Study of the FR-TO effect

Arthur Charles Butler

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A STUDY OF THE FR-TO EFFECT

by

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B.S., University of Utah, 1967

A committee draft submitted in partial fulfillment of the requirements for the Master's Degree in Psychology University of Montana 1972

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Date Jan 3, 1972
ACKNOWLEDGMENTS

I wish to express my sincere appreciation to my thesis director, Dr. Andrew Lee, for his guidance. The helpful comments from the members of my thesis committee, Drs. Charles K. Allen, Lawrence Berger, and Dr. Robert Chaney were also appreciated. Special thanks is due to my typist, Marlene Wilson.
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CHAPTER I
INTRODUCTION

In the natural environment, only on rare occasions is every response reinforced. Extending this notion to the laboratory, a number of partial or intermittent schedules of reinforcement have been developed in which reinforcement is presented according to some rule. Two of the most common ways to schedule reinforcement are based on the passage of time (Interval Schedule), and the number of responses made (Ratio Schedules, ratios being the number of responses per reinforcement; Catania, 1968).

With Interval Schedules reinforcement becomes available after some predetermined period of time, and this period may be either fixed or variable. Consequently, reinforcement is largely independent of rate of response. For example, with a Fixed Interval 30 second (FI 30 sec.) schedule, reinforcement follows the first response emitted 30 seconds after the preceding reinforcement, and this response is all that is necessary for reinforcement.

With ratio schedules, however, rate of reinforcement is determined by the rate of response, and the ratio required for reinforcement may be either Fixed (FR) or Variable (VR).
With FR, every Nth response is reinforced. FR responding is characterized by pauses after reinforcement, sometimes designated post-reinforcement pause (PRP), followed by a high and constant rate of responding.

Ferster and Skinner (1957) point out several relevant contingencies associated with FR reinforcement schedules. First, as stated above, the frequency of reinforcement depends upon the rate at which responses are emitted. Thus, increments in rate of response produce, and are presumably maintained by, high rates of reinforcement.

Also, the reinforcer serves as a discriminative stimulus. Because a response immediately following reinforcement is never reinforced, FR schedules typically produce low rates of response immediately after reinforcement.

Response-produced stimuli associated with the number of responses emitted can also serve as conditioned reinforcers. The strength of conditioned reinforcement associated with these stimuli increases with each successive response, becoming maximal at reinforcement.

Extending the above reasoning, since a count of zero responses immediately after reinforcement is never the occasion for reinforcement, and a count of N (Ratio requirement) responses indicates a maximum probability of reinforcement, number of responses could serve as a discriminative stimulus in FR.
In this context, Neuringer and Schneider (1968) have pointed out that, because the time between reinforcements usually covaries with the number of responses emitted between reinforcements, an animal's behavior may be controlled by either one, or both, of these variables. Neuringer and Schneider used a procedure which separated the effects of inter-reinforcement time and inter-reinforcement responses. Eight pigeons were divided into two equal groups, a Fixed Ratio (FR 15) and a Fixed Interval (FI 30) group. These ratio and interval values were maintained throughout the experiment. On both schedules every response except the reinforced response was followed by a brief blackout during which the key was inoperative and the chamber totally dark. The independent variable was the duration of the response-produced blackouts (0.0 sec., 0.34 sec., 0.64 sec., 1.13 sec., 2.13 sec., 4.96 sec., 0.34 sec., and 0.0 sec.), which were identical for both FI and FR groups. On the FR schedule, a constant 15 responses were emitted between reinforcements while inter-reinforcement time varied with blackout duration. On the FI schedule, inter-reinforcement time remained constant and number of responses varied with blackout duration. The two measures of behavior were response latency after blackout (interval between termination of blackout and emission of a response) and response latency after reinforcement (interval between termination of reinforcement and emission of a response). Both response latencies under the FR schedule
increased as approximately linear functions of average inter-reinforcement interval. Under the FI schedule, in which inter-reinforcement time was constant, both response measures remained approximately constant. Under neither schedule could response latencies be predicted from average number of inter-reinforcement responses, but were highly correlated with inter-reinforcement time.

