). During A2, T6 and T9 reduced their rate of licking to approximately the same rate as in A1. T4's licking rate increased beyond T0 rates in the A2 phase. T4 emitted the same rate of drinking during the A2, VI-60", and RC phases, dropping only slightly during A3. T9 showed no change in licking rate throughout A2, VI-60", RC and A3, these rates being approximately equal to those obtained in A1. T6 showed a slight increase in licking during VI-60", again increasing slightly during RC and finally reducing slightly in A3.

Summary of Licking Results

Generally, the rate of licking increased when the contingency was encountered. Three animals showed no difference in licking rates

Figure 17. The mean rate of licks per pellet, pellets, and mean rate of running per entry for the subjects receiving timeout first.



in the two punishment phases (two T, one R). Two animals showed slightly higher licking rates during T0 (one from each sequence), and one animal (R sequence) licked more in RC. Five animals showed differential increases in the licking rate during VI-60".

An inspection of the pellet rates during each phase suggests that some of the variation in licking rate may be accounted for by changes in pellet rate. In all but the VI-60" phase, the number of pellets obtained depended closely on the behavior of the animal. Either the pattern of lever-pressing or, in punishment phases, the running frequency determined the overall frequency of pellets. During VI-60" the rate of pellets was determined by the experimenter through a change of the average minimum inter-pellet-interval from 45secs to 60secs. This resulted in a decrease in pellet availability from a maximum of 67 to a maximum of 50 per session. Thus elevations in licking during the VI-60" phase would be due solely to an experimenter-contrived reduction in pellet rate independent of a direct effect by the contingency. It can be seen in Figures 16 and 17 that, with the exception of T9, a substantial proportion of the elevation in drinking might be an effect of the pellet density alone.

Running Intensity

Figure 16 shows the results on half-revolutions-per-entry (rate) obtained from the R animals. R1's run-per-entry rate is much higher in RC than A2. VI-60" and T0 rates are approximately equal and both are substantially higher than A2 and A3, respectively. The RC rate is substantially different from the VI-60" rates (using A2 as a

reference point), suggesting that there is some effect of the RC contingency on intensity above and beyond the effect of pellet rate, which is not substantially different from phase to phase.

Conversely, R8's RC rate is lower than that obtained from VI-60" (using A2 as a reference point), whereas the rate obtained in T0 is substantially higher than that of VI-60". Again these differences do not seem to be related to overall pellet rate. Note, however, that R8's lick rate was elevated in RC and remained unchanged in T0, suggesting that different response systems were similarly affected by the two procedures. R10 shows approximately equal rates in T0 and RC, and both rates are substantially higher than those obtained in VI-60".

Approximately the same rates were obtained from T4 in T0, VI-60", and RC (see Figure 17). These seem to be more proportional with the overall pellet rates. Note, however, that for this animal the lick rates are not consistent with the pellet rate. From T6, slightly higher rates are obtained in RC than T0; both of these are elevated in comparison to VI-60". These effects are not proportional to the pellet rates.

The rate of running-per-entry during T0 was much higher for T9 than the rate obtained in either VI-60" or RC. VI-60" rate was elevated compared to RC. All three animals in this sequence evidenced higher A3 rates than A2; in the case of T6 and T9, the A3 rate was equal to that obtained in VI-60".

Summary of Running Intensity

Five animals showed differential effects on running intensity during one of the two experimental procedures, beyond that accountable to reduction of pellet frequency alone. T6 and R10 showed differential effects over VI-60" in both RC and T0, whereas T4 rates were approximately equal in all T0, RC and VI-60". Two animals showed higher running intensity in T0 (R8, T9). Two animals showed higher intensity in RC (R1, T6). Two animals showed equal intensities during T0 and RC (R10, T4).

