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Punishment Correlations in a Multiple Schedule

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PUNISHMENT CORRELATIONS IN A MULTIPLE SCHEDULE

by

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ABSTRACT

Research indicates that punishment sometimes has discriminative as well as suppressive properties. The discriminative property of punishment usually has been exhibited by correlating punishment with positive reinforcement, then testing for facilitative effects of punishment on responding in the absence of positive reinforcement. In the present study, punishment was correlated with one or the other of the two components of a multiple fixed-ratio schedule after the discrimination based on differential frequency of reinforcement had been formed. The correlation of punishment with the components was reversed with the expectation that reversal of the correlations would reveal appropriate changes in responding in the newly punished component. Further tests were made of the presumed discriminative role of punishment by adding punishment to both schedule components during extinction. Punishment did suppress responding, although recovery of prepunishment response rate was observed in the high-frequency component of the multiple schedule as anticipated. However, evidence of a discriminative property of punishment was not obtained in any of the comparisons. Several explanations for the failure to find discriminative effects were considered. The most promising is an application of the Miller-Egger hypothesis to the effect that in a well-controlled multiple-schedule punishment is a redundant cue.

CHAPTER I

INTRODUCTION AND REVIEW OF THE LITERATURE

Historical Overview of Punishment

The first systematic statement concerning punishment was proposed by Thorndike in 1913. As Thorndike noted:

> Of several responses made to the same situation, those accompanied or closely followed by satisfaction to the animal will . . . . be more likely to recur; those which are accompanied or closely followed by discomfort to the animal will . . . have their connection with the situation weakened, so that, when it recurs, they will be less likely to occur. The greater the satisfaction or discomfort, the greater the strengthening or weakening of the bond (p. 244).

In advocating this view of punishment, Thorndike provided both associative and logical symmetry for his "law of effect" in that rewards stamp in S-R connections while punishments stamp out S-R connections. Thus, the reciprocal processes of punishment and reward could account for both response acquisition and dimunition. Based upon a series of later studies, Thorndike (1932) rejected the punishment half of his "law of effect" while maintaining the strengthening role of reward. He concluded that response dimunition following punishment is not due to weakened S-R associations, but rather that skeletal and emotional responses aroused by punishment successfully compete with the punished response and result in its attenuation.

Following Thorndike's restatement of the effect of punishment, several theorists followed him in asserting that the interference caused by emotional and skeletal responses could account for the varied effects of punishment. For example, Guthrie (1934) proposed that punished responses are conditioned to stimuli present at the time of punishment. Whether the response is weakened or strengthened depends upon its compatibility or incompatibility with the punished response. Conditioned skeletal responses that are incompatible with the punished response may also function to remove the subject from the source of aversive stimulation.

The importance of competing emotional responses aroused by punishment has been emphasized by several theorists. Skinner (1938) concluded that punishment establishes an emotional state which temporarily suppresses any behavior associated with it. This emotional state is conditionable to stimuli present at the time of punishment and can be reinstated by these stimuli at a later time. A similar position was maintained by Estes (1944). The competing emotional response hypothesis of Skinner and Estes was combined with a competing skeletal response hypothesis by Mowrer (1947, 1956) in order to provide a reinforcement theory of avoidance behavior. According to Mowrer, the motivational properties of fear can be conditioned to both response-produced and external (nonresponse-produced) stimuli. When fear is conditioned to response-produced stimuli the future occurrence of that response is blocked by aroused fear. Escape or avoidance behavior is reinforced by fear reduction and becomes more probable in the future. If fear is conditioned to external stimuli, fear reduction occurs when skeletal action removes the organism from these stimuli. The utility of Mowrer's avoidance approach has been affirmed by Solomon (1964).

The avoidance hypothesis proposed by Mowrer has been extended by Dinsmoor (1954, 1955) and Church (1963). Dinsmoor (1954), for example, states that " . . . the stimuli which come immediately before the punished responses are paired by the response itself with the ensuing punishment. By virtue of this pairing, they gain an aversive property in their own right" (p. 44). Thus, the punished response is part of a sequence of responses linked together by a series of discriminative or secondary reinforcing stimuli. Any behavior that is incompatible with a member of this response sequence and delays its completion will be reinforced and subsequently maintained by the elimination of the response-produced aversive stimuli.

In contrast to the avoidance aspects of punishment, Miller (1948) and Fowler and Miller (1963) have emphasized the escape aspects. Their approach is similar to that of Guthrie's competing response theory (1934) and this similarity is emphasized when they state that, " . . . the facilitation or inhibition of performance produced by punishment relates to the nature of the response which is elicited by shock and conditioned to the cues of the situation" (p. 804). Responses that are incompatible with the punished response will interfere, while responses that are compatible with the punished response will facilitate. Responses that are contiguous with punishment termination are reinforced by escape.

Although the great majority of theorists have emphasized punishment as a secondary or derivative process (e.g., competing skeletal responses; emotional responses) a recent review by Azrin and Holz (1966) takes the opposite view. Azrin and Holz (1966) view punishment as a fundamental behavioral process. They maintain that the most useful approach is that of describing the nature and degree of behavioral changes following punishment and identifying the independent variables preceding these changes. They state that other approaches prevent " . . . the investigator from focusing attention on the observable response reduction as a phenomenom that is of interest in its own right and not as an 'index' of some underlying process that defies direct measurement" (p. 436).

Suppressive Properties of Punishment

In contrast to the earlier investigations of punishment, current research has stressed the importance of determining the behavioral effects of punishment without postulating underlying causal factors. Within this framework, Azrin, Holz, and Hake (1963) investigated the suppressive effects of various frequencies of punishment upon VI 2 key peck behavior of the pigeon. In the VI 2 schedule, reinforcements were programmed according to a random series of intervals having a mean of 2 minutes. Following VI 2 training, punishment was administered according to the following series of fixed ratio schedules: FR 1, FR 100, FR 200, FR 300, FR 500, FR 1000. Following the introduction of punishment, responding was suppressed but gradually increased in rate until another punishment was delivered. With successive punishment deliveries a progressive reduction of the suppression was noted. When punishment was discontinued the rate increased until it exceeded the prepunishment rate, then returned to the prepunishment level. In addition, several differences were revealed between continuous and intermittent punishment. Continuous punishment produced suppression as long as it was maintained, while there was a recovery in rate during the time intermittent punishment was in effect. When continuous punishment was terminated, recovery occurred suddenly, but recovery from punishment was more gradual after termination of intermittent punishment. A temporary and immediate compensatory increase in responding occurred when continuous punishment was terminated, but was not observed following the termination of the intermittent punishment schedules.

Many of the punishment and recovery effects described by Azrin, Holz, and Hake (1963) have also been observed within the context of more complex maintenance schedules. Rachlin (1966) reported a series of studies of the long-term effects of punishment in a multiple schedule of positive reinforcement. Two phases of the suppressive effect were found: a strong temporary emotional aspect and a permanent instrumental aspect. In the first experiment pigeons were trained with a multiple variable interval reinforcement schedule (mult VI 1 VI 1). A multiple VI 1 VI 1 schedule consists of two independent VI schedules, each with an extroceptive discriminative stimulus. All responses in the first component were punished, while none were punished in the second component. As in the Azrin, Holz, and Hake study (1963), the introduction of continuous punishment resulted in a rapid decrease of responding in the punished component. Recovery during punishment and a compensatory recovery following intense FR 100 punishment was observed by Azrin, Holz, and Hake (1963), while Rachlin observed this phenomenon with lower intensity FR 1 punishment. In the second phase of this experiment, extinction of the operant and punishment occurred during the previously punished component, while extinction alone prevailed during the previously unpunished component. Responding extinguished more rapidly in the previously punished component and as Rachlin noted, "the relatively rapid extinction during the orange period [previously punished component] is evidence that, despite a virtually complete recovery in rate, the shock may still retain aversive properties" (p. 225). In the final phase of the experiment, extinction with no punishment prevailed in both components of the reinforcement schedule. The rate of responding initially increased during the previously punished stimulus condition. This initial increase was followed by a decreased rate, but the absolute rate remained higher than that during the corresponding unpunished stimulus period. Rachlin reasoned that if the aversive stimulus is capable of reducing the probability of a response that it follows, the sudden suppression was an emotional reaction to the sudden introduction of a strange stimulus (shock). Recovery was attributed to the independent disruption of this emotional effect.