It appears that organisms responding on FR schedules arrive at some optimal rate of reinforcement, and that this is accomplished by varying the length of the PRP rather than the rate of response. For example, Felton and Lyon (1966) investigated the relationship between length of post-reinforcement pause and FR length and found that consistent and stable increases in the length of the PRP occurred as the ratio requirement increased. Felton and Lyon also reported a general decrease in rate with increased ratios, but this increase was neither consistent or stable. The decrease was not due to changes in absolute local response rate, but was largely due to multiple pauses characteristic of higher ratios. The systematic relationship between responding and the value of the ratio could be explained in terms of the change in inter-reinforcement responses, but in light of the findings of Neuringer and Schneider an explanation in terms of the change in the correlated inter-reinforcement time variable seems more acceptable.
CHAPTER II

aversive aspects of fixed ratio schedules

Two explanations of the PRP have been offered, both of which will be examined in the proposed study. First, since the probability of reinforcement is low immediately following reinforcement, the probability of a ratio response is low. This would increase the likelihood of occurrence of any other competing behavior (Ferster and Skinner, 1957). Some recent evidence suggests, however, that the PRP may be an attempt to avoid some aversive aspect of the FR "run" size (Azrin, 1961). Azrin allowed pigeons to control the duration of their escape from an $s^D$ association with an FR schedule. One peck on a second key produced a Time-Out (TO) condition, during which all responding was ineffective in producing reinforcements; a second peck restored original $s^D$ contingencies. Azrin found that the time spent in TO increased as the FR requirement increased from 65 to 200 responses, and that TOs usually occurred during the PRP segment of the inter-reinforcement interval.

With regard to the TO procedure used by Azrin, Herrnstein (1955) has demonstrated that TO can function either to punish or reward behavior, depending on the nature of the baseline schedule. If the baseline schedule is one
of positive reinforcement, TO from such a schedule can be punishing. Zimmerman and Ferster (1958) conducted an extensive investigation of the stimuli associated with the discontinuation of positive reinforcement. This was done by using another stimulus in whose presence subjects (monkeys) could not obtain reinforcement. Ferster (1957) termed this the Time-Out stimulus and demonstrated that removal of stimuli associated with reinforcement had many features in common with other aversive events, such as electric shock.

MacMillan (1967), using squirrel monkeys, found that both TO from reinforcement and electric shock suppresses behavior to about the same degree. Although certain differences between the effects of shock and TO were evident, the similarities appeared more striking than the differences. Similar results have been found with rats (Kaufman and Baron, 1968), preschool children (Baer, 1960) and young adults (Baron and Kaufman, 1966).

If, however, baseline behavior is maintained by avoidance of aversive stimulation, electric shock for example, time out from such conditions may be positively reinforcing instead of punishing. Verhave (1962) has demonstrated this phenomenon in a fairly extensive series of experiments.

Verhave's subjects (rats) were presented with a two-bar situation, with a free-operant avoidance schedule programmed on one bar, and a time-out from avoidance contingency scheduled on the other bar. The shock-shock
interval was three seconds and the response-shock interval was 20 seconds. Thus, if the animal pressed neither bar, he received a shock every three seconds, but every time he pressed the avoidance bar, he postponed the shock 20 seconds. A 433 Hz tone was correlated with the TO period. Thus, avoidance responding during TO periods became unnecessary. Verhave observed a general tendency for avoidance responses to decrease during TO periods, with a simultaneous increase in the frequency of TO responses.

Sidman (1962), in an independent series of studies, has obtained similar results with monkeys, and Granada and Hammack (1961) have used the same procedure with sleeping adults.