In general, all animals showed some differential effects on either licking or wheel-rate or both when either of the contingencies were encountered. These effects varied from animal to animal and no differential effects may be clearly attributed to either of the two procedures. It is clear, however, that Negative Punishment contingencies alone account for substantial elevation in adjunctive responding.

Effects on Lever Pressing

Figure 18 shows the relations between lever-pressing and wheel-running for the R sequence animals. Figure 19 shows the same comparisons for the T sequence animals. Lever-presses required to exit from RC are not included in these data.

There is a collateral effect on the lever-pressing rate throughout the experiment. Generally, this takes the form of an inverse relationship between the lever-rate and the wheel-rate. It will

Figure 18. The mean rate of lever-pressing and wheel-running by condition for the subjects receiving response-cost first.

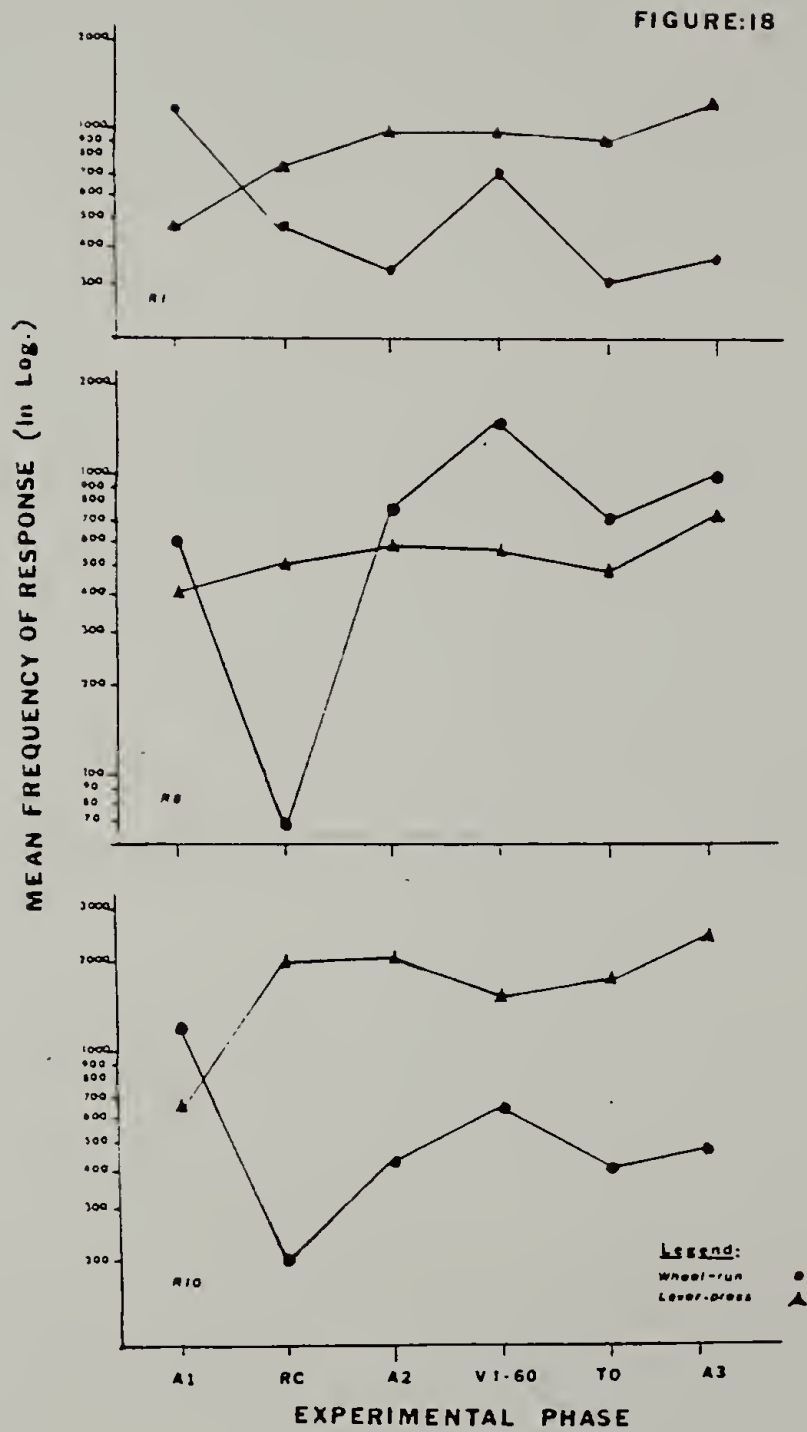
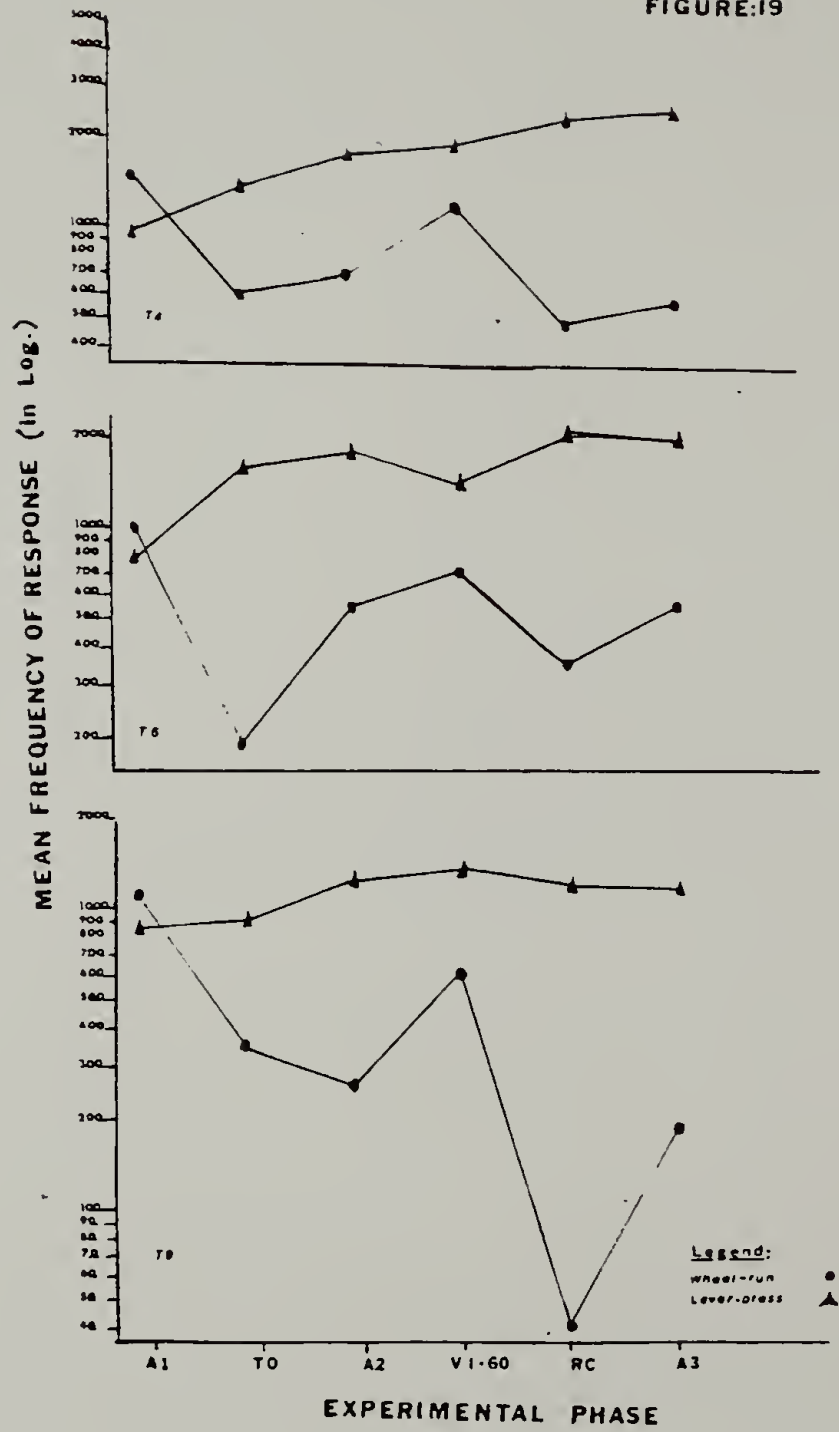