On the basis of this first experiment, Rachlin hypothesized that the instrumental suppressive punishing effects of a mild shock do not appear until the emotional aspects have subsided. In the second experiment, the transient emotional aspects of shock were compared with the instrumental punishing aspects using the same multiple schedule of positive reinforcement. When responding in both components of the multiple schedule had stabilized, continuous punishment was programmed during the previously punished component. Punishment produced a decreased rate of responding in this component relative to the other component. Following recovery of responding in the punished component, punishment was programmed for both components of the multiple schedule. No changes in response rates within either component occurred, thus indicating that recovery generalized from the previously punished to the previously unpunished component. When punishment was programmed to occur only during the previously unpunished component, an increase in the relative rate occurred. Following this rate increase, responding decreased slightly. Punishment was again programmed for responses in the previously punished component. Since this condition had already occurred previously, it was possible to examine the effects of punishment over time. It was found that rate depression during punishment in the previously punished component remained the same as observed earlier, but recovery was less at the second presentation of the punishing stimulus. Thus, as the experiment progressed recovery decreased. Each time shock was introduced, after 20 sessions, there was a sharp response suppression followed by response recovery, which reflected the emotional effect of the sudden shock. However, the temporary emotional suppression was followed by permanent suppression with continued training. Rachlin explained the slow development of this permanent suppression effect by asserting that the original emotional suppressive effect prevented the establishment of an association between the consequences of a response and a low rate of responding.

The studies of Azrin, Holz, and Hake (1963) and Rachlin (1966) were concerned with interactions of punishment and reinforcement schedules and suggest that continuous punishment is more effective than intermittent punishment in suppressing behavior when reinforcement frequency is held constant. However, the evidence is less clear regarding the effects of reinforcement frequency modulating the suppressive effects of punishment when punishment frequency is held constant. Church and Raymond (1967) found that punishment effectiveness was related to reinforcement rate. Their procedure consisted of training two groups of rats on different schedules of reinforcement. Responding for one group of rats was maintained on a VI 5 schedule, while the second group was maintained on a VI 0.2 schedule. Following training each group was partitioned into an experimental and a control group and a VI 2 punishment schedule was introduced for the experimental groups. During reinforcement training, response rates were positively related to reinforcement frequency; during punishment rates were a function of both reinforcement frequency and punishment frequency. In addition, a significant interaction was found between punishment and the schedules of positive reinforcement, indicating that punishment was more effective in producing suppression in the VI 5 group than in the VI 0.2 group.

This interaction between punishment and reinforcement schedules has been investigated by others. Tullis and Walters (1968) found evidence that relates to the modulating effect of punishment while investigating the disruptive effects of punishment upon established discriminations. The rats were given 30 minutes of lever training when both levers were operational. In the following session a house light remained on for 15 minutes when the left lever was operative and was off for 15 minutes when the right lever was operative. After this training the subjects were assigned to the different multiple schedules. For all subjects the high density reinforcement component was a VI 1, while the low density component was either VI 2, 4, or 8. Following extensive training, punishment was introduced for all responses on both the operative and extinction levers. This was accompanied by a reduction in the rates of responding, although there was no long term disruption of the discrimination. In agreement with Church and Raymond (1967), there was an indication of an interaction between punishment and reinforcement density.

The relationship between punishment and reinforcement probability was studied by Holz (1968) using a concurrent VI 1.9 VI 7.5 schedule. This schedule programmed reinforcement on a 4:1 ratio on two response keys. After extensive training, punishment was introduced for every bar press. Punishment intensity was increased following performance stabilization. As the intensity increased the rates of responding were reduced proportionally; the rates in the high reinforcement density component were higher before punishment and remained so at each punishment level. Contrary to the results of Church and Raymond (1967) and Tullis and Walters (1968), proportional suppression demonstrates independence of the reinforcement schedule. Holz noted that other studies of punishment superimposed upon different reinforcement schedules show results similar to his own (Azrin, 1959; Azrin and Holz, 1961; Holz, Azrin and Ulrich, 1963). In addition, he argued, that the discrepancy between the Church and Rayond experiment (1967) and the Holz (1968) study could be explained by the different methods employed. With the concurrent VI schedule the number of responses per reinforcement tend to be equal in both schedules, but in the Church and Raymond study the responses per reinforcement were greater with the VI 5 than with the VI 0.2 schedule of positive reinforcement. Another discrepancy noted by Holz involved the different punishment schedules employed in the two studies. In the Holz study responding generated by the VI 1.9 schedule received a greater number of punishments, but the number of punishments per reinforcement were similar for both the VI 1.9 and the VI 7.5 conditions. Conversely, the VI 2 punishment condition used by Church and Raymond (1967) tended to give the same number of punishments to responding maintained by both components of the multiple schedules. Thus, the punishments per reinforcement were greater in the lower reinforcement schedules.

Several conclusions can be drawn from these studies on the suppressive effects of punishment. Response suppression is more rapid under continuous than intermittent punishment (e.g., Azrin, Holz, and Hake, 1963). An increase in punishment intensity has been found to have similar effects to increases in duration of punishment (e.g., Church, Raymond, and Beauchamp, 1967). After removal of weak continuous punishment (Rachlin, 1966) or intense FR 100 punishment (Azrin, Holz, and Hake, 1963) a compensatory increase in responding can be observed. In addition, punishment would seem to have two phases: a temporary emotional and a permanent suppressive aspect (Rachlin, 1966). There does not appear to be uniform agreement about the modulating effect of reinforcement frequency on the suppressive effects of punishment when punishment frequency is held constant (Church and Raymond, 1967; Tullis and Walters, 1968; Holz, 1968). However, there is an inverse relationship between deprivation (weight loss) and suppression by intermittent punishment (Azrin, Holz, and Hake, 1963).

Discriminative Properties of Punishment

In addition to the emotional and suppressive properties of punishment, several investigators have noted the discriminative aspects of punishment. These properties of punishment are dependent upon temporal correlation between punishment and positive reinforcement. Discriminative properties of punishment were first reported in a series of studies by Muenzinger. Muenzinger (1934) demonstrated that a mild punishment could facilitate discrimination learning in a T maze. Three groups of rats were used in this study. One group was shocked while in the wrong alley, a second group was shocked in the correct alley while running to the goal box, and a third group received no shock.. Muenzinger found that in terms of the number of errors and trials to criterion the no-shock group was inferior to the two different shock groups, with the shock-wrong group only slightly superior to the shock-correct group.

In order to further evaluate this discriminative aspect of punishment, Muenzinger and Wood (1935) investigated the temporal relationship between punishment and response facilitation. Two groups of rats were used in the study: one group was shocked after the choice point, and the second group was shocked before the choice point. The investigators found that shock after the choice point accelerated discrimination learning similarly to the shock-correct and shock-wrong conditions of Muenzinger (1934).

The two studies just cited established that punishment could have facilitative effects upon discrimination learning. A buzzer before or after the choice point was found to have no facilitative effect

(Muenzinger and Newcomb, 1935), although a forced jump after the choice point resulted in facilitation (Muenzinger and Newcomb, 1936). These results led the investigators to hypothesize that a mechanically-enforced pause at a choice point had facilitating effects upon discrimination learning. Muenzinger and Fletcher (1937) further investigated the enforced-pause hypothesis. Two unframed glass doors were used to block the alleys of a T maze beyond the choice point. Five seconds after the rat arrived at the choice point the doors were opened, resulting in facilitation comparable to the shock-after-choice condition in the previous experiments.

The previous findings and an analysis of VTE (vicarious trial and error) activity led Muenzinger, Bernstone, and Richards (1938) to hypothesize that mild shock alerted the subject to relevant cues in the correct arm of the T maze. This hypothesis was subsequently confirmed by Freeburne and Taylor (1952).

In a series of studies, Fowler and Wischner (1969) investigated the effect of punishment upon learning in a T maze. One of these studies relates to the question of whether shock has a general alerting function. In this study light-dark and bright-dim discriminations were used to evaluate four training conditions: no-shock; shock-correct; shock for both correct and incorrect responses; and shock for both responses when a paired running mate in the shock-correct condition made a correct response and thus received shock. The shock-both and the shock-paired conditions allowed for the operation of the sensitizing function of shock while controlling for the discriminative cue effect by not correlating shock with the stimulus alternatives.

Performance was facilitated in the shock-correct group in the bright-dim discrimination, while the shock-both and the shock-paired groups did not differ significantly from the no-shock group in either of the two conditions. The authors concluded that the shock-correct facilitation cannot be attributed to the operation of a general alerting function of shock punishment. The authors cite this and several other studies (e.g., Fowler, Goldman, and Wischner, 1968) in support of a discriminative cue hypothesis.

Further research on the discriminative properties of punishment was undertaken in a series of studies by Logan (1960). In one of these studies, Logan correlated punishment and reinforcement with response speed in a straight alley. One group of rats received food and punishment only if the running speed exceeded a criterion which allowed the two fastest of six daily trials to be punished. Logan found that this group's running speed was significantly faster than either the unshocked or the matched-control groups. Following this condition there were four sessions of extinction during which the shocked group showed a greater resistance to extinction. Logan concluded that " . . . the shock may serve a specific 'informational' function by providing an immediate and distinctive cue indicating the adequacy of the response" (p. 218).

The previous research on the discriminative properties of punishment, conducted in a simple T maze or straight alley runway, was expanded by Holz and Azrin (1961, 1962) in studies in a free operant situation. They proposed that the discriminative properties of shock were gained by selective pairing of punishment with either positive reinforcement or extinction. Holz and Azrin (1962) applied punishment to all responses in one of three different portions of an FI schedule. Punishment followed all the responses in the last quarter, all the responses in the first three quarters, or all the responses in the third quarter of the FI schedule. Response dimunition resulted for the conditions where punishment occurred for all the responses in the first three quarters or the third quarter of the FI. Response acceleration occurred only in the condition where all responses were punished in the last quarter, i.e., the condition in which punishment is correlated with reinforcement.

