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The Effect of Timeout Locus and Duration on Fixed
Ratio Responding in a Multiple Schedule

by

Ellis I. Barowsky

A dissertation submitted to the Graduate Faculty in
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ABSTRACT

Either the location or the duration of a timeout (TO) was systematically varied in the within ratio sequence of a multiple fixed ratio (FR) schedule of reinforcement. In the first study (Experiment I, Phase A), six pigeons were run on a three-ply multiple FR - TO schedule of food reinforcement. The components of the schedule were FR 50, FR 50 with a 10-second TO at R 10, and FR 50 with a 10-second TO at R 40. Observation of pause and rate data indicated the formation of pause hierarchies as a function of TO location in the FR sequence, as well as differential response rates as a function of TO locus. The no-TO component (FR 50) generated relatively homogeneous rate of response across the entire ratio indicative of typical FR behavior. This condition also produced relatively short ratio pauses. The late TO (TO at R 40) generated a reduced response rate from R 1 to R 40 with a post-TO facilitation, as well as the longest ratio pause of the three scheduled contingencies. The early TO (TO at R 10) generated a reduced response rate for the first ten responses and an intermediate duration ratio pause. The TO location within the FR sequence added a temporal element to completion of the ratio requirement upon which reinforcement was contingent. As a result of this

temporal link which was added, the ratio pause increased. The ratio pause was observed to be correlated with the time the organism was involved responding on the ratio schedule rather than the number of responses emitted. In Phase B of Experiment I, a TO at R 20 was substituted for the no-TO contingency for three birds, while a TO at R 30 was substituted for the no-TO component for the other three pigeons.

The TO at R 20 component replaced the no-TO component in generating the shortest pause, while the TO at R 30 generated an intermediate duration pause for two birds and the longest pause for a third pigeon. Pause duration generally continued to correlate with time consumed in responding on a schedule contingency. In Phase C, deprivation was decreased to 88% of the ad lib weight for three birds and increased to 72% for the other three birds, irrespective of Phase B contingencies. While pause duration increased with reduction of motivation and decreased with increase in motivation, response rates were more variable and were a less reliable dependent variable.

With introduction of different duration TOs in Experiment II (FR 50; FR 50 with a 2.5-second TO at R 30; FR 50 with a 10-second TO at R 30), (with three naive birds) local

response patterns changed and pause increased as a function of TO duration. Further, the pause duration was again observed to be a function of time consumed in responding in a schedule rather than the number of responses emitted.

Interactive effects were also observed in Experiments I and II. Sequential analysis of ratio pause as a function of both impending and preceding schedule contingencies suggested an interaction of the two in determining the pause. The most reliable effect showed that repetition of a contingency yielded the shortest pause for the schedule component, suggesting the possibility of a recency phenomenon.

The results suggest that the TO serves as a stimulus which breaks up the typical FR chain of behavior. In addition, it adds a temporal component to the FR in a manner analagous to increasing the FR requirement.

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In the experimental analysis of behavior, it has been suggested that behavior occurs in a pattern which is both spatial and temporal, generated by the contingencies with which it comes in contact. These contingencies have been specified by a series of schedules of reinforcement. The response sequence generated by a reinforcement contingency is generally considered to be a chain, with the number of responses completed acting as both a discriminative stimulus (S^D) signalling the opportunity for emission of the next response, as well as a conditioned stimulus reinforcing responses already emitted. Most theorists assume that the adjacency or proximity of a response to primary reinforcement establishes its strength as both a discriminative as well as reinforcing stimulus, with a gradient of such magnitude decreasing as a function of increased separation. The fixed ratio (FR) schedule, one such contingency, calls for the emission of n responses with reinforcement contingent upon completion of the specified ratio. The frequency of reinforcement is therefore a function of the ratio length, concomitant with the rate at which the organism emits responses in the ratio (Ferster and Skinner, 1957).

Characteristic of this class of contingency is the generation of a bimodal distribution of rate. Following the chain of responses and its contingent reinforcement is a

period of time during which the tendency to respond on the operandum is at a low or zero probability. This period has descriptively been termed pause after reinforcement (PAR), post reinforcement pause (PRP), or ratio break. When responding is resumed, signalling termination of the break and initiation of the ratio run, the terminal response rate is quickly assumed. Thus, a "break-run" pattern has been regarded as typical FR behavior.

The present study is intended to assess the effects of an imposed period of non-response, a time-out (TO) of systematically varied locus within the response sequence, or varied duration, upon FR responding in a multiple schedule of reinforcement. Particular attention will be directed towards the effect of the locus and duration of TO upon ratio pausing and local response rate changes. Further, the inclusion of non-response time (TO) upon pause duration will come under particular scrutiny.

The TO is an exteroceptively cued period of time during which reinforcement is not attainable (Leitenberg, 1965; Striefel, 1965; Ferster, 1958) and which is therefore associated with extinction (Ferster and Skinner, 1957; McMillan, 1967). By removing the stimulus conditions under which reinforcement is available, responding in the presence of the stimulus signalling TO are ineffective (Hendry, 1969). The TO further imposes an added temporal parameter upon the contingency specified by a schedule of reinforcement, as it

separates responses in time (Ferster, 1958). This separation of responses by a stimulus-correlated period of time increases the time from the initiation of the behavioral sequence to subsequent reinforcement. In the case of the FR, the completion of the reinforcement contingency is no longer exclusively a function of ratio requirement and the rate at which the requirement can be emitted.

The TO may be implemented in a schedule of reinforcement in a number of ways. A prevalent method however, is through discrimination training, in which the organism is reinforced for responding in the presence of one stimulus (S^D), while responding in the presence of a second stimulus (S^{δ}) is not reinforced. The S^{δ} comes to signal TO. The more different the two stimuli signalling reinforcement and TO, the greater the stimulus control each maintains over respective behaviors (Ferster, 1958). The TO may be signalled by a tone (Verhave, 1959), extinguishing the key light (Leitenberg, 1965; Barowsky and Mintz, 1973), change of key color (Zimmerman and Baydan, 1963), gross change in chamber illumination (Azrin, 1961), multimodal changes in stimuli (Kaufman and Baron, 1968), or by presenting any stimulus during which the subject has never been reinforced for responding (Ferster, 1958).

Implementing a TO by changes in the visual stimulus may be particularly effective with the pigeon as they are sensitive to minor changes within the modality (Guttman,

1956). The present study employs a procedure by which the illuminated response key is extinguished to signal the TO. Extinguishing the chamber lights is also particularly effective as all responding ceases immediately (Leitenberg, 1965; Ferster and Skinner, 1957). However, as roosting may occur, of which little is known, (Ferster and Skinner, 1957) darkening the response key may be preferred. Leitenberg (1965) however, notes that as roosting renders the pigeon immobile and therefore eliminates the opportunity to respond, it could be considered a method for interrupting an instrumental response chain which formerly lead to reinforcement. This interruption may therefore serve as an effective TO. Similarly, removal of the response key, lever, treadle, or other such operanda also removes the opportunity to respond and may impose a TO.

The effects of TO have been assessed through the use of varied schedules and paradigms of reinforcement. These experiments and reviews of TO studies (Leitenberg, 1965) suggest that TO is neither inherently reinforcing nor punishing, but rather assumes a "character" only within the context of the paradigm in which it is employed. The TO, as any stimulus event, may be considered reinforcing when there is an increase in the relative probability of the response which produces it (Skinner, 1938), and aversive or punishing when there is an increase over operant level, in a response which will terminate or avoid it (Azrin and Holz, 1966). In

general, TO is aversive in a schedule of positive reinforcement, and reinforcing when imposed under a schedule of aversive contingencies. Studies of the former design may involve the organisms imposition of a TO on its own behavior. Self-imposed TOs are not confined to avoidance or escape paradigms (Sidman, 1962; Verhave, 1962; Mechner and Ray, 1959) but have been observed in schedules of positive reinforcement, suggesting aversiveness of stimuli signalling distance from reinforcement. As conditioned stimuli can either be rewarding or aversive, depending upon the manner in which they are related to primary reinforcement contingencies (Appel, 1963), the self imposition of TO whereby stimuli signalling a "psychological distance" to reinforcement may be removed, may be a measure of aversiveness.

In the FR schedule, organisms have been observed to remove the stimulus conditions signalling reinforcement and impose periods of extinction. The imposition of this TO is generally confined to the break following a ratio run, where the probability of a response producing reinforcement is low. Thomas (1966) suggests that behavior in the initial component of a chained schedule comes under the control of exteroceptive stimuli which have an unfavorable position in the overall reinforcement contingency. Supporting this contention, it has been observed that self-imposed TOs are never observed in a ratio sequence more closely correlated with reinforcement (Appel, 1963; Zimmerman and Ferster, 1964;

Azrin, 1961; Dardano, 1973), and that when imposed during the ratio break, the duration and frequency are correlated with the length of the ratio. This has been regarded as an escape response, removing the aversive stimuli signalling a low probability of reinforcement.

The TO has been shown to have an effect on response rate as well. Ferster (1960) reports that if a reduced rate of response in the presence of a pre-TO stimulus will avoid a TO in a schedule of positive reinforcement, monkeys exhibit a marked reduction in responding and learn to avoid the TO. This however, may be regarded as an instrumental avoidance response as reduced rate is reinforced by avoidance of the TO. Barowsky and Mintz (1973) have shown that TOs regularly scheduled in a multiple FR schedule suppress responding at a location in the response chain prior to imposition of the TO. Clark (1959) imposed a 3-minute TO after varying numbers of FRs and at loci ranging from the second to the eighth response on an FR 11 schedule of reinforcement. Although suppression was a transient phenomenon, one subject exhibited marked suppression prior to imposition of the TO. Kaufman and Baron (1968) reported an increase in response suppression as a function of TO duration in a FR schedule of reinforcement. Leitenberg (1965) has reported a facilitation in response rate prior to imposition of a TO in a multiple schedule, when the other component of the schedule produced electric shock. Clearly, the effects of TO vary as a

function of the baselines employed, as well as the paradigm of reinforcement.

The present study is particularly concerned with the differential effects of a TO imposed at various response loci, or a TO of different durations will have on the characteristic FR behavior. The TO imposes a temporal delay in reinforcement by interposing a separation between two appetitive responses within the behavioral sequence, much like the delay in reinforcement paradigm separates the final appetitive and first consummatory responses. When an interval with a correlated stimulus is interposed between a response and some consequence maintaining the response, a link has been effectively added to a chain of responses (Ferster, 1958). As a cued interval of time (TO) has been imposed between a response in the FR sequence and reinforcement maintaining the behavior, it in effect serves as an added link to the schedule of reinforcement. This has the effect of increasing the interreinforcement time, in a manner analogous to increasing the size of the ratio. To what extent does this time involved in completion of the contingency effect the break-run pattern generated by the FR schedule? In addition, the effects of deprivation will be assessed as they interact with TO locus, as motivation has been shown to interact with schedules of reinforcement.

Primary to the focus of this study is the effect of a regularly scheduled TO upon FR performance in a multiple schedule maintained by positive reinforcement. The multiple schedule is employed as it allows for the assessment of multiple treatments upon a baseline schedule of reinforcement.

Characteristics of Fixed Ratio Performance:

In the FR schedule, it has been suggested that the PAR is determined by the temporal discrimination that responses are never reinforced soon after a previous reinforcement (Ferster and Skinner, 1957). As the probability of subsequent reinforcement is low, the period of time following a reinforcement may be interpreted as showing certain aversive properties through its association with extinction. A minimum time must pass until the organism is capable of receiving reinforcement; that period of time is a function of the ratio length and the highest rate at which the organism can emit the ratio (Ferster and Skinner, 1957).

Employing FR schedules differing by sixty responses as criterion for reinforcement, Ferster and Skinner (1957) observed the generation of different duration PRPs. Pausing following an FR 60 schedule of reinforcement were a few seconds in duration, while pausing following an FR 120 schedule often exceeded 10 minutes. A similar relationship

was suggested by Boren (1953) using smaller FR schedules. These observations were primarily from the analysis of cumulative records (Ferster and Skinner, 1957), or where the PRP was not differentiated from the initial response sequence (Boren, 1953). No discrete quantitative data was obtained. It was suggested however, that the duration of the pause was under control of the ratio length.

Felton and Lyon (1966) obtained quantitative pause data for pigeons responding on FR schedules as a function of FR length. Using moderate changes in FR value in a series of schedules ranging from FR 50 to FR 150, successive changes were observed in pause duration as a function of ratio length. This supported the relationship suggested by Ferster and Skinner (1957) and Boren (1953).

The sensitivity of the PRP to differences in ratio length was further tested by Powell (1968), employing smaller differences in ratio size. Exposing pigeons to both an ascending and descending series of FR schedules, sometimes differing by no more than five responses at the lower values and thirty responses at the higher values, successive changes in pause duration were observed as a function of ratio length.

Similar findings have been reported by Laursen (1972), Sidman and Stebbins (1954), Schuster (1959), Premack, Schaeffer, and Hundt (1964), and Kaplan (1956).

Differential pausing accompanying ratios of different requirements indicates a discrimination between two different schedules (Ferster and Skinner, 1957).

In the multiple schedule, however, in which each component is exteroceptively cued, the pause associated with the ratio behavior is no longer exclusively a function of the ratio run completed, but rather is to a large extent a function of the impending contingency.

Schuster (1959) observed that when the ratio requirements of one component in a two-ply multiple FR schedule is increased while the other is held constant, the one held constant will generate a shorter pause than it did prior to the increase in the second component. Further, as the ratio requirement of one component is decreased while the other is held constant, the pausing prior to the latter ratio showed a marked increase.

Running pigeons on a two component multiple FR schedule in which "pairs of large and pairs of short ratios were alternated," Mintz, Mourer, and Gofseyeff (1967) found similar multiple determinants for the ratio pause. The pause was not merely a function of the ratio completed or the impending contingency, but rather an interaction of the two. In the absence of any interaction, the median pause prior to the longer ratio would be constant irrespective of the preceding contingency. However, the longer ratio generated a longer pause when it followed completion of the shorter

component than when it followed completion of a run on the longer ratio.

Griffiths and Thompson (1972) offer corroborative data based upon pausing generated by rats on multiple and mixed FR schedules. Rats responding on a mix (FR x FR 2x) schedule of reinforcement, where $x = 60, 30, \text{ and } 20$, did not show any systematic pausing before or after the ratio of either size, whereas rats responding on a multiple FR with the same components did. The multiple FR schedule generated a longer pause in the presence of the stimulus signaling the longer contingency. Further, analysis of pause duration as a function of both preceeding ratio run and forthcoming schedule of reinforcement indicated pause durations to result from an interaction of the two. As a result, the terms "pre-ratio pause" or "between ratio pause" were suggested as encompassing both the "descriptiveness" of the more traditional terms (PAR and PRP), while demonstrating a more appropriate assessment of the effective variables.

Similar findings supporting the stimulus control maintained by exteroceptive stimuli in multiple FR schedules have been reported by Grossman (1968), Thomas (1964) and Barowsky and Mintz (1973).

The immediacy of the shift from the zero response rate indicative of the pause to the ratio run has been demonstrated to be a function of ratio "length." Under a contingency employing exteroceptive cues, the multiple

schedule, the latency of this shift in rate is a function of both the preceeding ratio completed and the impending contingency. The rate at which the ratio is emitted appears to be a less precise correlate of the ratio length.

Boren (1953) submitted rats to a series of FR schedules ranging from FR 2:1 (FR 3) to FR 35:1 (FR 36) and observed generation of the typical FR pattern described above. Observing response rate as the major dependent variable as a function of ratio size, it was reported that response rate increases in a negatively accelerated pattern and "approaches asymptote at the largest ratios."

A subsequent study involving larger ratios with rats (Barofsky and Hurwitz, 1968) corroborate the findings of Boren (1953) within the limits he employed. Rate increased as a function of ratio size to a maximum rate at FR values of 40 and 80. However, with higher ratio values the response rate showed subsequent decline .

Felton and Lyon (1966) observed many inconsistencies in the relationship between ratio length and response rate. The Es reported a decrease in rate as ratio size increased to FR 150 but noted many reversals in the trend proceeding from FR 25 to FR 150.

Powell (1968) reported similar inconsistencies in systematic rate change as a function of FR length. Employing ratios ranging from FR 15 to FR 160 (both ascending and descending series), two birds generated successively lower

rates with increase in ratio, while one bird generated a relatively stable rate for the full range of ratio values employed. Other studies contributing to data with regard to response rate as a function of ratio length have been reported by Winograd (1965), observing decreases in rate with increased ratio requirements and Kaplan (1956), reporting data in support of Boren's (1953) findings.

Consistent, however, with regard to response rate in the FR schedule is the report of "homogeneity" in "within ratio responding," during emission of the ratio (Ferster and Skinner, 1957; Sidman and Stebbins, 1954; Felton and Lyon, 1966).

Temporal Properties of Fixed Ratio Behavior:

The relationship of the break in responding, correlated with the length of the ratio emitted has been shown to incorporate certain temporal factors. Primary is the rate at which the organism can emit the ratio and therefore the proximity of reinforcement. When the reinforcement maintaining control over FR responding is displaced from the initial response in the behavioral sequence, less control is maintained over the initial response sequence. This may have an inhibitory effect in initiating the ratio, just as increasing the ratio length displaces reinforcement from the initial response and concomitantly increases the ratio pause.

Time as a discriminative stimulus and as a discriminative property in the emission of a behavioral sequence has been found to be a tenable hypothesis by a number of investigators. Reynolds and Catania (1962) have observed that pigeons are capable of discriminating durations differing by as little as three seconds in a series of stimuli ranging from 3 to 30 seconds. Using a discrimination training procedure, pecking a response key was reinforced after exposure to a stimulus of one duration, whereas it was not reinforced after presentation of a second temporal stimulus. The pigeons both discriminated stimulus durations differing by three seconds and generalized this to stimuli of other durations. After the termination of a thirty second (S^D) stimulus, one pigeon pecked 550 times, while after a twenty-seven second (S^{delta}) stimulus only 300 pecks were emitted.

Pliskoff and Goldiamond (1966) exposed pigeons to a two-component chained schedule on the center key of a three-key response panel. The schedule contained either a smaller or a larger FR in the initial component. After completion of the requirement FR (mix FR:FR), a one second delay occurred, followed by illumination of the response keys on either side. If a larger FR had been completed as the initial component of the chain, a peck on the right key produced reinforcement. If a shorter FR had been completed as the initial component, a left key response produced reinforcement. The pairs of FRs presented were: FRs 95-5; 75-25; 65-35; 60-40; 58-42;

and 50-50. The frequency of S^{delta} responses was extremely low from FR 95-5 through FR 65-35, with sharp increases observed beginning with FR 60-40. The Es suggested that the larger FR required more time to complete and that the elapsed time from the first response to the final response was "an important source of discriminative control." With pairs of ratios differing by fewer responses, the time to complete the two ratios was indiscriminable.

Kileen (1969) placed a group of pigeons on schedules of FR 25, 50, 75, or 100. A second group were employed as a yoked control, where reinforcement was conditional on their emission of responses after the ratio birds had received food. Pause length for both the ratio and yoked birds were approximately equal, even though the number of responses emitted by the ratio birds was twice that of the yoked birds. This suggests that pause length varies with FR requirement as a result of the frequency of reinforcement over time rather than the precise number of responses emitted. Both ratio and yoked birds were equated on the basis of time involved responding on a schedule of reinforcement, not the number of responses emitted.

Neuringer and Schneider (1968) suggest that the relative importance of interreinforcement time exerts greater control over differential responding to different ratios than does the number of "interreinforcement responses." By placing short duration blackouts (TOs) after every non-

reinforced response on an FR schedule of reinforcement, the interreinforcement time could be varied without interfering with the number of responses emitted. The identical procedure was employed with an FI schedule, whereby the number of responses would be altered but not the interreinforcement time. The TO intervals varied between 0 and 4.96 seconds for birds on both schedules of reinforcement. Increasing the duration of the TOs and consequently the interreinforcement time under the FR schedule resulted in an increased PRP. The FI schedule which maintained an interreinforcement time of 30 sec. remained unchanged. Neuringer and Schneider found the "response latencies" (PRP) to be linearly related to interreinforcement time on both schedules, and not correlated with the number of responses.

With the addition of time limits, both minimum and maximum, to FR contingent reinforcement, Zeiler (1970, 1972) observed pausing to vary positively with the duration of time the organism spent responding on an FR schedule of reinforcement. Birds responded on an FR 15 or FR 30 schedule of reinforcement. When a "maximum" time criterion was imposed, the ratio had to be completed within a certain period of time. Contingent upon meeting the time criterion was food reinforcement, while completion of the ratio exceeding the specified time produced a TO. With the "minimum" criterion, a minimum duration must be exceeded for reinforcement to occur upon completion of the ratio. If the time taken to

complete the ratio did not exceed the minimum criterion, a TO would occur. Zeiler (1970, 1972) observed the covariance of pause and subsequent ratio time as corroborating the unitary view of FR performance suggested by Skinner (1938), where all responses function as a unit. Boren's (1953) data suggesting this to be only the property of short FRs appears prepotent. The covariance of pause duration and duration of within ratio responding in the FR schedule is however, clearly evident.

These studies suggest that the duration of the pause accompanying FR behavior to be more than the result of the ratio length. In situations where the ratio was held constant (Neuringer and Schneider, 1968; Zeiler, 1970, 1972) and only the interreinforcement time was varied, the pause increased as a function of interreinforcement time. Where interreinforcement time was held constant and response number was regulated by the subject (Killeen, 1969), the pause was a function of the time involved responding on the schedule of reinforcement, and not the number of responses emitted.

Analysis of procedures which contribute to increases in interreinforcement time appear germane to understanding increases in pause duration. Such a procedure may involve the addition of a temporal delay between completion of the instrumental response chain and the delivery of reinforcement.

The postponement of reinforcement by imposing delays after appetitive responding in the ratio have also contributed to the literature surrounding temporal properties of FR behavior. Skinner (1938) observed that when reinforcement was "simultaneous with the response," rats responded at a rate of approximately 193 responses/hour. When a 5 sec. delay of reinforcement was introduced, responding immediately declined to 120 responses/hour. Subsequent increased delays resulted in greater reduction in responding.

Morgan (1972) observed that signalled delays of reinforcement of 12, 3, and 0.75 sec. imposed after the response requirement was satisfied under FR reinforcement resulted in increased pausing. The duration of the pause increased with the duration of the delay in reinforcement. As the FR was held constant and the only change was the inclusion of the non-response time in the behavioral sequence, the increased pause duration is suggested to be a function of the time elapsed between initiating the chain and reinforcement. There were however, no consistent effects of the delay upon response rate.

Similar findings have been reported by Azzi, Fix, Keller, and Silva (1964), where increased delays in reinforcement resulted in increased pausing after reinforcement. Azzi, et al., however, found no consistent relationship between the extent of the delay and response rate. Short duration delays appeared to generate lower response rates, while

delays of 20 and 30 sec. generated increased response rates.

Similar studies of delay in reinforcement in concurrent situations (Chung, 1965; Chung and Herrnstein, 1967) have reported response suppression increasing as a function of the length of the delay in reinforcement. Preference was also exhibited for the schedule with the shortest imposed delay.

Timeout has been shown to effect FR behavior in a similar manner. Striefel (1972) indicates that preference for the shorter of two FRs presented concurrently is abandoned in favor of the originally longer ratio, when TOs of sufficient duration are added to the shorter ratio. The S thus switches to a schedule requiring the emission of a greater number of responses for reinforcement. The imposed interval of delay appears to add a link to the behavioral sequence (Ferster, 1958) in a manner analagous to increasing the ratio.

Response Loci in the Fixed Ratio:

Studies involving TO in FR schedules have not systematically examined the effect of the locus of TO imposition within the FR sequence. Most studies of self imposed TOs have indicated that imposition by the organism is confined to either the ratio pause, or the early sequence of FR responding. The TO is rarely imposed at a location more

closely correlated with reinforcement. When the TO is imposed by the experimenter, it, too, is usually restricted to one location within the FR sequence, or during the pause following reinforcement. Reports of TO at different loci are limited (Clark, 1959; Rilling, 1968; Barowsky and Mintz, 1973), and show the need for further investigation in this area.

Rilling (1968) has reported that discriminations between FR schedules of different values are disrupted as a function of TO locus, while Clark (1959) reports no differential effects as a function of TO locus in a FR schedule of reinforcement. Barowsky and Mintz (1973) offer the most comprehensive analysis of the effects of TO locus on FR responding in a multiple schedule.

Barowsky and Mintz (1973) employed a three-ply multiple FR schedule of reinforcement. One component was a FR 60 with no TO; a second was an FR 60 schedule with a 10-sec. TO occurring after response 10; and the final component was an FR 60 with a 10-sec. TO occurring after response 50. Each component was exteroceptively cued by illumination of the response key, while TO was signalled by extinguishing the key light. As a result of manipulating the TO locus within the FR sequence, a pause hierarchy was generated. The FR component without the TO generated the shortest response pause; the component with the TO at response 50 generated the longest response pause; and the component with

the TO at response 10 generated an intermediate duration response pause. Observation of the local response rates indicated marked response suppression prior to imposition of the TO, with a post-TO facilitation. The response suppression generated by the TO at response 50 component disrupted the sequence of behavior for the first 50 responses, while the TO at response 10 component disrupted only the first 10 responses. The no-TO component generated typical FR behavior. As a result of the disruptions prior to imposition of the TOs at their respective loci, the time during which the pigeons were involved responding in the schedule was increased. These increases can be attributed to the duration of the TO as well as the response suppression it generated. The Es observed a high correlation between the duration of the response pauses in each component of the multiple schedule and the duration of time necessary to complete the schedule. As the ratio requirement remained the same for all three components (FR 60), the TO interposed a delay with a correlated stimulus and effectively added a link to the behavioral chain.

Further data suggesting the locus at which an experimental manipulation occurs differentially effects the behavioral pattern generated by FR schedules has been offered through punishment studies. Evidence from FR punishment studies indicate that "scheduling punishment at a particular locus in each reinforced sequence will differentially modify

the pattern of responding in the sequence" (Dardano, 1970). As both electric shock, and darkening the response key signalling S^{delta} may act as correlated stimuli in a behavioral sequence, the effects of T0 may come to signal a particular location in the chain with respect to the location of reinforcement.

Punishment was scheduled on a variable ratio (VR) schedule in an FR schedule of positive reinforcement (Dardano, 1972). Imposition of the shock at various loci within the FR markedly increased the length of the PRP and the time to complete the first 50 responses in the FR 100 schedule. The mean time to complete the initial half of the ratio exceeded the average time necessary to complete the FR 100. As only one punished response occurred in every FR 100 schedule, the VR contingency of shock served as a stimulus indicating completion of the sequence without any additional punishment, after a response had already produced one punishing stimulus. This could account for the higher rate of response after cessation of the response contingent punishment within a reinforced sequence. Similarly, this may account for the post-T0 facilitation observed by Barowsky and Mintz (1973).

Dardano (1964) further showed that the locus of an aversive stimulus could differentially modify the response pattern in the FR. On an FR 50 schedule of positive reinforcement, either the first, middle, or last response was

punished. Punishment of the first response prolonged the PAR, and disrupted the initial sequence of responses preceeding the shock locus in the ratio. Responding was severely broken and long duration pauses were often observed. The terminal, or post shock sequence of responding however, occurred at the pre-shock level. Punishment at response locus 25 disrupted responding in the first half of the ratio, generating bursts and breaks up until imposition of the shock. When shock was contingent with response 50 (last response), only brief response breaks and local rate changes occurred; although the PAR was increased, it did not exceed the levels generated by punishment of the first response contingency. Dardano suggests that the shock stimulus functioned discriminatively as a function of locus. Under response-1 punishment, the shock functioned as a stimulus change in establishment a chained FR 1 shock FR 49 schedule. As an aversive stimulus, the shock controlled responding in the first half of the ratio, but occurrence was the occasion for non-punished responding on the food reinforced member of the chain. Similar properties may have prevailed in the response 25 shock contingency. However, under the response-50 shock contingency, Dardano ascribes the non-localized disruptions to the weakened control by food reinforcement. This analysis follows the theory advanced by Ferster and Hammer (1965), "that when an interval with a correlated stimulus is interposed between a

response and some consequence maintaining the response, a link has been effectively added to a chain of responses." The shock has been shown to function as a discriminative stimulus (Dardano and Sauerbrunn, 1964), while the interval added results from the response suppression attributed to the aversive properties of the shock.

In a similar study, Dardano (1972) shocked either the first, middle, or last response on an FR 70 schedule of reinforcement. The shock contingency was exteroceptively cued and the bird could change the prevailing contingency by a response on a second switching key. The frequency of switching to or from a contingency enabled assessment of preference and "dislike" for a contingency. Although each pigeon showed a preference by responding under on particular contingency more frequently than other contingencies, "no single shock schedule occurred most or least frequent for all pigeons." However, when switching was prevented, punishment of the initial response suppressed responding to a greater extent than did punishment of the middle or final response in the FR 70 sequence.

Presentation of a shock stimulus at one of three loci (first third, second third, or final third) of FR 60 and FR 99 schedules of reinforcement also produced differential effects (Dardano, 1970). Punishment of the initial third of the ratio resulted in response suppression of the initial sequence and marked increase in the PRP. Similar

effects were observed for punishment of the middle third of the ratio, although PRPs were not as extended. Responses following the punished sequence of responses appeared to occur at the pre-shock level of responding. When the final segment of the ratio was punished, partial suppression was evident for birds responding on the FR 99 schedule, but not under the FR 60 schedule of reinforcement. Punishment of the final sequence was more resistant to the disruption, and further showed no marked PRPs. Response-produced stimuli more closely correlated with reinforcement may have maintained greater stimulus control over the instrumental behavior generated by the FR contingency, and therefore the final sequence were least susceptible to disruption.