Figure 19. The mean rate of lever-pressing and wheel-running by condition for the subjects receiving timeout first.

FIGURE:19



be recalled that there was a general increase in pellet rate from the A1 baseline to A2 baseline and, in some cases, again in the A3 baseline. There is every indication that an indirect effect of the punishment contingencies is that they produced a change in the lever-press rate. This increase might have been maintained by an increased pellet rate, and decreased Inter-Pellet-Interval. It is interesting to note that collateral with this increase in lever-pressing is a generally reduced wheel-running rate in A2 compared to A1, the one exception being T8 who shows an increased A2 rate and also shows the least change in lever-pressing rate.

Observations

As was noted earlier, the animals established a pattern of eating and drinking such that these two might almost be seen as a unitary response. Clearly consuming a pellet reliably elicited drinking. Changes in the licking rate during punishment phases consisted in longer post-pellet drinking bouts. The number of licks emitted while the animal was actually in punishment (food unavailable) were minimal and are not figured in the data as presented here.

Running during baseline usually occurred during the longer IPIs programmed on the VI schedule. These might be seen as a way of breaking up or even "escaping" from the long IPIs.

During punishment the animals tended to still enter the running wheel, although they did not run. In some instances they would run into the wheel and then immediately out again. Other times they might briefly sit in the bottom of the wheel. In some cases the animals

would run partway up the wheel in the direction opposite from that in which they ran. This would lock the wheel against the ratchet such that it would not revolve. Occasionally, they would run against the ratchet with sufficient intensity to reach the top of the wheel, at which time they would flip over, landing at the front of the wheel. In this way they managed to run the wheel backward while not causing the wheel to revolve. This never occurred more than once at a time and rarely more than once per session.

During punishment the animals tended to lever-press more persistently during the longer IPIs; that is, they continued to press when previously they might have run in the wheel. This increased the likelihood of obtaining a pellet as soon as one was available.

Additionally, following the discontinuation of punishment (either extension of the lever in TO or offset of the noise in RC) the animals often emitted rapid bursts of lever-presses. Intermittently, these bursts were followed by delivery of a pellet.

Sequence Effects

The sequence in which the animals were exposed to the two punishment procedures did not seem to have much of an effect on performance in the two conditions. In general the reported effects were consistent regardless of the position a particular procedure had in the sequence.

The one effect that did seem to occur due to sequencing is the average time spent in the punishment contingency. All but one animal spent less time-per-entry in punishment in the second punishment phase

regardless of the contingency. For the R sequence animals, the mean number of seconds-per-entry was 128 in RC and 121 in T0. For the T sequence animals, the mean number of seconds-per-entry was 95 in T0 and 60 in RC. R8 was the only exception, with 141 sec in RC and 174 in T0. R8 also showed virtually no suppression of wheel-running in T0.

Generally there seems to be no relation between the time spent in the punishment contingency (no food available) on suppression of wheel-running or wheel-entry, or any of the other measured responses.

C H A P T E R I V

DISCUSSION

This experiment was originally planned to achieve two goals. The first of these goals was to investigate the phenomenon of Negative Punishment and to evaluate two commonly used procedures, based in Negative Punishment, in terms of their immediate and long-term effectiveness and their effect on other behavior occurring in the same situation. The second goal was the validation of a multi-operant method for the investigation of more complex behavioral interactions and the elaboration of more complete accounts of behavior.