In order to further evaluate the discriminative properties of punishment, Holz and Azrin (1961) used a procedure with two separate training sessions per day to establish shock as a discriminative stimulus. The first session was a positively correlated condition in which shock was paired with positive reinforcement. This consisted of a VI 2 reinforcement schedule with punishment for every response. In this condition the rate of responding was reduced to approximately one-half of the prepunishment rate, but later recovered to the prepunishment level. A second daily experimental condition consisted of a two hour period of extinction during which no responses were punished. After three weeks of training, the rates of responding were greater in the VI 2 punishment period than in the unpunished extinction period. The discriminative properties of punishment were assessed by introducing ten minute periods of punishment into the middle of the extinction sessions. The introduction of punishment produced a positive acceleration in the rate of responding; the removal of punishment was followed by decreased responding. A second condition was introduced into the experiment in order to determine whether punishment could serve as a discriminative stimulus for absence of a positive reinforcer. This was a negatively correlated condition in which extinction was paired with punishment. As in the first experiment, two sessions were used: the first consisted of a VI 2 schedule with no punishment, while the other session consisted of punishment paired with extinction. After rate stabilization, punishment was temporarily eliminated from the two hour sessions resulting in an increase in the rate of responding. Thus, these results indicate that punishment can discriminatively control either a high rate of responding or a low rate of responding by the way it is correlated with reinforcement or extinction.

Murray and Nevin (1967) distinguished between a secondary reinforcer and a discriminative stimulus as the basis of their investigation of punishment. A chained schedule was used because " . . . in fact, the discriminative function of shock in a single-response procedure is not easily separable from its reinforcing or punishing effects." One way to separate these functions is to use a two-component chain. In the training sessions, responses on the left bar produced light, while responses on the right bar in the presence of light produced water. During the experiment, the first press on the left bar after a fixed interval of 30 seconds had elapsed in darkness turned on the light, reset the FI timer, and produced shock with a 0.50 probability. Three conditions were used in the study: a positively correlated, a negatively correlated, and an uncorrelated condition. The positively correlated condition occurred when light and shock indicated reinforcement for responses on the right bar, and light and no shock indicated lack of reinforcement on the right bar. The negatively correlated condition consisted of the opposite relation: light and shock indicated the lack of reinforcement on the right bar, while light alone indicated reinforcement. The uncorrelated condition existed when there was no correlation between shock and reinforcement, but shock on the left bar and reinforcement on the right bar occurred with a 0.50 probability. Two shock intensities, 0.4 and 0.8-ma, were used. With the 0.4-ma shocks the response rates in the positively correlated group exceeded those in the preshock training period, while in the negatively correlated condition responding was generally suppressed. The rate of responding was less affected by shock in the uncorrelated condition than in the positively or negatively correlated conditions. The 0.8-ma intensity suppressed responding substantially in the first components of all three conditions.

Several conclusions can be drawn from these studies on the discriminative properties of punishment. Punishment gains discriminative properties when it is correlated with positive reinforcement. This has been investigated in both the straight alley runway (Logan, 1960) and the free operant situation (Holz and Azrin, 1961, 1962). Although there is a controversy about whether punishment serves as a general alerting stimulus (Muenzinger, Berstone, and Richards, 1938) or an informational cue (Fowler and Wischner, 1969).

Statement of the Problem

Although punishment research supports the hypothesis that shock has discriminative as well as suppressive properties (Holz and Azrin, 1961, 1962), little is known about the effect of different schedules of reinforcement upon establishing this discrimination. The present study will investigate the discriminative aspects of punishment within a multiple schedule of positive reinforcement. It was designed to provide a partial replication of the Holz and Azrin (1961) study by using a different schedule of reinforcement. The present study will incorporate a variant of Murray and Nevin's positively and negatively correlated punishment procedure.

The proposed study will employ a multiple FR 3 FR 33 schedule with positively and negatively correlated punishment. The positively correlated condition will consist of punishment correlated with high reinforcement density, while the negatively correlated condition will consist of punishment correlated with a low reinforcement density. Four experimental conditions will prevail during this study. During the first phase subjects in both the positively and negatively correlated groups will be placed in a multiple FR 3 FR 33 discrimination training situation--punishment will be absent. As in the typical discrimination study it is expected that the rate of responding will increase in the FR 3 component and decrease in the FR 33 component.

Similar to the Murray and Nevin (1967) study, the second phase for the positively correlated group will consist of punishment for every response in the FR 3 component and no shock in the FR 33 component. From the Azrin, Holz, and Hake study (1963) and Rachlin (1966), it is expected that the rate of responding in the positively correlated FR 3 condition will decrease sharply upon the introduction of punishment. Following this decrease the rate should then increase to the prepunishment level. It might be expected that the FR 33 rate would increase temporarily when FR 3 responding is suppressed.

The negatively correlated group will be punished for every bar press in the FR 33 component while no punishment will occur in the FR 3 component. In this condition the FR 33 rate should decrease to a baseline value and later recover. Because of response generalization the FR 3 rate should also decrease slightly and then recover.

In the third condition the positively correlated group will receive punishment for every response in the FR 33 component and no punishment in the FR 3 component of the multiple schedule. Conversely, the negatively correlated group will receive punishment for every response in the FR 3 component and no punishment in the FR 33 component. On the basis of punishment as a discriminative stimulus (Holz and Azrin, 1961) it is expected that the rate of responding in the positively correlated group will increase in the FR 33 component. Conversely, the rate should decrease in the FR 3 component. Holz and Azrin suggest that the negatively correlated group's rate of responding would increase during the FR 33 component and decrease during the FR 33 component.

The final condition for both groups will consist of extinction with punishment for all responses in both components. In this condition the rates of responding in the FR 33 component should increase temporarily.

CHAPTER II

METHOD

Subjects

The subjects were nine rats of the Sprague-Dawley strain maintained at 85% of their free-feeding weight. The rats were between 120 and 160 days old at the beginning of the discrimination training.

Apparatus

A Scientific Prototype rat chamber containing one bar was located inside a sound-attenuating chamber. The chamber was ventilated by a 110-vac fan which also served as a masking noise. A white 5-w light, located at floor level on the same wall as the bar and food cup, was lighted when the FR 3 component of the multiple schedule was in effect and not lighted for the FR 33 component. Reinforcements of 0.45-mg Noyes food pellets were delivered by a Gerbrands pellet dispenser. The shock, delivered through the grid floor, was stepped down from 110-vac to 38-vac by a 140,000 ohm fixed resistor in series with the animal and was in effect for 0.1 seconds; the nominal current drawn by the animal was approximately 0.25-ma. Programming and data collection were in adjacent rooms. The FR programmer was reset following each two minute cycle, so that reinforcements did not accumulate.

Procedure

The number of sessions that each condition was in effect for the different groups appears in Table 1. For the first positively correlated group, Subjects 1, 2, and 3, a multiple FR 3 FR 33 discrimination schedule was in effect during the first phase. In the next phase punishment was introduced for every response in the FR 3 component; no punishment was given in the FR 33 component. An equipment failure resulted in the delivery of a 110-vac shock instead of the programmed 34-vac. This higher intensity shock resulted in almost complete suppression, therefore another positively correlated group was introduced.

TABLE 1

The Number of Days in Each Phase for the Three Groups

Phase	Subjects 1,2,3	Days	Subjects 4,5,6	Days	Subjects 7,8,9	Days
1.	FR 3 FR 33	14	FR 3 FR 33	9	FR 3 FR 33	14
2.	FR 3 + 110-vac	8	FR 3 + 34-vac	14	FR 3 + 110-vac	8
3.			FR 33 + 34-vac	8	FR 3 + 34-vac	14
4.			Ext + 34-vac	10	Ext + 34-vac	10

The second positively correlated group, Subjects 4, 5, and 6 had a mult FR 3 FR 33 discrimination schedule for the first phase. After the discrimination had been established a 34-vac shock followed all responses in the FR 3 schedule (second phase). In the third phase the shock conditions were reversed and shock followed all responses in both components. The final phase consisted of extinction and shock for all responses in both components.

The negatively correlated group, Subjects 7, 8, and 9, had a multiple FR 3 FR 33 discrimination schedule in phase 1. The second phase consisted of punishment for every response in the FR 33 component. Because of an equipment failure a 110-vac shock was delivered. Since the FR 3 rates had recovered to the prepunishment levels this group was not terminated but was immediately switched to the next phase. The third phase consisted of 34-vac shock for every response in the FR 3 component. The last phase consisted of extinction and punishment for every response in both components.