As "a schedule of reinforcement is a prescription for initiating and terminating stimuli, either discriminative or reinforcing in time and in some relation to some behavior," (Morse, 1966) modifications of the schedule may result in changes which are specific to the particular contingency. For example, while Dews (1965) observed no effect of multiple S^{delta} periods or TOs on fixed interval (FI) responding, innumerable variations have been cited above, regarding the effects of S^{delta} periods in FR responding. Similarly, manipulation of other variables may prove neutral in their effects upon simple schedules of reinforcement, where their effects on second-order schedules or in combination with other manipulations may yield significant interactional

effects.

Although the effects of deprivation have been shown to effect the pausing in FR schedules to the exclusion of response rate (Sidman and Stebbins, 1954; Ferster and Skinner, 1957; Dews, 1956), the present study will further assess the interaction of TO and deprivation level upon FR responding in the multiple schedule.

The first study will assess the effects of an imposed period of non-response time, a 10-sec. TO occurring at different loci upon responding and pausing in a three-ply multiple FR 50 schedule. In Experiment I, Phase A, all six pigeons will respond on a multiple schedule containing a no-TO component, a 10-sec. TO at response 10 (R 10) component, and a 10-sec. TO at response 40 (R 40) component. In Experiment I, Phase B, a TO at R 20 will be substituted for the no-TO component for three of the birds, while a TO at R 30 will be substituted for the no-TO component for the other three birds. In Experiment I, Phase C, all birds will continue at their Experiment Ib contingencies while deprivation levels are adjusted. Three birds, irrespective of their Ib contingencies will have their weights adjusted to 72% of their ad lib weights, while three will be adjusted to 88% of their ad lib weights.

In Experiment II, three experimentally naive birds will be exposed to a three-ply multiple FR 50 schedule where the TO locus will remain at R 30, and the TO duration will

vary in each component. The components of the schedule are, FR 50 with no TO, FR 50 with a 2.5-sec. TO at R 30, and FR 50 with a 10-sec. TO at R 30.

In Experiments I and II inclusive, the effects of location and duration of the TO upon FR responding will be observed. Particular attention will focus upon the effects of an imposed period of non-response time on typical FR behavior.

Method

Experiment I:

Subjects

The subjects were six male White Carneaux pigeons (# 2567, # 456, # 2615, # 3765, # 2699, # 3783) obtained from the Palmetto Pigeon Plant, Sumter, South Carolina. The subjects were 2 to 3 years old and were experimentally naive at the start of the experiment. Upon arrival at the laboratory, the birds wings were clipped and each was assigned to separate living cages. Identification of pigeons in home cages was done by placing each bird's band number on its respective cage. In the home cage, grit, water, and grain (50% Kafir, 40% vetch, 10% hemp) were continuously available for 21 days. The grit and grain were obtained from Animal Feeds of New York City. The same grain mixture was subsequently used as reinforcement during experimental sessions. The mean free-feeding weight of each bird for the last three of these days of ad libitum access to grain was determined. The birds were then placed on a food deprivation regimen to reduce their body weight to 80% of their free feeding weights. This was done by feeding each pigeon 5 grams of grain every second day. All birds were maintained at 80% throughout the first two phases of the

experiment. In addition, each bird was food deprived for approximately 23 hours prior to the start of an experimental session. The third phase of the experiment necessitated a change in deprivation level for all birds. Three pigeons (# 2567, # 456, # 2615) were reduced to 72% of their ad lib weight. The other three birds (# 3765, # 3783, # 2699) were increased to 88% of their ad lib weight. The birds were tested at approximately the same hour daily. Birds which exhibited excessively long pauses which would preclude completing a run session in 2 hours or less (strain) were subsequently run later in the day so as not to disrupt scheduling and deprivation levels of non-strain birds. All subjects were tested seven days a week for the length of the study.

Apparatus

Two nominally identical Lehigh Valley Electronics standard two-key operant chambers for pigeons were employed. The two-key response panel divided the chamber into two sections. One section contained the necessary electrical equipment and the other which measured 30.5 cm wide x 35.6 cm deep x 36.8 cm high housed the subject during the experimental session. Each response panel contained two apertures which were 2.5 cm in diameter, behind which were the pecking keys. The two apertures were 14 cm apart and the center of each was 8.25 cm from the sides of the chamber. Each key was 23.5 cm above the chamber floor. A minimum force of 2 N

was required to operate the microswitch connected to the key. Behind each key was a multiple stimulus display consisting of three bulbs (Sylvania 24 ESB). Two were covered with filters to present colors red and green, while one contained no filter thus presenting a white light (to the experimenter's eye). This unit served to project on the key, a nominally white, red, or green light. For the purposes of this study only the left key was employed. A rectangular opening located 9.5 cm from the base of the chamber and 14.6 cm from the sides of the chamber, measuring 5 cm (high) x 5.6 cm (wide) gave the subjects access to a grain hopper during reinforcement. The hopper located on the other side of the response panel was raised to the opening in the response panel during reinforcement by means of a solenoid. The hopper area was illuminated only during reinforcement for the duration equal to the subjects access to grain. Reinforcement consisted of three seconds access to grain. A houselight was located along the vertical midline of the response panel and 2.5 cm from the chamber top. The houselight illuminated the test compartment of the chamber throughout each experimental session. A 7.5 cm (diameter) speaker through which masking noise was presented was located below the left response key, 11 cm from the base of the chamber. The masking noise was produced by a Grason-Stadler Noise Generator (model 901b) and was maintained at -20 db as measured from its source by a meter contained in

the unit. Each chamber had an 18.75 cm x 16.25 cm window, covered by a two-way mirror. This allowed the experimenter visual access to the chambers' interior during the experimental session. The chambers contained fans for ventilation and were located on the chamber wall opposite the response panel. The chambers were further enclosed in a plywood sound attenuated housing. Additional ventilation to the operant chamber was supplied by auxiliary fans, maintaining air exchange between the plywood chamber and the laboratory. Experimental contingencies were programmed by an Ohr-tronics 8-channel tape reader, in conjunction with a system of Scientific Prototype (SP) 10 AMP, 28V DC Regulated Power Supply. Only channels 5 through 8 were used for purposes of this study. A tape containing a sequence of 124 punches of channels 5 through 7 was used. Each of these channels selected one of the three contingencies used in the multiple schedules. The first 62 cycles were semi-random, with each channel punched in equal frequency and juxtaposition to each other channel. The same channel was never active greater than two times in succession. The second series of 62 punches was a repeat of the first 62 cycles, creating a quasi-loop tape. A punch corresponding with channel 8 on the tape reader was placed at both ends of the tape to effect a reversal of the tape by programming relays. A table of random numbers was employed as a means of selecting the first contingency of each experimental session.

A key peck response was defined by closure of the microswitch for a time sufficient to activate a relay. The fixed ratio 50 (FR 50) and timeout (TO) loci were programmed by two reed decades (SP # 4003J). TO duration was regulated by calibrated timers (SP # 4005J). Temporal data were recorded by two Pressin Printing Counters contained in control housings (SP # 4089J) and pulsed by a reed clock (SP # 4006J) at 10 Hz. Responses during TOs were counted by three electromechanical counters, but did not contribute to the ratio count. A cumulative recorder (SP # CR2D) was operated in conjunction with digital recording equipment.

Procedure

Experiment I: Phase A:

After a reduction to 80% of their free-feeding weight, each bird was shaped to peck the left key of a Lehigh Valley Electronics standard two-key operant chamber. All shaping was done in one of the two nominally identical chambers, by the experimenters reinforcement of successive approximations to the key peck response. The response key was transilluminated during shaping with the key color switching from red to green to white after each reinforcement. Each bird was kept in the chamber for 62 reinforcements, each of which consisted of three seconds access to grain. (A mixture of 50% Kafir, 40% vetch, 10% hemp). Water was present in the chamber throughout each experimental session. Weight losses

below 80% were recovered by feeding additional grain in the bird's home cage immediately following a test session. Once responding had stabilized on a schedule of continuous reinforcement (CRF), the contingency for reinforcement was increased systematically according to the schedule in Table A.

During session 6, bird # 2615 paused sporadically for durations not indicative of the ratio requirement. Observation of the bird's behavior indicated that it was pecking at the two-way mirror which gives the experimenter visual access to the chamber's interior. The plexiglass covering the mirror was removed and a piece of black felt was inserted over the mirror. Subsequent responding became more stable. When responding on the FR 50 had stabilized, the birds were transferred to a nominally identical Lehigh Valley Electronics two-key operant chamber, which had been programmed to present the three-ply multiple schedule. The multiple schedule employed in Phase A of Experiment I was FR 50; FR 50 with a 10-sec. TO contingent upon Response 10 (R 10); and FR 50 with a 10-sec. TO contingent upon response 40 (R 40). The three components were designated as, "no-TO, early TO, and late TO," respectively.

Coupled to the 10-sec. TO was a dro requirement. Any response during the 10-sec. TO recycled the timer so that a minimum of 10 seconds had to elapse with no responding. The key light was extinguished to signal the TO, while the houselight remained on at all times. The three contingencies

were cued exteroceptively by transillumination of the key light by colors red, green, and white. To guard against an inherent color preference which the birds might have, colors representing the different contingencies were counter-balanced across birds. Each combination of colors representing the three contingencies was shared by two birds.

When transferred to the chamber programmed to present the multiple schedule, the first bird (# 2567) failed to respond. A "free reinforcement" further failed to result in responding. Removal of the two-key response panel and replacement with the interchangeable response panel from the chamber in which the birds had been shaped resulted in a stabilized pattern of pecking behavior. All birds were run daily for sessions 1 through 33 on the three-ply multiple schedule. Sessions 1 through 23 constituted training days and data was collected every second day. Sessions 24 through 33 served as criterion sessions and data was collected for analysis daily. The Pressin Printing Counters pulsed at 10Hz recorded the following temporal data:

Counter 1

Elapsed time $R_1 - R_{10}$	3 digits
Elapsed time $R_{11} - R_{20}$	4 digits
Response Pause	4 digits

Counter 2

Elapsed time $R_{21} - R_{30}$ 4 digits
 Elapsed time $R_{31} - R_{40}$ 2 digits
 Elapsed time $R_{41} - R_{50}$ 2 digits
 Code for contingency 1 digit

All responses during the TOs were recorded by means of two electromechanical counters. The cumulative recorded remained running during all TOs.

Birds # 2567 and # 2615 began to show marked strain by session 25. They were subsequently run later in the day to avoid disruption of deprivation levels of the non-straining birds.

Phase B

There was a three day lapse between Phase A and Phase B of Experiment I. The birds from Phase A were divided into two groups (see Plate 1). For three of the birds (# 2567, # 2615, # 2699) the no-TO component was eliminated from the three-ply multiple schedule and a component containing a 10-sec. TO at response 20 (R 20) was substituted. This new component was exteroceptively cued by the key color originally signalling the no-TO component. The other three birds (# 456, # 3765, # 3783) were placed on a three-ply multiple schedule where the no-TO component was replaced by a 10-second TO at response 30 (R 30). The component was exteroceptively cued by the color initially signalling the no-TO

component. For both groups, the components containing TO at R 10 and TO at R 40 remained in effect. The 10-second dro requirement was coupled to all TO components as in Phase A.

The birds were assigned to the two groups on the basis of which two birds from Phase A had the same exteroceptive cues for the three-ply schedule. These pairs were separated: one bird being assigned to each of the two groups.

A third electromechanical counter was employed to record responses during the added TO contingency. All other data collection remained the same as in Phase A. All birds were run daily for thirty sessions, differing from Phase A only in the replacement of the no-TO component with a TO component in the multiple schedule, while data was analyzed daily.

By session 3, bird # 2615 showed prolonged periods of strain. As a result, its experimental session was altered to 62 reinforcements or 2-1/2 hours, whichever occurred first. This same procedure was adopted for bird # 2567 after the fourth session when severe strain was exhibited. During sessions 8 and 18, birds # 3783 and # 2699 respectively, began to exhibit strain. From sessions 8 through 30, each bird was run for 62 reinforcements or 2 hours, whichever occurred first. No bird was ever removed during a strained cycle, but only after the first reinforcement following the strained

behavior. Weight deficits were recovered by feeding supplemental grain in the home cage, immediately following the test session. Following a "strained session" a period of about 30 minutes was allowed to elapse before supplemental feeding was done. This procedure was employed to prevent adventitious reinforcement of strain.

Phase C

Birds from Phases A and B were divided into two groups, irrespective of their Phase B contingencies. Birds # 2567, # 456, and # 2615, were reduced to 72% of their ad lib weight. Birds # 3765, # 3783, and # 2699 were increased to 88% of their ad lib weight. These birds were then run for three sessions on their Phase B contingencies, with data analyzed for all three experimental sessions.

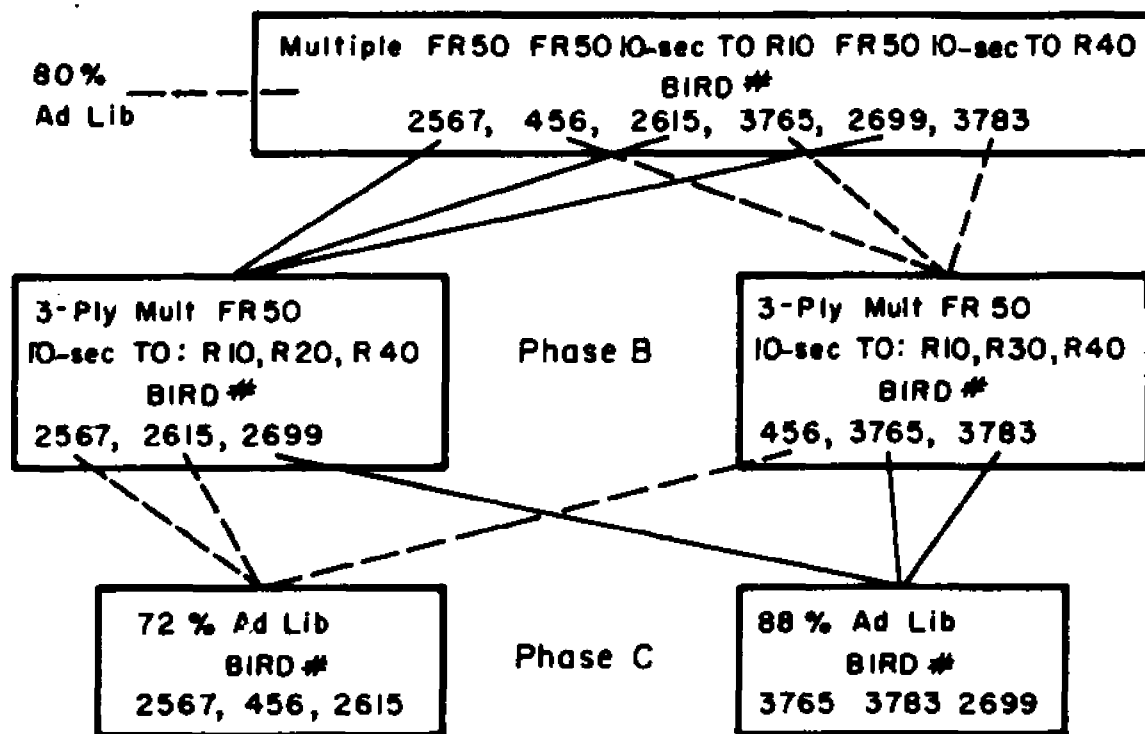
TABLE A

NUMBER OF REINFORCEMENTS AT EACH RATIO FOR BIRDS IN
EXPERIMENTS I AND II

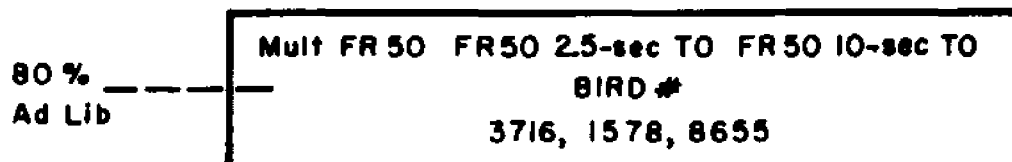
Session	Contingency	Number of Reinforcements
1	Magazine training: shaping	60
2	CRF	30
	FR 3	30
3	FR 3	30
	FR 6	30
4	FR 6	20
	FR 9	20
	FR 12	20
5	FR 12	20
	FR 15	20
	FR 18	20
6	FR 21	30
	FR 25	30
7	FR 25	30
	FR 30	30
8	FR 30	30
	FR 35	30
9	FR 35	30
	FR 40	30
10	FR 40	30
	FR 45	30
11	FR 45	30
	FR 50	30

EXPERIMENT I

Phase A



EXPERIMENT II



Results

Experiment I: Phase A:

(Pausing)

The major concern of Experiment I was the influence of the locus of TO in the ratio sequence. The primary variable of interest as a result of the multiple loci of TO was the pre-response pause (PreRP). The daily median PreRP as a function of TO locus is shown in Figs. 1, 2, 3, 4, 5, and 6, for the six birds. Section IA of these figures shows the last ten days of thirty daily sessions and constitutes criteria days.

All birds exhibit shortest duration pausing in the presence of the stimulus signalling the no-TO contingency of the three-ply multiple schedule. The duration of the PreRP is in the order of 1.4 to 8.0 seconds, and exceeds 10 seconds only in the case of bird # 2615; there only on two occasions. Clear PreRP hierarchies are evident for birds # 3765, # 2615, and # 2699, in Figs. 1, 2, and 3, respectively. These birds exhibit shortest pausing in the presence of the illuminated response key signalling the no-TO component, longest pausing in the presence of the stimulus signalling the TO at R 40 component, and intermediate duration pausing in the presence of the stimulus

Fig. 1. Experiment I. Daily median pre-response pause (PreRP) for bird # 3765 as a function of timeout locus in the fixed ratio sequence and deprivation level.

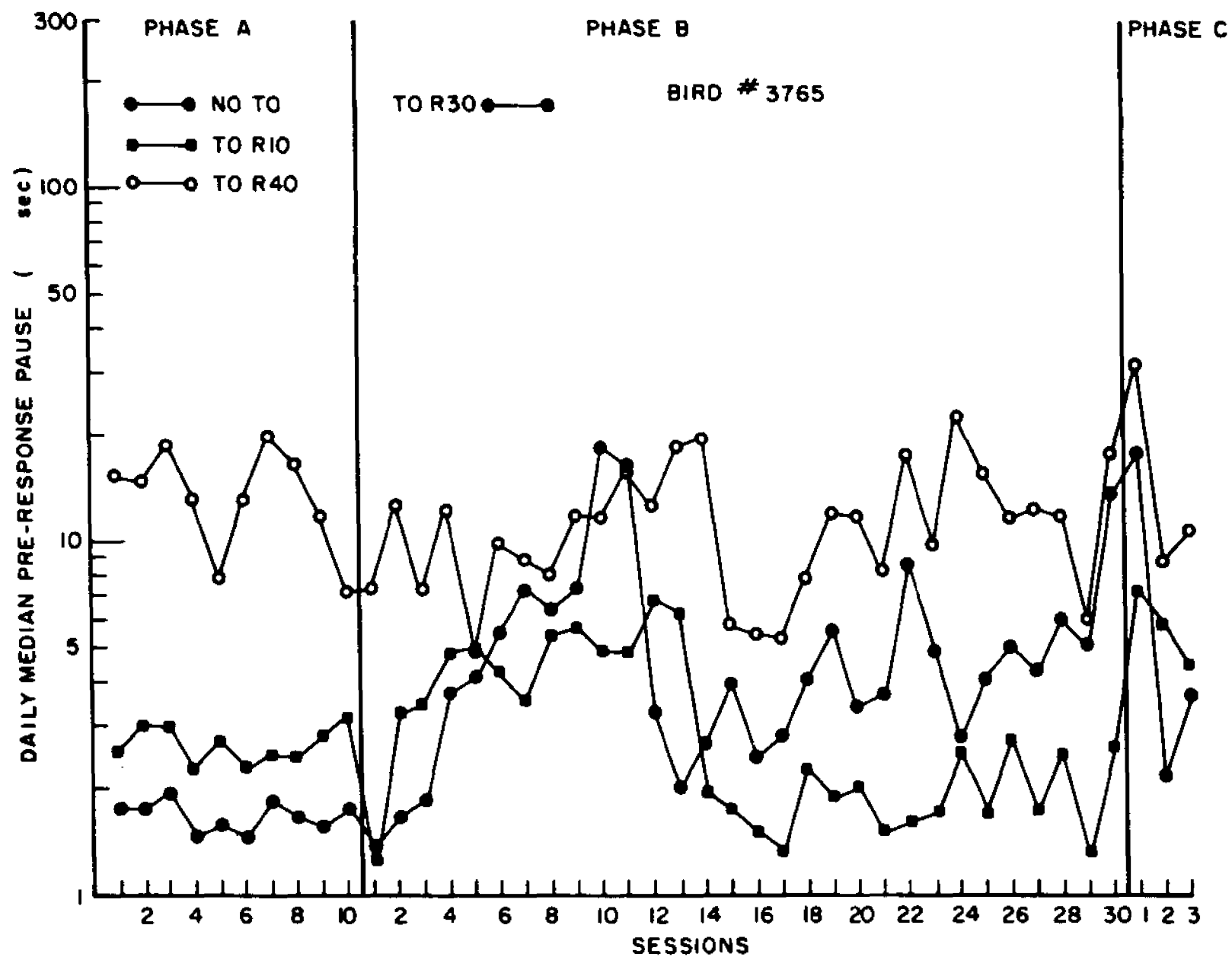


Fig. 2. Experiment I. Daily median pre-response pause (PreRP) for bird # 2615 as a function of timeout locus in the fixed ratio sequence and deprivation level.

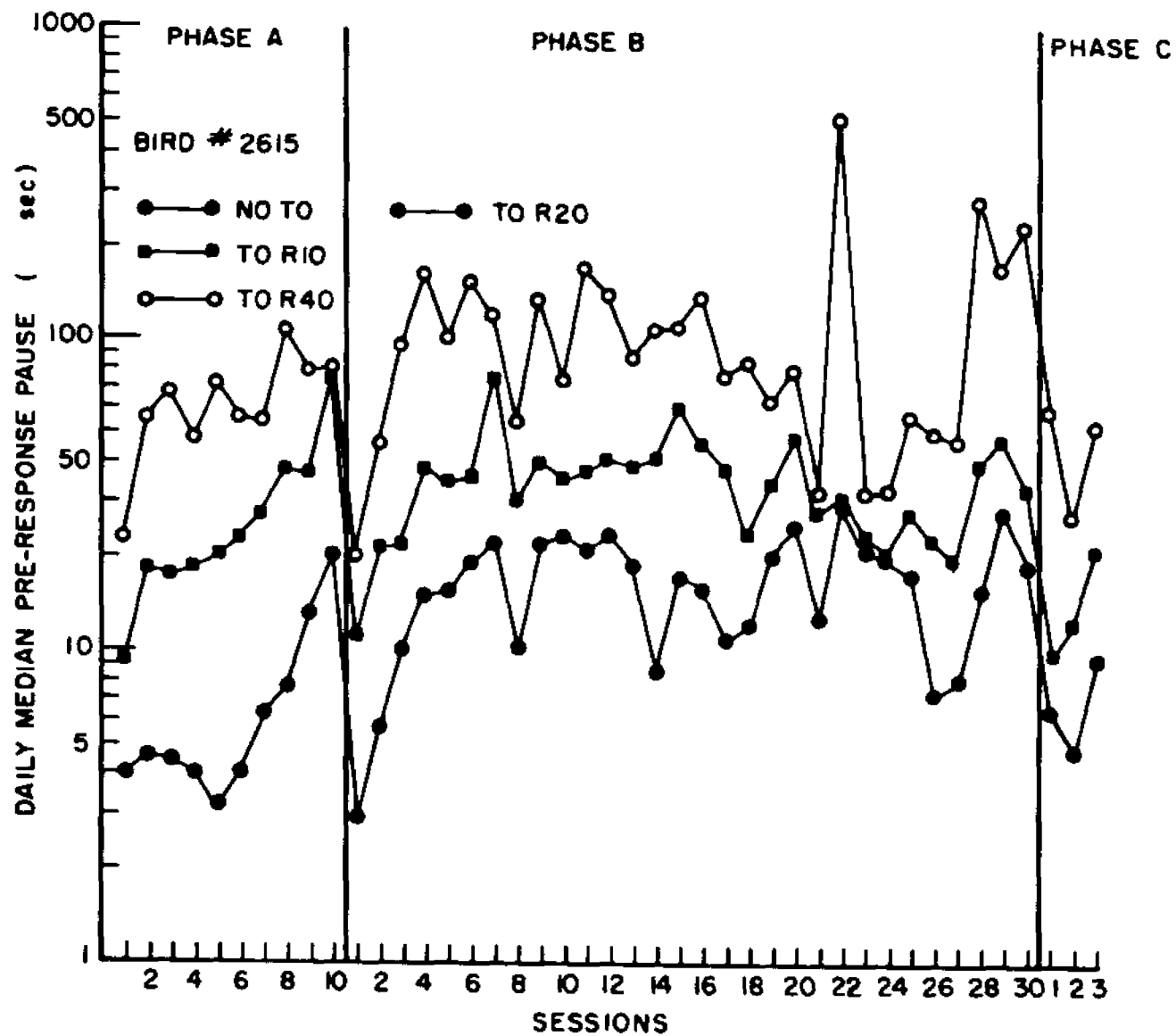
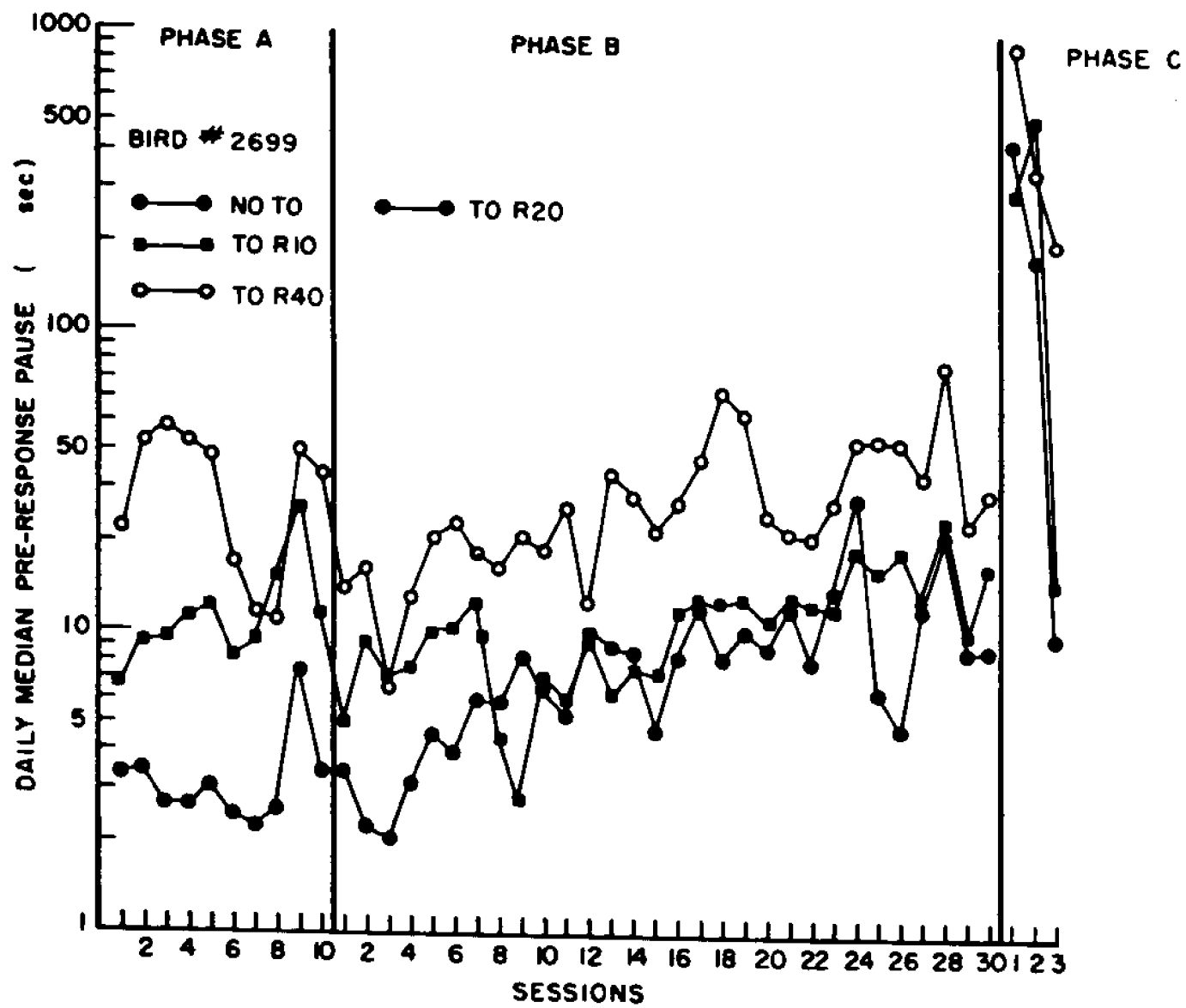


Fig. 3. Experiment I. Daily median pre-response pause (PreRP) for bird # 2699 as a function of timeout locus in the fixed ratio sequence and deprivation level.



signalling the TO at R 10 component. At criterion session eight, bird # 2699 (Fig. 3) shows a one session reversal in hierarchy, exhibiting a longer pause for the early TO component (TO at R 10) than for the late TO component (TO at R 40). The session immediately following showed a recovery of the original response pause hierarchy.

