Effect of Fixed-Ratio Size on Response-Latencies Produced by Other Variables

Albert Edward Neal

Western Michigan University

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EFFECT OF FIXED-RATIO SIZE ON RESPONSE-LATENCIES PRODUCED BY OTHER VARIABLES

by

Albert Edward Neal

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Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
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Western Michigan University
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EFFECT OF FIXED-RATIO SIZE ON RESPONSE-LATENCIES PRODUCED BY OTHER VARIABLES

Albert Edward Neal, M.A.
Western Michigan University, 1985

Using a discrete-trial, two-component multiple schedule, pigeons were required to complete a fixed-ratio in the presence of stimuli correlated with different probabilities of reinforcement (Experiment 1), or different amounts of reinforcement (Experiment 2). The amount of separation of graphed median latencies to the onset of the two stimulus conditions as a function of the different reinforcement conditions was investigated in relation to various fixed-ratio values. It was found that previous researchers had chosen an optimal fixed-ratio size; larger ratios produced greater separation between median latencies, but at the expense of increased session-to-session variability, while smaller ratios failed to produce median latency separations that were useful in evaluating the effects of the other variables.
ACKNOWLEDGEMENTS

I would like to thank Drs. Howard Farris and Richard Malott for their patience and continued support. Their support during times in which I was less productive made it easier to return to the task.

I am indebted to Drs. Bruce Hesse and Henry Schlinger for sharing their research with me; they and Dr. Jack Michael contributed greatly to the methodology and direction of the present study. Appreciation is also owed Dr. H. Keith Rodewald, of Central Michigan University, for his assistance in programming the computer for this research and for the time he devoted to discussions of the research with me.

Dr. Jack Michael has been my mentor, friend, and role-model during more than 20 years of graduate training and teaching; I am especially indebted to him. Without his encouragement, support, and guidance, this thesis would not exist. Furthermore, because of his assistance and his enthusiasm for this research area, I have renewed my own interest in conducting research; I thank him for returning me to the laboratory.

Albert Edward Neal
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CHAPTER I

INTRODUCTION

Latency, the time between the onset of a stimulus and the onset of the response that is controlled by that stimulus, has a long history as a dependent variable in experimental psychology. During the late 19th century, Wundt employed latency as a response measure in human psychophysics. His research was continued by Cattell and his students at Columbia University during the early part of the 1900s (Moody, 1970). Cattell believed that one could use latency as a dependent variable to measure human responsiveness to various levels of physical stimuli: "When differences (in stimuli) acquire equal times for discrimination, the discriminations are equally difficult, and the differences are equal for consciousness" (Cattell, 1902, cited in Cattell, 1947, p. 356). At about this same time, Anrep (1920) used latency as one measure of classical conditioning. The length of time between the onset of the conditioned stimulus (CS) and the onset of the conditioned response (CR) was one of the indicators of classical conditioning progress.

The first adaptation of human reaction time methods, developed and used in psychophysical experiments, to the animal laboratory is credited to B. F. Skinner (Moody, 1970). Skinner (1946) described an experiment in which a pigeon's response-latencies were differentially reinforced during stimulus presentations. In a forced-trial experimental setting, the response key was illuminated for 3 seconds; at
the end of the 3-second "ready signal", a buzzer sounded. Key pecks during the 3-second light extinguished the light and began another trial. The first peck during the buzzer was reinforced. Reaction times (latencies) in the order of 200 to 300 milliseconds were attained by progressively shortening the buzzer duration. In spite of this contribution, Skinner discouraged the use of latency in favor of rate of responding in a free-operant setting (Skinner, 1950). His argument was two-fold: (1) Latency measured "the development of effective waiting" (1950, p. 197) rather than changes in the behavior being studied, and (2) "this measure does not vary continuously or in an orderly fashion" (1950, p. 197). The first argument suggests that latency does not show changes in the behavior of interest but, rather, demonstrates changes in collateral, competing behaviors. The second argument was made in response to the results of his research in which the latency was shown to be insensitive to changes in deprivation with pigeons (Skinner, 1946).