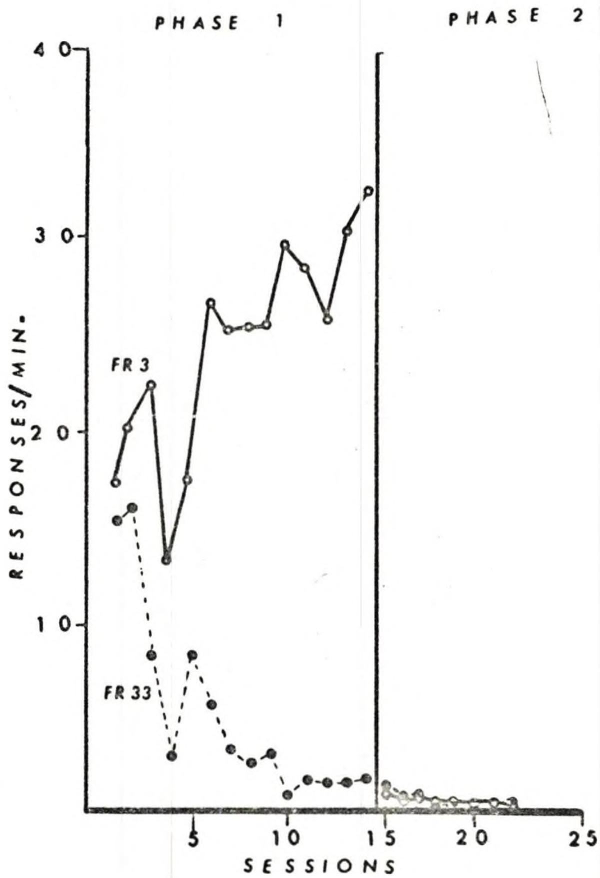
CHAPTER III

RESULTS

First Positively Correlated Group

The response rates of the first positively correlated group are represented in Figures 1, 2, and 3. The first phase consisted of multiple FR 3 FR 33 discrimination training. As discrimination training proceeded the response rates for the three subjects gradually increased in the FR 3 component and decreased in the FR 33 component; response variability decreased in both components of the multiple schedule as training proceeded. For all subjects the response rates were greater than 27 responses per minute in the FR 3 component and less than two responses per minute in the FR 33 component by the last session of phase 1. No subject appears to have completed an FR 33 ratio in any two minute period of any session of any phase of the experiment after the second day of the multiple FR 3 FR 33 training. Thus, despite the theoretical possibility of reinforcement in the FR 33 component, the schedule was functionally a multiple FR 3 EXT from the third day onward. Because of this fact, the experiment turned out to be more similar procedurally to the Holz and Azrin (1961) experiment than it was intended to be.

Following discrimination training, shock was introduced for all responses in the FR 3 component (phase 2). When response contingent


PHASE 1
PHASE 2
RESPONSES/MIN.
40
30
20
10
FR 3
FR 33
5
10
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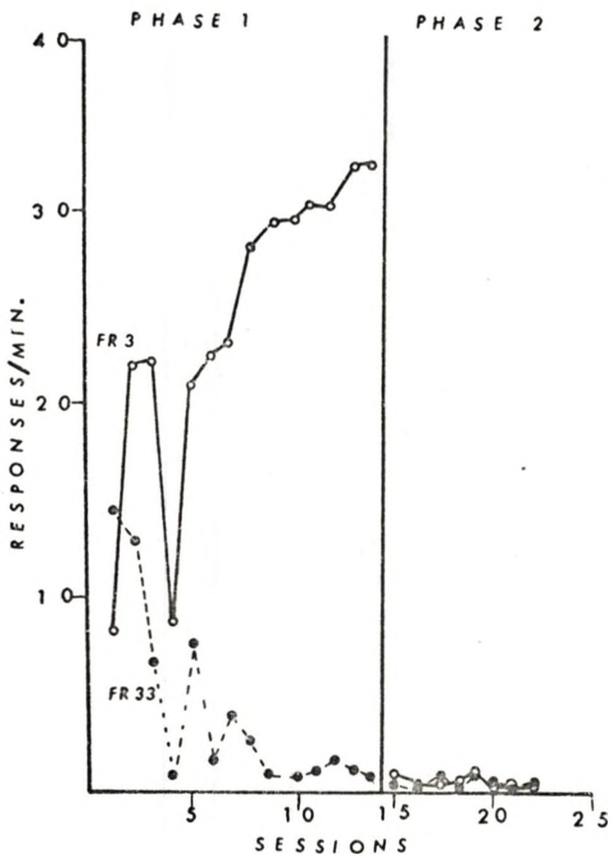
20
25
SESSIONS



PHASE 1
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RESPONSES/MIN.
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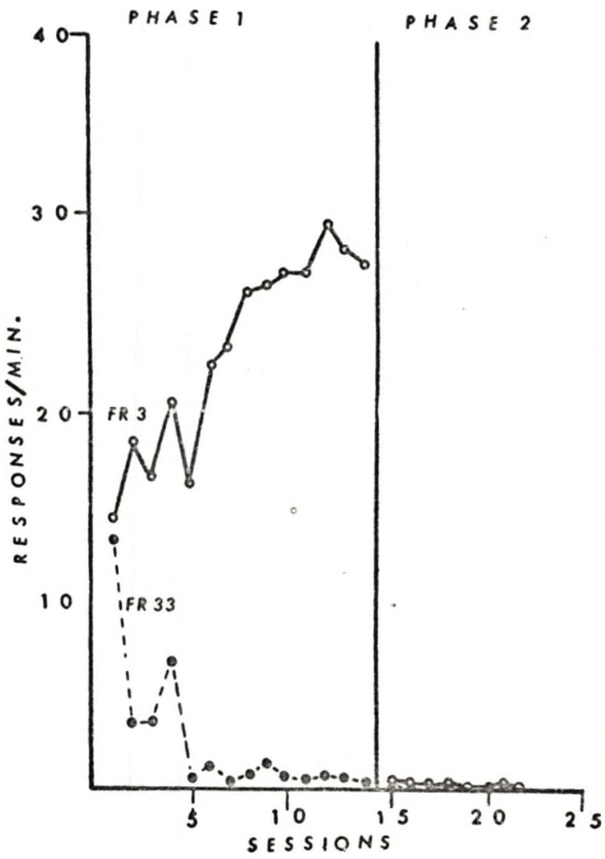
PHASE 1
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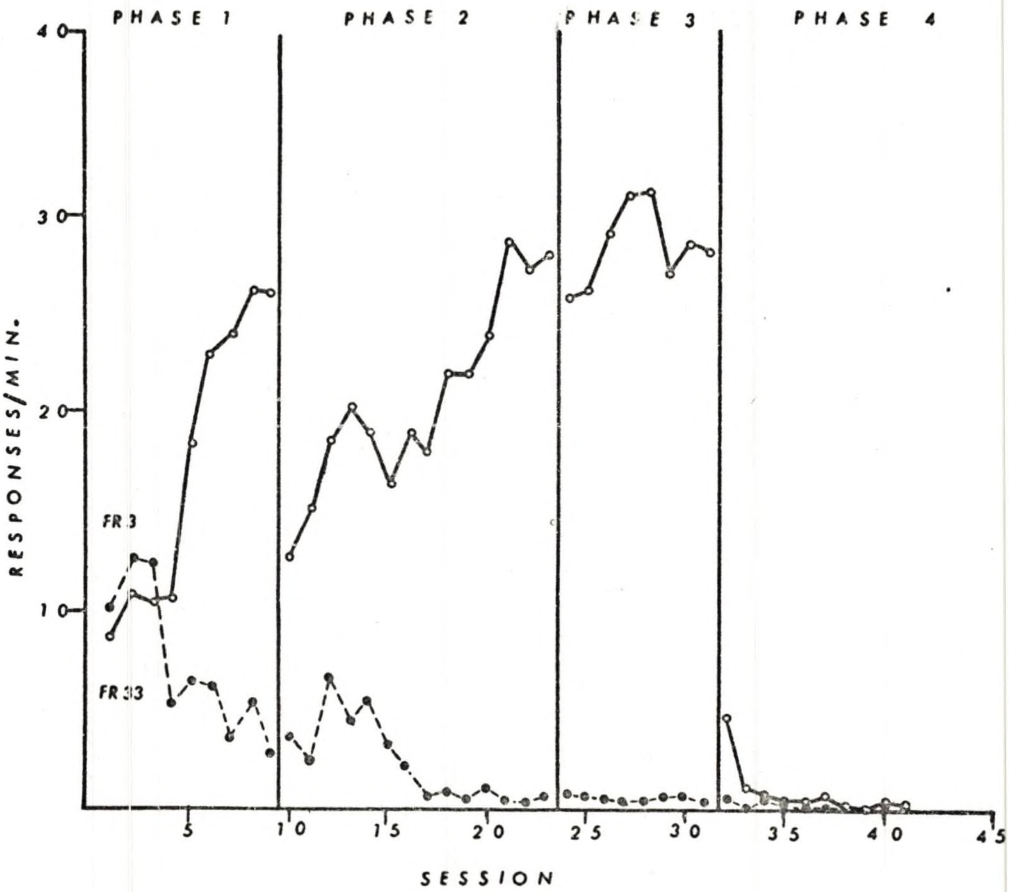
SESSIONS

shock was introduced the rate of responding in the FR 3 component immediately decreased from the prepunishment level of greater than 27 responses per minute to less than one response per minute. The FR rate continued to remain depressed for the remaining seven sessions. The FR 33 rates, which were already low, were also immediately decreased in this phase and remained depressed throughout. Although it was perfectly safe (and potentially reinforcing) for the rat to respond in the non-punishment FR 33 component, no rat did so. The absolute depression appeared to be greater for Subjects 2 and 3 in the FR 33 component than in the FR 3 component. After eight sessions the group was discontinued because the subjects had inadvertently received 110-vac instead of the programmed 34-vac and responding was almost completely suppressed. In fact, in the FR 3 component, Subjects 1, 2, and 3 each responded less than 25 times in the eight sessions. Therefore another positively correlated group was introduced.