Systemic Contingency Effects

These data clearly show that when either a response-cost or timeout contingency was imposed on behavior or some aspect of behavior a direct suppressive effect was obtained in that behavior. It is also clear that when these procedures were imposed there was an effect obtained in all other behavior occurring and measured in that situation. It is these collateral effects which may be most important in understanding the process of Negative Punishment.

The data here obtained suggest that Negative Punishment effects may consist in two components. One is the effect of the contingency itself, and the second is the indirect effect on overall reinforcer density occurring in the setting. Leitenberg (1965) addressed this

distinction when he argued that the reduction in behavior observed in timeout might be partly the result of the subject's ability to earn more reinforcers by not emitting the target response.

The data from this experiment suggest that reduction in pellet density alone has little effect on the frequency (number of entries) of running and may actually increase the intensity (rate of running per entry) of running. Increases in pellet density seem to correlate with the maintenance of reduced running after the contingency has been removed.

What is not known is the effect on running rate which would be obtained by increasing the reinforcer density available to lever-pressing. It is possible that simply increasing the rate of reinforcement for lever-pressing (an alternative response) would produce some reduction in wheel-running.

A sustained reduction in the A2 and A3 phase, on both running frequency and running rate, was obtained in all but one animal. This was collateral with an increase in the overall pellet density and a sustained increase in the rate of lever pressing throughout the experiment. This could be seen as evidence that reinforcement of "other behavior" occurred. In this study the effect was not specifically programmed by the experimenter, occurring instead as a side-effect of the contingencies which were imposed on wheel-running. It would be interesting to see what effect on wheel-running would be obtained if the experimental contingencies were imposed on the lever. It is interesting to note that the one animal (R8) whose A2 and A3 running exceeded A1 levels is also the animal to show the least change in both

pellet and lever-press frequency in those phases.

The mechanics of this might be that the T0 and RC contingencies, when imposed, created a condition in which different patterns of lever-pressing were acquired. These changes in lever-pressing, if they produced greater reinforcer densities, were maintained even when the contingencies were removed.

During the punishment phases lever-pressing could be seen to be programmed on multiple schedules. Multiple schedules are compound schedules where two component schedules occur in alternation, usually accompanied by a stimulus change (Catania, 1979). In the T0 phase a Mult VI Timeout schedule would be in effect (the stimulus change being the lever extension) and the RC phase would effectively consist in a Mult VI VR stimulus change schedule.

Multiple schedules of this sort have been shown to produce contrast effects (Reynolds, 1961). Contrast is the increase or decrease in response rate beyond that which is expected from the reinforcer frequency when the components change in a compound schedule. It may be seen as an "overshooting" (or undershooting) of the response rate normally obtained with the particular schedule in effect.

Marcucella and MacDonald (1977) have shown that Positive Contrast (an increase in responding at the onset of the higher density schedule) consists in more rapid bursts of responding than is normally obtained, and that these bursts might be selectively reinforced by the increased reinforcer frequency (responses emitted this quickly might be more likely to result in pellet delivery and hence might tend to re-occur). Marcucella and MacDonald (1977) argue that these bursts of

responding might be seen as an "emotional" reaction to the reintroduction of the high-density schedule.

This description might be seen to apply to the changes obtained in lever-pressing in the present experiment. There was evidence of high rate lever-pressing immediately following termination of the punishment contingencies. These high-rate bursts were more likely to encounter reinforcement on the VI-45 schedule, resulting both in more rapid as well as more persistent lever-pressing. This in turn would result in delivery of pellets more immediately following their availability, eventually resulting in a higher overall pellet density. Collaterally, a suppressive effect on wheel-running might have been a side effect of this process. There was a ceiling effect, however, in this experiment such that there was little opportunity for increasing pellet density substantially over A1 rates.