Although research in the experimental analysis of behavior has been strongly influenced by these arguments, some researchers have found latency a useful dependent variable. Beginning in the late 1950s, many research efforts utilized latency in the study of (a) animal psychophysics (Green, Terman, & Terman, 1979; Moody, 1970; Moody, Stebbins, & Iglauer, 1971; Randlich, Klein, & LoLordo, 1978; Saslow, 1968; Stebbins, 1966; Stebbins & Lanson, 1961; Stebbins & Lanson, 1962; Stebbins, Lundin, & Lyon, 1960; Stebbins & Miller, 1964; Stebbins & Reynolds, 1964; Terman & Terman, 1963), and (b) schedules of reinforcement (Cross & Lane, 1962; Hienz & Eckerman, 1974; Keller...
Renewed interest in employing latency as a measure of the effect of traditional independent variables (size of fixed-ratio, probability of reinforcement, and amount of reinforcement) has developed at Western Michigan University (Hesse, 1984; Hesse, Michael, Whitley, Nuzzo, & Sundberg, 1984; Nuzzo, 1981; Schlinger, 1984). The Hesse et al. (1984) research, which demonstrated that response latency could be used as a sensitive and reliable measure of the effect of these variables, is the most relevant to the present studies. After initial key-peck training, pigeons were placed on a fixed-trial, two-component multiple schedule. A trial began with the onset of either a red or green illuminated key; each color correlated with one of the two values of the variables under study. One group of birds was required to respond to different fixed-ratio sizes (FR 15 and FR 3), another to different probabilities of reinforcement (0.9 and 0.3), and still another to different amounts of reinforcement (6s and 2s).

These studies are an extension of that work. Using an experimental setting modelled after Hesse et al. (1984), the present research is designed to study the interaction of fixed-ratio size with (a) the probability of reinforcement in Experiment 1, and (b) the amount of reinforcement in Experiment 2.

According to Michael (personal communication, 1982) the size of the fixed-ratio was chosen pragmatically; the value of FR 15, when used to demonstrate the effect of different probabilities of
reinforcement or different amounts of reinforcement, produced a sufficient separation of median latencies to warrant its use.

The two experiments presented here are designed to establish the upper and lower limits of the fixed-ratio that would be most effective in investigating the role of probability of reinforcement (Experiment 1) and the amount of reinforcement (Experiment 2).
CHAPTER II

EXPERIMENT I: INTERACTION OF FIXED-RATIO SIZE AND PROBABILITY OF REINFORCEMENT

Method

Subjects

Two naive White Carneaux male pigeons (Palmetto Pigeon Plant, Sumter, North Carolina) were used as experimental subjects. They were maintained at approximately 80% of their free-feeding weight for a portion of the experiment, then reduced to and maintained at approximately 75% of their free-feeding weight for the remainder of the experiment. Although the level of deprivation was relevant, it did not operate as a variable in this particular experiment.

Apparatus

The birds were trained in a standard three-key test chamber (Lehigh Valley Electronics) with in-line digital display cells (IEE, In-line Readouts, Industrial Electronics Engineers, Inc.) mounted behind each key. Only the center key, mounted directly over the food hopper, was used; the keys on either side were available but inoperative and nonilluminated. The house light was not used. The test chamber was housed in a sound- and light-attenuating Accoustical Environment (Industrial Acoustic Co., Model #102311); additional auditory isolation was achieved by the masking sound of the exhaust fan.
Programming of events and recording of data were performed by a Digital computer (PDP8-8/1) which was interfaced with the chamber by a Lehigh Valley Electronics Interact System. Data (latencies) were displayed on a standard teletype printer terminal.