Second Positively Correlated Group

The second positively correlated group (Figures 4, 5, and 6) was placed on a multiple FR 3 FR 33 discrimination schedule in phase 1. The response rates gradually increased in the FR 3 component and decreased in the FR 33 component. After nine sessions the FR 3 rates were greater than 23 responses per minute and the FR 33 rates were less than five responses per minute.

Following the discrimination training, 34-vac shocks followed all responses in the FR 3 component (phase 2). During this phase FR 3 response rates initially decreased, later returning to the prepunishment level. This decrease in response rates, from the last session of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RESPONSES/MIN.
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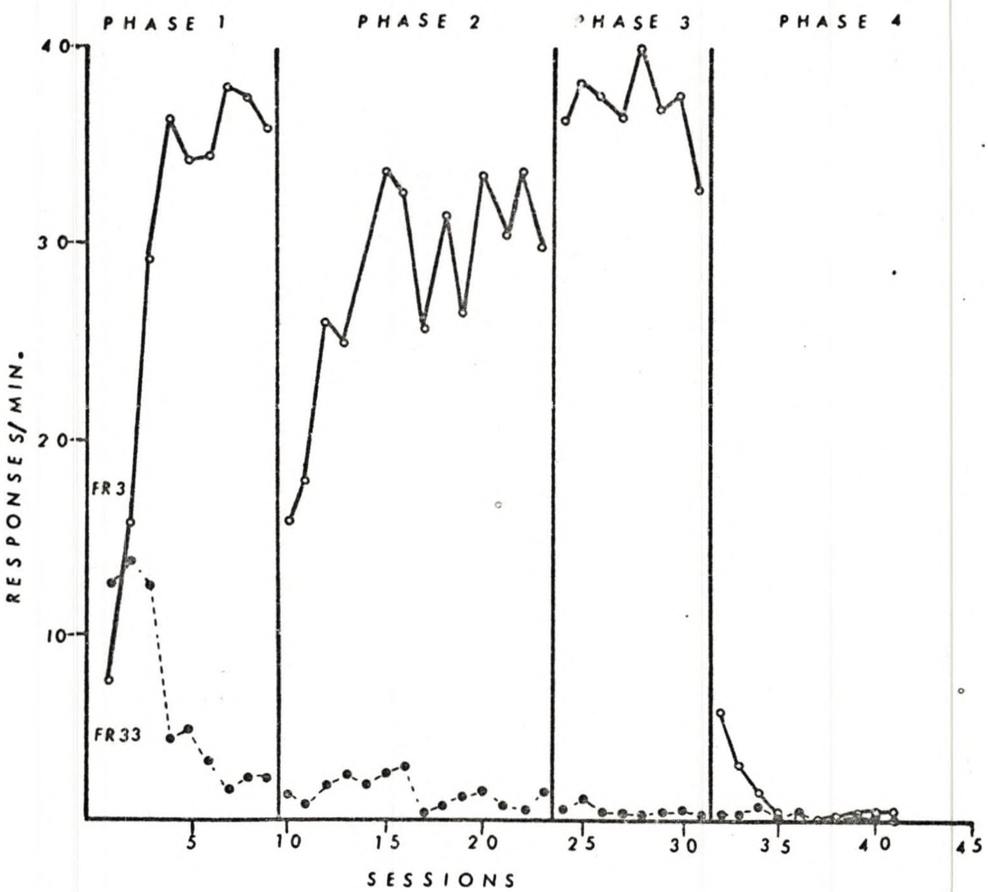
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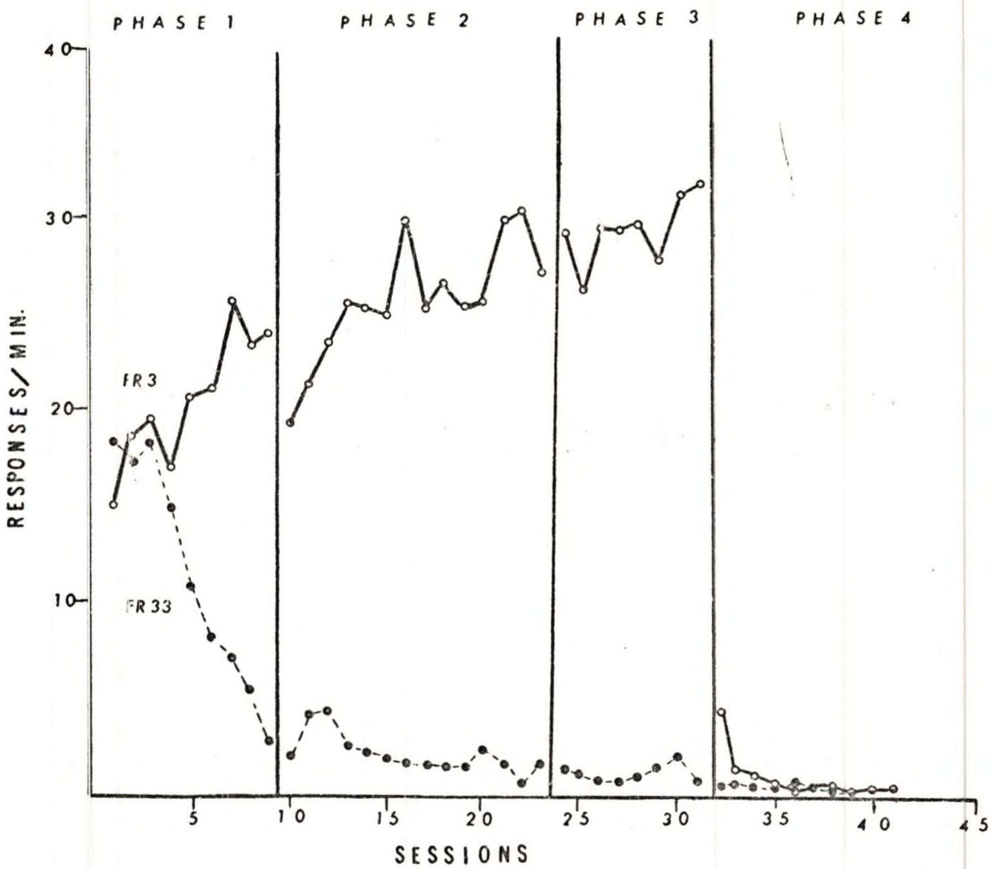

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RESPONSES/ MIN.
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SESSIONS

phase 1 to the lowest rate in phase 2, was 49% for Subject 4, 57% for Subject 5, and 19% for Subject 6. The lowest rate occurred in the first session of this phase for all subjects. Response rates fully recovered after 12 sessions for Subject 4 and four sessions for Subject 6. Although the response rate for Subject 5 was within three responses per minute of the phase 1 rate by the sixth session, recovery was not complete in the second phase. These results suggest that following the initial response decrease, speed of recovery is directly related to the degree of initial response suppression. Over a series of three sessions the FR 33 rates temporarily increased from the last session of phase 1 to the highest rate in phase 2 at least 28% for Subjects 4 and 6 and then slowly decreased. Rates for Subject 5 remained essentially constant for several sessions and then decreased.