Birds # 456, # 3783, and # 2567, as indicated by Figs. 4, 5, and 6, respectively, show a similar pause duration hierarchy. However, as Fig. 5 indicates, bird # 3783 exhibited a two-session reversal in the pausing hierarchy. Although the no-TO component always maintained the shortest PreRP, during sessions 8 and 9 the PreRP was longer for the early TO component than for the late TO component. By criteria session 10, the original hierarchy was recovered. Bird # 2567 also showed a two-session reversal in the response pause hierarchy, as indicated by Fig. 6. While maintaining shortest pausing for the no-TO component throughout the criteria sessions, the two TO contingencies exhibited reversals. During sessions 6 and 7, pausing was longer prior to responding on the early TO component than on the late TO component. Again, the original hierarchy was recovered by session eight. While maintaining the no-TO, early-TO, late-TO order of pausing during sessions 9 and 10, bird # 2567 appeared to show less differential behavior in the presence of the stimuli signalling the two TO components. Bird # 456, as indicated by Fig. 4 exhibited a

Fig. 4. Experiment I. Daily median pre-response pause (PreRP) for bird # 456 as a function of timeout locus in the fixed ratio sequence and deprivation level.

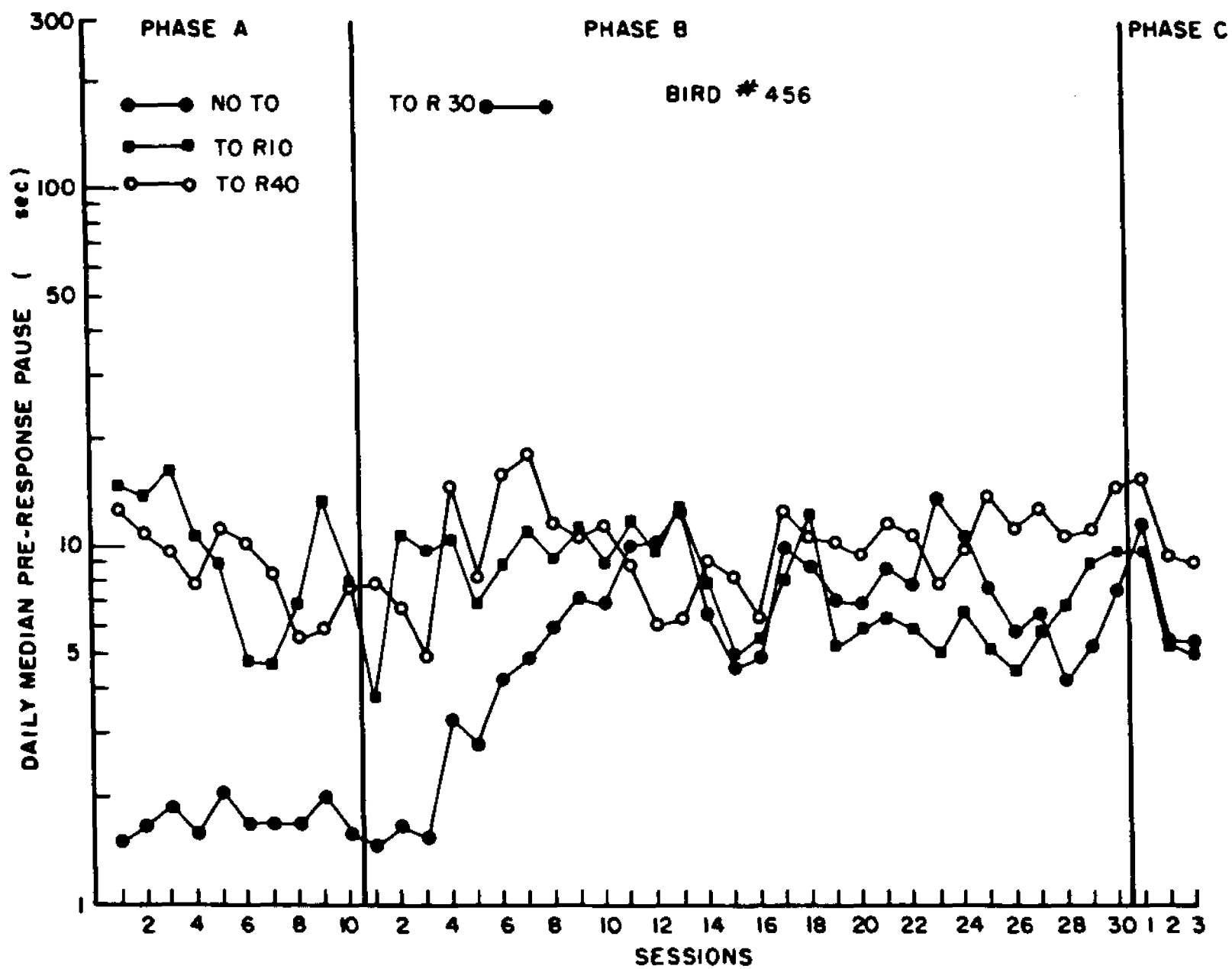


Fig. 5. Experiment I. Daily median pre-response pause (PreRP) for bird # 3783 as a function of timeout locus in the fixed ratio sequence and deprivation level.

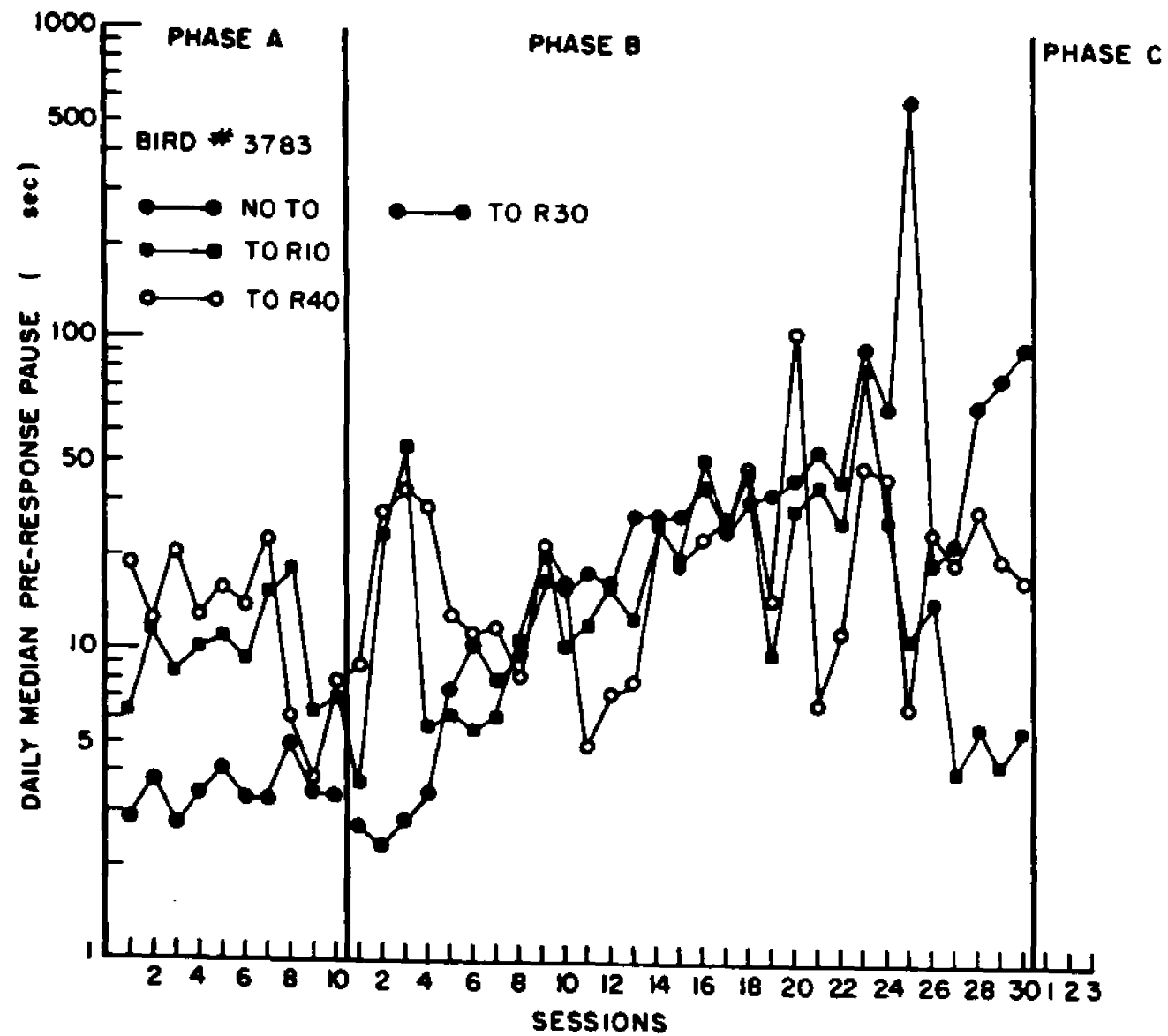
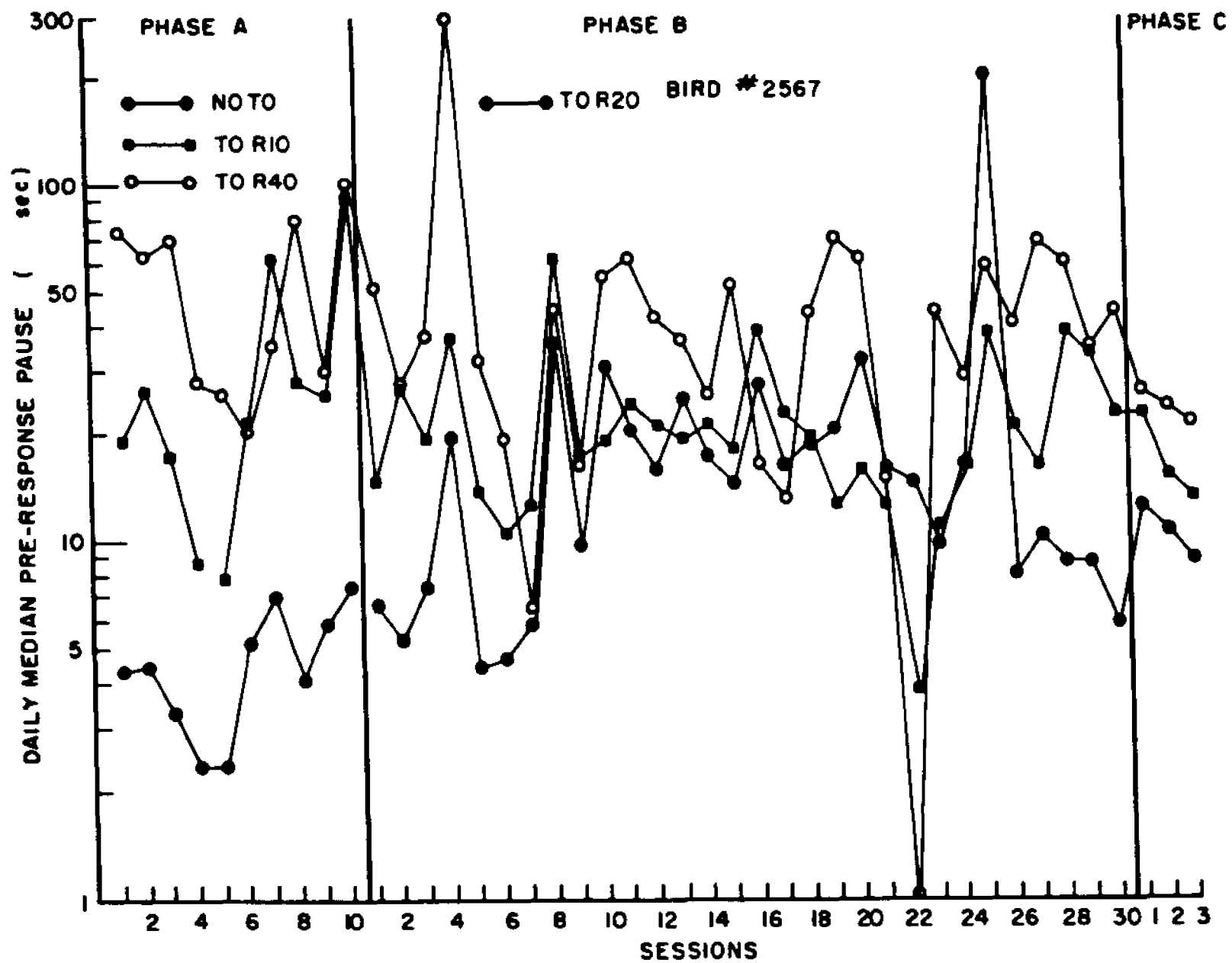


Fig. 6. Experiment I. Daily median pre-response pause (PreRP) for bird # 2567 as a function of timeout locus in the fixed ratio sequence and deprivation level.



similar hierarchy for the first four criteria sessions. Sessions 5 through 7 witnessed a reversal in the pause duration hierarchy. Again, pause durations generated by the early TO component were longer than pause durations generated by the late TO component. By session eight, the hierarchy resumed its initial order. Session ten, however, suggests less differential behavior in the presence of the stimuli signalling the two TO components. The no-TO component generated shortest pausing throughout the criteria sessions.

A general profile of the pause pattern exhibited by the six birds indicates the presence of a PreRP hierarchy. As indicated, the no-TO component maintained shortest pausing throughout the ten criteria sessions for all birds. Pausing preceding responding on the two TO components indicates longest pausing in the presence of the stimulus signalling the late TO component on 52 of 60 sessions, with the early TO component generating an intermediate duration pause.

In order to assess sequential interactions which may have resulted from the order in which the components were presented, the pre-response pause was analyzed as a function of the preceding schedule component.

Table 1 shows the mean of median PreRP for the ten criteria sessions across birds. As previously indicated, a PreRP hierarchy is suggested. Table 1 further suggests

TABLE 1

Mean of Median Pre-response Pause (in sec) as a Function
of Present and Preceding Contingency Across Birds
Experiment I: Phase A.

Preceding Contingency		Present Contingency		
		FR 50	FR 50 TO at R 10	FR 50 TO at R 40
	FR 50	2.7	15.1	37.3
	FR 50 TO at R 10	3.5	9.4	32.6
	FR 50 TO at R 40	3.4	14.4	15.5

Note.— The term "pre-response pause" is used to describe the ratio pause which precedes the ratio run in the fixed ratio schedule.

an interaction between pausing prior to an impending contingency and the component just completed. Two major trends are further suggested from this data. The pause preceding the ratio run appears longest for both TO contingencies when they are preceded by the no-TO component, and it can also be observed that repetition of a contingency resulted in the shortest PreRP for that component. The latter was relatively consistent for all three schedule components, although certain deviations from the generalized profile obtained from group data are evident in the behavior of individual birds. Similar matrices constructed from the data generated by the individual birds are shown in Tables 2 and 3.

Resolution of these sequential differences and general conformity by the six birds (Tables 1, 2, and 3) suggest the presence of interactions among the components of the multiple schedule.

(Ratio Strain)

Strained pre-response pausing is suggested by long daily median pauses in Figs. 1, 2, 3, 4, 5, and 6, and by the matrix analysis of pause duration in Tables 1, 2, and 3. In order to assess sequential interactions resulting in these strained pauses, the probability of these strained events was analyzed as a function of the present and preceding contingency. Strain was defined as any PreRP

TABLE 2
Median Pre-response Pause (in sec) as a Function
of Preceding and Present Contingency

Experiment I: Phase A

PRECEDING CONTINGENCY		PRESENT CONTINGENCY		
		FR 50	FR 50 TO at R 10	FR 50 TO at R 40
S 3783	FR 50	2.6	10.9	19.1
	FR 50 TO at R 10	3.4	5.1	15.8
	FR 50 TO at R 40	4.2	13.2	5.4
S 2567	FR 50	3.4	27.7	55.6
	FR 50 TO at R 10	5.4	17.2	61.2
	FR 50 TO at R 40	5.4	22.6	29.9
S 456	FR 50	1.8	9.6	13.4
	FR 50 TO at R 10	2.0	5.4	8.8
	FR 50 TO at R 40	1.6	12.2	5.1

Note.— The term "pre-response pause" is used to describe the ratio pause which precedes the ratio run in the fixed ratio schedule.

TABLE 3
Median Pre-response Pause (in sec) as a Function
of Preceding and Present Contingency

Experiment I: Phase A

PRECEDING CONTINGENCY		PRESENT CONTINGENCY		
		FR 50	FR 50 TO at R 10	FR 50 TO at R 40
S 3765	FR 50	1.7	2.7	17.0
	FR 50 TO at R 10	1.8	2.4	16.7
	FR 50 TO at R 40	1.6	3.2	4.5
S 2699	FR 50	2.5	13.4	35.6
	FR 50 TO at R 10	3.4	8.0	27.2
	FR 50 TO at R 40	3.0	11.6	15.5
S 2615	FR 50	4.0	26.1	82.9
	FR 50 TO at R 10	4.9	18.1	66.1
	FR 50 TO at R 40	4.9	23.4	32.3

Note.—The term "pre-response pause" is used to describe the ratio pause which precedes the ratio run in the fixed ratio schedule.

exceeding 90 secs. The probability of strain was obtained by dividing the number of strained pauses in a condition by the number of times that condition was in effect. The measure, strain, is not one which is independent from the PreRP, rather it is a population of events which comprise the rather positively skewed tail of the distribution of pauses.

Table 4 shows the generalized profile of strain averaged for all six birds in Phase A of Experiment I. As indicated, strain occurs with lowest probability for the no-TO contingency, highest probability for the late TO contingency, and at an intermediate probability for the early TO contingency. Deleting the one occasion of strain for bird # 2699 during the no-TO component, the probability for the no-TO contingency would be 0. Discordant with the matrix analysis for median PreRP is the probability of strain occurring with repetition of a contingency. Although repetition of the no-TO and late TO components result in the lowest probability of strain, this relationship does not hold for repetition of the early TO contingency. Repetition of the early TO component results in a higher probability of strain than when the early TO component follows the late TO component. The probability of strain is greatest for the two TO components when they follow the no-TO ply of the multiple schedule.

TABLE 4
Probability of Strain as a Function of Present
Preceding Contingency Across Birds
Experiment I: Phase A

Preceding Contingency		Present Contingency		
		FR 50	FR 50 TO at R 10	FR 50 TO at R 40
	FR 50	0.00	0.07	0.16
	FR 50 TO at R 10	0.00	0.03	0.13
	FR 50 TO at R 40	0.00	0.02	0.05

Note.— Strain is defined as any pre-response pause greater than 90 seconds. The probability of strain is obtained by dividing the number of strained pauses of a contingency by the number of times that contingency was in effect.

TABLE 5

Probability of Strain as a Function of Present
and Preceding Contingency for Individual Birds

Experiment I: Phase A

PRECEDING CONTINGENCY		PRESENT CONTINGENCY		
		FR 50	FR 50 TO at R 10	FR 50 TO at R 40
S 3783	FR 50	0.00	0.01	0.04
	FR 50 TO at R 10	0.00	0.00	0.02
	FR 50 TO at R 40	0.00	0.00	0.00
S 2699	FR 50	0.00	0.02	0.06
	FR 50 TO at R 10	0.01	0.03	0.03
	FR 50 TO at R 40	0.00	0.00	0.00
S 2567	FR 50	0.00	0.23	0.32
	FR 50 TO at R 10	0.00	0.16	0.31
	FR 50 TO at R 40	0.00	0.06	0.08

Note.— Strain is defined as any pre-response pause greater than 90 seconds. The probability of strain is obtained by dividing the number of strained pauses of a contingency by the number of times that contingency was in effect.

TABLE 5

Probability of Strain as a Function of Present
and Preceding Contingency for Individual Birds

Experiment I: Phase A

Preceding Contingency		Present Contingency		
		FR 50	FR 50 TO at R 10	FR 50 TO at R 40
S 2615	FR 50	0.00	0.15	0.50
	FR 50 TO at R 10	0.00	0.00	0.40
	FR 50 TO at R 40	0.00	0.06	0.22

Note.— Strain is defined as any pre-response pause greater than 90 seconds. The probability of strain is obtained by dividing the number of strained pauses of a contingency by the number of times that contingency was in effect.

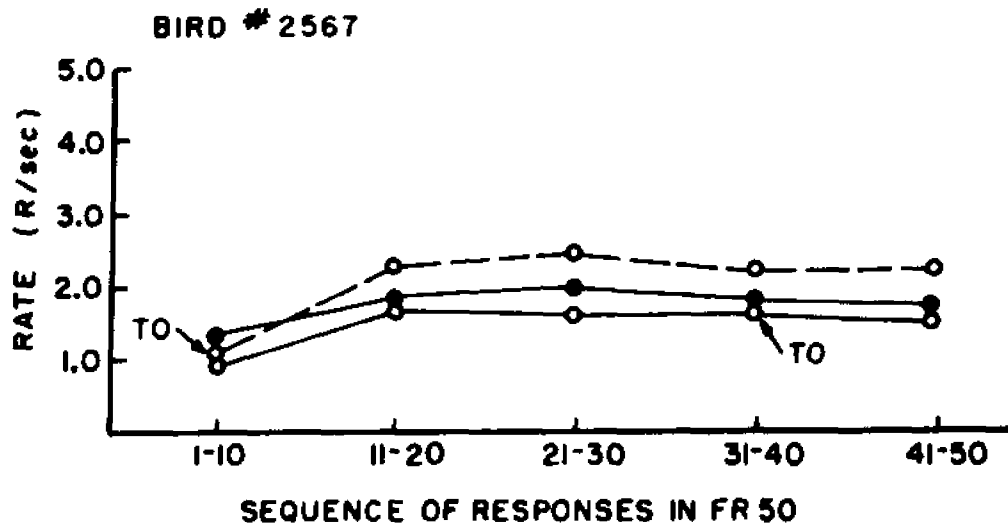
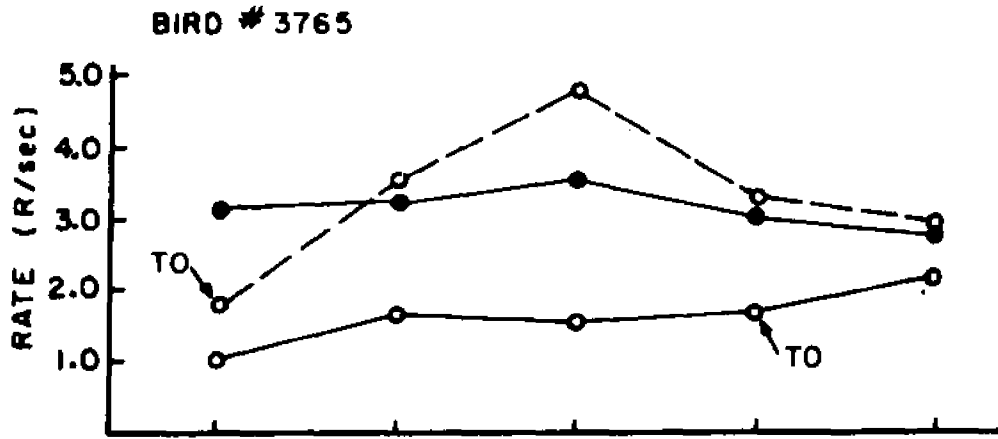
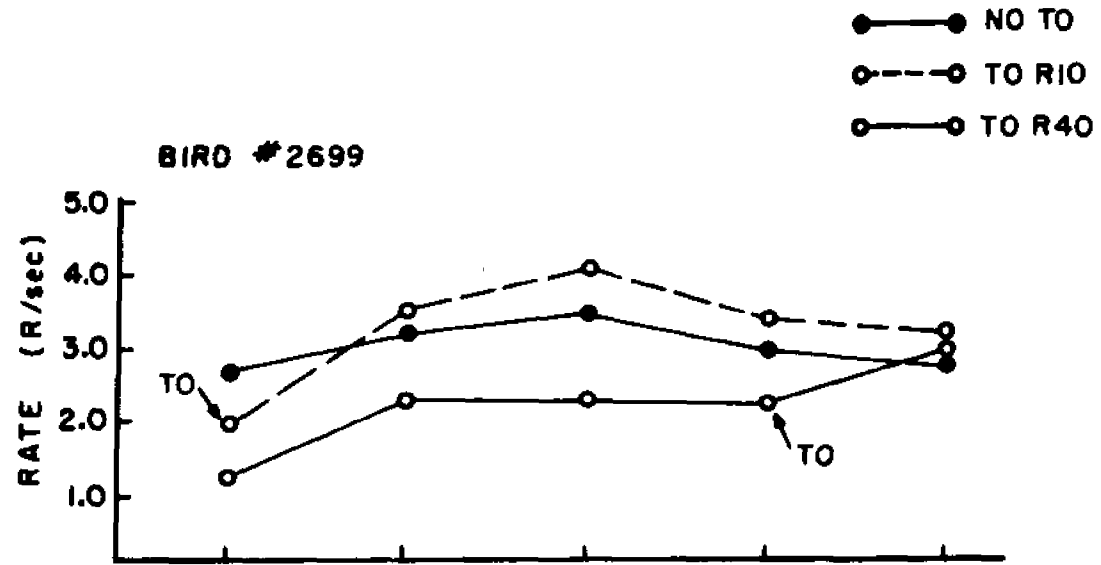
There is a general conformity to the profile by four of the six birds, although individual differences can be found in Table 5. Two of the birds, # 456 and 3765 however, exhibited no strained pausing. These findings correspond to the relatively short duration pausing generated by the three-ply multiple schedule.

(Response Rate)

In order to assess the effects of TO locus upon local response rate, temporal data were collected for successive 10-response sequences for each component of the multiple schedule. These measures were used to calculate the average rate of response for each successive block of 10 responses in the FR 50.

Bird # 2699 as indicated by Fig. 7, exhibits a hierarchy of response rates in the initial response sequence of the three contingencies. A notably low rate can be seen for the first ten responses during the late TO component. Responding continues at a relatively low but homogeneous rate through response 40 which initiates the TO. Cessation of the TO witnesses a marked facilitation in response rate. Responding in the initial 10 response sequence of the ratio during the early TO component is not as markedly reduced in rate. However, after R 10, a sharp rise in rate can be seen. Post-TO responding is facilitated through response 30, where a reduction in rate is again evident. Terminal response rate, however, slightly exceeds that

Fig. 7. Experiment I: Phase A. Sequential analysis of local response rates generated by the three-ply multiple schedule for birds #2699, #3765, and #2567.



produced by late and no-TO components. The no-TO component generates the least variation in response rate across the FR cycle. Responding is accelerated up to response 30, where a decline in rate is observed terminating with reinforcement. For the three components, terminal response rate is highest for the early TO contingency, lowest for the no-TO contingency, and of an intermediate order for the late TO contingency.

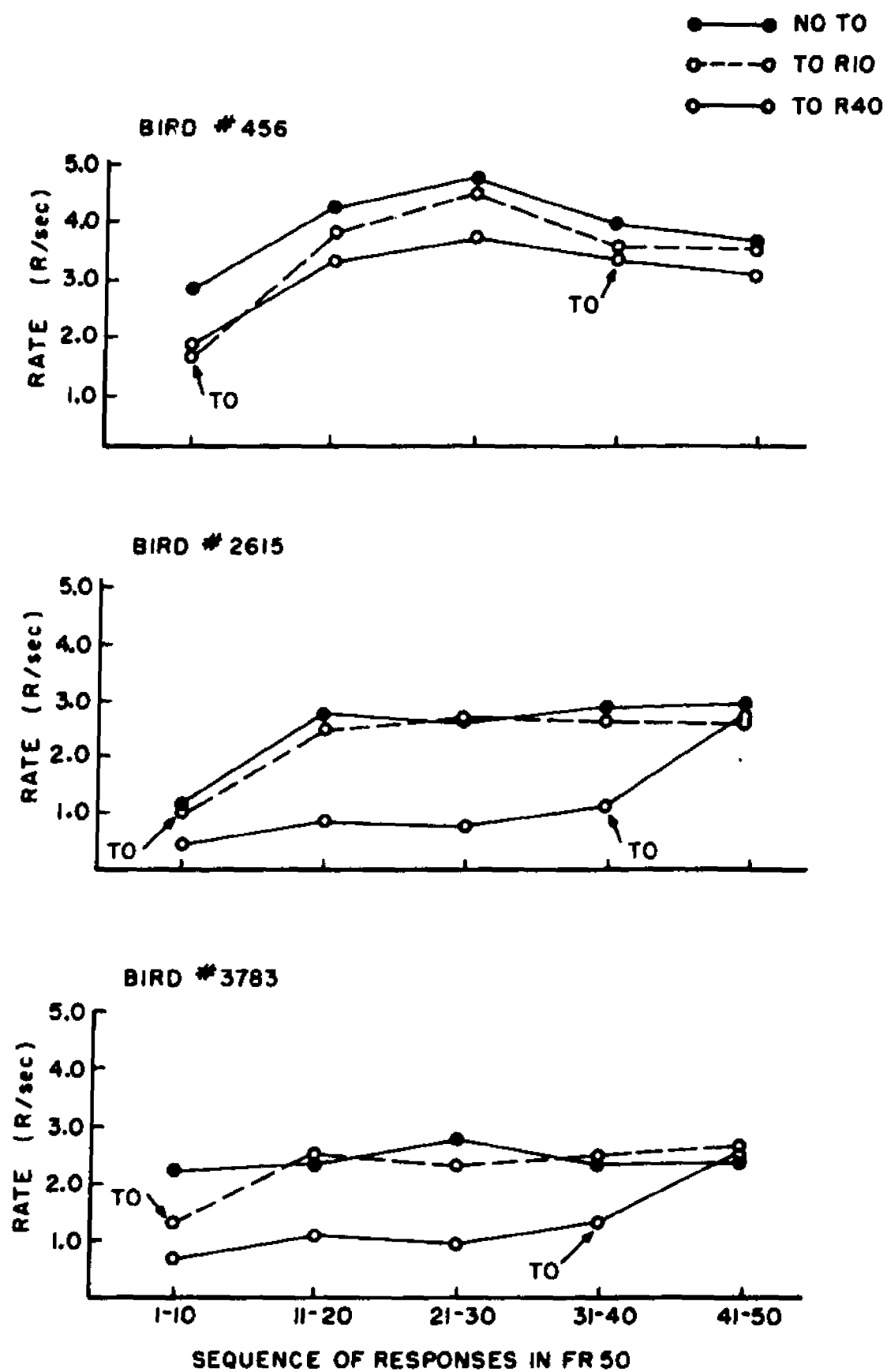
Sequential response rates for bird # 3765 (Fig. 7) again indicates the presence of a hierarchy. Early into the ratio, response rate is lowest for the late TO component, highest for the no-TO component, and of an intermediate order for the early TO contingency. The no-TO and late TO components appear to generate the typical FR pattern, although there is a local facilitation for responses 21 through 30 during responding on the no-TO component. Further, the late TO component generates the lowest response rate up to response 40 of the ratio. Post-TO responding is slightly facilitated for this component, although response rate retains its position as lowest in the hierarchy for the three components. Terminal response rates form a hierarchy with the early TO component generating the highest response rate, late TO the lowest response rate, while the no-TO component assumes an intermediate rate.