Procedure

The birds were trained to peck a white center key through the use of a variation of the autoshaping procedure developed by Brown and Jenkins (1968). During a general experimental training phase, they were required to complete successively higher ratios until consistent fixed-ratio performance on an FR 25 was reached. Subsequent to this training, both birds were placed on a two-component multiple schedule in which the center key was illuminated with either a red or green light, each with a probability of 0.5. Once illuminated, a single key peck would, with a probability of 0.9, extinguish the light, illuminate the hopper opening, and raise the food hopper for 4s, after which an intertrial interval of 5s was imposed. Should the pigeon peck during the intertrial interval, an additional 5s of non-pecking was required. Should the pigeon not peck or not complete the ratio requirement during 30s of stimulus presentation, an intertrial interval was imposed and a new trial began. The FR component was then increased to an FR 15 in both stimulus conditions. Figure 1 represents the experiment in State Diagram (Interact Programming Manual, 1969). Training at the higher ratio continued until a visual inspection of the graphed median latencies on two-cycle semi-log paper for each stimulus condition showed no systematic changes across
Figure 1. Description of the Experiments as Represented in State Diagram (Interact Programming Manual, 1969).
sessions. For each bird, after baseline data were collected, the color associated with the shorter median latencies was chosen as the stimulus correlated with the less favorable independent variable parameter. Both birds exhibited shorter median latencies to red; therefore, red was correlated with the less favorable value of the independent variable.

Following this general experimental phase, and the subsequent baseline training during which the parameters of the potential variables were the same in the presence of both stimulus conditions (i.e., FR 15 and a probability of reinforcement of 0.9), the probability of reinforcement for both birds was held constant (0.9 in green and 0.3 in red) and the fixed-ratio requirement in both stimulus conditions was varied according to the schedule in Table 1.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Sessions</th>
<th>Stimuli</th>
<th>Fixed Ratio</th>
<th>Probability of Reinforcement</th>
<th>Amount of Reinforcement</th>
</tr>
</thead>
<tbody>
<tr>
<td>#5670</td>
<td>1-15</td>
<td>G/R</td>
<td>15/15</td>
<td>0.9/0.9</td>
<td>4s/4s</td>
</tr>
<tr>
<td></td>
<td>16-35</td>
<td>G/R</td>
<td>15/15</td>
<td>0.9/0.3</td>
<td>&quot;</td>
</tr>
<tr>
<td></td>
<td>36-49</td>
<td>G/R</td>
<td>40/40</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td></td>
<td>50-72</td>
<td>G/R</td>
<td>25/25</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>#4695</td>
<td>1-30</td>
<td>G/R</td>
<td>15/15</td>
<td>0.9/0.9</td>
<td>4s/4s</td>
</tr>
<tr>
<td></td>
<td>31-49</td>
<td>G/R</td>
<td>15/15</td>
<td>0.9/0.3</td>
<td>&quot;</td>
</tr>
<tr>
<td></td>
<td>50-62</td>
<td>G/R</td>
<td>25/25</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td></td>
<td>63-76</td>
<td>G/R</td>
<td>5/5</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td></td>
<td>77-90</td>
<td>G/R</td>
<td>40/40</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td></td>
<td>91-100</td>
<td>G/R</td>
<td>15/15</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td></td>
<td>101-109</td>
<td>G/R</td>
<td>40/40</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td></td>
<td>110-135</td>
<td>G/R</td>
<td>25/25</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
</tbody>
</table>
Results

Bird #5670

The data for Bird #5670 are shown in Figure 2 and Figure 3. During the baseline sessions (FR 15, probability of reinforcement, 0.9, and amount of reinforcement, 4 seconds access to grain during both stimulus conditions), the subject emitted shorter median latencies in the presence of the red stimulus condition during 73% of the sessions. In spite of the variability in responding across sessions, there was little separation between stimulus conditions; increases and decreases in the median latencies during one stimulus condition were tracked consistently by the median latencies during the other stimulus condition.