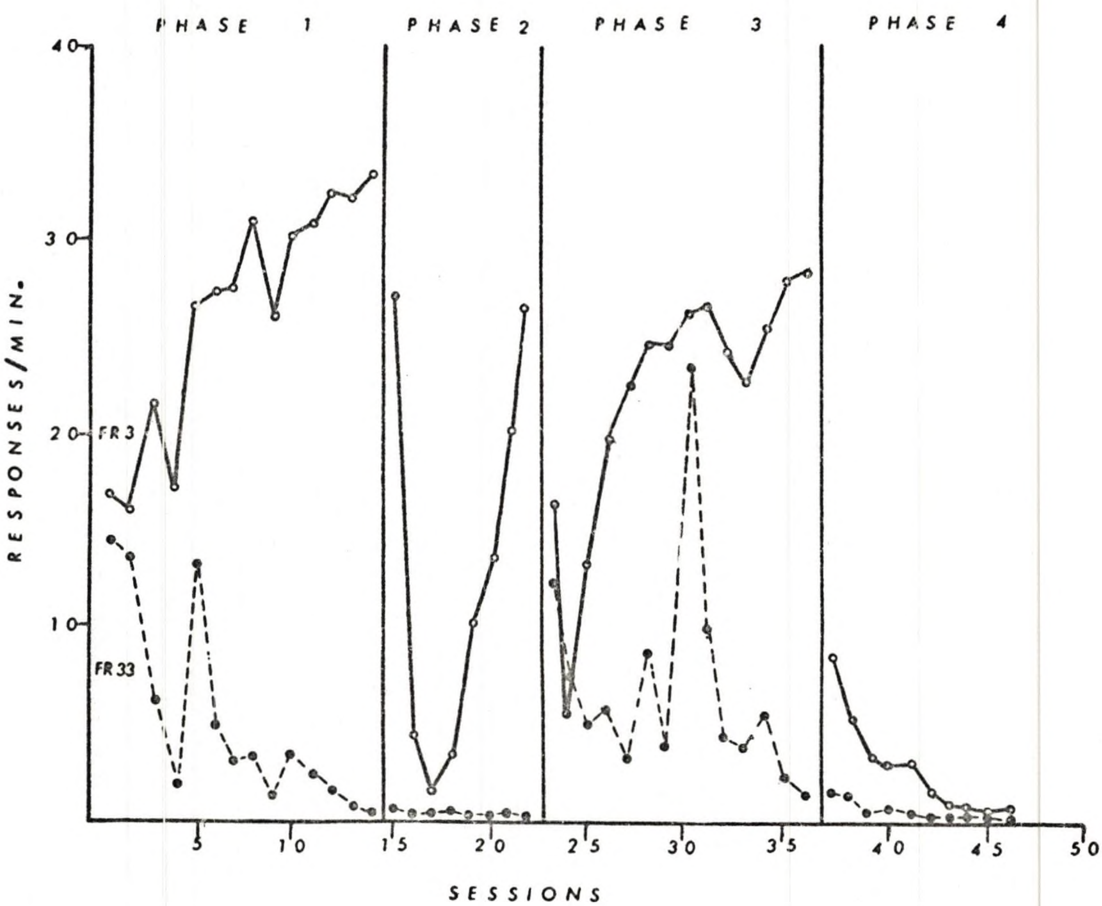
During the next phase shock conditions were reversed and every FR 33 response received shock (phase 3). During this phase the FR 3 rates for Subjects 4 and 6 remained fairly constant, while the FR 3 rates of Subject 5 increased from a high of 33.63 responses per minute in phase 2 to a high of 40.38 in phase 3. In all cases the FR 33 rates continued to decrease and by the end of phase 3 the subjects were responding less than 0.50 times a minute.

The final phase consisted of extinction and punishment for all responses in both components. One session produced an FR 3 rate decrease of at least 82.1% of the previous phase. Although extinction and punishment for all responses in both components were in effect, the FR 3 response rate remained greater than the FR 33 rate for the average of 4.7 sessions.

Negatively Correlated Group

Phase 1 of the negatively correlated group (Figures 7, 8, and 9) consisted of multiple FR 3 FR 33 discrimination training. The response rates increased in the FR 3 component and decreased in the FR 33 component. By the last session of phase 1 the FR 3 rates were greater than 20 responses per minute while the FR 33 rates were less than two responses per minute.

The next phase consisted of punishment for every response in the FR 33 component (phase 2). For all subjects this condition resulted in a rate decrease in both components. The FR 3 rate decrease, measured from the last day of phase 1 to the lowest rate in phase 2, was 95% for Subject 7, 29% for Subject 8, and 13% for Subject 9. Subject 7 did not recover to the prepunishment level, although the greatest FR 3 response rate was within seven responses per minute of the prepunishment level. By the fifth session the response rate of Subject 8 was within three responses per minute of the prepunishment rate. In contrast, the rate of Subject 9 appeared to recover and increased slightly from a prepunishment level in which the highest rate was 22.69 responses per minute on the last session of phase 1 to 24.18 responses per minute by the last session of phase 2. There seems to be no relationship between the amount of suppression and the length of time for recovery. In the FR 33 component the response rates continued to decrease and become less variable. After eight days of punishment the second phase was discontinued because the subjects had inadvertently received 110-vac instead of the programmed 34-vac shock for every FR 33 response. Since recovery was complete for one subject and almost complete for another the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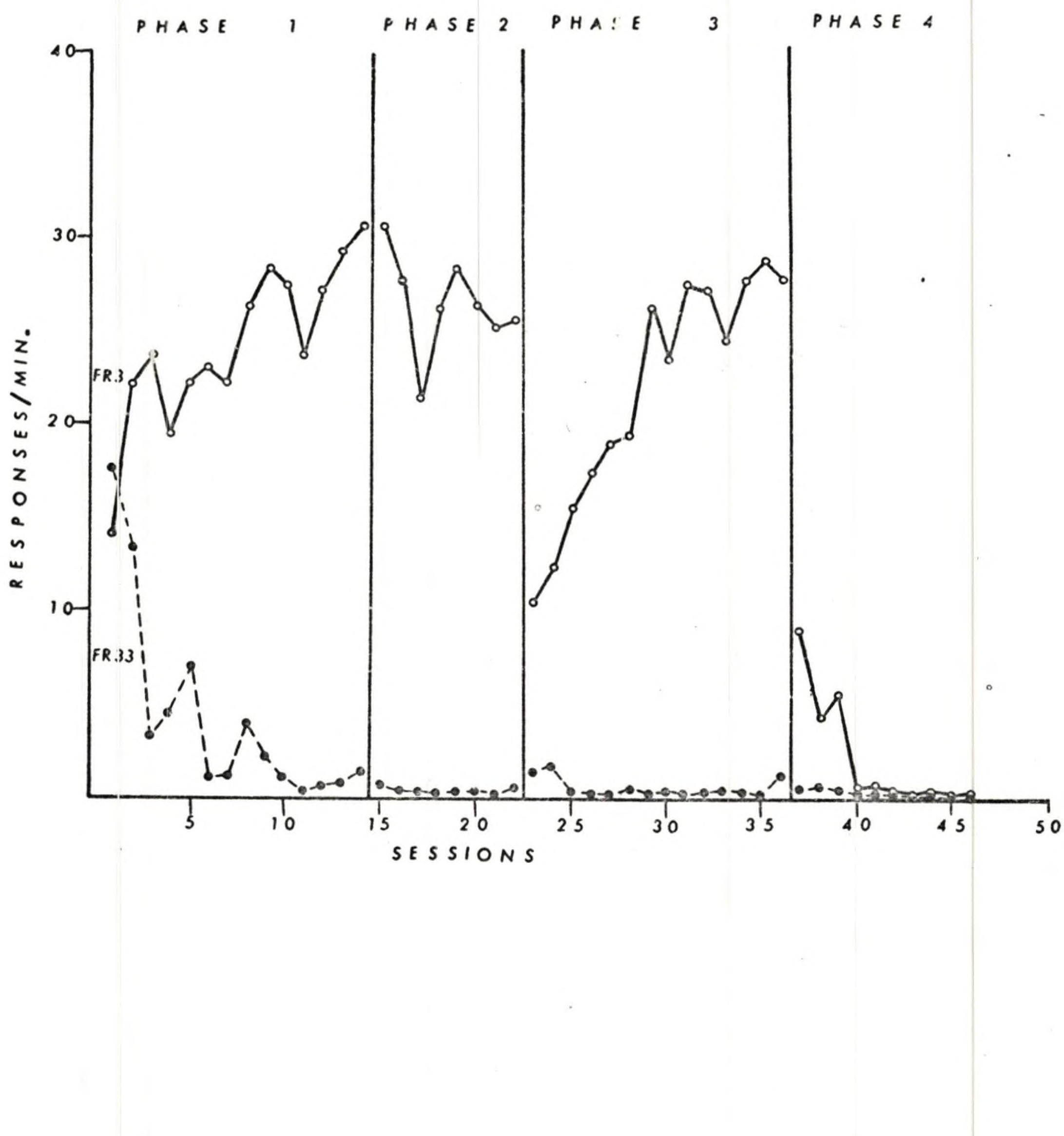
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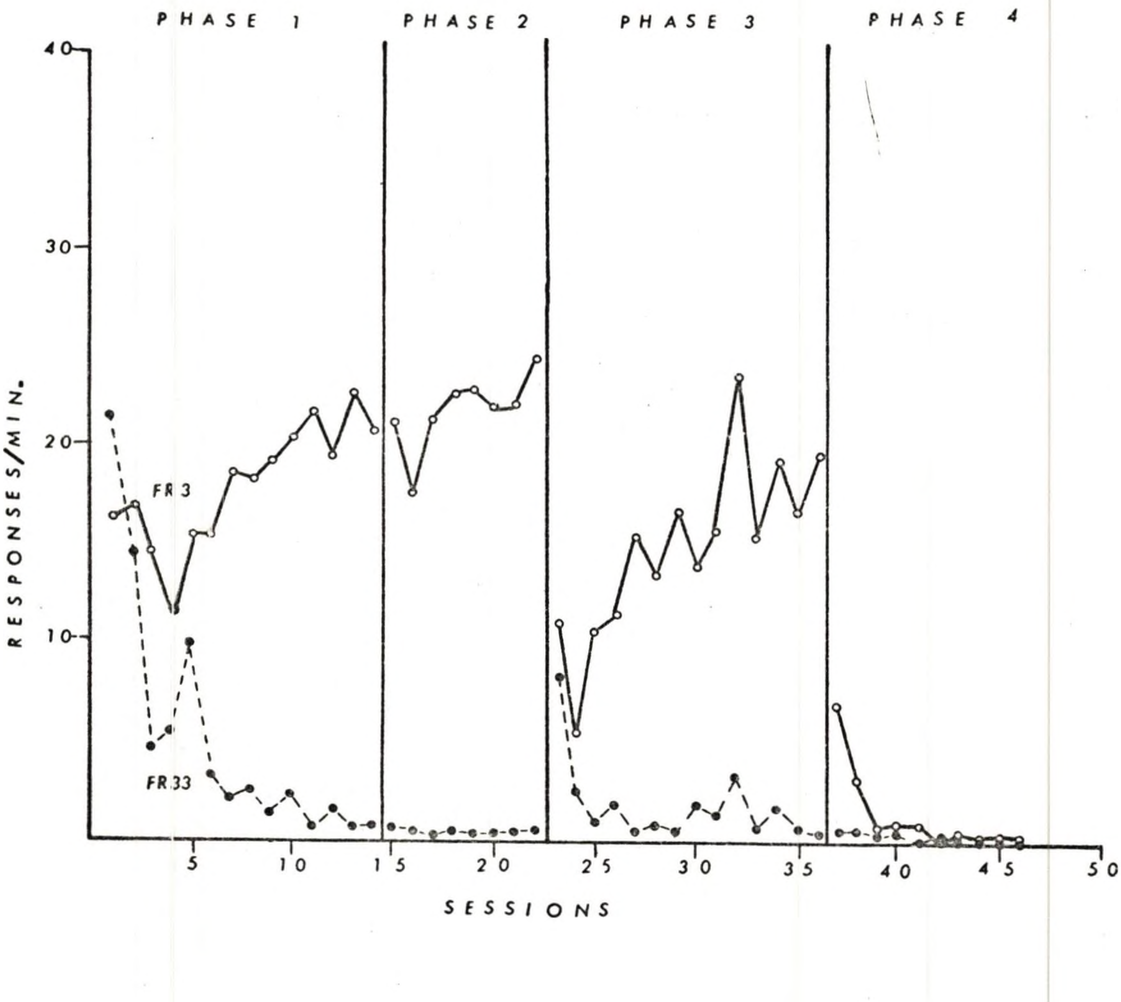