Figure 7 also shows the local response rates for bird # 2567. After the initial sequence of responses in

the ratio, all three contingencies appear to generate a homogeneous response chain indicative of FR responding. Within the initial response sequence a hierarchy emerges. The lowest rate is generated by the late TO component, highest by the no-TO component, and of an intermediate order by the early TO component. Post-TO responding is markedly facilitated for the early TO component, while post-TO responding for the late TO component continues at a relatively low rate. Terminal rates appear to exhibit a hierarchy like those of bird # 3765. Within this hierarchy, the late TO generates the lowest terminal rate, the early TO the highest terminal response rate, and the no-TO an intermediate order response rate.

Sequential response rates for birds # 456, # 2615, and # 3783, are shown in Fig. 8. For bird # 456, the lowest response rate early in the ratio is generated by the early TO component of the multiple schedule. Post-TO responding for the early TO contingency, however, is markedly facilitated. The no-TO contingency generated the highest response rate early in ratio responding, while the late TO generated an intermediate order response rate. All three contingencies generated negatively accelerated response rates up to response 30, where a marked decline in rate was observed terminating with reinforcement. The terminal sequence of responding for the three contingency assumed a hierarchy. The no-TO contingency continued at the highest rate of

Fig. 8. Experiment I: Phase A. Sequential analysis of local response rates generated by the three-ply multiple schedule for birds #456, #2615, and #3783.



response for the three contingencies, with the late TO component generating the lowest rate of response. The early TO contingency generated an intermediate order terminal response rate, although not markedly different from that of the no-TO component.

Analysis of sequential response patterns for bird # 2615 (Fig. 8) also indicates the presence of a hierarchy. The lowest initial response rate is generated by the late TO contingency, while the highest is generated by the no-TO component. The early TO contingency generates an intermediate order response rate in early ratio responding. After the initial staggered responding sometimes accompanying the FR chain, the no-TO component maintains the typical FR pattern of a homogeneous rate of response. As indicated, responding is staggered early in the ratio under the early TO component, until imposition of the TO at response 10. A post-TO facilitation is observed continuing up to response 30, where a slight decrease in rate is observed. The late TO component maintains the lowest rate until cessation of the TO at response 40. Post-TO responding is markedly facilitated, surpassing the response rate generated by the early TO contingency for the terminal response sequence of the ratio. Although the differences between the terminal response rates of the three contingencies are minimal, a hierarchy nevertheless emerges. The no-TO component generates the highest terminal response rate, while the early TO

generates the lowest response rate. The late TO contingency generates a terminal response rate of an intermediate order.

Sequential analysis of local response rates for bird # 3783 (Fig. 8) also indicates differences in response patterns generated by the three contingencies. The no-TO component generates the least variation in response rate across the FR cycle, showing only a very slightly reduced rate over the first 10 responses. The early TO component also generates the typical FR "break-run" behavior, although the rate for the first 10 responses is considerably reduced. The three components appear to form a response rate hierarchy for initial responding in the ratio. The highest initial response rate is generated by the no-TO component, while the lowest rate is generated by the late TO component. An intermediate order response rate is generated by the early TO contingency. Post-TO responding for the early TO contingency is markedly facilitated and is maintained at a homogeneous rate throughout the remainder of the ratio. The late TO contingency generates a low rate of response which is accelerated prior to imposition of the TO at R 40. The differences in rate among the three conditions are trivial in their terminal sequence of responses.

Segments of the final session's cumulative record are shown for all six birds in Figs. 9 and 10. Since the recorder paper continued to move during the imposition of

Fig. 9. Experiment I: Phase A. Segments of the final sessions' cumulative record generated by the three fixed ratio contingencies: FR 50; FR 50, 10-sec TO at R 10; FR 50, 10-sec TO at R 40.

Bird # 2567

Bird # 456

Bird # 2699

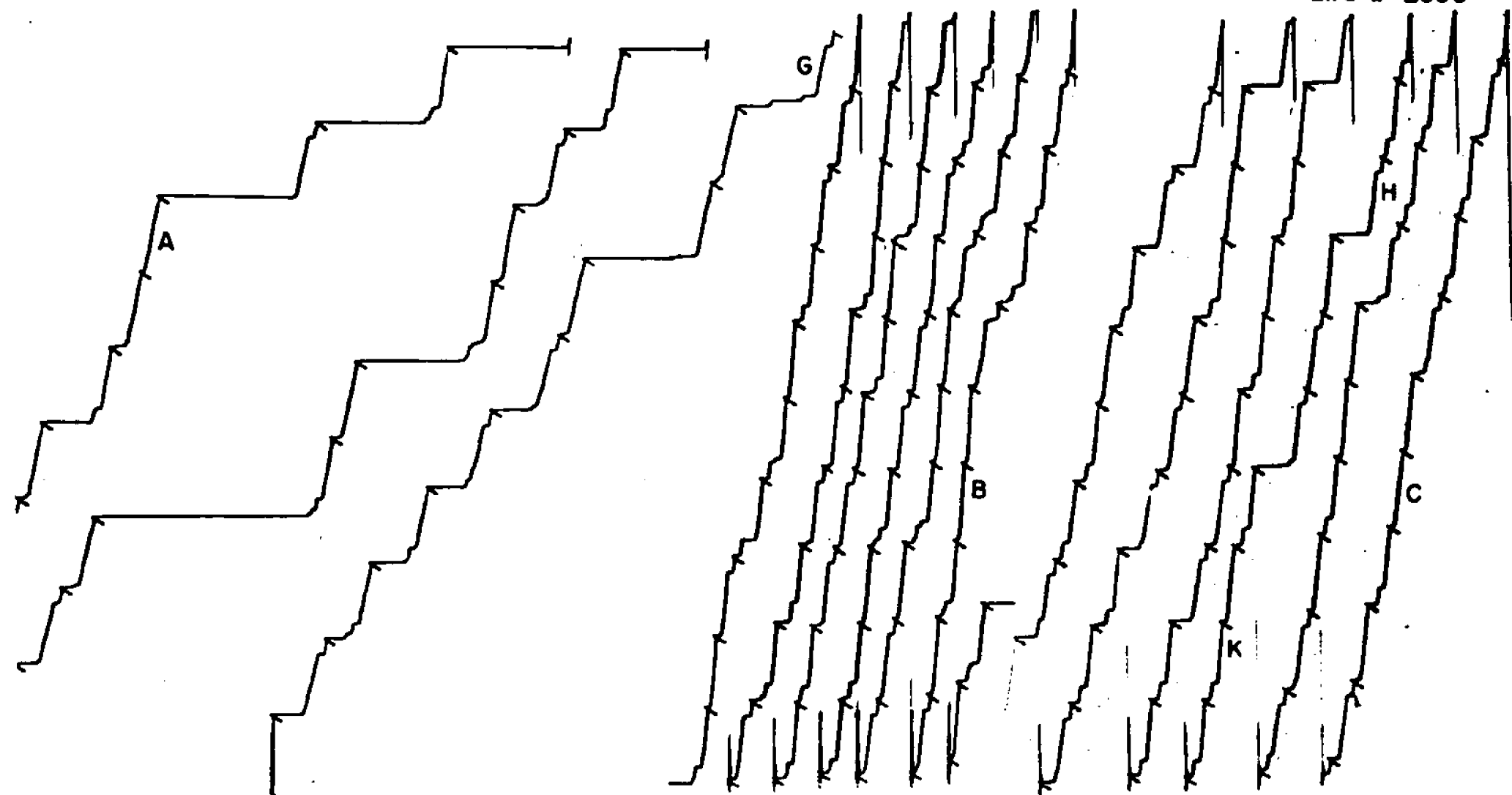
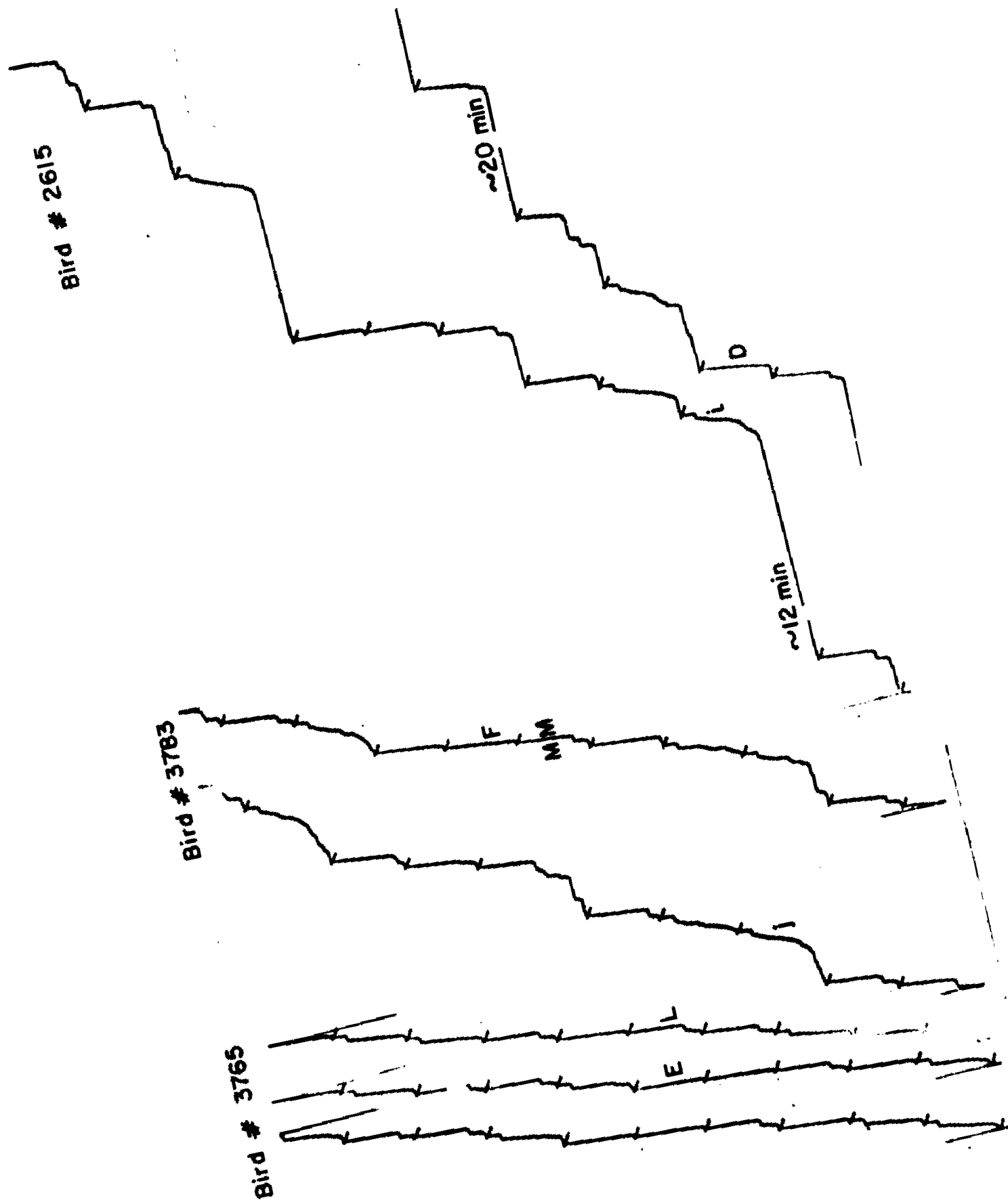


Fig. 10. Experiment I: Phase A. Segments of the final sessions' cumulative record generated by the three fixed ratio contingencies: FR 50; FR 50, 10-sec TO at R 10; FR 50, 10-sec TO at R 40.



the TOs, the three contingencies are generally easily identifiable from the cumulative record. Points a, b, c (Fig. 9), d, e, and f (Fig. 10) show cycles indicative of performance under the no-TO component of the multiple schedule. The short pause prior to the ratio run and the relatively homogeneous response chain which follows are indicative of FR behavior. Points g, h (Fig. 9), i, and j (Fig. 10), show the relatively long PreRPs and staggered responding generated by the late TO contingency. The low rates of response extend beyond the initial sequence of responses in the ratio. Points k (Fig. 9), l, and m (Fig. 10) on the cumulative record exhibit the response pattern generated by the early TO contingency. Responding occurs at a low rate prior to imposition of the TO at R 10. Both TO contingencies appear to generate rather stable and often accelerated responses rates after cessation of the TO in their respective components. The no-TO contingency generates the more uniform response pattern typical of FR behavior.

A general pattern for response rate appears to emerge in terms of a hierarchy. Both observation of cumulative records and analysis of quantitative data indicate less variation in the response pattern generated by the no-TO contingency. Subsequent to low level staggered responding in the initial sequence of the FR, the ratio is emitted by the organism at a homogeneous rate. This homogeneous pattern of responding observed in the no-TO component of the

multiple schedule is not observed during the two TO contingencies. The early TO contingency generates "somewhat" lower initial response rates than that generated by the no-TO component. The initial sequence of responses prior to imposition of the TO at R 10 is slightly disrupted, while the pause is also more extended than that generated by the no-TO contingency. Post-TO responding is more typical of FR behavior, as the response rate shows less local variations. The late TO contingency appears to generate the lowest initial response rates of the three contingencies, and the longest PreRPs. The ratio is disrupted up to imposition of the TO, which occurs rather late in the FR cycle. Prolonged pausing, followed by often severely broken ratio performance has been observed to be a common occurrence. With the late TO contingency, however, post-TO responding also appears to be accelerated, as in the case of the early TO contingency.

This response pattern appears typical of all birds with the exception of bird # 456. While the highest initial response rate is generated by the no-TO contingency, the lowest initial rate is generated by the early TO component of the multiple schedule. In addition, post-TO facilitation in response rates were observed under all TO contingencies with the exception of those generated by bird # 456, and the late TO contingency for bird # 2567.

The location of the TO appears to exert an inhibitory effect in initiating ratio behavior, as well as a disruptive

effect in maintaining the response pattern typical of FR performance. While the absence of a TO generates a homogeneous response chain, the further into an FR a TO is imposed, the greater the inhibitory and disrupting the effect.

Time of Involvement

In the following analysis, it is important to remember that the amount of actual responding is constant across all conditions; only the temporal parameters of the "situation" vary. The data suggests a regular relationship between PreRP, in a given contingency, and the subsequent response rate at which the ratio is emitted. The preceeding data have shown that longer PreRPs occur in the same conditions that generate lower response rates. To assess this relationship between PreRP and time to subsequent reinforcement, a PreRP/Time of Involvement (TOI) relationship has been analyzed in the form of a scatter diagram. The TOI is defined as the period of time elapsing between response 1 of the FR and subsequent reinforcement: TO duration, latency to resumption of responding, and rate of response all contribute to TOI.

The Tables presented in the following analysis are relevant to Phases of the study to be presented in subsequent sections. Their presentation in this section will extend in scope only to the experimental manipulations heretofore presented as Phase A.

TABLE 6
Summary of Median Pause and Time of Involvement
Across Conditions (in sec) for Bird # 2699
Experiment I

LOCATION OF TO IN FIXED RATIO							
Phase	Multiple Schedule	Measure	No TO	R 10	R 20	R 30	R 40
A	FR 50	Pause	3.4	12.1			31.3
	TO R 10	TOI	16.7	26.4			34.1
	TO R 40						
B	TO R 10	Pause		14.9	11.1		34.4
	TO R 20	TOI		28.1	29.9		33.5
	TO R 40						
C	Change in	Pause		22.8	18.1		325.4
	Depri- vation to 88 %	TOI		36.6	30.9		45.5

Note.— Time of Involvement (TOI) denotes the time elapsed between response 1 and reinforcement. This measure does not include the Pre-response pause or time during which the bird is feeding during reinforcement.

Fig. 11. Experiment I: Phase A. Scatter diagram of the pre-response pause/time of involvement (PreRP/TOI) relationship for bird #2699 generated by the three schedule contingencies: FR 50; FR 50, 10-sec TO at R 10; FR 50, 10-sec TO at R 40.

Table 6 summarizes median PreRP and TOI for bird # 2699. Shortest pausing which occurs during the no-TO contingency also exhibits the shortest TOI; longest pausing which occurs during the late TO contingency exhibits the longest TOI; while the early TO contingency exhibits an intermediate length pause and a corresponding intermediate order TOI. The scatter diagram for bird # 2699, as indicated by Fig. 11 suggests a positive relationship between the two variables. This figure provides a datum point for each of the ten criterion days of Phase A for each component of the multiple schedule. The PreRP/TOI scatter for each of the three contingencies appears to represent different populations of events, as indicated by their relatively discrete clustering. However, points deviating from their main cluster tend to conform to the general regression line. The empirical regression line which was fit according to the equation $Y = b_{(Y.X)} (X - \bar{X}) + \bar{Y}$ (Hays, 1963), indicates that as the TOI increases, the PreRP also increases. Transformation of this equation to $\text{Log } Y = b_{(Y.X)} (X - \bar{X}) + \bar{Y}$ was necessary as the PreRP is on a logarithmic axis. The highly skewed distribution of pauses made the transformation desirable.

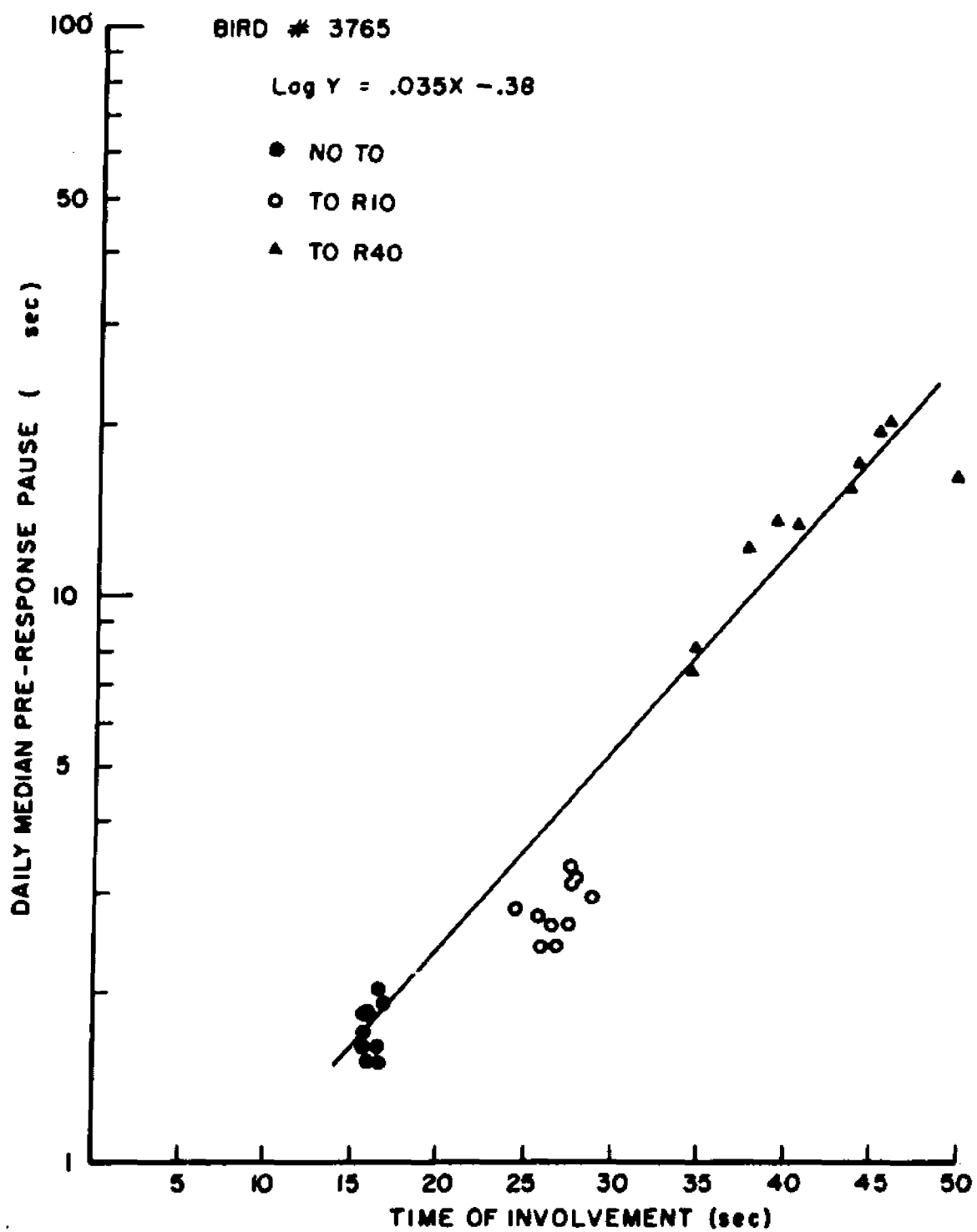
Table 7 summarizes the median PreRP and TOI for bird # 3765. A hierarchy of pausing with corresponding TOIs is observed. Shortest pausing which occurs during the no-TO contingency also exhibits the shortest TOI; longest pausing which

TABLE 7
Summary of Median Pause and Time of Involvement
Across Conditions (in sec) for Bird #3765
Experiment I

LOCATION OF TO IN FIXED RATIO							
Phase	Multiple Schedule	Measure	No TO	R 10	R 20	R 30	R 40
A	FR 50	Pause	1.7	2.8			14.5
	TO R 10	TOI	15.9	26.8			41.4
	TO R 40						
B	TO R 10	Pause		1.9		5.5	10.2
	TO R 30	TOI		26.8		28.6	41.0
	TO R 40						
C	Change in	Pause		5.5		3.8	10.9
	Depri- vation to 88 %	TOI		28.6		29.0	41.3

Note.— Time of Involvement (TOI) denotes the time elapsed between response 1 and reinforcement. This measure does not include the Pre-response pause or time during which the bird is feeding during reinforcement.

Fig. 12. Experiment I: Phase A. Scatter diagram of the pre-response pause/time of involvement (PreRP/TOI) relationship for bird #3765 generated by the three schedule contingencies: FR 50; FR 50, 10-sec TO at R 10; FR 50, 10-sec TO at R 40.



occurs during the late TO contingency exhibits the longest TOI; while the early TO contingency exhibits an intermediate duration pause and corresponding intermediate order TOI. The scatter diagram shown in Fig. 12 again shows a positive relationship between the two variables with relatively discrete clustering for the three contingencies. The within cluster variance seems reasonably well accounted for by the regression line. The empirical regression line indicates that as the TOI increases, a corresponding increase in pause may be predicted (or vice versa).

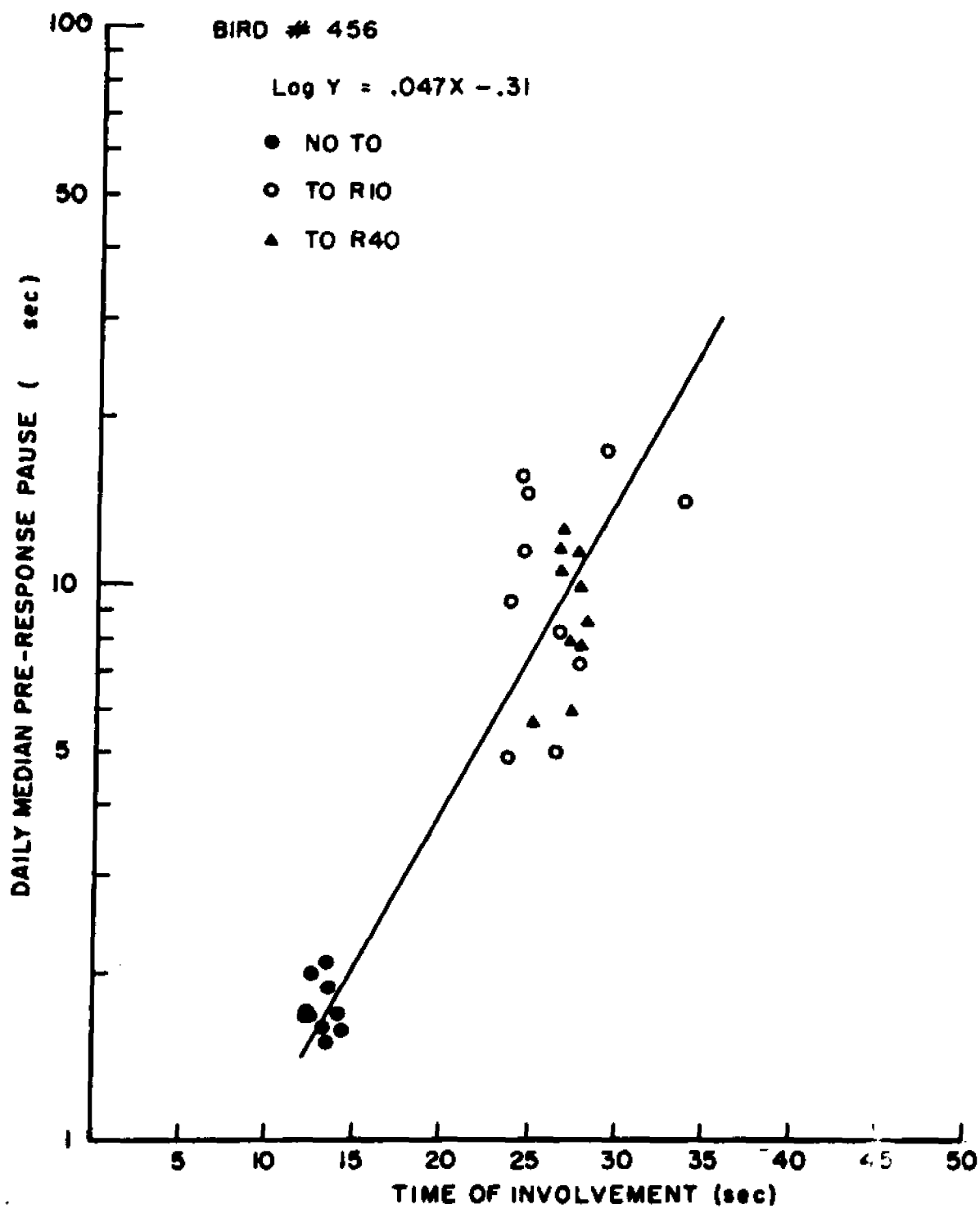
Median PreRP and TOI for bird # 456 are shown in Table 8. Although the no-TO contingency generates both shortest PreRP and TOI, the relationship is less clear for the two TO contingencies. Table 8 indicates that the longest median pause in Phase A occurs during the early TO component, while the longest TOI accompanies the late TO component. It is worthy of note that the difference which exists between the pause and TOIs of these two contingencies are of a small magnitude. These differences may not warrant their division into two relatively discrete populations of events. This assumption is seen further in Fig. 13. While the PreRP/TOI relationship for the no-TO contingency is tightly clustered, the two TO contingencies exhibit a high degree of overlap. The empirical regression line, however, suggests that as the TOI increases, a concomitant pause increase can be expected. For this bird, much of the form of the regression line is attributable to variance between, not

TABLE 8
Summary of Median Pause and Time of Involvement
Across Conditions (in sec) for Bird # 456
Experiment I

LOCATION OF TO IN FIXED RATIO							
Phase	Multiple Schedule	Measure	No TO	R 10	R 20	R 30	R 40
A	FR 50	Pause	1.7	10.8			9.5
	TO R 10	TOI	14.1	26.5			27.1
	TO R 40						
B	TO R 10	Pause		6.4		7.7	12.0
	TO R 30	TOI		21.9		25.9	29.3
	TO R 40						
C	Change in	Pause		6.2		7.6	10.8
	Deprivation to 72 %	TOI		24.5		32.0	30.2

Note.— Time of Involvement (TOI) denotes the time elapsed between response 1 and reinforcement. This measure does not include the Pre-response pause or time during which the bird is feeding during reinforcement.

Fig. 13. Experiment I: Phase A. Scatter diagram of the pre-response pause/time of involvement (PreRP/TOI) relationship for bird #456 generated by the three schedule contingencies: FR 50; FR 50, 10-sec TO at R 10; FR 50, 10-sec TO at R 40.



within clusters.

Table 9 summarizes the median PreRP and TOI for bird # 2567. The hierarchy of pausing is again consistent with the hierarchy of TOIs generated by the three contingencies. The positive relationship between these two variables is suggested by Fig. 14. As the empirical regression line indicates again, an increase in TOI corresponds to an increase in PreRP. For this bird, there is a fairly high measure of overlap among the data points for the three contingencies. The regression line seems to account fairly well for variance within and between conditions.

Median PreRP and TOI for bird # 2615 maintain a similar hierarchy with correspondence between the two measures as indicated by Table 10. The positive relationship between the two variables is again observed in the scatter diagram of Fig. 15. Again, the regression line provides reasonable intra and inter condition fit.