The probability of reinforcement was changed to 0.3 during the red stimulus condition beginning with the 16th session; probability of reinforcement during the green stimulus condition remained 0.9. By the second session, a modest separation existed between the median latencies for the two stimulus conditions; this increased separation was produced by the simultaneous lengthening of latencies during the red condition and the shortening of latencies during the green condition, reflecting the change in probability of reinforcement. This disparity between stimulus conditions continued and reached its greatest value by the eighth session. The differences between median latencies for the rest of this condition showed no systematic change. There was considerable variability, however, in the session-to-session median latencies during the red stimulus condition.
Figure 2. Median Latencies for Bird #5670 Across Sessions.

Note. Phases of the experiment following baseline condition represent different fixed-ratio sizes for both stimulus conditions.
Figure 3. Median Latency Separation for Bird #5670.

Note. Each session's value was obtained by subtracting the median latency for the green stimulus from the median latency for the red stimulus.
Beginning with the 36th session, the fixed-ratio requirement was increased to FR 40 in both stimulus conditions, while the probability of reinforcement and amount of reinforcement values remained the same as in the previous condition. As a result of this increased ratio, the median latencies during both the red and green increased. As can be seen in both Figures 2 and 3, but particularly Figure 3, the disparity between stimulus conditions was greater than during the FR 15 of the previous condition at the beginning of this condition (Sessions 36, 39, and 42), but in spite of increased latencies during both stimulus conditions, there was no appreciable difference between the median latencies. That is, with the exception of the early sessions within this condition, the difference between the latencies was no greater than was found during the previous FR 15 condition.

During the final condition, beginning with the 50th session, the ratio requirement was reduced to FR 25 during both stimulus conditions. The median latencies for responses in both stimulus conditions, as well as the separation between median latencies in both stimulus conditions, returned to a level similar to that exhibited during the previous FR 15 condition. As in the FR 15 condition, the median latencies exhibited considerable variability across sessions.

**Bird #4695**

The data for Bird #4695 are presented in Figures 4 and 5. Stability of the baseline data was demonstrated during the first 30 sessions in which the parameters of the three variables were the same in the presence of both stimulus conditions. These variables and
Figure 4. Median Latencies for Bird #4695 Across Sessions.

Note. Phases of the experiment following baseline condition represent different fixed-ratio sizes for both stimulus conditions.
Figure 5. Median Latency Separation for Bird #4695.

Note. Each session's value was obtained by subtracting the median latency for the green stimulus from the median latency for the red stimulus.
parameters were the same as in the baseline of Bird #5670. The subject emitted shorter latencies in the presence of the red stimulus condition during 80% of the sessions.

Once the probability of reinforcement variable was changed from 0.9 to 0.3 in the red stimulus condition, one sees little change in the responding to the two stimulus conditions during the next eight sessions. Beginning with the 38th session, the median latencies during the two stimulus conditions separate; latencies during red become longer and latencies during the green become shorter. Sessions #46 and #47 exhibit a perplexing reversal. These inconsistencies in the performance of this bird occur throughout the experiment and will be addressed later.

During the remainder of the experiment the probability of reinforcement was held constant as in the last condition, and the fixed-ratio requirement was systematically manipulated according to the following sequence: FR 25, FR 5, FR 40, FR 15, FR 40, and FR 25. As the ratio was manipulated, the median latency separation changed commensurate with the size of the ratio, greater with FR 25, still greater with FR 40, less with FR 5, etc. In addition to the separation between the median latencies for individual sessions, one finds a change in the absolute median latency for both stimulus conditions whenever the fixed-ratio size is changed; as the requirement is made more rigorous in both stimulus conditions, the median latency increases in both stimulus conditions, albeit greater in the low probability of reinforcement condition. In summary, increases in the ratio requirement for both stimulus conditions, while maintaining
unequal probabilities of reinforcement across stimulus conditions, produce two outcomes: (1) The difference between the median latencies changes as a function of fixed-ratio size, and (2) the absolute median latencies of both stimulus conditions change as a function of fixed-ratio size.

Bird #4695's behavior differed from expectations in two important ways: (1) It exhibited latencies of abnormally short duration, and (2) it often reversed an established performance under the two stimulus conditions or seemed to be unaffected by the programmed contingencies for no clear reason.