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PHASE 4
RESPONSES/MIN.
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group was immediately switched into the third phase instead of being terminated.

Phase 3 consisted of 34-vac shocks for every FR 3 response. Initially the FR 3 response rates decreased sharply but later increased to the prepunishment level. The FR 3 response decreases, measured from the last session of phase 2 to the lowest response rate in phase 3, were 79% for Subject 7, 58% for Subject 8, and 23% for Subject 9. Response rates recovered after eight sessions for Subject 7, seven sessions for Subject 8, and the response rates were within one response per minute of recovery for Subject 9 after 10 sessions, but throughout the 14 sessions of phase 3, recovery was not complete. The rates of responding in the FR 33 component increased becoming more variable than responding in the previous phase.

The final phase consisted of extinction and punishment for every response in both components. After one session the FR 3 rate decreased at least 60% of that in the previous phase. Although extinction and punishment for all responses in both components were in effect, the FR 3 response rate remained greater than the FR 33 rate for the average of seven sessions.

CHAPTER IV

DISCUSSION

Holz and Azrin (1961) proposed that punishment may be established as a discriminative stimulus for a high rate of responding when it is selectively paired with positive reinforcement; punishment may also be established as a discriminative stimulus for a low rate of responding when it is selectively paired with extinction. Holz and Azrin trained pigeons to respond on a VI 2 reinforcement schedule. Punishment was introduced and maintained until the rate of responding recovered from initial suppression. Alternating cycles of VI 2 reinforcement with continuous punishment and extinction without punishment were scheduled for several weeks. Responding was maintained in the reinforcement--punishment cycle, but not in the extinction--no punishment cycle. When the extinction--no punishment cycle was altered to a extinction--punishment cycle, responding was observed to increase substantially. Holz and Azrin interpreted this rate increase as confirmation of the discriminative properties of punishment.

In order to determine whether non-aversive punishment can decrease response rates when paired with extinction, pigeons were trained on a VI 2 schedule. After responding had stabilized punishment was paired with responding in the two hour extinction sessions. After several weeks the response rate decreased in the punishment-extinction sessions, but remained high in the VI 2 reinforcement sessions. When punishment was temporarily eliminated from the two hour sessions of extinction, the rate increased revealing that ". . . the punishment had come to control a low response rate simply because of its discriminative property" (p. 231).

The present study used a multiple FR 3 FR 33 schedule in an attempt to replicate these findings. Every FR 3 response in the second positively correlated group was punished; FR 33 responses were not punished. If the correlation between positive reinforcement and punishment is sufficient to establish punishment as a discriminative stimulus, the reversal of the punishment correlations should temporarily increase the rate of responding in the FR 33 component. If suppressive properties are primarily gained through the correlation between punishment and extinction (or low density reinforcement), a reversal of the correlation in the next phase should result in a temporary decrease in the FR 3 response rate.

In establishing the multiple schedule it was found that the rates of responding in the high density component increased, while the rates decreased in the low density component. Following discrimination training in the positively correlated group, FR 3 punishment was introduced. As many other investigators have found, responding immediately decreased when punishment was initially introduced. However, by the end of the phase the rates had recovered for two of the three subjects. In evaluating the presence of discriminative properties of punishment, it is clear that no increase in the FR 33 rates or decrease in the FR 3 rates of responding occurred in phase 3 (Figures 4, 5, and 6). Therefore, as a further test of discrimination formation ten sessions of extinction with punishment for every response were introduced. If punishment developed discriminative properties, FR 33 responding in the last phase should show a temporary increase in rate of responding. Phase 4 (Figures 4, 5, and 6) shows no such increase in FR 33 rates. In fact when punishment and extinction were paired immediate and substantial suppression resulted.

In the Holz and Azrin study (1961) following rate stabilization punishment and reinforcement were paired for three weeks. However, in the present study the number of pairings of punishment and reinforcement after rate stabilization was less (14 sessions) than in the Holz and Azrin study (1961). In conjunction with this, Rachlin's study (1966) helps to explain the negative results in the present study. Rachlin conducted a series of studies with pigeons in which the long term effects of punishment were investigated in a multiple schedule. In the first experiment, Rachlin noted that shock retained emotional suppressive properties despite a full recovery in rate during punishment. The data would suggest that even after 180 sessions following the introduction of shock, emotional effects are still noticeable. In the present study it is possible that the number of sessions of paired punishment and reinforcement were insufficient for emotional aspects to dissipate. If this did occur, then the emotional aspects may have interfered with the formation of the punishment-reinforcement discrimination. It seems possible that if the number of sessions of punishment-reinforcement had been increased, the discriminative aspects of punishment may have become evident. However, the subjects did receive many punishment-reinforcement pairings. Subject 4 made

4724 responses that were punished; 1575 of these responses were punished and reinforced in the presence of S^D, while 1206 were not reinforced or punished in the presence of S^Δ. Subject 5 made 6223 responses that were punished; 2074 of these were punished and reinforced in the presence of S^D, while 789 were not reinforced or punished in the presence of S^Δ. Finally, Subject 6 made 5774 responses that were punished; 1925 of these were punished and reinforced in the presence of S^D, while 1582 were not reinforced or punished in the presence of S^Δ.

The present study also differs from the Holz and Azrin study (1961) in terms of the reinforcement schedule used to form the discrimination. Holz and Azrin (1961) used a schedule that is functionally equivalent to a mixed schedule, while the present study used a multiple schedule. Two studies by Egger and Miller (1962, 1963) are relevant to this scheduling variable. Egger and Miller found that a redundant cue would not acquire secondary reinforcing properties. In these studies they employed two stimuli that were paired together and always preceeded positive reinforcement. However, the second cue (shorter stimulus) was redundant because the first cue provided reliable information about the availability of positive reinforcement. They found that the second stimuli (redundant) could be restored as a relevant cue if the first stimuli was made an unreliable predictor of positive reinforcement. In a mixed schedule such as Holz and Azrin (1961) employed there is no extroceptive stimuli that could serve as relevant cues to the availability of positive reinforcement. However, in the present study both light and punishment (in the positively correlated group) indicated the availability of positive reinforcement. It is possible that punishment acted as a redundant cue since in the present study light initially indicated the presence of a high density reinforcement component. If this occurred, punishment would not have gained an informational value and no discrimination would have occurred.