Table 11 summarizes the median PreRP and TOI for bird # 3783. Pausing and corresponding TOI assume a hierarchy suggested by the other birds, although the difference in pausing for the two TO contingencies is less discriminable. Observation of Fig. 16, however, reveals the relatively discrete clustering of points for each ratio contingency. The regression line for Fig. 16 also suggests that as TOI increases, a corresponding increase in pause may be predicted. Three points for the TO at R 40 contingency deviate

TABLE 9
Summary of Median Pause and Time of Involvement
Across Conditions (in sec) for Bird # 2567
Experiment I

LOCATION OF TO IN FIXED RATIO							
Phase	Multiple Schedule	Measure	No TO	R 10	R 20	R 30	R 40
A	FR 50	Pause	4.8	32.5			55.0
	TO R 10	TOI	29.0	36.0			45.9
	TO R 40						
B	TO R 10	Pause		15.3	11.7		32.1
	TO R 20	TOI		34.2	35.9		42.2
	TO R 40						
C	Change in	Pause		17.3	11.3		25.4
	Depri-	TOI		32.6	37.9		44.6
	vation to 72 %						

Note.— Time of Involvement (TOI) denotes the time elapsed between response 1 and reinforcement. This measure does not include the Pre-response pause or time during which the bird is feeding during reinforcement.

Fig. 14. Experiment I: Phase A. Scatter diagram of the pre-response pause/time of involvement (PreRP/TOI) relationship for bird # 2567 generated by the three schedule contingencies: FR 50; FR 50, 10-sec TO at R 10; FR 50, 10-sec TO at R 40.

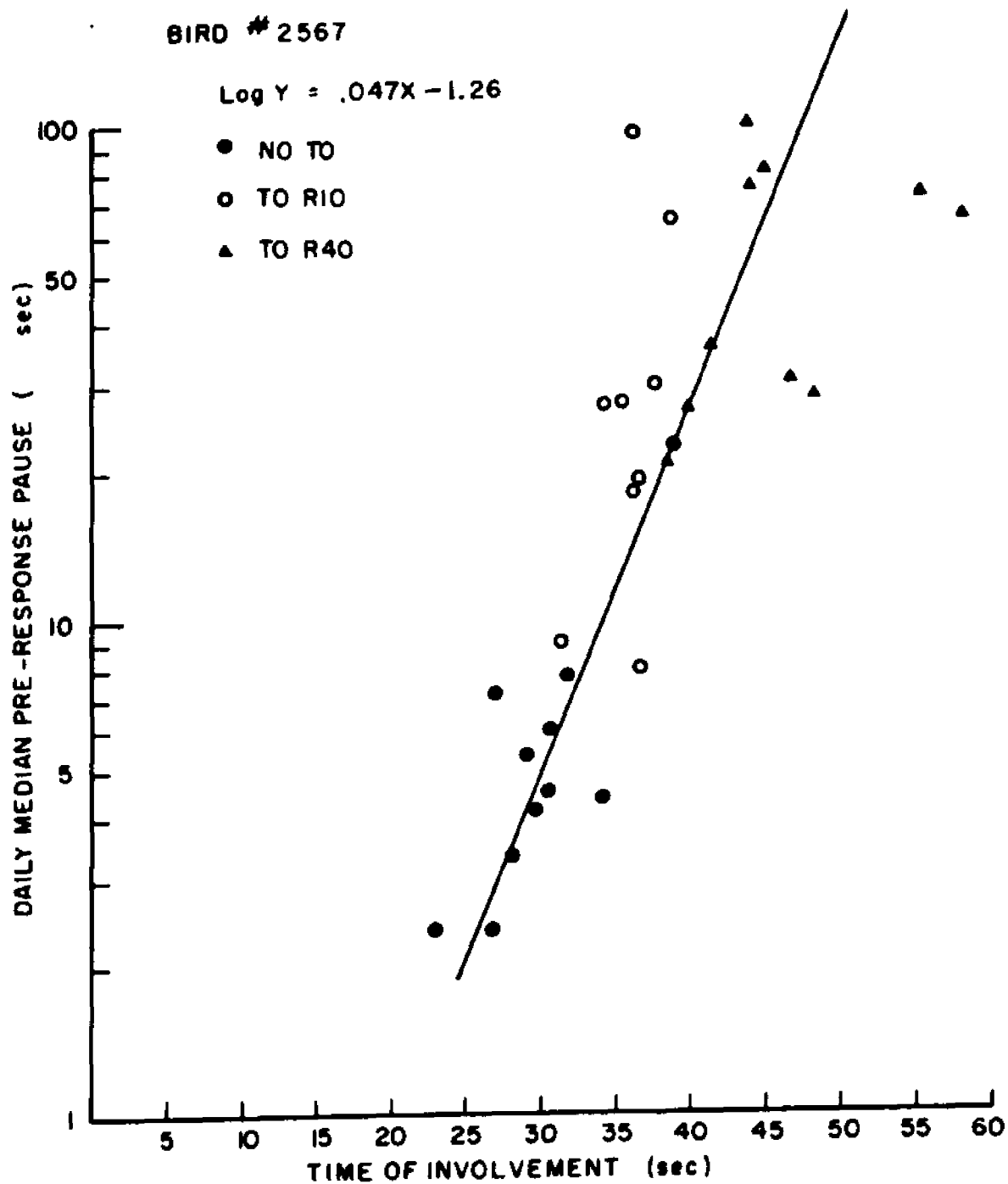


TABLE 10
Summary of Median Pause and Time of Involvement
Across Conditions (in sec) for Bird # 2615
Experiment I

LOCATION OF TO IN FIXED RATIO							
Phase	Multiple Schedule	Measure	No TO	R 10	R 20	R 30	R 40
A	FR 50	Pause	6.2	24.8			66.3
	TO R 10	TOI	21.6	34.4			63.8
	TO R 40						
B	TO R 10	Pause		28.7	15.6		59.0
	TO R 20	TOI		31.1	33.3		61.1
	TO R 40						
C	Change in	Pause		13.5	6.5		38.9
	Depri- vation to 72 %	TOI		28.7	31.3		60.2

Note.— Time of Involvement (TOI) denotes the time elapsed between response 1 and reinforcement. This measure does not include the Pre-response pause or time during which the bird is feeding during reinforcement.

Fig. 15. Experiment I: Phase A. Scatter diagram of the pre-response pause/time of involvement (PreRP/TOI) relationship for bird #2615 generated by the three schedule contingencies: FR 50; FR 50, 10-sec TO at R 10; FR 50, 10-sec TO at R 40.

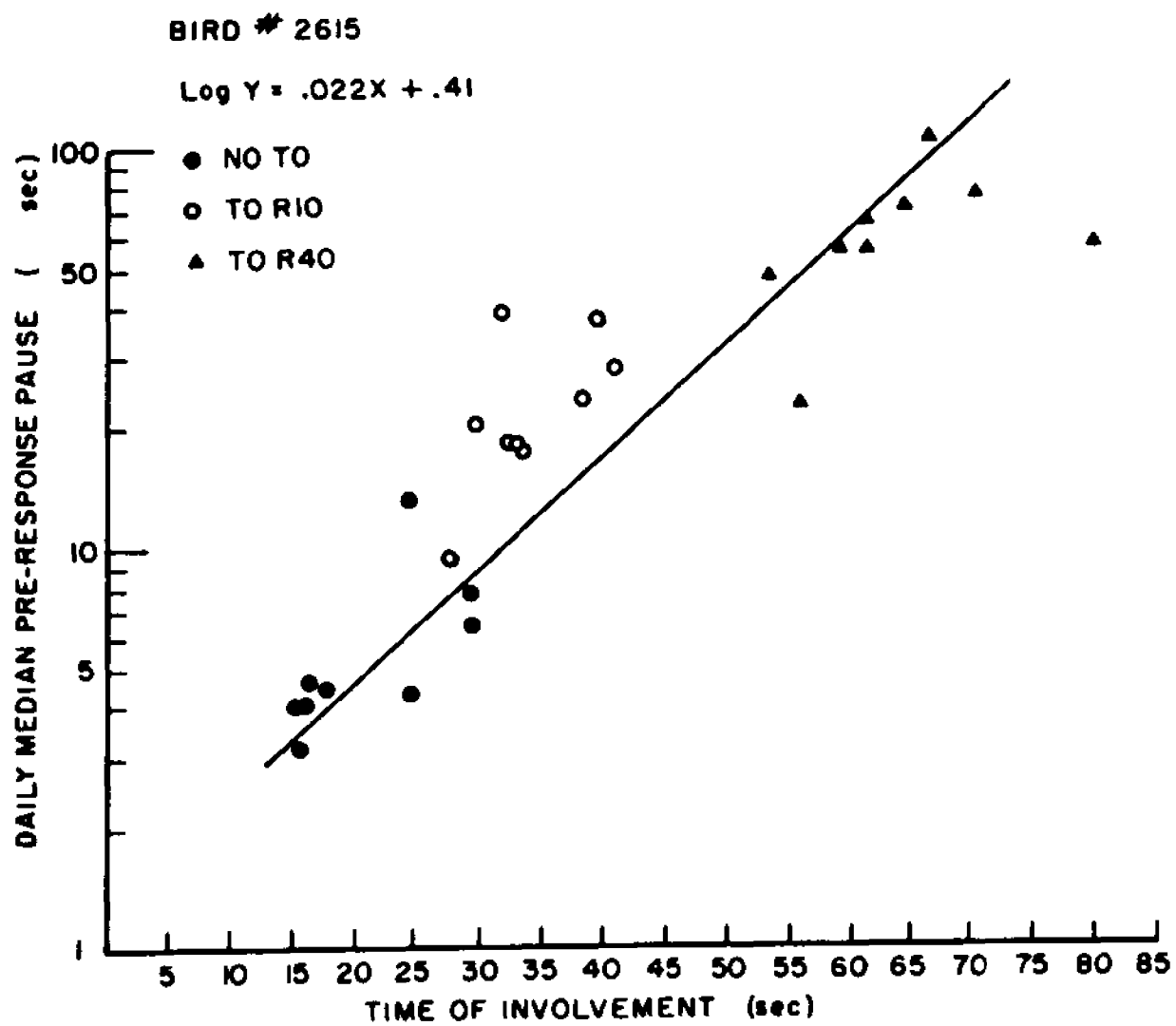
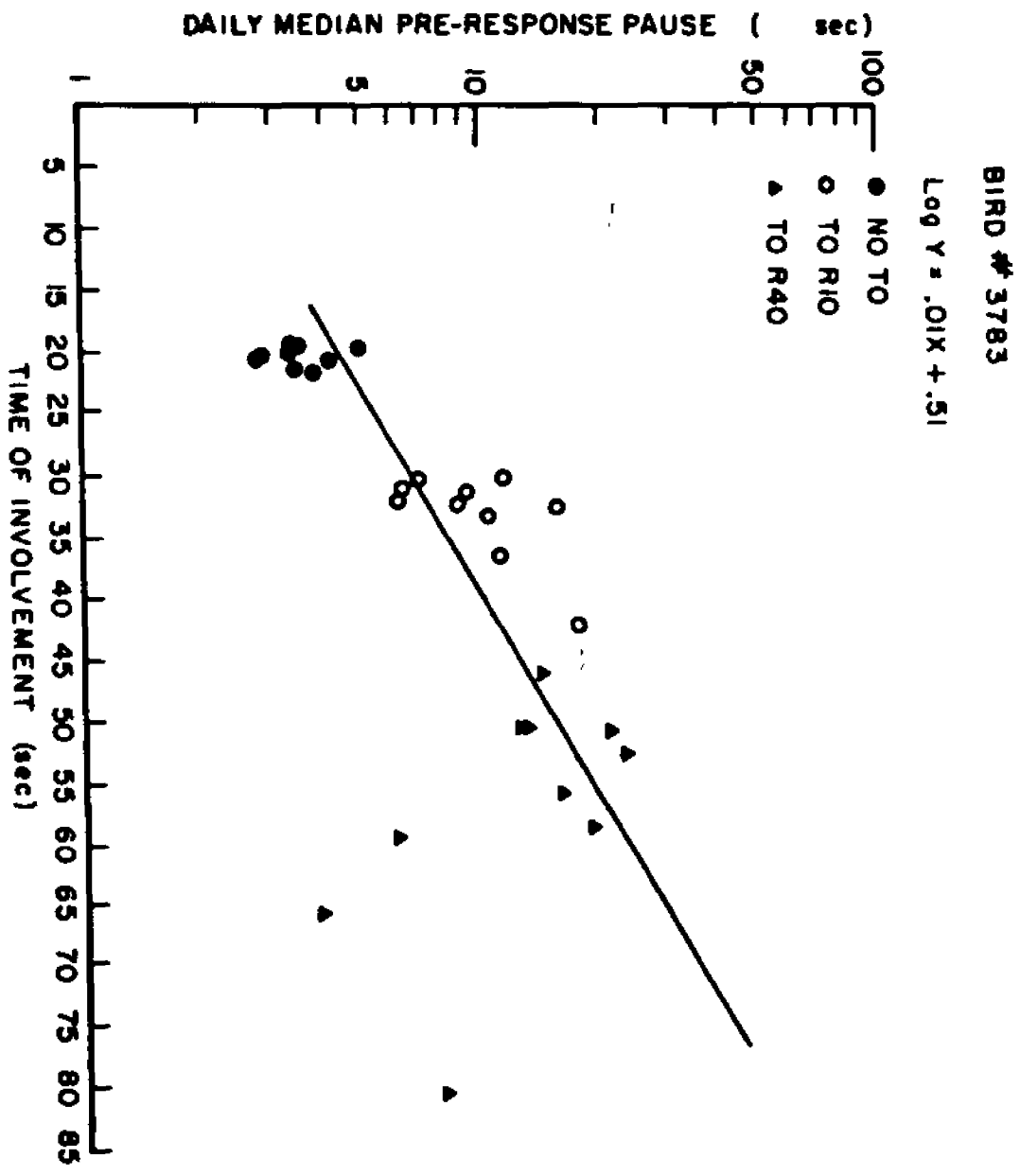


TABLE 11
Summary of Median Pause and Time of Involvement
Across Conditions (in sec) for Bird # 3783
Experiment I

LOCATION OF TO IN FIXED RATIO							
Phase	Multiple Schedule	Measure	No TO	R 10	R 20	R 30	R 40
A	FR 50	Pause	3.6	10.6			11.8
	TO R 10	TOI	20.3	33.3			58.3
	TO R 40						
B	TO R 10	Pause		11.6		58.5	19.4
	TO R 30	TOI		34.0		53.2	58.9
	TO R 40						
C	Change in Depri- vation to 88 %	Pause TOI	D I D N O T R E S P O N D				

Note.— Time of Involvement (TOI) denotes the time elapsed between response 1 and reinforcement. This measure does not include the Pre-response pause or time during which the bird is feeding during reinforcement.

Fig. 16. Experiment I: Phase A. Scatter diagram of the pre-response pause/time of involvement (PreRP/TOI) relationship for bird #3783 generated by the three schedule contingencies: FR 50; FR 50, 10-sec TO at R 10; FR 50, 10-sec TO at R 40.

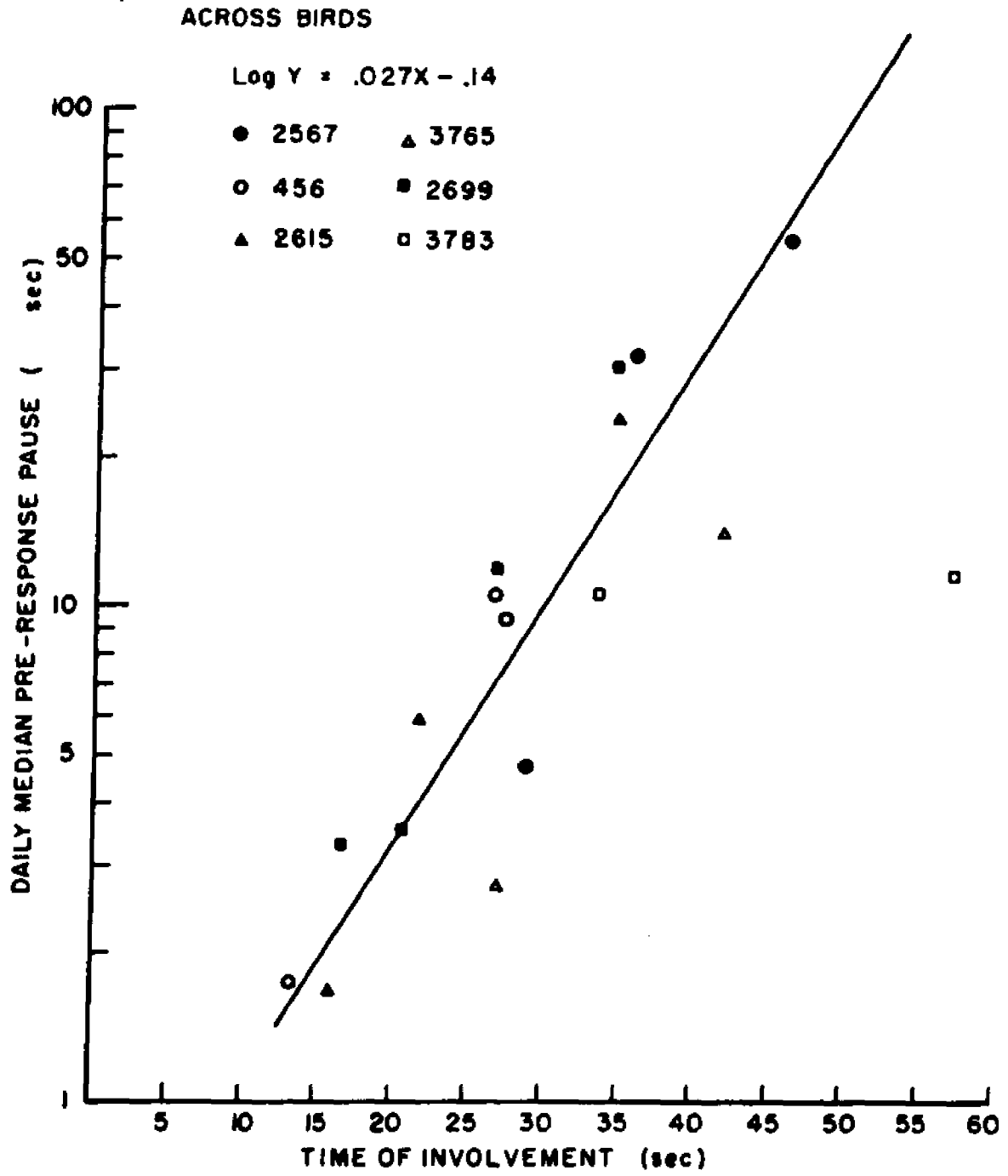


considerably from the overall pattern and appear to contribute much to the nearly flat regression line. Although these points cannot be legitimately excluded from the analysis, inspection of the figure clearly indicates closer conformity to the general pattern of the other subjects than the regression equation indicates.

Figure 17 summarizes the relationship between PreRP and TOI across birds in Phase A of Experiment I. Each data point reflects the combined data for the 10 criteria days on each condition. Although the scatter is rather diffuse to accommodate bird specific patterns, a generalized function according to the equation $\text{Log } Y = b_{(y.x)} (X - \bar{X}) + \bar{Y}$ can be fit. The function suggests that as there is a change in the value of one variable, a corresponding change may be predicted for the other variable. The empirical regression line further suggests that this relationship is positive in direction.

Figures 11, 12, 13, 14, 15, and 16 suggest a positive relationship between PreRP and TOI, although the degree of this relationship, as indicated by the regression line for each bird, may be specific to the individual bird. However, the regression line averaged across birds also presents a function not grossly dissimilar from the functions of the individual birds. Further, the PreRP/TOI function suggests

Fig. 17. Experiment I: Phase A. Scatter diagram of the pre-response pause/time of involvement (PreRP/TOI) relationship summarized for all birds responding on the three-ply multiple schedule: FR 50; FR 50, 10-sec TO at R 10; FR 50, 10-sec TO at R 40. Each data point represents the median for the ten criteria sessions at each component of the multiple schedule for each bird.



the feasibility of predicting the time an organism will be involved in a chain of behavior, given the antecedent period of "non'activity."

Experiment I: Phase B:

(Pausing)

After criterion session 10 in Phase A, a component with a 10-sec. TO at response 20 (TO at R 20) was substituted for the no-TO contingency for birds # 2567, # 2615, and # 2699. Similarly, a 10-sec. TO at response 30 (TO at R 30) was substituted for the no-TO component for birds # 3765, # 456, and # 3783. Each new contingency assumed the exteroceptive stimulus associated with the no-TO contingency of Phase A. Section B of Figs. 1, 2, 3, 4, 5, and 6 show the median PreRP as a function of the new TO contingencies. The early TO and late TO (Phase A) remained in effect for both groups of birds. These schedule components maintained the exteroceptive stimuli from Phase A.

(Introduction of TO at R 20,

Figure 2 indicates that upon imposition of the TO at R 20, bird # 2615 showed a decrease in median PreRP for all contingencies. By the fourth session under the new contingency, all levels of pausing either recovered or exceeded previous baselines. A pause hierarchy was maintained from session 1 through the 10 criteria sessions indicated as sessions 21 through 30 in Section B of Fig. 2. The TO at R

20 component generated the shortest duration pause; the TO at R 40 (late) generated the longest pause; while the TO at R 10 (early) generated an intermediate duration pause. The pause generated by the TO at R 20 component was longer than the pause generated by the no-TO component of Phase A. The phase generated by the early TO component showed an increase in duration over its Phase A level, while the late TO component showed a decrease in magnitude below its Phase A level.

Figure 3 indicates that upon imposition of the new TO contingency, bird # 2699 also showed a decrease in median pause for all contingencies. The decrease was immediately evident for the early and late TO components, while the new contingency showed a shortened pause by session 2. A gradual increase in pause duration was noted for all three contingencies during the thirty experimental sessions. Relative pause duration for the TO at R 10 and TO at R 20 components showed a series of reversals, while the late TO component consistently generated the longest PreRP. The last sixteen sessions witnessed a rather stable hierarchy. The new TO contingency generated the shortest median PreRP; the late TO the longest median PreRP; and the early TO an intermediate order response pause. During sessions 23 and 24, however, the TO at R 10 and TO at R 20 components showed a two-session reversal in pause hierarchy.

Figure 6 indicates that upon imposition of the TO at R 20 contingency, bird # 2567 also showed a decrease in median PreRP for all contingencies. This decrease was followed by a rapid recovery of baseline and subsequent increases over previous baselines within two sessions. No consistent pause hierarchy emerges until session 25. From session 25 to completion of Phase B, the late TO contingency generated the longest median PreRP, the new TO contingency the shortest PreRP, and the early TO component an intermediate length pause.

With substitution of the TO at R 20 (new) contingency for the no-TO contingency of the multiple schedule, all birds demonstrated an initial decrease for all response pauses generated by the three contingencies, followed by a rapid recovery of baseline. In addition, the new contingency assumed the hierarchical position of the no-TO component in generating the shortest duration pause. The pause duration, however, showed an increase over the levels generated by the no-TO component in Phase A. All other positions in the hierarchy appeared to persist.

(Introduction of TO at R 30)

Figure 1 indicates that upon introduction of the TO at R 30 contingency (new), bird # 3765 exhibited a decrease in pause duration for the early TO contingency and in the presence of the stimulus originally signalling the no-TO contingency (now TO at R 40), while the late TO contingency

showed little initial change in pause duration. The following sessions witnessed a "reshuffling" of the original hierarchy generated during Phase A. The new TO component showed a gradual increase in pause duration, approaching the level generated by the early and late TO contingencies. The pause generated by the early TO contingency also showed a marked increase. A subsequent reduction in pause duration generated by the early and new TO components resulted in the formation of a stable hierarchy by session 14, and which was maintained throughout Phase B. The early TO component now maintained the shortest pause; the late TO component the longest pause; and the new TO component assumed an intermediate position in the hierarchy.

Figure 4 indicates that upon introduction of the TO at R 30 contingency, bird # 456 showed an initial decrease in pausing generated by the early and new TO components, while the late TO component showed little change. Subsequent pause durations generated by the new TO contingency increased rapidly, although differences between the three contingencies were often indiscriminable. No discernable hierarchy was evident, although the late TO component appeared to manifest the longest PreRP for 10 of the final 12 sessions. The early and new TO components exhibited a series of reversals in hierarchy formation.

Figure 5 indicates that upon imposition of the TO at R 30 contingency, bird # 3783 exhibited a decrease in pausing for the early TO component, and in the presence of the

stimulus originally signalling the no-TO component, with a concomitant increase in pausing for the late TO contingency of the multiple schedule. Subsequent increases in pausing generated by the early and new TO contingencies along with decreases generated by the late TO contingency resulted in transient hierarchies. An over-all increase in pause duration is, however, observable, with a pause hierarchy emerging by session 24. In the hierarchy, the new TO contingency maintained the longest pause, the early TO contingency the shortest pause, and the late TO contingency an intermediate duration pause. Reversals in the hierarchy are, however, noted! During session 25, the early TO generated a pause exceeding that of the late TO component, while during session 26, the late TO component generated a pause exceeding the new TO contingency. Over-all pausing was longer than during Phase A.

It is worth noting that the initial effect of Phase B was to reduce the early TO pausing for every animal.

(Sequential Analysis of Pause: TO at R 20)

Table 12 shows the median PreRP for the ten criteria sessions as a function of the preceding and present contingency, when the TO at R 20 component was substituted for the no-TO component.

The formation of a hierarchy is indicated for bird # 2615. Pausing with TO at R 20 is the shortest, which is in conflict with a hierarchy related to TO location within the

TABLE 12
Median Pre-response Pause (in sec) as a Function
of Present and Preceding Contingency

Experiment I: Phase B

PRECEDING CONTINGENCY		PRESENT CONTINGENCY		
		FR 50 TO at R 10	FR 50 TO at R 20	FR 50 TO at R 40
S 2615	FR 50 TO at R 10	23.9	16.3	193.3
	FR 50 TO at R 20	34.9	15.6	57.2
	FR 50 TO at R 40	27.8	13.2	37.6
S 2699	FR 50 TO at R 10	14.1	13.7	34.0
	FR 50 TO at R 20	17.9	6.3	42.2
	FR 50 TO at R 40	14.5	10.2	22.1
S 2567	FR 50 TO at R 10	13.2	11.7	36.0
	FR 50 TO at R 20	15.4	7.3	35.8
	FR 50 TO at R 40	15.2	13.9	22.2

Note.— The term "pre-response pause" is used to describe the ratio pause which precedes the ratio run in the fixed ratio schedule.

FR cycle. It should be remembered that this condition is cued by the key color formerly associated with the no-TO condition. Further, pause duaration has increased considerably for all schedule components, with the greatest increase observed for the late TO contingency. With the exception of the newly imposed TO at R 20 component, repetition of a contingency continues to yield the lowest PreRP for that schedule component. The shortest pause for the TO at R 20 component occurs when it follows responding on the late TO contingency.

Sequential analysis of schedule interactions for bird # 2567 (Table 12) again indicates that pausing generated by the TO at R 20 is shortest of the three conditions. Pause duration shows an increase for all contingencies with the exception of the late TO component which exhibits a marked decrease. Further, shortest pausing within a contingency is maintained with repetition of that contingency.

(Ratio Strain with Introduction of TO at R 20)

With the increase in PreRP duration for bird # 2615, a concomitant increase in strained pausing is observed, as indicated by Table 13. The increased pausing for bird # 2699 is also accompanied by increased stain (Table 13). The decrease in pause duration generated by the late TO contingency is accompanied by a decrease in strain for that contingency for bird # 2567. Bird # 2567 (Table 13) also exhibits a decrease in probability of strain for the early

TABLE 13
Probability of Strain as a Function of
Present and Preceding Contingency
Experiment I: Phase B

PRECEDING CONTINGENCY		PRESENT CONTINGENCY		
		FR 50 TO at R 10	FR 50 TO at R 20	FR 50 TO at R 40
S 2615	FR 50 TO at R 10	0.23	0.00	0.61
	FR 50 TO at R 20	0.19	0.14	0.39
	FR 50 TO at R 40	0.14	0.02	0.17
S 2699	FR 50 TO at R 10	0.03	0.00	0.12
	FR 50 TO at R 20	0.05	0.07	0.14
	FR 50 TO at R 40	0.00	0.00	0.02
S 2567	FR 50 TO at R 10	0.09	0.07	0.19
	FR 50 TO at R 20	0.05	0.06	0.24
	FR 50 TO at R 40	0.09	0.09	0.13

Note.— Strain is defined as any pre-response pause greater than 90 seconds. The probability of strain is obtained by dividing the number of strained pauses of a contingency by the number of times that contingency was in effect.

TO contingency.

(Sequential Analysis of Pause: TO at R 30)

Table 14 shows the median PreRP for the ten criteria sessions as a function of the preceeding and present schedule contingency when the TO at R 30 component was substituted for the no-TO component.

With imposition of the TO at R 30 for bird #456, pausing generated by the early TO component decreased while pausing generated by the late TO component increased. With the increase in pausing generated by the late TO component, and decrease generated by the early TO component, the newly imposed TO at R 30 contingency assumed an intermediate position in the hierarchy. Within a condition, repetition continued to maintain shortest pausing.

With imposition of the TO at R 30 for bird # 3783, pause duration increased for both early and late TO components, although pausing generated by TO at R 30 exceeded those levels. In effect, a new hierarchy emerged, with the early TO maintaining the shortest pause, TO at R 30 the longest pause, and the late TO an intermediate duration pause. Pausing remained shortest with repetition of a contingency for all schedule components.