Although the program required the stimulus to be present before a peck could arrange the reinforcement contingency, it appears, from the extremely short latencies produced, that this subject often began the pecking response before the stimulus was presented. This pattern of anticipatory responding frequently caused the 5-second intertrial interval timing sequence to recycle. Further, it is suspected that in some cases the bird started a premature peck during the last portion of the intertrial interval, but made contact with the now-illuminated key. These pecks produced latencies shorter than the bird is capable of making in response to the color onset. Extremely short latencies, below 0.25 second, are probably the result of this behavior. No attempts were made to control these premature pecks other than the recycling of the intertrial interval timer.

The second difference in this bird's performance may have been related to its physical condition. During the time this research was conducted, the bird drank considerable amounts of water (twice that
of the other subjects) and produced watery stools. A local veterinarian suggested that the bird might be diabetic; examination confirmed that the feces contained considerable amounts of glucose. The relationship between this physical condition and the occasional inexplicable behavior of the subject remains unknown.
CHAPTER III

EXPERIMENT II: INTERACTION OF FIXED-RATIO SIZE AND AMOUNT OF REINFORCEMENT

Method

Subject

One naive White Carneau male pigeon (Palmetto Pigeon Plant, Sumter, North Carolina) was used as the experimental subject. It was maintained at approximately 80% of its free-feeding weight for a portion of the experiment, then reduced to and maintained at approximately 75% of its free-feeding weight for the remainder of the experiment. Although the level of deprivation was relevant, it did not operate as a variable in this particular experiment.

Apparatus

The apparatus was the same as used in Experiment I.

Procedure

Key-peck training and the general experimental training procedures were the same as for the two birds of Experiment 1. Bird #6723 also pecked the red stimulus condition with shorter latencies than to the green.

Following the general experimental training phase and the subsequent baseline training in which the parameters of the potential
variables were the same in the presence of both stimulus conditions (i.e., FR 15 and the amount of reinforcement, 4s), the amount of reinforcement was held constant, 6s in green and 2s in red, while the fixed-ratio requirement in both stimulus conditions was varied according to the schedule shown in Table 2.

Table 2  
Sequence of Experimental Conditions for Bird #6723

<table>
<thead>
<tr>
<th>Subject</th>
<th>Sessions</th>
<th>Stimuli</th>
<th>Fixed-Ratio</th>
<th>Probability of Reinforcement</th>
<th>Amount of Reinforcement</th>
</tr>
</thead>
<tbody>
<tr>
<td>#6723</td>
<td>1-30</td>
<td>G/R</td>
<td>15/15</td>
<td>0.9/0.9</td>
<td>4s/4s</td>
</tr>
<tr>
<td></td>
<td>31-61</td>
<td>G/R</td>
<td>15/15</td>
<td>&quot;</td>
<td>6s/2s</td>
</tr>
<tr>
<td></td>
<td>62-69</td>
<td>G/R</td>
<td>25/25</td>
<td>&quot;</td>
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<td></td>
<td>70-81</td>
<td>G/R</td>
<td>5/5</td>
<td>&quot;</td>
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<td></td>
<td>82-98</td>
<td>G/R</td>
<td>40/40</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td></td>
<td>99-104</td>
<td>G/R</td>
<td>25/25</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
</tbody>
</table>

Results

Bird #6723

The data for Bird #6723 are shown in Figures 6 and 7. During baseline the bird's performance is characterized by considerable stability. The subject emitted shorter median latencies in the presence of the red stimulus condition during 77% of the sessions. Following the 30 sessions of baseline, during which all of the parameters of the three variables were held constant, the amount of reinforcement was altered in both stimulus conditions, 2 seconds access to grain during the red condition and 6 seconds access during the green. Although presented with 600 trials over the next 12 sessions, the
Figure 6. Median Latencies for Bird #6723 Across Sessions.

Note. Phases of the experiment following baseline condition represent different fixed-ratio sizes for both stimulus conditions.
Figure 7. Median Latency Separation for Bird #6723.