Several other relationships were found in the present study. Because one group of positively correlated subjects received 110-vac and the other positively correlated group received 34-vac, it was possible to evaluate the effects of punishment intensity upon response suppression. The data from the present study would seem to indicate that there was a direct positive relationship between the degree of suppression and punishment intensity. This tends to support Azrin, Holz, and Hake (1963) and Church, Raymond, and Beauchamp (1967). There also was an indication of a relationship between amount of initial suppression and speed of recovery. In the second positively correlated group recovery speed was directly related to the degree of initial suppression, while in the negatively correlated group there was no relationship between degree of initial suppression and speed of recovery.

APPENDIX A

TABLE 2

Response Rates of the First Positively Correlated Group

	Subject 1		Subject 2		Subject 3	
Day	FR 3	FR 33	FR 3	FR 33	FR 3	FR 33
1	17.37	15.25	08.43	14.62	14.12	13.06
2	21.12	15.93	22.43	13.18	18.50	08.63
3	22.62	08.25	22.50	06.87	16.56	03.50
4	13.31	03.06	09.18	00.93	20.62	03.50
5	17.31	08.37	21.37	07.87	16.18	06.68
6	26.87	05.81	22.81	01.62	22.31	00.87
7	25.06	03.18	23.27	04.06	23.18	01.31
8	25.25	02.31	28.37	02.62	26.00	00.68
9	25.56	03.00	29.56	00.75	26.43	00.81
10	29.87	01.17	29.75	00.81	27.12	01.68
11	28.62	01.93	30.37	00.93	27.06	00.43
12	25.81	01.68	30.43	01.44	29.94	01.00
13	30.56	01.50	32.56	01.00	28.31	00.75
14	32.31	01.69	32.63	00.63	27.38	00.06
	FR 3+110 v	FR 33	FR 3+110 v	FR 33	FR 3+110 v	FR 33
15	00.25	00.38	00.75	00.06	00.50	00.00
16	00.06	00.13	00.06	00.00	00.06	00.00
17	00.13	00.25	00.06	00.19	00.06	00.00
18	00.06	00.00	00.13	00.00	00.06	00.00
19	00.06	00.06	00.31	00.19	00.00	00.00
20	00.06	00.06	00.00	00.13	00.00	00.00
21	00.06	00.06	00.06	00.00	00.06	00.00
22	00.00	00.06	00.13	00.13	00.00	00.00

APPENDIX B

TABLE 3

Response Rates of the Second Positively Correlated Group

	Subject 4		Subject 5		Subject 6	
Day	FR 3	FR 33	FR 3	FR 33	FR 3	FR 33
1	08.54	10.06	07.19	12.25	15.06	18.56
2	11.06	12.87	15.25	13.43	18.97	17.50
3	10.68	12.50	29.00	12.06	19.81	18.43
4	10.87	05.37	36.37	04.25	17.06	15.12
5	19.31	06.43	34.06	04.93	20.87	11.00
6	23.18	06.31	34.37	03.00	21.25	08.31
7	24.31	03.56	38.00	01.50	25.81	07.25
8	26.62	05.12	37.50	02.06	23.62	05.50
9	26.56	04.63	35.93	02.06	24.00	02.87
	FR 3+34 v	FR 33	FR 3+34 v	FR 33	FR 3+34 v	FR 33
10	13.00	03.50	15.31	01.12	19.50	02.06
11	15.13	02.44	17.62	00.88	21.44	04.19
12	18.94	06.43	25.94	01.75	23.75	04.44
13	20.81	04.50	24.81	02.25	25.81	02.56
14	19.56	05.13	29.06	01.88	25.25	02.19
15	16.56	03.06	33.63	02.38	25.00	01.94
16	19.19	02.44	32.50	02.94	29.94	01.94
17	18.06	00.69	25.50	00.38	25.37	01.69
18	22.44	00.75	31.31	00.81	26.50	01.50
19	22.44	00.31	26.25	01.19	25.13	01.44
20	24.13	00.94	33.44	01.25	25.94	02.31
21	28.94	00.38	30.25	00.50	29.69	01.63
22	27.75	00.31	33.63	00.50	30.19	00.81
23	28.31	00.56	29.69	01.63	27.37	01.68
	FR 3	FR 33+34 v	FR 3	FR 33+34 v	FR 3	FR 33+34 v
24	26.25	00.81	36.25	00.69	29.13	01.25
25	26.56	00.44	38.31	01.00	26.00	01.00
26	29.31	00.38	37.63	00.38	29.44	00.88
27	31.44	00.13	37.13	00.31	29.80	00.75
28	31.50	00.31	40.38	00.25	29.75	00.88
29	27.19	00.50	36.69	00.31	27.13	01.25
30	28.88	00.44	37.50	00.38	30.94	02.00
31	28.44	00.13	32.75	00.19	31.56	00.44

TABLE 3--Continued

	Subject 4		Subject 5		Subject 6	
	Ext + 34v	Ext + 34v	Ext + 34v	Ext + 34v	Ext + 34v	Ext + 34v
32	04.69	00.25	05.88	00.19	04.56	00.19
33	00.94	00.00	02.81	00.19	01.06	00.63
34	00.81	00.25	01.56	00.69	00.81	00.50
35	00.13	00.06	00.25	00.06	00.31	00.13
36	00.13	00.00	00.00	00.13	00.06	00.38
37	00.63	00.00	00.00	00.00	00.25	00.25
38	00.06	00.06	00.38	00.00	00.31	00.06
39	00.00	00.00	00.06	00.19	00.06	00.06
40	00.06	00.31	00.13	00.06	00.13	00.13
41	00.06	00.13	00.31	00.00	00.13	00.13

TABLE 4

Response Rates of the Negatively Correlated Group

	Subject 7		Subject 8		Subject 9	
Day	FR 3	FR 33	FR 3	FR 33	FR 3	FR 33
1	17.06	14.87	14.25	17.75	16.12	21.12
2	16.18	13.25	22.31	13.50	17.00	14.50
3	21.81	06.31	23.62	03.56	14.81	04.75
4	17.50	02.00	19.50	04.87	11.19	05.27
5	26.50	13.37	22.37	07.25	15.37	10.00
6	27.31	05.00	23.12	01.06	15.37	03.25
7	27.56	03.12	22.37	01.25	18.37	02.18
8	31.00	03.43	26.50	04.00	18.31	02.50
9	26.18	01.56	28.68	02.25	19.13	01.37
10	30.31	03.43	27.31	01.12	20.25	02.12
11	30.93	02.37	23.75	00.68	21.67	00.87
12	32.56	01.75	27.31	01.00	19.25	01.50
13	32.19	01.00	29.06	01.00	22.69	00.63
14	33.50	01.44	30.44	01.69	20.50	00.75
	FR 3	FR 33+110v	FR 3	FR 33+110v	FR 3	FR 33+110v
15	27.18	00.44	30.44	00.83	21.19	00.50
16	04.68	00.06	27.50	00.38	17.81	00.13
17	01.75	00.25	21.69	00.38	21.43	00.06
18	03.62	00.44	26.18	00.13	22.57	00.31
19	10.62	00.25	28.06	00.31	22.87	00.19
20	13.39	00.19	26.25	00.31	22.00	00.19
21	20.25	00.25	25.06	00.13	22.12	00.13
22	26.50	00.00	25.50	00.50	24.18	00.31
	FR 3 + 34v	FR 33	FR 3 +34v	FR 33	FR 3 +34v	FR 33
23	16.50	12.12	10.75	01.43	11.06	08.31
24	05.62	07.56	12.18	01.81	05.56	02.43
25	13.31	05.00	15.87	00.44	10.43	01.00
26	19.99	06.00	17.62	00.31	11.25	01.93
27	22.31	03.43	19.00	00.25	15.25	00.34
28	24.62	08.75	19.69	00.56	13.56	00.88
29	24.37	03.93	26.25	00.13	16.37	00.56
30	26.12	23.87	23.87	00.50	13.87	01.93
31	26.75	10.00	27.50	00.18	15.43	01.12
32	24.37	04.68	27.37	00.25	23.37	03.12
33	22.87	04.00	24.69	00.56	15.25	00.56
34	25.44	05.64	27.81	00.44	19.06	01.25
35	27.81	02.12	29.00	00.18	16.87	00.56
36	28.13	01.19	28.00	01.19	19.75	00.50

TABLE 4--Continued

	Subject 7		Subject 8		Subject 9	
	Ext + 34v	Ext + 34v	Ext + 34v	Ext + 34v	Ext + 34v	Ext + 34v
37	08.75	01.81	09.06	00.56	06.94	00.25
38	05.50	01.63	04.56	00.94	03.00	00.31
39	03.62	00.50	05.88	00.69	00.63	00.06
40	03.06	00.94	00.44	00.13	00.69	00.19
41	03.25	00.69	04.94	01.88	00.69	00.00
42	01.50	00.31	00.38	00.13	00.00	00.06
43	00.94	00.39	00.06	00.06	00.06	00.00
44	01.00	00.31	00.31	00.06	00.00	00.00
45	00.44	00.38	00.06	00.06	00.06	00.00
46	00.44	00.19	00.13	00.00	00.06	00.00

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