The contrast effect might not have been obtained had the animals been earning the maximum number of pellets available in A1. It is serendipitous that this relation was observed. A more gradual "stretching" of the VI schedule during acquisition might have reinforced more persistent lever-pressing during the longer intervals programmed on the VI-45" schedule. This alone might possibly have produced a lower A1 rate of running. Fortunately, this was not the case, or this relation between running and pressing might not have emerged in later phases.

It was clear that the onset of the negative punishment procedures created a disruption in the baseline distribution of wheel-running such that substantial variability in both the frequency and

intensity of running emerged as a stable effect.

This unstable rate of running is similar to that obtained in some negative reinforcement (avoidance) procedures. In these procedures the rate of lever-pressed emitted to avoid or delay shock and the shock frequency itself show substantial fluctuation. We may see the wheel-running data as showing the inverse of this. That is, omitting wheel-running (emitting an other response) avoids the termination of reinforcer delivery. Thus, the omission of the response is the "avoidance response" and this and the concomittant pellet rate fluctuate substantially. One of the findings of avoidance research has been that these procedures tend to elicit such behavior as aggression, which will not postpone shock, and avoidance and escape from the situation itself. The nature of this "unauthorized" avoidance can often not be controlled or even predicted. The best that can be attained is the minimization of the conditions of their occurrence (Hineline, 1977). In form, these behaviors are often termed counter-control (Skinner, 1953), and in clinical settings often take the form of "passive-aggressive resistance." An example of this occurred in this experiment. During the experimental phases, when the contingency was in effect, animals were observed to run the wheel backward against the ratchet such that the wheel did not actually revolve. One could almost imagine the little fellows saying (if they could talk!) in an ingenuous and yet insolent voice: "But you said not to revolve the wheel, you didn't say anything about running in it. I didn't revolve the wheel so you can't punish me." In negative reinforcement one needs to be very precise in defining the specifications of the contingency or unauthorized

avoidance may occur. Negative punishment seems to be similar in form, but opposite in direction, to negative reinforcement, and it would seem that this specificity requirement would be parallel as well. This is further evidenced by the differential effect on wheel entry and intensity by these procedures. As the contingency only directly contacted entries, overall rate of running freely varied.

This analysis, if correct, would require us to consider the effect of the experimental procedures as disrupting the established distribution of responses such that the distribution of the other responses changed. If this latter change was differentially reinforced, then the distribution of the target response in turn was changed. The question is whether this disruption is necessary in order for new learning to take place.

It has been suggested that a discrepancy in the occurrence of reinforcing (or punishing) events in the environment is necessary for the acquisition of new responses or modifications to previously acquired responses in classical conditioning (Rescorla, 1969) and in operant conditioning (Donahoe, 1977). It is possible that some portion of the effectiveness of negative punishment procedures is due to the discrepant environmental conditions created by those procedures. If this is the case, the disruption of responding reported here would have resulted from the reorganization of the animals' behavior patterns in adapting to the new environmental conditions.

Given these findings, it is likely that the direct effect of the Negative Punishment contingencies is to disrupt existing response patterns by creating discrepancies in the environment; that is, in the

local reinforcer density and distribution. It is also possible that this indirectly effects subsequent permanent change in the response distributions on the occasion when these changes result in enduring changes in local environmental influences.

It might be argued that the clinical usefulness of these procedures is in making more discriminable previously indiscriminated sources of reinforcement, but that the effectiveness of these procedures depends on the availability of increased reinforcement available for concurrently occurring behavior. If this is the case, procedures like timeout and response-cost ought not to stand independently as behavior change procedures. They should be implemented in conjunction with other techniques designed to facilitate the extension or acquisition of more effective behavioral repertoires such as proposed by Goldiamond (1974).