Again Azrin (1961), using pigeons as subjects, first reinforced key pecks according to an FR 50 schedule. Simultaneously, a second TO key was made continuously available to the subject. A single response on this key changed the color and intensity of the ambient illumination, as well as the light projected on the two translucent response keys. Under conditions of changed illumination, responses on the food key had no programmed consequences. A second response on the TO key restored original conditions of illumination as well as the possibility for reinforcement. Results showed that time spent in TO was a function of FR size, when FR was increased from FR 65 to FR 200 (Figure 1). At low ratios only a few seconds were spent in TO, but at
FR 200, Ss spent about 50 percent of the experimental period in TO. Azrin also demonstrated that, since the TO was typically initiated toward the end of the PRP, TO was not exclusively associated with lack of responding. Azrin suggests that his subjects may have placed themselves under extinction in order to avoid some aversive aspect of the FR schedule of positive reinforcement.

Thompson (1964) points to several lines of evidence to show the aversive quality of FR schedules. For example, Herrnstein (1958) reports that pigeons placed in a two-key situation with different valued FRs programmed on each key (e.g. FR 20 and FR 50), consistently prefer the key with the lower requirement.

Using a somewhat different procedure, Findley (1958) has demonstrated what could be described as FR aversiveness. He employed a switching-key procedure in which pigeons could receive reinforcement for pecking a key which was illuminated either red or green. Pecking in a given color, however, became less favorable the longer the color and the associated schedule were in effect. A second (switching) key was also available, and any time following a reinforcement in a given color, a peck on the switching key changed the color and reset both schedules to zero. The number of responses required for reinforcement increased by 100 responses with each successive reinforcement. Thus, the first reinforcement in either color required 100 responses; the second, 200
responses; the third, 300 responses; etc. With extended training under these conditions, Findley reported an increase in the strength of the switching response, indicating a preference for smaller over larger ratios. Apparently, schedule aversiveness increases with increases in ratio size, as evidenced by preference for smaller ratios. It may be however, that both Herrnstein's and Findley's subjects preferred the lower FR requirements simply because they provided higher rates of reinforcement (Neuringer and Schneider, 1968).

Thompson (1964) reports three experiments which attempt to extend the generality of Azrin's results. In the first study four subjects (rats) were trained to press a bar to obtain water reinforcement, according to an FR schedule which was gradually increased from FR 1 to FR 25. After stabilization at FR 25 the requirement on the water bar was increased by increments of 25 until FR performance was extremely strained (the appearance of pauses in FR or VR responding at times other than after reinforcement, due to large ratio sizes and/or insufficient reinforcement). Then, FR requirement was decreased, by increments of 25, back down to the baseline of FR 25. During this time the second (TO) bar was made available. Three presses on this bar resulted in 30 seconds of S-delta. During S-delta house lights were turned off and responses on either bar had no programmed consequences. Appropriate measures were taken
to control for the possible aversiveness of S-delta per se, apart from its association with FR. Thompson reports that schedule aversiveness increased in a monotonic fashion as a function of FR requirement. This increase was measured by both an increase in TOs and decreased reinforcement rate. Also, ratio "strain", which is arbitrarily defined by Thompson as PRPs greater than 50 seconds, increased as a function of FR requirement. Both in terms of TO and post-reinforcement pauses, descending sequences successfully recovered ascending values. Examination of cumulative records showed that TO responding occurred almost exclusively during the post-reinforcement pause, and that once Ss began responding at a terminal rate, this continued uninterrupted until reinforced.

In his second experiment, Thompson compared TO performance during a mixed FR 25 FR 225 schedule and a straight FR 225 schedule. During both schedules three responses were required on a second bar to produce TO. As before, house lights were on during S_d, and off during S-delta. Again, TO duration was 30 seconds. Under straight FR contingencies TOs usually occurred during the post-reinforcement pause, but with MIX FR 25 FR 225 TOs occurred in the FR 225 component only after the emission of 25 responses (the lower ratio), and in no instances were TOs produced in the FR 25 component. Also, PRPs characteristic of straight FR 225 were essentially displaced to a point within the inter-reinforcement interval corresponding to the unreinforced completion of the lower ratio.
In his final study, one subject was exposed to an ascending FR sequence until no reinforcements were produced during a 1.5 hour session. Holding constant the FR at this breaking point (FR 475), the TO requirement was increased from 3 to a value just sufficient to eliminate TOs entirely. During this phase, TO duration remained constant at 30 seconds. TO responding became strained at a requirement of 15 responses and when 27 responses were required to impose TO, Ss completely avoided both levers.