With imposition of the TO at R 30 for bird # 3765, pausing generated by the early TO component decreased, while pausing generated by the late TO component remained relatively unchanged. Pausing generated by the TO at R 30

TABLE 14
Median Pre-response Pause (in sec) as a Function
of Present and Preceding Contingency
Experiment I: Phase B

PRECEDING CONTINGENCY		PRESENT CONTINGENCY		
		FR 50 TO at R 10	FR 50 TO at R 30	FR 50 TO at R 40
S 456	FR 50 TO at R 10	5.6	7.7	13.6
	FR 50 TO at R 30	6.6	7.2	13.6
	FR 50 TO at R 40	6.6	7.9	9.7
S 3783	FR 50 TO at R 10	5.7	40.0	30.5
	FR 50 TO at R 30	13.8	36.7	32.2
	FR 50 TO at R 40	11.1	74.5	3.8
S 3765	FR 50 TO at R 10	1.6	5.7	17.6
	FR 50 TO at R 30	3.0	4.7	15.8
	FR 50 TO at R 40	1.6	5.0	5.8

Note.— The term "pre-response pause" is used to describe the ratio pause which precedes the ratio run in the fixed ratio schedule.

component was of an intermediate value and assumed an intermediate position in the hierarchy. Once again, repetition of a component within a contingency resulted in shortest duration pausing for that contingency.

(Ratio Strain with Introduction of TO at R 30)

With increase in pausing generated by the late TO component, bird # 456 showed a slight increase in the probability of strain, as indicated by Table 15. Although a decrease in pausing was evident for the early TO contingency, it, too, showed a small increase in probability of strain.

Bird # 3783 also showed a marked increase in probability of strain along with the increase in pause duration (Table 15). The levels of strain generated by the three TO components correspond to their respective levels in the pause hierarchy.

Bird # 3765 continues to show an absence of strain. This again, corresponds to the relatively short duration pausing which continued even with imposition of a third TO contingency.

Differential effects were observed as a function of imposing either a TO at R 20 or TO at R 30, as a replacement for the no-TO contingency in a three-ply multiple schedule. Pausing generated by imposition of the TO at R 20 assumed the hierarchy position previously generated by the no-TO contingency. In addition, a general increase in pause duration was observed during responding on both the early

TABLE 15

**Probability of Strain as a Function of
Present and Preceding Contingency**

Experiment I: Phase B

PRECEDING CONTINGENCY		PRESENT CONTINGENCY		
		FR 50 TO at R 10	FR 50 TO at R 30	FR 50 TO at R 40
S 456	FR 50 TO at R 10	0.00	0.00	0.02
	FR 50 TO at R 30	0.00	0.00	0.00
	FR 50 TO at R 40	0.02	0.00	0.00
S 3783	FR 50 TO at R 10	0.11	0.35	0.29
	FR 50 TO at R 30	0.12	0.46	0.28
	FR 50 TO at R 40	0.06	0.45	0.00
S 3765	FR 50 TO at R 10	0.00	0.00	0.00
	FR 50 TO at R 30	0.00	0.00	0.00
	FR 50 TO at R 40	0.00	0.00	0.00

Note.— Strain is defined as any pre-response pause greater than 90 seconds. The probability of strain is obtained by dividing the number of strained pauses of a contingency by the number of times that contingency was in effect.

and late TO components of the schedule. The effects produced by imposition of the TO at R 30 appear less consistent. On two occasions, the pausing generated by the TO at R 30 assumed an intermediate position in the hierarchy, suggesting that the further into the ratio a TO was imposed, the longer the PreRP. However, for the third bird, the TO at R 30 generated the longest PreRP of the three contingencies.

The probability of strain for all birds, however, appeared to correspond with the relative pause durations in the pause hierarchy.

(Response Rate)

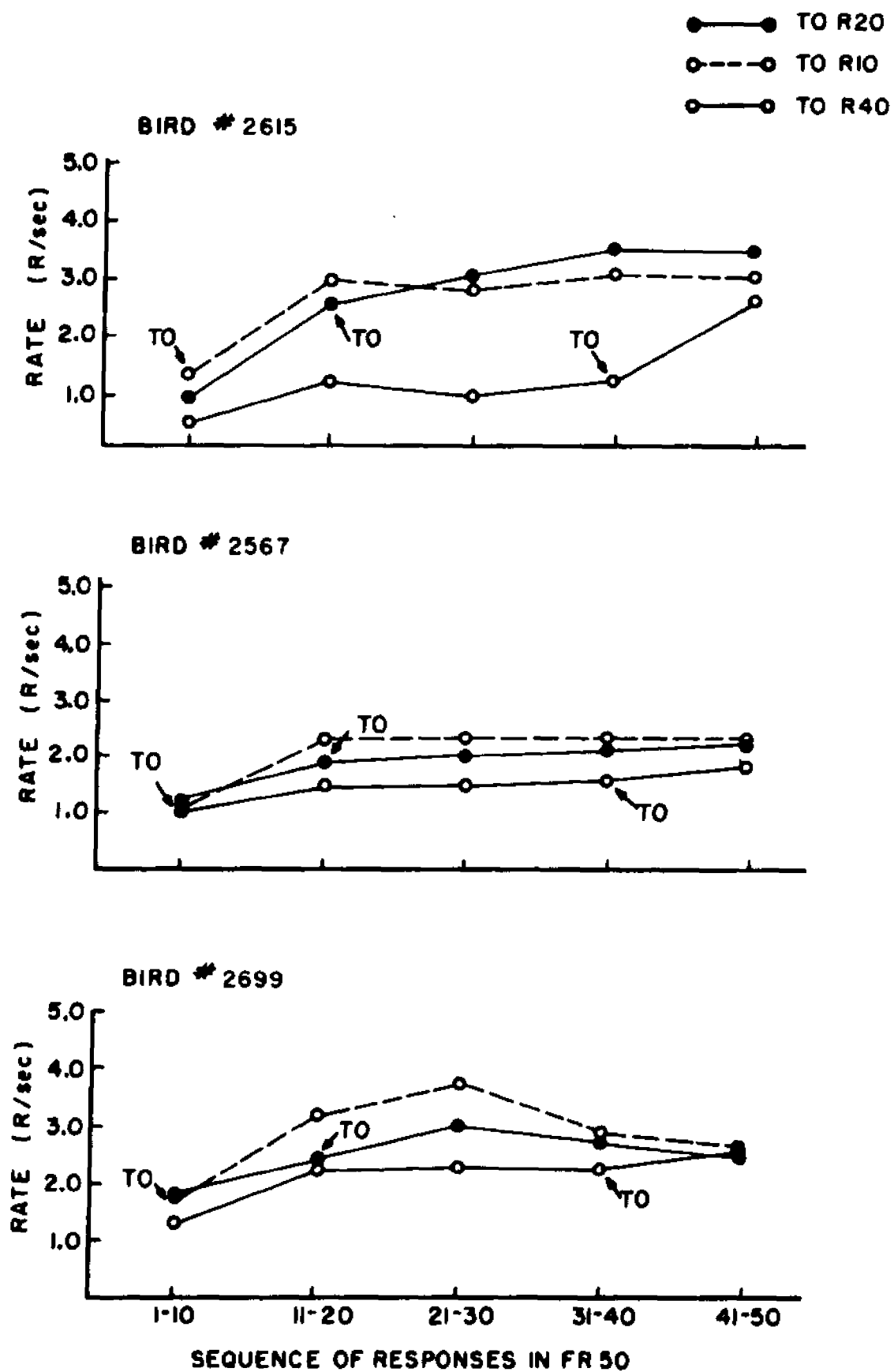
To assess the imposition of the new TO contingencies on local response rates, temporal data were collected for successive 10-response sequences in each component of the three-ply multiple schedule. From this data, local response rates were calculated for each successive sequence of 10 responses in the FR 50.

(Introduction of TO at R 20)

Figure 18 indicates the local response rates for birds # 2615, # 2567, and # 2699, following substitution of the TO at R 20 for the no-TO component.

For bird # 2615, the late TO component generates the lowest response rates for the first 30 responses of the FR 50. After R 30, a moderate acceleration is observed up to imposition of the TO at R 40. Post-TO responding is

Fig. 18. Experiment I: Phase B. Sequential analysis of 1 local response rates for birds #2615, #2567, and #2699, when a TO at R 20 was substituted for the no-TO contingency.



markedly facilitated, although never attaining the rates generated by the other two components. Initial responding generated by the new TO contingency is also "somewhat" lower than that generated by the early TO component of the multiple schedule. Post-TO responding is facilitated, terminating with reinforcement at a rate exceeding that of the early TO component. The early TO component shows the highest initial response rate exhibiting a post-TO facilitation and terminating with a response rate intermediate to the late and new TO contingencies.

Little initial differences in response rate is observed for the three contingencies for bird # 2567, although a hierarchy emerges shortly thereafter. Post-TO responding generated by the early TO contingency is facilitated and assumes its terminal rate by response 20. A homogeneous chain indicative of typical FR behavior persists until reinforcement. The early TO component generates the highest over-all response rate. The new TO contingency generates an acceleration prior to imposition of the TO at R 20, and a subsequent post-TO facilitation. The terminal rate generated approaches that of the early TO component. Response rate remains relatively lower for the late TO contingency with a small acceleration prior to onset of the TO at R 40. Post-TO responding is again facilitated, terminating with a rate below the two other schedule components.

For bird # 2699, the lowest response rate is again generated by the late TO component, with little difference existing between the early and new TO contingencies. Post-TO responding is markedly facilitated for the early TO component up to response 30, followed by a subsequent decrease in rate terminating with reinforcement. A similar response pattern had been generated by this subject in Phase A, prior to imposition of the new TO contingency. An acceleration in rate is observed prior to the onset of TO for the new TO contingency, with a post-TO facilitation following. At response 30, a decrease in rate is again evident, maintaining this lower rate up to reinforcement. The late TO component shows an increase in response rate after the initial sequence of ratio responses. A relatively homogeneous response chain is maintained up to imposition of the TO at R 40. A post-TO facilitation is observed, with the terminal rate exceeding that generated by the other two schedule components.

For all three birds,* lowest over-all response rate was generated by the late TO contingency. As indicated by Table 12, this contingency also generated the longest PreRP. Initial response rates generated by the early and new TO components were not markedly different for birds # 2567 and # 2699.

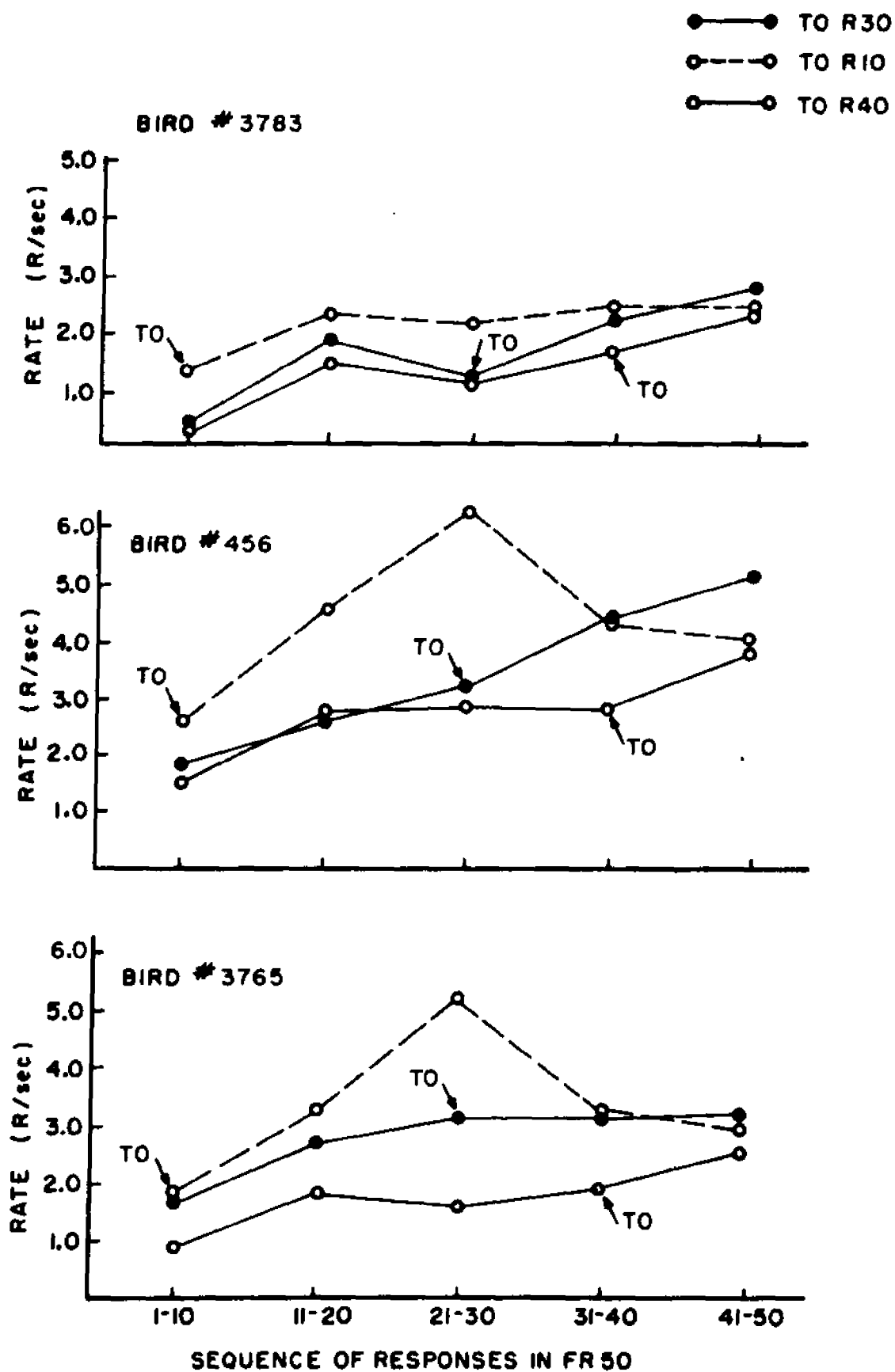
*Cumulative records for final session to be found in Appendix.

(Introduction of TO at R 30)

Figure 19 shows the local responses rates generated by substitution of the TO at R 30 component for the no-TO component for birds # 456, #3783, and # 3765.

As indicated (Fig. 19), both an initial and terminal response rate hierarchy is apparent for the three contingencies and consistent across birds. All three subjects maintained lowest initial response rate when responding on the late TO component, highest initial response rate when responding on the early TO component, and an intermediate order response rate when responding on the new TO contingency. The terminal response rate hierarchy witnesses highest terminal rate generated by the new TO contingency, lowest by the late TO contingency, while the early TO component assumes an intermediate order response rate. All subjects, under all conditions manifest a facilitation in response rate after cessation of the TO. This rate facilitation is, however, trivial for bird # 3765 during the TO at R 30 component. Within cycle differences in response patterns are, however, also evident in Fig. 19. During the early TO component, both birds # 456 and # 3765 exhibit an acceleration in response rate up to response 30, where a subsequent marked reduction in rate is observed. Further, bird # 3783 shows a progressive decline in response rate up to imposition of the TO during the new TO contingency.

Fig. 19. Experiment I: Phase B. Sequential analysis of local response rates for birds #456, #3783, and #3765, when a TO at R 30 was substituted for the no-TO contingency.



The rate hierarchy which emerges from the initial sequence of responses in the ratio corresponds to the pause hierarchy maintained by birds # 456 and # 3765. For these birds, the longest PreRP generated by the late TO contingency is followed by the lowest rate, while the shortest pause generated by the early TO contingency is followed by the highest rate. The new TO component which assumes an intermediate position in the pause hierarchy for these two birds, also generates intermediate order response rates.* Bird # 3783 which exhibits longest pausing for the new TO contingency does not support the correspondence of these two hierarchies.*

(Time of Involvement)

With imposition of the new contingencies, the PreRP/TOI relationship was reassessed.

(TO at R 20)

As Tables 6, 9, and 10, indicate, for birds # 2699, # 2567, and # 2615, respectively, the longest PreRP and TOI are generated by the late TO component. The PreRP/TOI relationship is not as clear, however, for the remaining two contingencies. Although the early TO component generates the shortest TOI, it generates a PreRP which exceeds that of the new TO at R 20 contingency. The regression lines in

*Cumulative records for final session to be found in Appendix.

Fig. 20. Experiment I: Phase B. Scatter diagram of the pre-response pause/time of involvement (preRP/TOI) relationship for bird #2699, when a TO at R 20 component was substituted for the no-TO component of the multiple schedule.

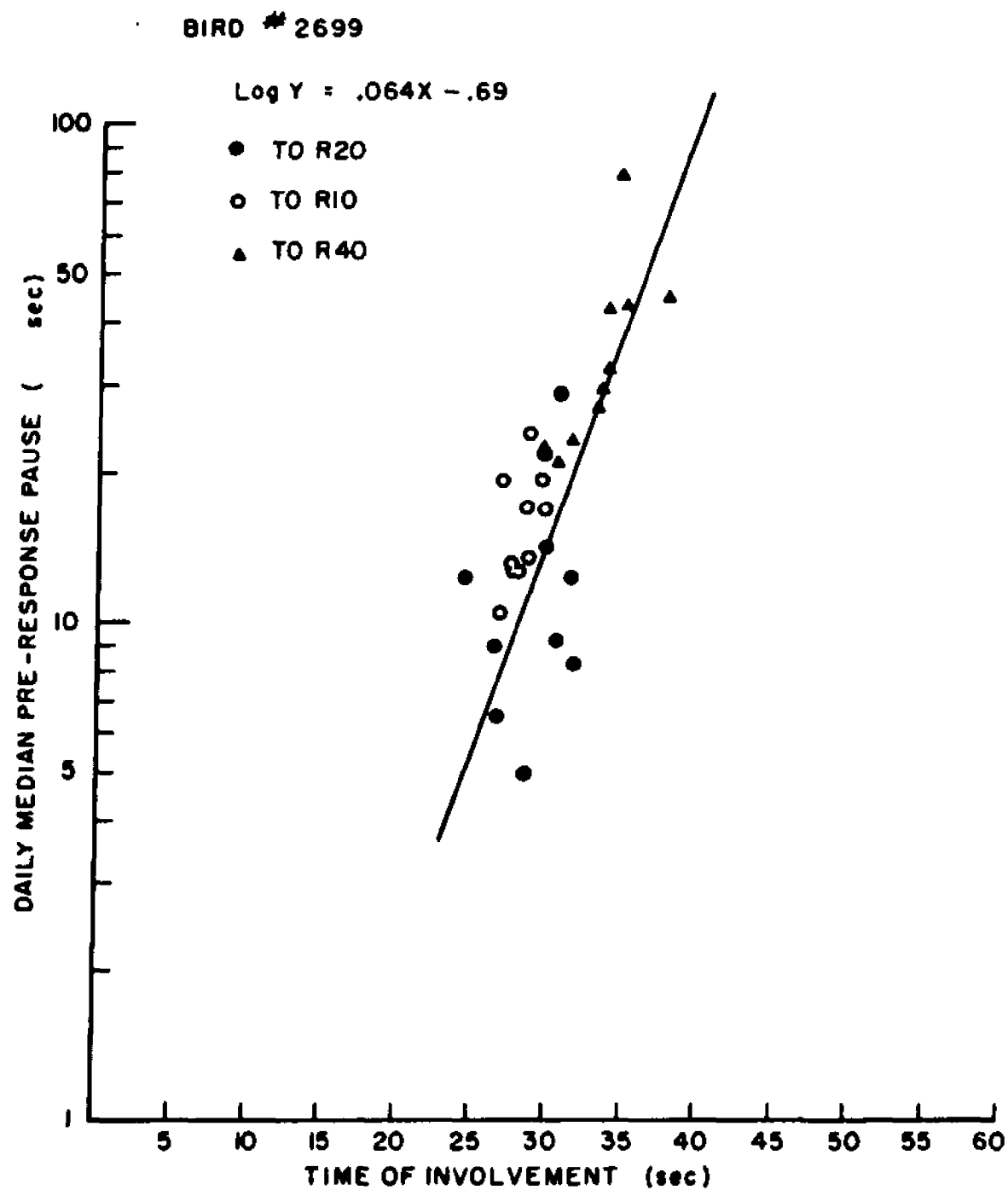


Fig. 21. Experiment I: Phase B. Scatter diagram of the pre-response pause/time of involvement (PreRP/TOI) relationship for bird #2567, when a TO at R 20 component was substituted for the no-TO component of the multiple schedule.

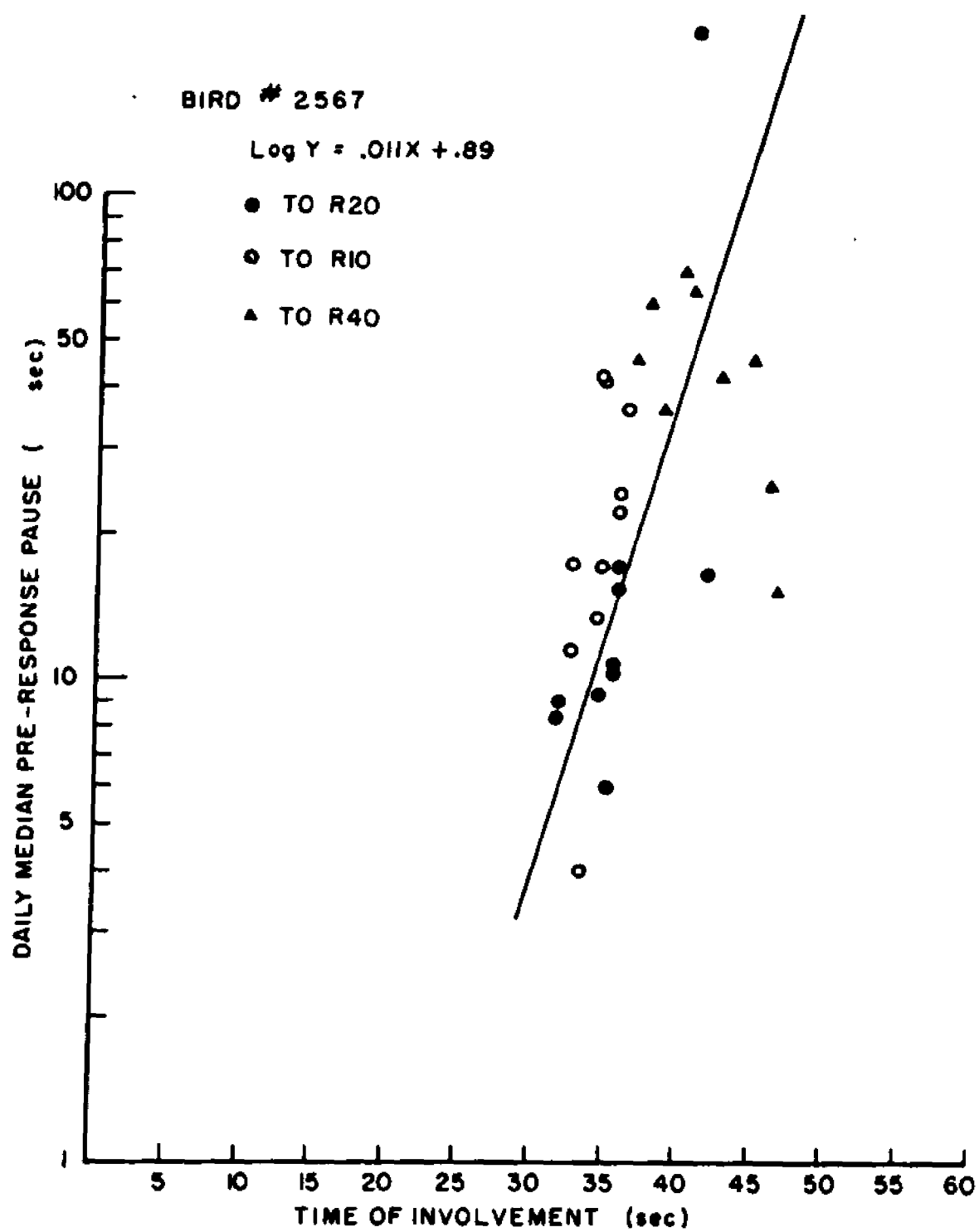
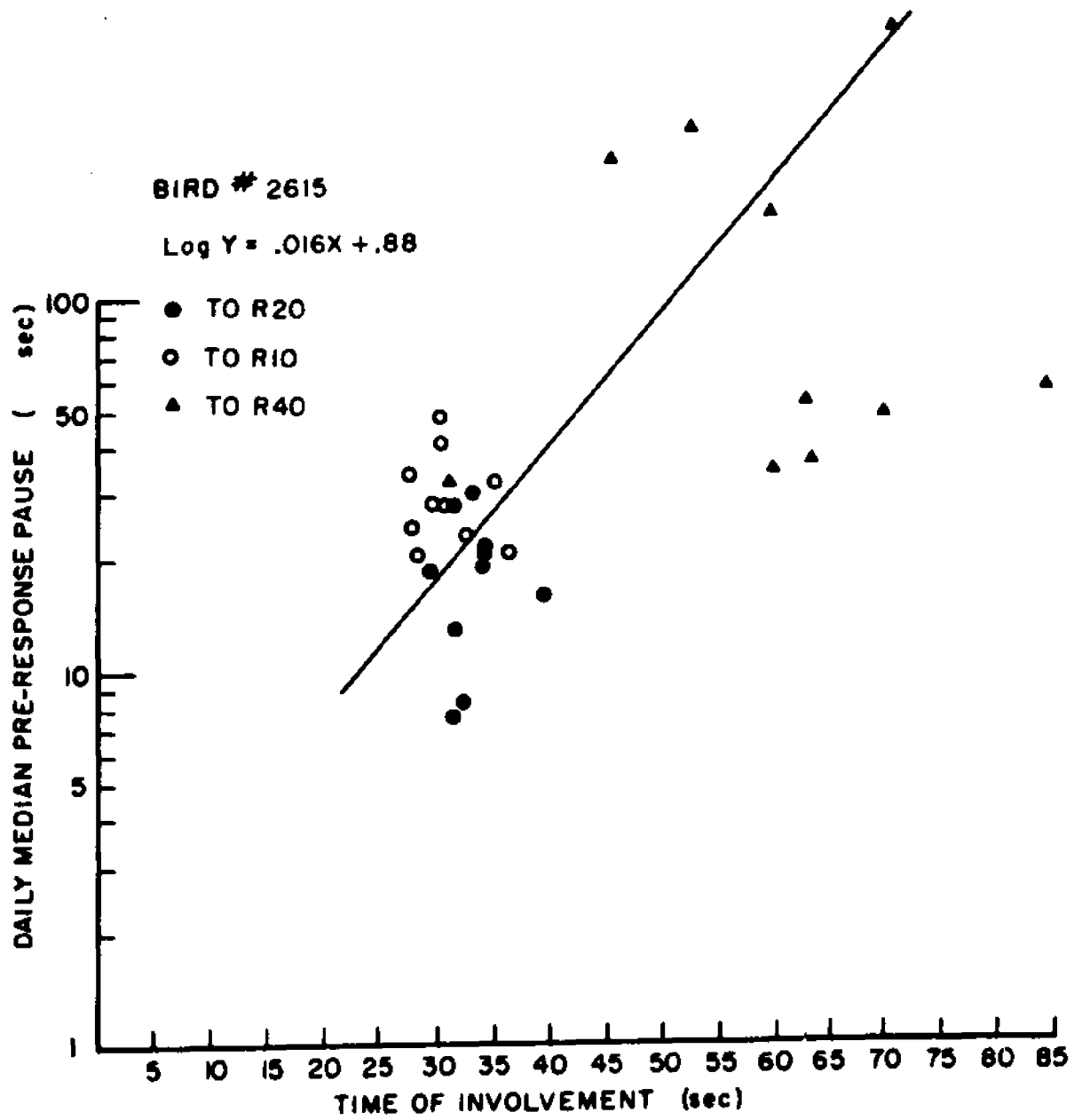


Fig. 22. Experiment I: Phase B. Scatter diagram of the pre-response pause/time of involvement (PreRP/TOI) relationship for bird #2615, when a TO at R 20 component was substituted for the no-TO component of the multiple schedule.



Figs. 20, 21, and 22, which have been fit by the equation $\text{Log } Y = b(y.x.) (X - \bar{X}) + \bar{Y}$ suggest, however, that as the TOI increases, the corresponding PreRP also increases.

Further, while the scatter points for the late TO contingency for all subjects appear relatively discrete in their clustering, those for the TO at R 10 and TO at R 20 components exhibit a high degree of overlap. This considerable overlap may suggest a lack of discrimination in responding to the two components. The "similarity" in loci of the two TOs, as well as the possibility that the respective rates may have become conditioned may be factors.

(TO at R 30)

As Tables 7 and 8 indicate, for birds # 3765 and # 456, respectively, both PreRP and TOI increase as the TO is imposed at locations further into the FR. Shortest pausing and TOI are generated by the early TO component, longest by the late TO component, and an intermediate duration PreRP and TOI by the new TO component. This relationship is supported by the regression lines in Figs. 23 and 24 for the two birds. As indicated, the PreRP increases with an increase in TOI. Further, the scatter points generated by the three contingencies appear to constitute relatively discrete populations of events and may suggest discriminative responding.

Fig. 23. Experiment I: Phase B. Scatter diagram of the pre-response pause/time of involvement (PreRP/TOI) relationship for bird #3765, when a TO at R 30 component was substituted for the no-TO component of the multiple schedule.