Immediate and Long-Term Effects

RC tended to produce slightly more suppression in both wheel-entries and overall running rate, as well as less recovery of running in subsequent baseline phases. This makes some sense when one considers that in RC both the withdrawal and reintroduction of reinforcer delivery was directly response dependent. In TO only the withdrawal of reinforcer delivery is directly response dependent, the criterion for reintroduction of reinforcer delivery being arbitrarily set by the experimenter.

It might also be argued that VI-60" was the other pole of this dimension of response dependence/independence. In this phase neither

withdrawal nor reintroduction of pellet delivery was response dependent and yet approximately seventeen pellets were withdrawn during each session by the experimenter's manipulation of the schedule.

Thus, we might expect that in the RC procedure the conditions governing maximization of pellet density might be more discriminable to the animal given that its behavior directly controls both the termination and presentation of pellets.

Unfortunately, there is no direct evidence to substantiate these interpretations. Rather, they are possible explanations derived from evidence which is, at best, circumstantial.

Adjunctive Responding

Both procedures produced elevations in adjunctive responding that are not completely accounted for by co-variation of the pellet density. Differential effects were noted in both licking and wheel-run intensity. These findings are problematic. The effect of the pellet density on both licking and wheel intensity is clear. What is not clear is the differential effects produced during the experimental contingencies which are not accounted for by the reduction in pellets. There clearly was some effect on these responses exercised by the contingency alone. These effects, though occurring in all subjects, occur inconsistently and are not predictable simply from the contingencies as imposed.

What is clear is that there were regular changes in some other concurrently occurring activity when the contingencies were imposed. That the specific changes varied among the animals perhaps owes to the

fact that this experiment did not impose constraints on what response distributions were to change. Thus, the animals are telling us something about chance features of the environment which varied among the animals as well as their own histories with those chance features. We may say that different sequential dependencies emerged from these data. Unfortunately, we do not have access to the dependencies peculiar to each animal. Clearly, future work should take these dependencies into account, specifically measuring them and attempting to document the conditions of their emergence. This finding of variable effect is consistent with previous work in Negative Punishment, where variable and unsystematic side-effects have been reported.

These findings would seem to underscore the need for understanding the source of these effects and the development of techniques for anticipating and controlling them in applied settings. The differential experience of chance features of the environment is much more likely in applied settings where contingencies may not be imposed so precisely and where the subjects of the interventions have extensive learning histories which further interact with the direct effects of these procedures.

The situation where the frequency of a response is reduced and the intensity increased is one of direct concern to applied workers. Often situations are encountered where a contingency has been imposed and a reduction in frequency obtained, only to find that the intensity of the response has increased. This can be seen as a form of counter-control and is often referred to as "escalation." Manipulative behavior (complaining, cajoling) may be ignored and may decline in

frequency, only to re-emerge in the form of suicide threats, which will produce the effect complaint previously obtained. Aggressive behavior, when subjected to timeout or response-cost, may become less frequent, but when it is emitted it may be considerably more violent. This is analogous to the subject, in this experiment, who enters the wheel less frequently, but upon entry (and contact with the contingency) runs considerably more than in baseline.

A number of solutions are possible. One, and perhaps the most obvious, is the "more of the same" technique. In this, an additional or refined contingency is imposed directly on the escalation. For instance, the length of the timeout period or the response-cost requirement could vary according to the intensity of the emitted target response. This is analogous to "making the punishment fit the crime," and is more like positive punishment, where an aversive stimulus could be more precisely delivered following every response. The risk of side-effects, however, is likely to be substantial, as in positive punishment. One might speculate that this "escalation" by the therapist (or parent) might be likely to result in further escalation of counter-control by the subject (Watslawick et al., 1967; Skinner, 1953).

Another alternative suggested by the results of this study might be to minimize the conditions for this escalation by equating, or even increasing, the frequency of reinforcement relative to the frequency occurring prior to the onset of the contingency. This is suggested because a substantial effect on intensity was demonstrated to be accounted for by reduction in pellet density alone.