Thompson concludes that his subjects time out in order to avoid aversive properties associated with FR schedules. Since TOs were produced regardless of whether S-delta was light or dark, Thompson dismisses the notion of the direction of stimulus change as an alternative explanation of the TO data. A reasonable alternative interpretation is that animals time out in order to produce stimulus change. This notion is supported by results from Thompson's third experiment, in which three responses on the TO bar no longer produced stimulus change, and subsequently extinguished.

Appel (1963) also concerns himself directly with two aspects of the TO, namely escape from aversive aspects associated with FR responding, and stimulus change, in an attempt to explain what maintains it. His subjects (pigeons) were trained to peck one (left) of two keys to obtain food on various FR schedules. Concurrent first pecks on a second (right) key had one of three effects: 1. Both keys
turned yellow, house lights were extinguished, and the food reinforcement contingency was removed from the left key. A second peck on the TO key turned both keys green and restored the reinforcement contingency on the left key. 2. Same as 1, except Ss could obtain reinforcement by pecking the left key when both keys were yellow.

Responses on the right key had no programmed consequence.

Appel demonstrated that when a response on the right key produced stimulus change, the number of right key responses increased as a function of the size of the ratio requirement on the left key. Also, in condition 1, subjects rarely spent more than five percent of their time in the yellow at any FR value. But, when reinforcement could be obtained in either set of stimulus conditions (condition 2), the time spent in yellow was an exponential function of the number of responses in the FR. Right key responses nearly always occurred prior to the ratio runs and during the pause after reinforcement. Ss usually restored baseline conditions (both keys green) before running off ratios.

The results of Appel's experiment partially agree with those of Azrin (1961). Pigeons pecked at a key which changed stimulus conditions and the frequency of responding on that key was a function of the value of the FR on the other key. The relative influence upon behavior of the TO period associated with right key responses is less clear.
CHAPTER III

PROBLEM

The phenomenon of self-imposed TO concurrent with FR seems to be fairly well established although there seems to be some confusion as to what aspects of TO are maintaining this behavior, and how these aspects are related to ongoing reinforcement contingencies. One possible explanation, suggested by Azrin, is that animals time out in order to avoid an aversive state of affairs associated with the FR run. This explanation would seem to be supported by several things, e.g. the location of the TO just preceding the FR run, and that TO rarely occurs once the FR run has begun. With it may be, however, that the TO response occurs simply because the probability of an FR response is low immediately following reinforcement, which increases the likelihood of occurrence of other behavior, namely stimulus change responses. Zimmerman and Ferster suggest that TO behavior could represent temporary losses of control of the FR schedule of food reinforcement, implying that the extinction component of TO is not necessary. In terms of the two explanations of the PRP, competing behavior could be defined as pecks on a second key which changes stimulus conditions but does not remove the possibility of reinforcement, whereas pecks on a second key which changes stimulus conditions but also
removes the possibility for reinforcement could be said to remove the organism from an aversive state of affairs.

The present experiment is designed to compare these two explanations of the PRP by obtaining a preference measure of FR with a TO option vs. FR with a stimulus change option. One technique for obtaining preference measures with operant procedures is the use of the concurrent chain schedule (Autor, 1960; Herrnstein, 1964). In this procedure the organism responds on two concurrently available keys, each of which is illuminated by the stimulus associated with the initial link of one of the chains. Responses on each key produce the stimulus, and schedule, associated with the terminal link of the chain on that key according to a VI schedule of reinforcement. The VI schedules associated with the initial links of the chains on each key are equal. When the stimulus associated with the terminal link of one key is obtained the other key becomes dark and inoperative (Fantino, 1970).