Note. Each session's value was obtained by subtracting the median latency for the green stimulus condition from the median latency for the red stimulus condition.
subject failed to respond differentially to the two stimulus conditions. Beginning with Session #42, however, one begins to observe longer median latencies in the presence of the red stimulus condition, while the latencies in the presence of the green remain essentially the same as observed during baseline. Once stability of the data was reached, beginning with Session #62, the fixed-ratio requirement was systematically manipulated according to the following sequence: FR 25, FR 5, FR 40, FR 25. As the ratio was altered, the median latencies during the stimulus condition associated with less reinforcement changed commensurate with the size of the ratio, longer latencies when the ratio was increased, shorter latencies when the ratio was decreased.

In addition to the amount of separation between median latencies across sessions, several other observations merit noting: (a) With the exception of the FR 40 condition, median latencies during the larger amount of reinforcement were relatively unaffected by the size of the fixed-ratio; magnitude of separation was almost entirely a function of changes in median latencies of the smaller reinforcement condition; (b) the FR 5 condition produced results similar to, in separation and absolute median latencies, that of the baseline condition; (c) beginning with Session #95, during the FR 40 condition, the bird failed to respond at all to the red stimulus condition; however, during Session #99, the first session after returning to FR 25 following the FR 40 condition, the subject began to respond to the red stimulus within the session without having earned a reinforcer for responding to red; (d) when the bird was returned to the FR 25 following the
FR 40; the median latencies resemble those seen during the earlier
FR 15 condition; and (e) the data provided by Session #92 are diffi-
cult to interpret; after many sessions and followed by many sessions
during which there was considerable separation between the median
latencies associated with the two stimulus conditions, this session
shows no separation at all. This oddity in the data may reflect an
undiscovered equipment malfunction.
It would seem that the fixed-ratio value (FR 15) previously used by Hesse et al. (1984) was well-chosen. The current research demonstrates that values as low as FR 5 produce little separation; the difference between the median latencies as shown in the data for Birds #4695 and #6723 (Figures 4, 5, 6, and 7) is hardly greater than one finds when the independent variable is of the same value in both stimulus conditions (baseline condition). If one chooses ratios higher than FR 15 (FR 25 and FR 40), one produces differences between latencies, but at the expense of greater variability from session to session; further, at the extreme value of FR 40, one subject, Bird #6723, stopped responding altogether during the less favorable stimulus condition, the stimulus associated with less reinforcement. This "ceiling effect" precludes the use of latency as a dependent variable that is sensitive to subtle changes in values of the independent variable.

An additional undesirable result of using large ratios is partially related to the nature of logarithmic scales for plotting data. As one moves up the logarithmic scale, one loses the visual effect of separation even though a greater difference between median latencies exists; as a "judgemental aid" (Michael, 1974), the graphed data are weakened. This concealment of the effect is remedied by the use of median separation graphs (Figures 3, 5, and 7) but the reader is one more derivation removed from the behavior of the subject. However,
if one is viewing the differences between median latencies as the dependent variable, nothing is lost other than the absolute values of the latencies.

Hesse et al. (1984) described instances of component interaction. When the stimulus condition associated with the more favorable value of the independent variable was presented, medial latencies did not decrease during that stimulus condition as one might expect but, rather, increased in the presence of the stimulus condition associated with the less favorable value of the variable. Hesse et al. suggested that this might be a "floor effect"; that is, the pigeon could not physically produce latencies shorter than those already being observed. The disparity between median latencies reflected the contrast between the two conditions in the only way possible.

The present research does not demonstrate, in all cases, the component interaction seen by Hesse. In examining the data of the two subjects used to investigate the effects of probability of reinforcement on ratio size (Birds #5670 and #4695), one finds that they both decreased their median latencies in the presence of the more favorable reinforcement probability, and increased their median latencies in the presence of the less favorable reinforcement probability. Later in the experiment, when the probability of reinforcement variable was held constant and the ratio sizes were manipulated, the median latencies during both stimulus conditions moved up and down the ordinate, together, as a function of ratio size.