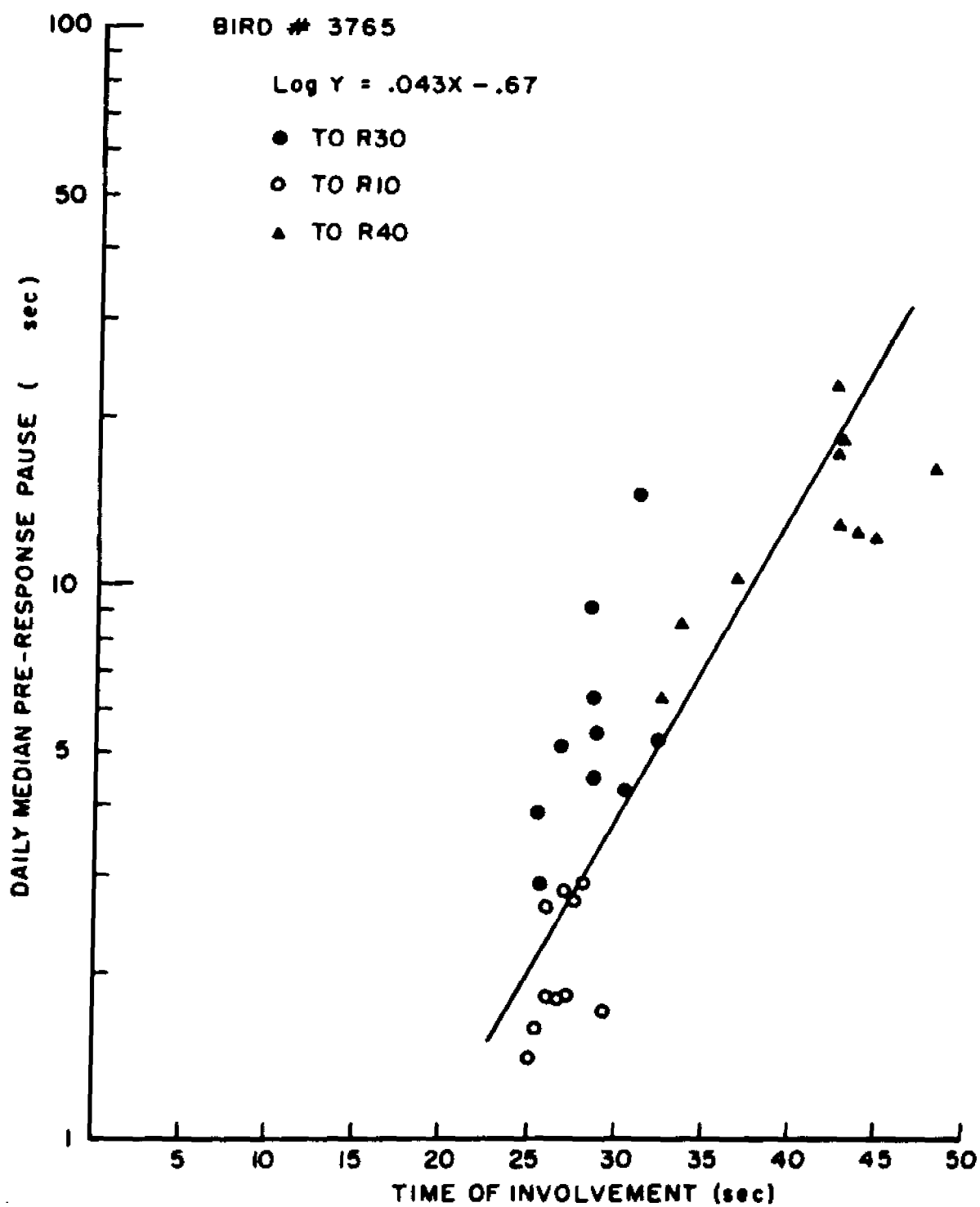
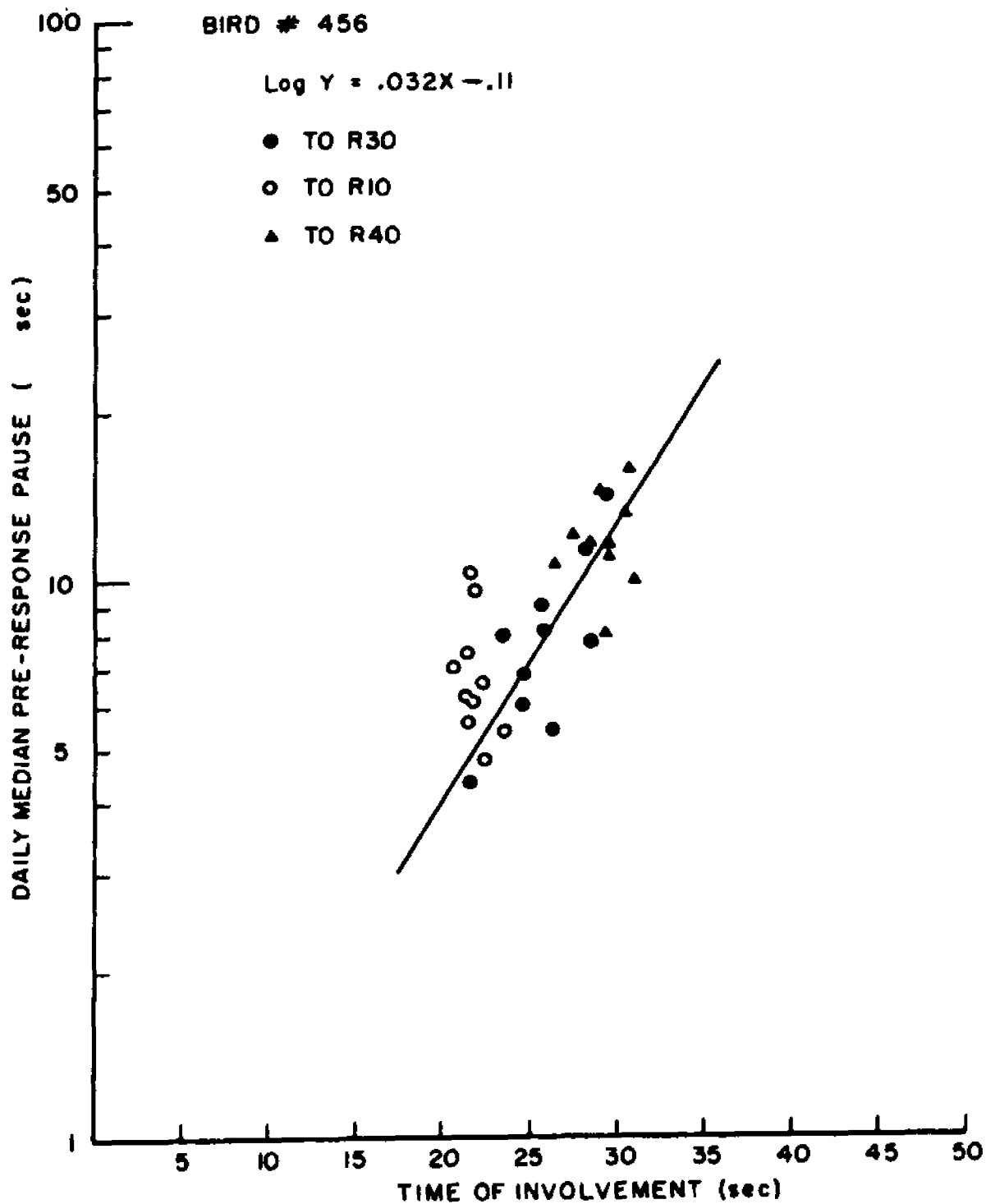


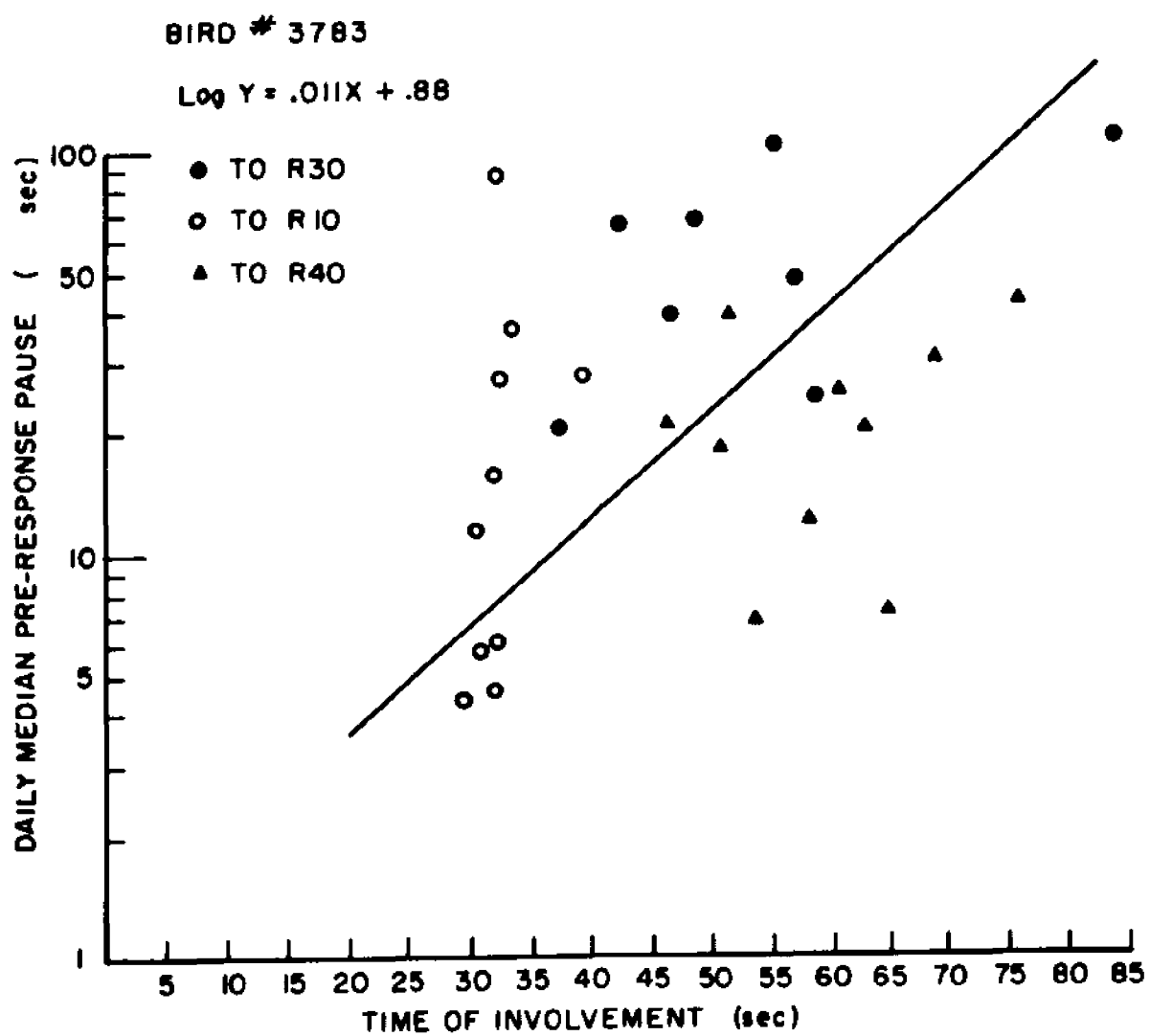
Fig. 24. Experiment I: Phase B. Scatter diagram of the pre-response pause/time of involvement (PreRP/TOI) relationship for bird #456, when a TO at R 30 component was substituted for the no-TO component of the multiple schedule.



Bird # 3783, as indicated by Table 11, does not contribute to support of the hypothesis that TOI and PreRP increase as a function of imposing a TO further into an FR. For this subject, the shortest PreRP and TOI are generated by the early TO contingency, while the relationship is not as clear for the remaining components. While the TO at R 30 component generates the longest PreRP, it generates an intermediate order TOI. Although the scatter pattern in Fig. 25 is relatively diffuse, the regression line suggests that as TOI increases, the PreRP will increase accordingly.

Imposition of the TO at R 20 contingency resulted in an inverse PreRP/TOI relationship for components TO at R 10 and TO at R 20. At the same time, the TO at R 40 generated both the longest TOI and PreRP. With imposition of the TO at R 30 component, only one bird exhibited disruption of the PreRP/TOI relationship. Bird # 3783 which exhibited longest pausing to the TO at R 30 component, maintained longest TOI during the TO at R 40 contingency. The TO at R 10 generated both the shortest pause and the shortest TOI. At this time, it is suggested that the adjacency of TO loci may have contributed to the reversal, contrary to the prediction of the respective lines for each bird.

Fig. 25. Experiment I: Phase B. Scatter diagram of the pre-response pause/time of involvement (PreRP/TOI) relationship for bird #3783, when a TO at R 30 component was substituted for the no-TO component of the multiple schedule.



Experiment I: Phase C:

(Pausing)

Section C of Figs. 1, 2, 3, 4, 5, and 6, show the change in daily median PreRP which occurred with changes in deprivation levels. Birds # 2615, # 456, and # 2567, as indicated by Figs. 2, 4, and 6, respectively, were reduced to 72% of their ad lib weight. Birds # 3765, # 2699, and # 3783, as indicated by Figs. 1, 3, and 5, respectively, were raised to 88% of their ad lib weight.

(Reduction to 72%)

With reduction to 72% of its ad lib weight, bird # 2615 showed an immediate decrease in pause durations for all contingencies, as indicated by Fig. 2. The second session at this weight witnessed a further decrease in pause duration for the TO at R 20 and TO at R 40 contingencies, while the TO at R 10 component showed a partial recovery in pause duration. During session three, all contingencies generated longer duration pausing, although still below the level generated at 80% for the TO at R 20 and TO at R 40 contingencies. The pre-response hierarchy established in Phase B persisted with the change in deprivation level, although the absolute pause durations decreased.

Bird # 456, as indicated by Fig. 2 showed an initial increase in pause duration for the TO at R 30 and TO at R 40 components, while the pause generated by the TO at R 10

component remained virtually unchanged. During sessions 2 and 3, pause directions showed further decreases for all contingencies. The pause hierarchy which underwent a series of reversals in Phase B remained fairly stable during the three sessions at 72% ad lib weight.

Bird # 2567, as indicated by Fig. 6 maintained the pause hierarchy which emerged during Phase B. During the first session at 72% ad lib weight, the pause generated by the TO at R 10 component increased as pauses generated by the TO at R 20 and TO at R 40 contingencies decreased. Sessions 2 and 3 witnessed succeedingly shorter pauses under all contingencies.

(Increase to 88%)

With an increase to 88% of ad lib weight, bird # 3765 as indicated by Fig. 1, showed an immediate increase in pause duration for all contingencies. Session 2 witnessed a change in the pause hierarchy as a result of disproportional changes in pause duration for the TO at R 30 contingency. Although all pausing decreased, the TO at R 30 assumed the lowest level in the pause hierarchy, replacing the TO at R 10 component of the multiple schedule. This hierarchy persisted through session 3, although pausing generated by the TO at R 30 and TO at R 40 components increased, while that of the TO at R 10 component decreased.

Bird # 2699 exhibited marked increases in pause duration for all contingencies at the 88% deprivation level, as indicated by Fig. 3. A "reshuffling" of the pause hierarchy occurred during sessions 1 and 2, with a hierarchy similar to that of Phase B emerging by session 3. Pausing generated by the TO at R 10 and R 20 contingencies returned to their baseline levels (80% levels) while the TO at R 40 maintained extremely long pauses.

Bird # 3783 failed to respond at the 88% level. The bird was placed in the experimental chamber at the start of each session and remained there for two hours on each of three days. An occasional response was emitted, although no ratios were ever completed. Responding had been stable at the 80% deprivation level of Phases A and B.

With reduction to 72% of the ad lib weight, birds # 456 and # 2615 exhibited decreases in pause durations generated by all three contingencies. Bird # 2567 showed a decrease in pause duration for the TO at R 20 and R 40 contingencies, while the TO at R 10 component generated a slightly longer PreRP.

With an increase to 88% of the ad lib weight, birds # 2699 and # 3765 exhibited a general decrease in pause duration. Only during the TO at R 30 contingency did bird # 3765 exhibit a shorter pause than in Phase B. Bird # 3783 failed to complete a single ratio at the 88% level. It might be suggested that # 3783's PreRP under all

contingencies was of such great magnitude as to preclude any other recordable behavior.

(Response Rates: 72%)

With a reduction to 72% of ad lib weight, no consistent effect upon response rate was observed for all birds. Birds # 2615 and # 456 retained the initial and terminal response rate hierarchies which emerged from Phase B. Bird # 2567 maintained the terminal response rate hierarchy while an increase in local response rates by the TO at R 10 component resulted in its assuming the highest initial rate of the three components. Over-all rate changes were inconsistent across the three birds responding at 75%. Bird # 2615 showed an increase in response rate for all three components, while bird # 456 showed an increase in response rate for the late TO component only. Further, bird # 456 showed a marked decrease in response rate for both the TO at R 10 and TO at R 30 contingencies. Bird # 2567 showed a decline in response rate for the TO at R 20 and TO at R 40 components, and a small order increase in the TO at R 10 component.

(Response Rate: 88%)

With an increase to 88% of the ad lib weight, all subjects showed a marked decline in response rates. Bird # 3783, however, failed to complete a ratio. This decline in response rate was consistent for all three schedule contingencies.

Although a decrease to 72% of ad lib weight generated an over-all decrease in pausing, its effect upon response rate was more variable. The increased motivational state resulted in a facilitated response rate across all contingencies for only one bird (# 2615), while its effect was inconsistent for the other two birds responding at this drive level.

Increases to 88% of the ad lib weight generated longer pauses for birds # 2699 and # 3765, as well as depressed response rates. At 88%, bird # 3783 exhibited extremely strained behavior. When responding was finally initiated after strained PreRPs, rate was so depressed that the subject never completed the FR during any of the three, two-hour experimental sessions.

These findings suggest that the decrease in motivational state to 88% has a more consistent effect upon the resulting behavior than the increase to 72% had. Further, while the effect of these changes is readily observed with respect to the pause preceeding the ratio run, the change in deprivation has little predictable effect upon response rates in the FR schedule of reinforcement.

Responses on the Darkened Response Key:

After initial training on the multiple FR-TO contingencies, responding on the darkened response key signalling the TO was not a frequent occurrence. On the occasion that such a response did occur, it appeared early into the TO

and might be interpreted as an "over-run" of the initial sequence of ratio responses. Discrete stimulus control by the stimuli signalling the opportunity to receive reinforcement and T0 appeared to have been maintained throughout all phases of Experiment I.

Method

Experiment II

Subjects

The subjects were three male White Carneaux pigeons (# 1578, # 8655, # 3716) obtained from the Palmetto Pigeon Plant, Sumter, South Carolina. The birds were two to three years old and experimentally naive at the start of the experiment. Subjects in Experiment II received care and dietary regimen as those in Experiment I. All birds were maintained at 80% of their free-feeding weight throughout the study. In addition, each bird was food-deprived for approximately 23 hours prior to each experimental session, and at approximately the same time daily. All thirty sessions were run on consecutive days except for a one day interruption between sessions 5 and 6, and sessions 10 and 11.

Apparatus

Instrumentation was essentially the same as in Experiment I. However, an additional calibrated timer (SP 4005J) was employed as the TOs were of two different durations. All TOs occurred immediately following the thirtieth response, and were imposed by a reed decade (SP # 4003J). In addition to the punch tape regulating the

three contingencies which were FR 50; FR 50 with a 2.5-sec. TO at R 30; FR 50 with a 10-sec. TO at R 30, an additional tape punched for only two contingencies was employed. This second tape was punched for channels 5 and 6 only. Channel 5 effected a no-TO component, while channel 6 produced a 2.5-sec. TO component.

Procedure

The birds were magazine trained to peck the left key of a Lehigh Valley Electronics standard two-key operant chamber for pigeons. During shaping, the illumination of the response key switched from red to green to white as in Experiment I. The same procedure and ratio increments employed in Experiment I were used to increase the FR from CRF (FR 1) to FR 50. Bird # 1578 exhibited strain at FR 40 and was immediately reduced to an FR 30 schedule for two sessions. Subsequent ratio increases were not affected by ratio strain.

When responding had stabilized on the FR 50 schedule, all birds were transferred to a second nominally identical Lehigh Valley Electronics chamber. The response panel employed during shaping was substituted for the panel already present in the chamber, in order to prevent the difficulties incurred in Experiment I. The chamber was programmed to present the three contingencies which were exteroceptively cued by illumination of the response key. The components were FR 50; FR 50 with a 2.5-sec. TO at R 30; FR 50 with a

10-sec. TO at R 30. The presentation of these contingencies was accomplished by means of the tape reader in conjunction with a series of standard timers and relays. At session 10, all three birds exhibited severe strain during the stimulus signalling the 10-sec. TO component. During the following session, a tape programmed to present only the no-TO component and the 2.5-sec. TO component was employed. The following session (session 12) when the original three-ply schedule was resumed, strain was less evident.

All birds were run for thirty sessions of which the last ten constituted criterion days. Data was analyzed for the measures stated in Experiment I.

Results

Experiment II

The major concern of Experiment II was the influence of the duration of TO in the ratio sequence. The primary dependent variable of interest as a result of the multiple TO durations was the PreRP.

(Pausing)

The three-ply multiple schedule generated a PreRP hierarchy which was similar for all birds in Experiment II. As indicated by Figs. 1, 2, and 3, for birds # 8655, # 3716, and # 1578 respectively, the median daily PreRP was shortest for the no-TO component, longest for the 10-sec. TO component, and of an intermediate order for the 2.5-sec. TO component. All three birds maintained this hierarchy through the ten criterion days. The pause generated by the no-TO component showed less variation across successive experimental sessions. While greater variability was observed for the 2.5-sec. and 10-sec. TO components, each maintained its respective position in the hierarchy.

To assess sequential interactions which may result from the order of component presentation, the PreRP was analyzed as a function of the preceding and present schedule

Fig. 1. Experiment II. Daily median pre-response pause (PreRP) for bird #8655 as a function of timeout duration in the fixed ratio sequence.

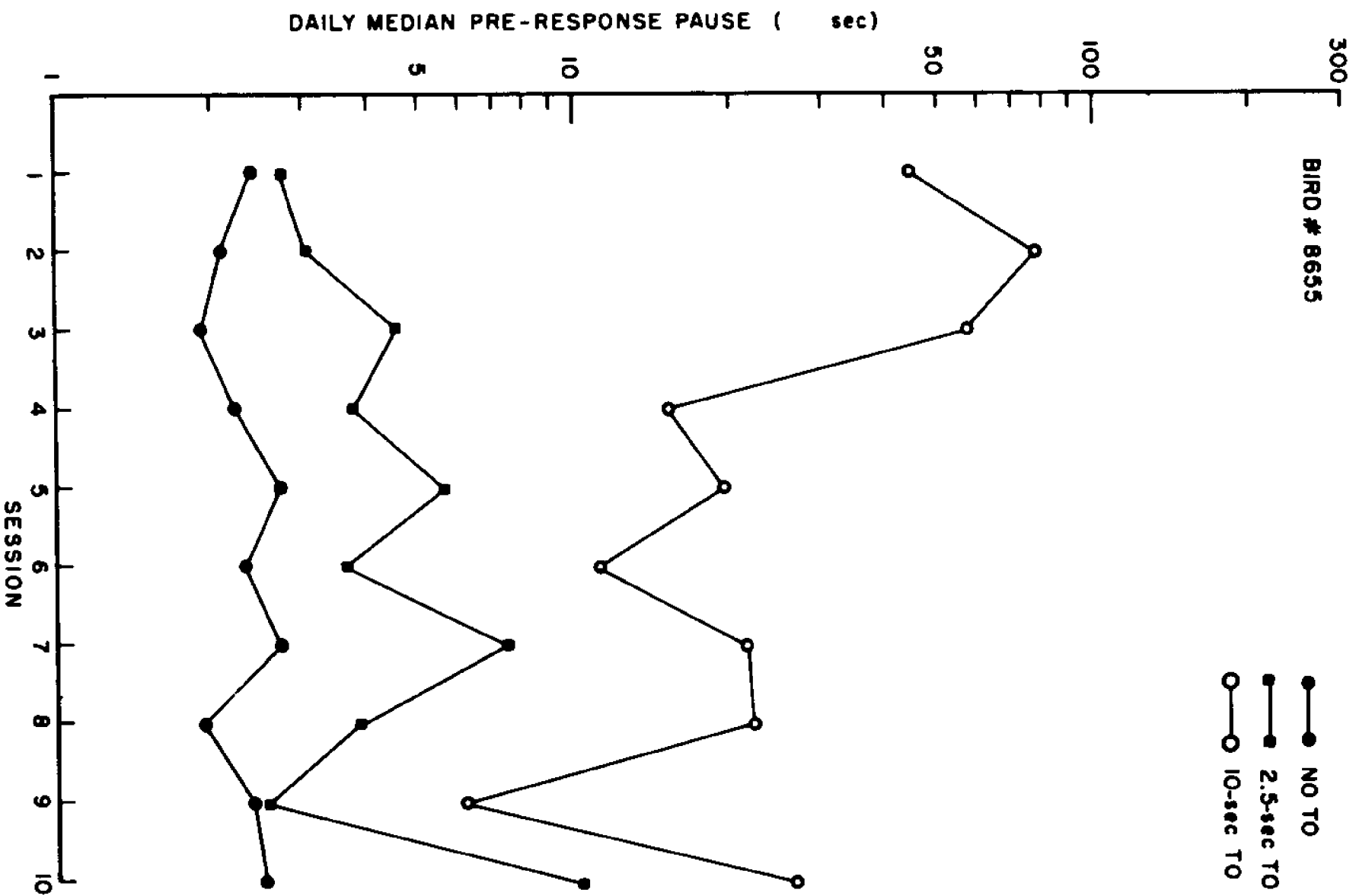


Fig. 2. Experiment II. Daily median pre-response pause (PreRP) for bird #3716 as a function of timeout duration in the fixed ratio sequence.

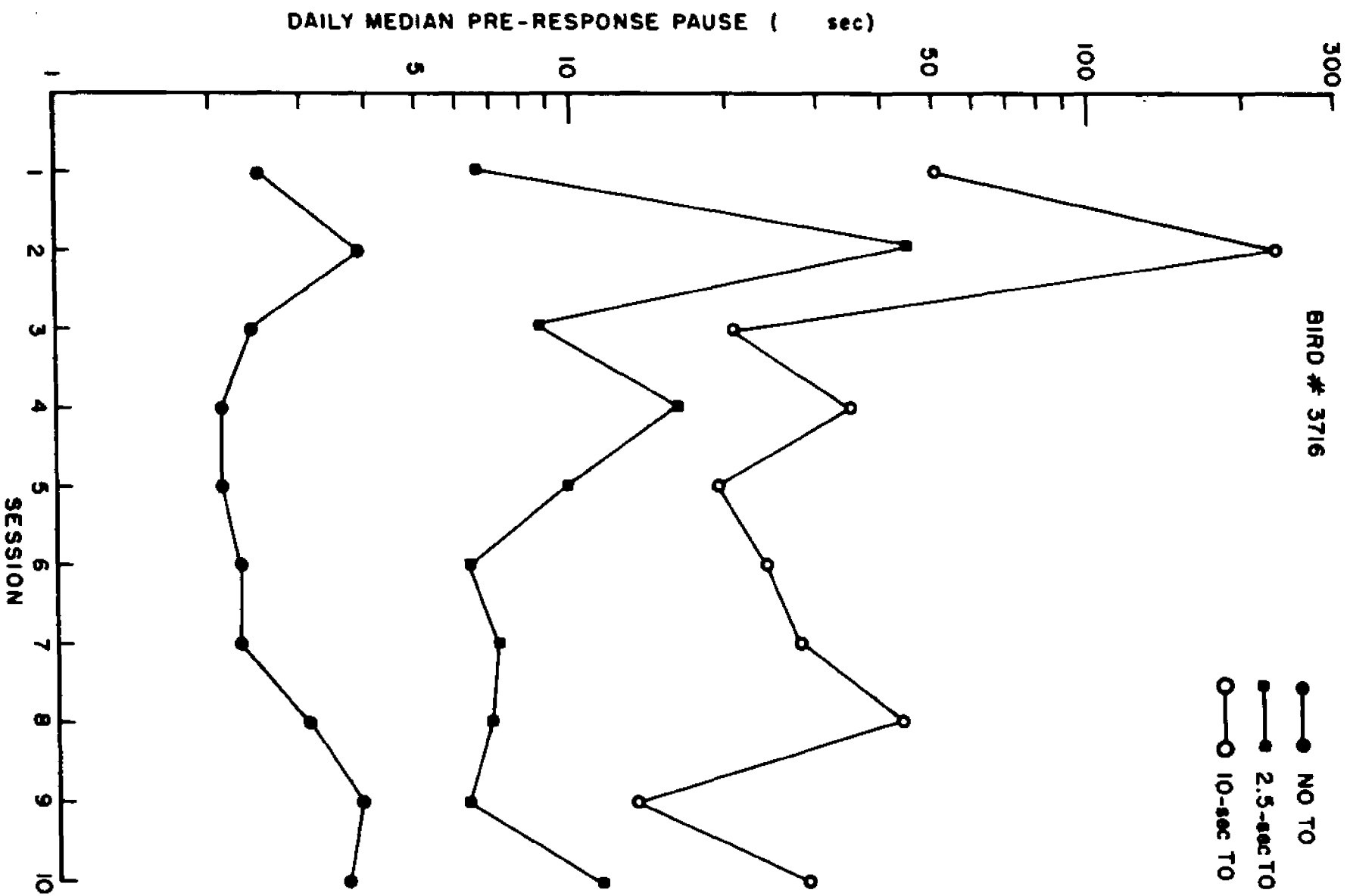
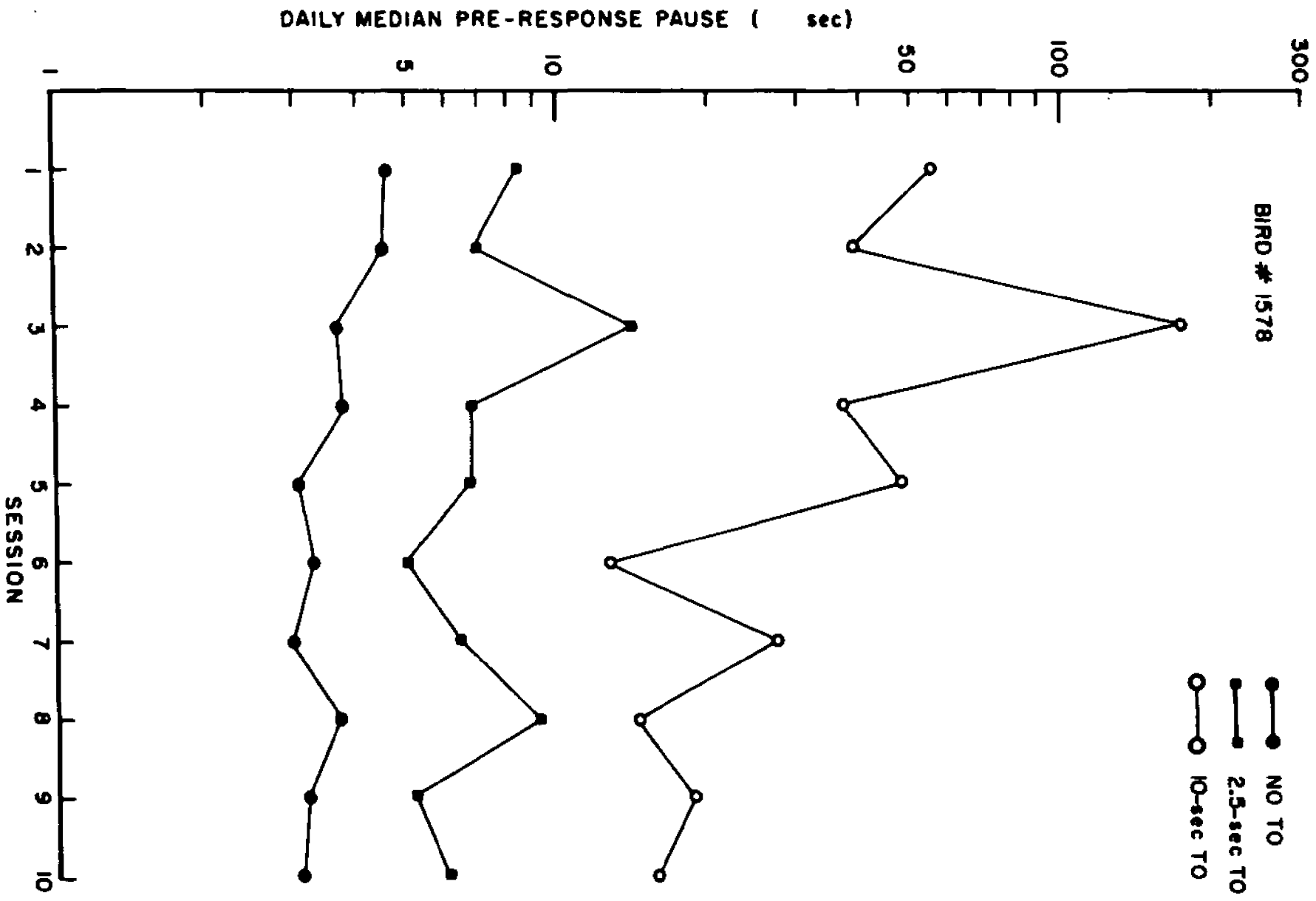


Fig. 3. Experiment II. Daily median pre-response pause (PreRP) for bird #1578 as a function of timeout duration in the fixed ratio sequence.



components.