Autor and Herrnstein showed that, during concurrent chain responding, the pigeon allocates its choice responses during the initial links in the same proportion as reinforcements are distributed in the terminal links, i.e. the organism matches proportions of responses to proportions of reinforcement. Thus, if the rate of reinforcements per minute in the terminal link of the right key were twice as great as the rate of reinforcement in the terminal link of
the left key, pigeons would emit twice as many responses on the right key as on the left key during the concurrently presented initial links of the two chains.

Fantino (1969) has shown that the values of the VI schedules in the initial links were important determiners of choice. Fantino (1970) also found that pigeons consistently prefer the smaller of two terminal FRs, but that such preference seemed not to be based on relative rates of reinforcement. If the difference between two terminal FRs is held constant while the absolute size of the FRs is increased, relative rates of reinforcement approach .50 for either terminal link. In this case, Fantino's birds showed strong preferences for smaller FRs even though relative rates of reinforcement approach .50 for either terminal link.

Fantino also demonstrated that, when choice proportions are defined as the number of responses during the concurrently available links, with identical FRs in both terminal links, choice proportions of from .45 to .55 can be expected.
CHAPTER IV

METHOD

Subjects

Subjects were three experimentally naive, adult male White Carneau pigeons, maintained at 80 percent normal body weight.

Apparatus

A three-key pigeon chamber measuring 12 x 13 x 13 inches was employed. The response keys, one inch diameter, were mounted eight and one half inches from the floor and two and three fourths inches above the center key. Reinforcement was three to four seconds access to grain, obtained through a two and one half by two inch feeder aperture, located two inches above the floor and directly below the center key. An attenuation shell (Lehigh Valley Electronics) and white noise were used to control exteraneous noise.

Solid-state digital logic was used to program all experimental events. Responses and reinforcements were recorded on cumulative recorders. Inter-reinforcement interval lengths were taken from electromagnetic counters. The programming circuitry and the pigeon chamber were housed in adjacent rooms.

Procedure

A variation of the concurrent chain procedure was used in which the initial links were VI schedules and the
terminal links were two successive FRs. After magazine training, pecks were shaped with initial link colors illuminating the respective keys. The concurrent chain procedure was then instituted.

A diagram of the three-key concurrent chain procedure is shown in Figure 2. The center key was inoperable until stable choice proportions (.45 to .55) were reached. Then, each session began with a choice period during which both outside keys were illuminated with a white light. During this period the center key was dark. Pecks on the left key occasionally (VI 1') caused both the left and center keys to turn red and the light key to darken. During the red light periods pecks on the left key were reinforced according to the particular FR in effect. Two successive FRs were programmed, both of the same value. During this period, a peck on the stimulus change (center) key had the following effect: both the left and center keys turned pink and the house lights were extinguished, during which time reinforcement could still be obtained by pecking the left key. The second peck on the center key turned both the left and center keys back to red and turned on the house lights, with reinforcement still available on the left key. During terminal link responding on the left and center keys, pecks on the darkened right key had no programmed consequence. Upon completion of the second FR on the left key, both outside keys turned white and the center key became darkened, signalling another choice period.
Similarly, right key pecks occasionally (VI 1') caused the right key to turn green, the center key green, and the left key to become darkened. During this period pecks on the right key were reinforced according to the particular FR in effect. Two successive FRs were programmed, both of the same value. During this period a peck on the TO (center) key had the following effect: both the right and center keys turned yellow and the house lights were extinguished, during which time pecks on the right key had no programmed consequence. A second peck on the TO key turned the center and right keys back to green and turned on the house lights, at which time reinforcement could again be obtained by pecking the right key. Upon completion of the second FR on the right key, the center key became darkened and both outside keys turned white signalling another choice period.

The asymmetry between the two terminal links was defined by the consequences of pecks on the center key. In the left hand case, center key pecks resulted in stimulus change but no loss of the opportunity to obtain reinforcement. In the right hand case, first pecks were correlated with stimulus change plus loss of the opportunity to obtain reinforcement, while second pecks on the center key resulted in stimulus change plus reinstatement of FR contingencies.