The one subject used to investigate the effect of ratio size on the amount of reinforcement (Bird #6723), however, produced data
similar to those provided by Hesse. Median latencies produced in the stimulus condition with the more favorable value of the amount of reinforcement variable (6 seconds access to grain) remained unchanged while latencies produced by less favorable values became longer. Interestingly, the floor effect as an explanation of these results is not relevant for this subject; the bird pecked with latencies much shorter later in the experiment when the ratio was made very small (FR 5) in both stimulus conditions (sessions 70-80).

The present research also supports the conclusions made by Hesse and his associates regarding the relative length of the inter-trial-interval (ITI) to pre- and post-ratios. Hesse found that when the ITI was made long with respect to the ratios that preceded and followed it, the separation between median latencies was very small, whereas making the ratios long with respect to the length of the ITI produces the opposite effect. As one increases the ratio size in both stimulus conditions, when each stimulus condition is associated with reinforcement conditions that are quite different, one produces more separation between median latencies.

One last observation requires further discussion. After several sessions of no responding during the less favorable stimulus condition (red), when the fixed-ratio requirement during both stimulus conditions was FR 40, Bird #6723 began responding during the red stimulus condition when the ratio was changed to FR 25 for both stimulus conditions. Re-emergence of responding during the less favorable stimulus condition began "spontaneously" during the first session (Session #99) of this new ratio. This abrupt change, when the bird
had not responded during that stimulus condition for four successive
sessions, suggests that the bird's behavior in the red stimulus condi-
tion is being controlled by some feature of the green stimulus condi-
tion. The most salient feature of the green condition is the change
in the ratio performance from FR 40 to FR 25. Several researchers
have demonstrated that the pigeon can be trained to respond differen-
tially to its own ratio behavior (Pliskoff & Goldiamond, 1966; Ril-
(1968) study provides an appropriate model for the present discussion.
In a three-key pigeon chamber, Rilling arranged either an FR 25 or
FR 50 on the center key; after the pigeon completed the required ra-
tio, the center key was darkened and the two side keys were illumi-
nated. If the previous ratio on the center key were FR 25, a single
peck on the left key provided food reinforcement; if the previous ra-
tio on the center key were FR 50, a single peck on the right key pro-
duced food reinforcement. Errors, pecking the wrong side key, re-
sulted in considerable delay of reinforcement. Using this procedure,
Rilling produced discrimination accuracy of 80-90%. Pliskoff and
Goldiamond (1966) hypothesized that the relevant stimuli to which the
subjects responded in this research are either the time required to
complete different size ratios, or the difference in terminal rates
on the respective ratios. Rilling (1967), however, found no correla-
tion between either of these variables and successful discriminations.
It is his conclusion that the number of responses in the individual
ratios comprise the relevant discriminative stimulus for the choice
of keys.
Although the present research did not intentionally subject this bird to frequent alternations of ratio size, the pigeon did have some experience with going from one ratio size to another during the course of the entire experiment. Given that Rilling's analysis is accurate, one might conclude that the pigeon, in the present study, is responding differentially to the different ratio sizes.
FOOTNOTES

1. Bird #5670 had had some training in the same setting with different sized fixed-ratios associated with the two stimulus conditions. For graphed data of these sessions see Appendix.

2. The general experimental training procedure and the initial portion of the independent variable manipulation, along with the method of collecting and representing the data, were developed by Hesse et al. (1984).

3. According to the veterinarian, Robert Spalding, DVM, Mount Pleasant, Michigan, diabetes among birds is not a common ailment and is difficult to treat. Upon the recommendations by Dr. Spalding and Dr. O'Hanley of the Michigan State University Small Animal Veterinarian Clinic, Lansing, the bird was placed on a low carbohydrate, high protein diet. After considerable time on this diet, water consumption decreased as did the watery stools. Attempts to reinstate the condition by placing the bird back on its original diet have not been successful.
Experimental History of Bird #5670 Prior to Experiment 1