This raises an issue, and that is there seem to be two types of

adjunctive effect, one due directly to the contingency and one due to the pellet frequency, which is indirectly changed by the contingency.

Studies of the induction of adjunctive behavior have employed identical contingencies and have varied the parameters within that contingency. In these studies the magnitude, pattern, type, or frequency of reinforcers have been varied in positive reinforcement paradigms (cf. Christian, Schaeffer & King, 1976), shock parameters have been varied in punishment paradigms (cf. Hutchinson, 1977), and response-shock parameters have been varied in avoidance paradigms (cf. Hineline, 1977). It has been assumed that these effects are similar in kind. These data lead one to speculate that the type of contingency produces an effect separate from the schedule employed within that contingency, and that these effects interact in the procedures as we apply them.

The Status of Adjunctive Behavior

A larger issue as to how we may categorize adjunctive effects is implied here. Generally speaking, we have seen a variety of changes in activities not directly affected by the programmed contingencies. These have taken the form of changes in running intensity, which is best seen as elicited by the contingency, as well as drinking, which is normally elicited by pellet delivery, but which increases when the contingency is imposed. Contrast effects were produced in lever-pressing as the contingency on the wheel effectively changed the schedule on the lever from a simple VI to multiple schedule. These contrast effects were reinforced and maintained by changes in

reinforcer delivery, which was itself a side-effect of the contingencies.

It would seem that the contingencies affect more than the target behavior. We must conclude then that contrast effects and schedule-induced effects are not anomalies to behavioral effects, but rather that all behavior occurring in a situation is systemically affected by interventions at any point in the situation. An implication here is that the frame of reference of behavioral principles must be expanded to include these systemic effects as integral components.

Multi-Operant Methods

The multi-operant method employed in this study has yielded data which are complex and not easily interpreted. The procedures, and the processes through which they achieve their effects, have been revealed as complex and not easily conceptualized.

The analysis of behavior has proceeded through a process of methodological evolution. Starting with the transition from discrete trial to free-operant methods (Skinner, 1938), each refinement in method has produced concomittant expansion of the conceptual framework.

Thus there has been a progression from simple descriptions of relations between a reinforcing stimulus and a single response to the description of reinforcing relations between activities (Premack, 1959). The effect of different schedules operating concurrently on two discrete but topographically similar responses have expanded the framework of operant accounts by including choice, matching and maximizing (cf. deVilliers, 1977).

Studies of schedule and shock-induced behavior (cf. Staddon, 1977; Hutchinson, 1977) began to expand the scope of investigation to consider more than one response occurring in a given experimental setting. Other investigators (e.g., Dunham, 1972; Brethower & Reynolds, 1962) have looked at response interactions between members of different operant classes. There have been recent attempts to account for the complexities that these methods have revealed in more systematic and inclusive descriptive principles (Donahoe, 1977; Myerson & Miezin, 1980), and to begin to develop conceptual frameworks for providing multi-operant analyses (Rachlin, Kagel & Battalio, 1980).

A problem inherent in studying one operant at a time is that the principles yielded by this method of necessity describe a single organism doing one thing at a time. The principles thus derived become strained when they must be expanded to describe the organism doing more than one thing in a given setting.

The goal of the Behavior Analysis is to eventually be able to account for the complexity of behavior in the naturally occurring environment. What might be required is the synthesis of findings from diverse simple investigations into more complex unitary accounts, and the extension of these accounts into more and more complex methods which more closely approximate conditions in the "real world."

The data obtained from this experiment would seem to indicate that there are relations which may be more easily observed through the use of multi-operant methods. These data are complex, inconclusive and difficult to interpret. They are also provocative and perhaps a bit controversial. There are some who would argue that the value of an

experiment lies not in the answers which it provides but in the further questions it raises. This experiment seems to have raised some interesting, at least to me, questions.

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