Three FRs were run in the following sequence: FR 96, FR 136, and FR 192. Each session ended after 30 reinforcements but because of the extended length of sessions while FR 192 was being examined, the number of reinforcements
received in each session was reduced to 26. All birds were run for a minimum of 16 days at each FR condition. When visual inspection of the proportion of right key choice responses showed no systematic variation for a minimum of five consecutive days, the next FR condition was initiated.
CHAPTER V
RESULTS

Preference

Figure 3 shows preference data for all three birds, reported as a function of FR value. Each point was obtained by calculating the mean proportion of right key choice responses for the last five days at each FR value. The first point represents the matching condition, obtained with FR 96 in both terminal links and prior to the introduction of the center key contingency. Points above the .50 mark indicate a preference for the terminal link with the stimulus change (SC) option.

Bird #1 showed slight preferences for the right key at FR values of 96 and 136. During these two ratio values, #1 placed himself in both TO and SC conditions, but always reinstated the original FR stimulus conditions before completing ratios. With FR 192 in the terminal links, however, this bird began receiving reinforcements during SC, which corresponded with a marked preference for the left key. This preference was probably maintained because the relative novelty of receipt of reinforcement during the SC condition resulted in a higher rate of reinforcement for that key. Visual inspection of cumulative records showed that a
shortening of the post-reinforcement pause in the left terminal link following reinforcement during SC was responsible for the increased reinforcement rate.

Bird #2 showed consistent, although slight, preferences for the left key at all FR values. Bird #3 showed somewhat stronger preferences for the left key at all FR values. Both birds placed themselves in both TO and SC conditions, but always reinstated the original FR stimulus conditions before completing ratios.

It is clear from Figure 3 that, with the exception of #1 at FR 192, the center key consequences did not systematically influence initial link choice responding. However, neither were subjects indifferent between equal terminal link FRs. The assumption that animals will be indifferent between equal terminal link reinforcement conditions is one of the defining characteristics of the concurrent chain procedure (Autor, 1960; Fantino, 1970). The following results suggest the possibility that different rates of reinforcement developed in the two terminal links, which acted to control both preference and center key behavior.

Inter-reinforcement Interval

Table 1 shows inter-reinforcement intervals for each bird under each FR condition. Data were taken from the last five days of responding at each FR condition. The total time (seconds) spent in the first and second FRs of each terminal link was divided by the appropriate number of.
reinforcements to obtain inter-reinforcement intervals for the first and second FRs. These two figures were then averaged, yielding the over-all inter-reinforcement interval for that terminal link.

Inspection of Table 1 reveals three things. First, reinforcement rate decreased with increase in FR value. Second, inter-reinforcement intervals were generally shorter for the first FRs in the terminal link sequences. This difference may have arisen because the first ratio was preceded by terminal link entry, not by the usual post-reinforcement pause. The second ratio was, however, preceded by both a post-reinforcement pause and a ratio run. This difference was not due to differences in running rates, because visual inspection of cumulative records showed that, for any one bird, all running rates were essentially identical. The values for Bird #3 paused extensively during both the first and second FRs in the right terminal link at FR 136 and FR 192.

Finally, if inter-reinforcement intervals are compared with the preference measures in Figure 3, with the exception of #1 at FR 136, the terminal link with the highest reinforcement rate was preferred. This finding is in agreement with other literature using the concurrent chain procedure (Fantino, 1970). Since the rate of reinforcement was not under direct experimental control, it is impossible
to determine which came first, the preference or the higher reinforcement rate.

**Center Key Behavior**

Figures 4, 5, and 6 show, for each bird, the time spent in TO or SC as a function of FR value. Each point was obtained by dividing the total time spent in TO or SC by the appropriate number of reinforcements. Only values from the last five days at each FR condition were used.

Birds #2 and #3 treated both center key contingencies similarly, placing themselves in both TO and SC conditions, but always reinstating the original FR stimulus conditions before completing ratios. Time spent under both center key conditions occurred almost exclusively during post-reinforcement pauses and prior to ratio runs. Both birds occasionally pecked the FR keys during both TO and SC, and these occasional responses never completely extinguished. Both birds always reinstated the original FR conditions before running off ratios, regardless of the center key contingency.

Bird #1 treated both center key contingencies similarly at FR values of 96 and 136. During FR 192, however, #1 received a reinforcement during SC. The following day, this bird began placing himself in SC before running off ratios. This behavior continued until #1 reached stability at FR 192. At one point during this period, #1 also made between 400 and 500 successive extinction responses on the FR key during TO.
All three birds produced a monotonically increasing relationship between time spent in both SC and TO, and the required number of ratio responses. Although birds #2 and #3 spent more time in TO at FRs of 136 and 192, this was apparently not because of different center key contingencies, since both birds treated both contingencies similarly. Bird #1 spent slightly more time in TO at FRs 136 and 192, even though the SC contingency was being used differently at FR 192. When the time spent during the preferred and non-preferred center key conditions is plotted against FR size for all birds, as in Figure 7, it becomes apparent that subjects spent substantially more time in that center key condition associated with the non-preferred terminal link. Thus, reinforcement rate covaries with both preference and time spent in center key conditions.
CHAPTER VI
DISCUSSION

The purpose of this experiment was to determine the maintaining aspects of self-imposed TO concurrent with FR responding. Two explanations were examined. The first, proposed by Azrin (1961) states that pigeons time out in order to avoid an aversive state of affairs associated with FR responding. In his original experiment, Azrin argued that the extinction component of the time out was necessary for maintenance of TO responding, and that such responding was not maintained by stimulus change per se. Others (Appel, 1963; Zimmerman and Ferster, 1964) have suggested that, since the probability of reinforcement is low immediately following reinforcement, there will be an increased likelihood of occurrence of other behavior, namely stimulus change responses. If this is the case, TO responses would be maintained by the change in stimulation that they produce, and the extinction component associated with TO would be unnecessary. The data from the present experiment will be offered as further tentative evidence that the second of the above explanations is correct.

The strongest support for the second of the above explanations comes from the fact that, with the exception of Bird #1 at 192, all birds treated both center key contingencies identically. The degree of change in
stimulation resulting from center key pecks was the same for both schedules. The asymmetry lay in the difference of the consequences of center key pecks. Center key pecks during the right terminal link resulted in stimulus change plus loss of opportunity to obtain reinforcement. Here, subjects had to reinstate original FR stimulus conditions before reinforcement could be obtained. With one exception, the birds were not sensitive to this difference. The lack of sensitivity to the center key consequences implies that the extinction component may not have been necessary, and that the change in stimulation maintained center key pecks.

Other lines of evidence also support the stimulus change notion. Appel (1963) examined TO behavior when TO responses resulted in stimulus change but not extinction, a condition similar to the left key situation in the present study. Under these conditions time spent in TO increased with ratio size. When TO responses resulted in stimulus change and extinction, a condition similar to the right key situation in this experiment, no such relationship was obtained. Appel reports that several of his birds experienced reinforcement during SC, whereas only one bird did so in the present study. Had all three birds obtained reinforcement during SC, a difference in functions, similar to that reported by Appel, may have been found. Zimmerman and Ferster (1964), also failed to find a monotonic relationship between ratio size and TO behavior, but did show that
the degree of TO activity increased as the amount of stimulus change produced by TO responses increased.

These data, together with the results from the present experiment, suggest that a response produced change in stimulation is necessary to maintain TO responding, and that production of extinction conditions is unnecessary.
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* preferred key
minutes spent in time-out from reinforcement
choice period

left and center keys operative

two FRs: SC

pecking on left key occasionally leads to

two outside keys operative

choice period restored

after which

pecking on right key occasionally leads to

right and center keys operative

two FRs: TO

after which
time spent (seconds) in center key condition per FR

BIRD 2
O SC
O TO

159 sec.

Fig. 5
ALL BIRDS
- preferred key
- nonpreferred key

Fig. 7
REFERENCES