Table 1 shows the median PreRP as a function of the preceding and present schedule components for all three subjects (birds # 8655, 3716, 1578). As indicated, the PreRP hierarchy is maintained. Further, it is interesting to note that the shortest PreRP within a contingency occurs with repetition of a schedule component. The only exception noted is during the no-TO component for bird # 3716. This subject generates the shortest PreRP for the no-TO component when the no-TO component follows a ratio run on the 10-sec. TO component of the multiple schedule.

(Strain)

Strained pausing is suggested by long daily median PreRPs in Figs. 1, 2, and 3, and by the matrix analysis of pausing in Table 1. Strain, as a measure, is not independent from pausing. Rather, strained events are pauses which comprise the positive tail of a skewed distribution of PreRPs.

As indicated by Table 2, a matrix analysis of strain presents a pattern very similar to that presented by the similar analysis of response-pause. For birds # 8655 and # 1578, strained pausing is restricted to the 10-sec. TO component of the multiple schedule. For bird # 3716, however, while strain is more pronounced for the 10-sec. TO contingency, it is also generated by the 2.5-sec. TO component. Bird # 3716 also generated longer PreRPs for the 2.5-sec. component than the other two subjects.

TABLE 1
Median Pre-response Pause (in sec) as a Function
of Present and Preceding Contingency
Experiment II

PRECEDING CONTINGENCY		PRESENT CONTINGENCY		
		FR 50	FR 50 2.5-sec TO	FR 50 10-sec TO
S 8655	FR 50	1.9	4.4	19.8
	FR 50 2.5-sec TO	2.6	2.8	20.6
	FR 50 10-sec TO	2.4	4.9	9.2
S 1578	FR 50	3.2	7.0	50.6
	FR 50 2.5-sec TO	3.6	5.3	31.1
	FR 50 10-sec TO	3.4	7.0	18.0
S 3716	FR 50	2.6	15.8	33.2
	FR 50 2.5-sec TO	3.5	3.7	35.1
	FR 50 10-sec TO	2.2	11.4	13.2

Note.— The term "pre-response pause" is used to describe the ratio pause which precedes the ratio run in the fixed ratio schedule.

TABLE 2
Probability of Strain as a Function of
Present and Preceding Contingency
Experiment II

PRECEDING CONTINGENCY		PRESENT CONTINGENCY		
		FR 50	FR 50 2.5-sec TO	FR 50 10-sec TO
S 1578	FR 50	0.00	0.00	0.33
	FR 50 2.5-sec TO	0.00	0.00	0.20
	FR 50 10-sec TO	0.00	0.00	0.07
S 3716	FR 50	0.00	0.01	0.15
	FR 50 2.5-sec TO	0.00	0.01	0.24
	FR 50 10-sec TO	0.00	0.03	0.12
S 8655	FR 50	0.00	0.00	0.13
	FR 50 2.5-sec TO	0.00	0.00	0.15
	FR 50 10-sec TO	0.00	0.00	0.15

Note.— Strain is defined as any pre-response pause greater than 90 seconds. The probability of strain is obtained by dividing the number of strained pauses of a contingency by the number of times that contingency was in effect.

The probability of strain assumes a hierarchy resembling that which emerges from the pause duration data. The no-TO contingency which generates the shortest pauses, concomitantly generates no strain, while the 10-sec. TO component generates both, longest pauses and highest probability of strain.

(Rate)

To assess the effects of TO duration on local response rates, temporal data were collected for each successive sequence of 10 responses for all components of the multiple schedule. Local response rates for each successive sequence of 10 responses in the FR 50 were calculated from this data.

Figure 4 shows the sequential response rates for all three subjects as a function of TO duration. All three birds indicate the formation of a similar rate hierarchy for the initial sequence of responses in the ratio. The lowest initial response rate is generated by the 10-sec. TO component, while the 2.5-sec. TO component generates an intermediate order initial response rate. Within cycle responding does, however, indicate differences across subjects. While bird # 3716 indicates a lower response rate prior to imposition of the TO at response 30, and a marked rate facilitation in post-TO responding, birds # 8655 and # 1578 show less marked facilitation in post-TO responding for the 10-sec. TO components, and almost no rate increase in post-TO responding

Fig. 4. Experiment II. Sequential analysis of local response rates for birds #8655, #3716, and #1578, as a function of TO duration.

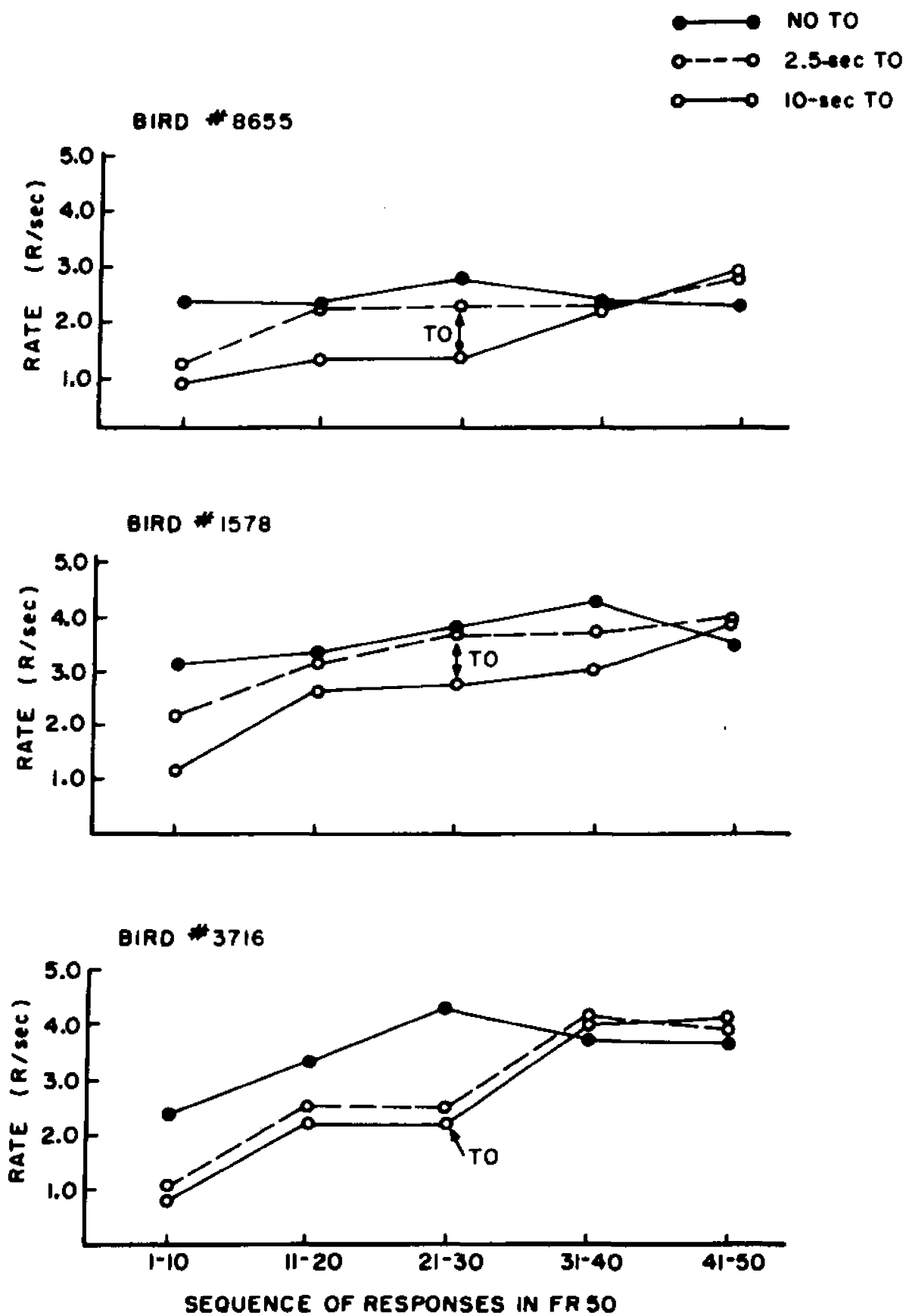
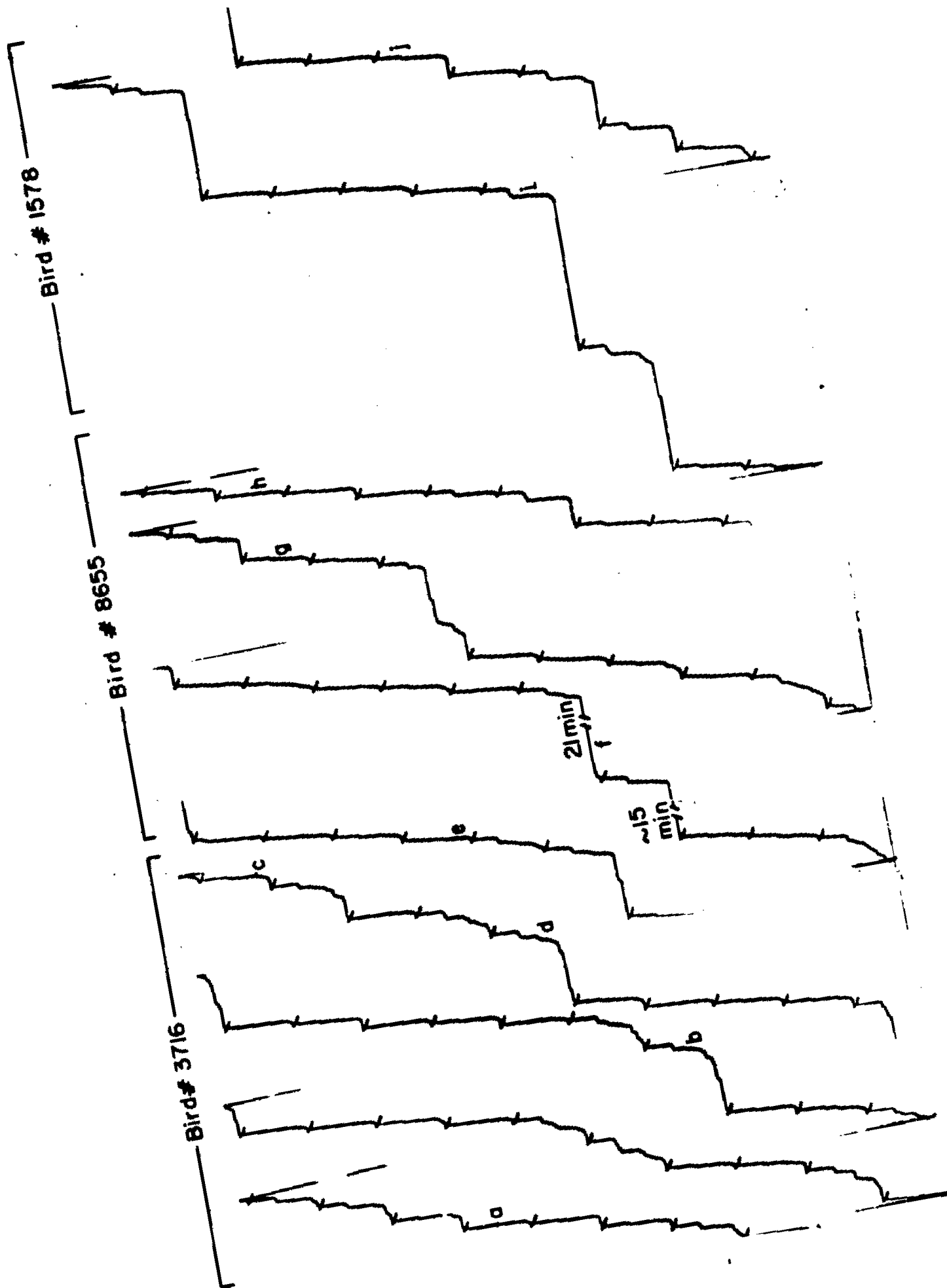


Fig. 5. Experiment II. Segments of the final sessions' cumulative record generated by the three schedule contingencies: FR 50; FR 50, 2.5-sec TO at R 30; FR 50, 10-sec TO at R 30.



on the 2.5-sec. TO component. All birds exhibit the lowest terminal response rate for the no-TO component, while the difference between the terminal rates for the two TO components appears trivial. The only recognizable difference in terminal response rates for the two TO components is for bird # 3716, where the rate for the 10-sec. TO exceeds that of the 2.5-sec. TO.

Figure 5 shows segments of the final session's cumulative record for all three birds. Points a, e, and h, show the relatively short pause and homogeneous response chain generated by the no-TO contingency. This is typical of FR behavior. Points b, d, f, and i, show the response patterns generated by the 10-sec. TO component. Longer pausing, followed by staggered responding are evident. The rather grainy and "step-like" initial sequence of responses accounts for the lower rates often found early in the ratio. Points c, g, and j, indicate the response pattern generated by the 2.5-sec. TO component. Responding is broken up early in the ratio, although not to the extent as found during the 10-sec. TO component. Pause durations again assume an intermediate order length.

(Time of Involvement)

As in Experiment I, a relationship between pause duration and the response rate which follows can be seen; the shorter the pause, the higher the rate; the longer the pause, the lower the rate. Time of Involvement (TOI) refers to the

period of time taken by the bird to complete the fixed ratio requirement and is defined in Experiment I.

Figures 6, 7, and 8, are scatter diagrams for the PreRP/TOI relationship for birds # 8655, # 1578, and # 3716, respectively. The regression lines of the three figures were fit according to the equation:

$$\text{Log } Y = b_{(y.x)} (X - \bar{X}) + \bar{Y} \text{ (Hays, 1963)}$$

and indicate that as TOI in the schedule increases, the pause preceding the ratio can also be expected to increase. All three figures exhibit relatively discrete clusterings of points for each of the three contingencies, but the regression appears appropriate to the within as well as the between cluster variance. As indicated, pausing and TOI are shortest for the no-TO component, longest for the 10-sec. TO component, and of an intermediate order for the 2.5-sec. TO component. The longer TOI generated by the 2.5-sec. TO component may be attributed to the lower response rate early in the ratio, whereas the 10-sec. TO component exhibits a more marked disturbance in initial responding in the ratio and consequently a longer TOI. The increase in TOI is accompanied by an increase in pause duration in the presence of the stimulus signalling that contingency.

Fig. 6. Experiment II. Scatter diagram of the pre-response pause/time of involvement (PreRP/TOI) relationship for bird #8655 generated by the three schedule contingencies: FR 50; FR 50, 2.5-sec TO at R 30; FR 50, 10-sec TO at R 30.

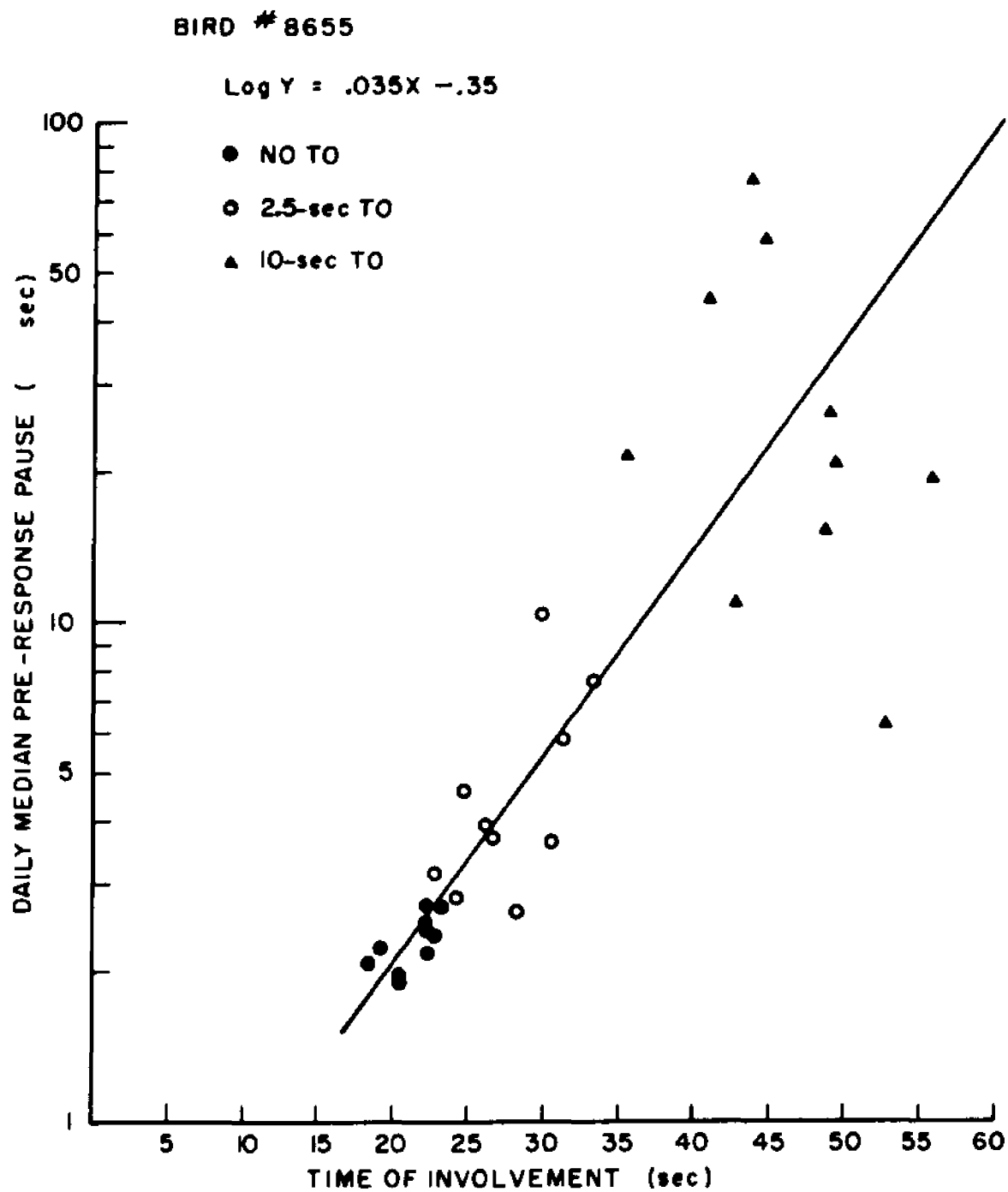


Fig. 7. Experiment II. Scatter diagram of the pre-response pause/time of involvement (PreRP/TOI) relationship for bird #1578 generated by the three schedule contingencies: FR 50; FR 50, 2.5-sec TO at R 30; FR 50, 10-sec TO at R 30.

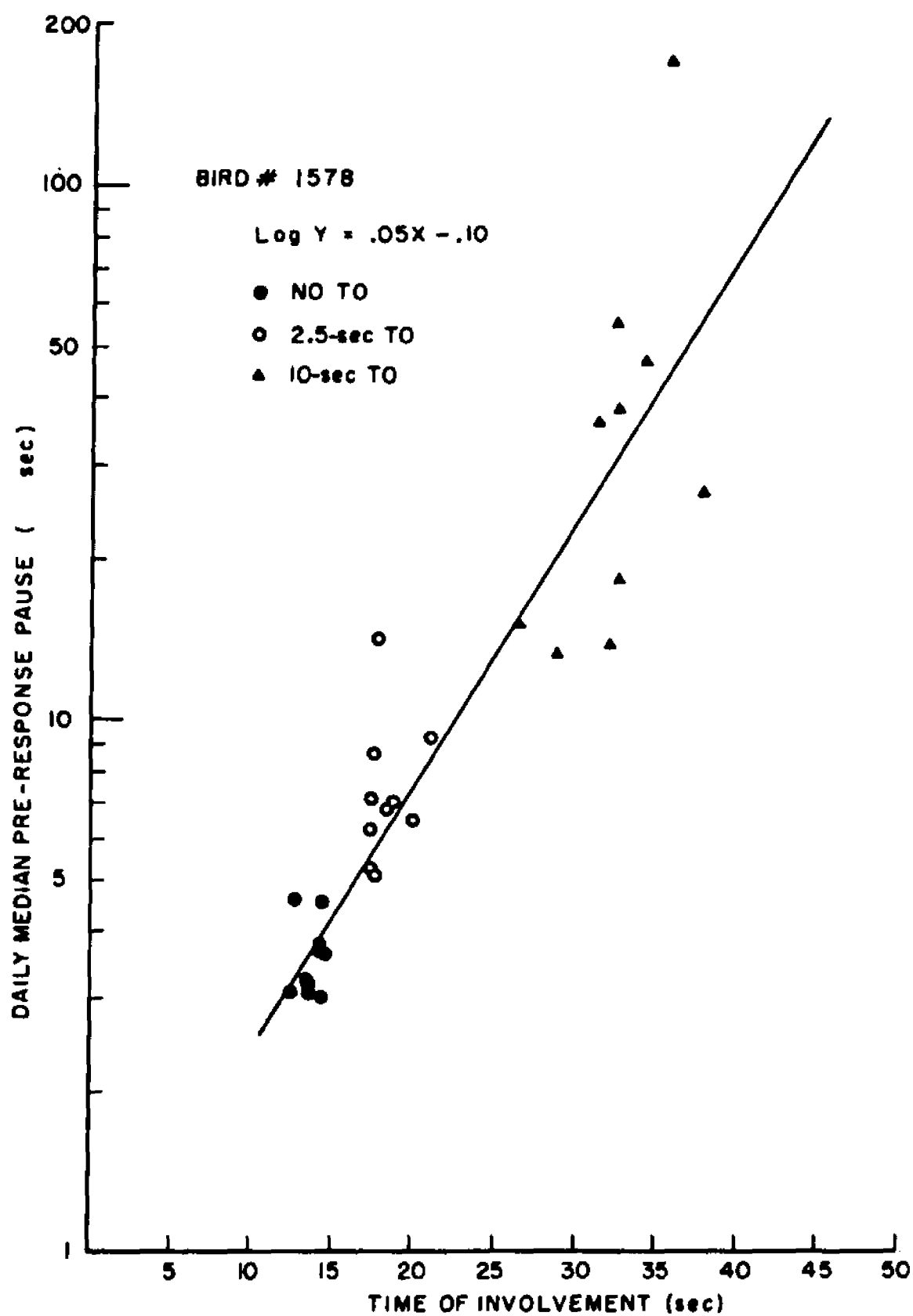
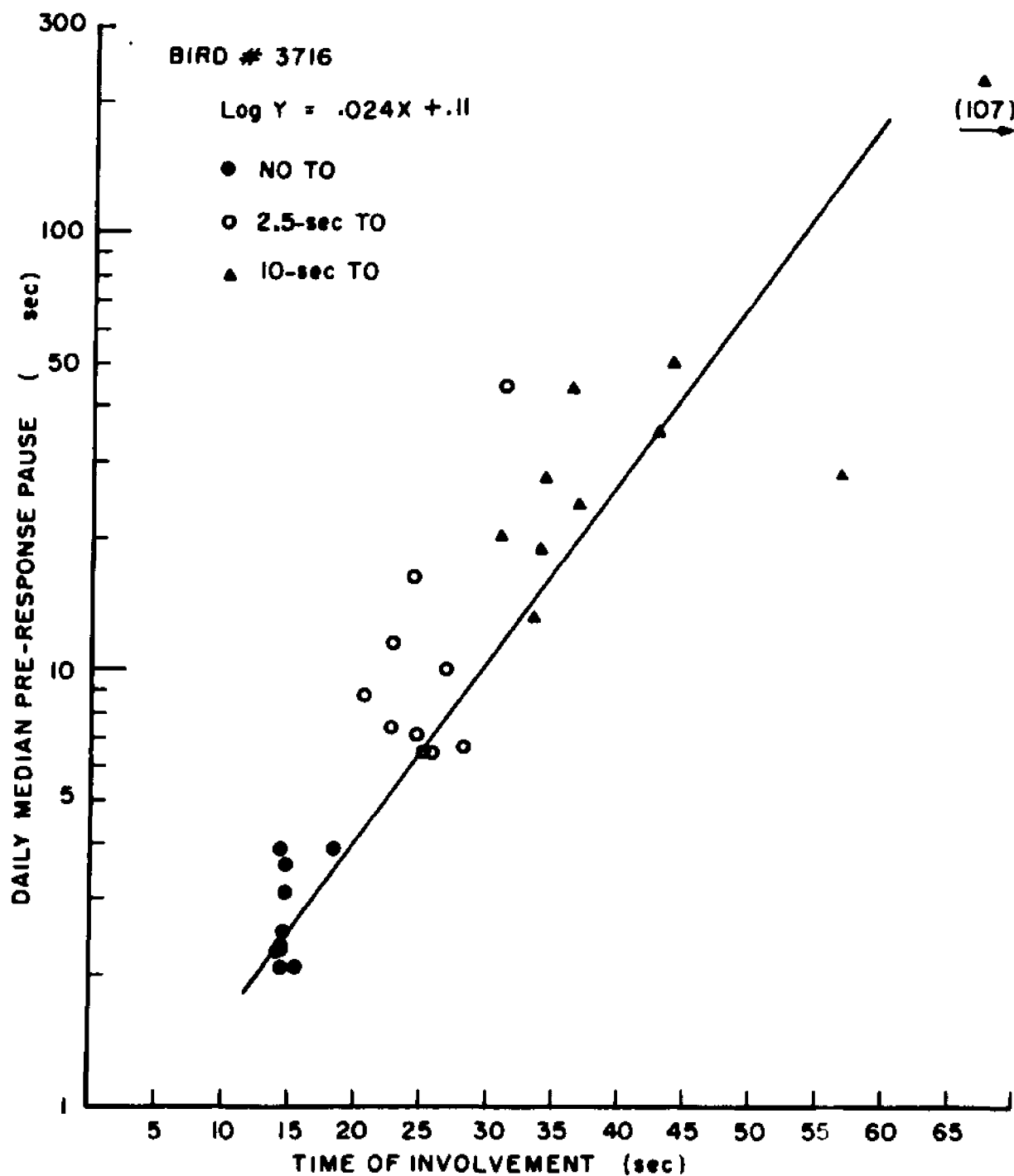


Fig. 8. Experiment II. Scatter diagram of the pre-response pause/time of involvement (PreRP/TOI) relationship for bird #3716 generated by the three schedule contingencies: FR 50; FR 50, 2.5-sec TO at R 30; FR 50, 10-sec TO at R 30.



SUMMARY OF RESULTS

In summary, the main effects of TO appear to be both a function of the location within the FR sequence and the duration.

It has been shown that the further into an FR sequence a TO is imposed, the greater the sequence of FR responding disrupted. With imposition of a TO at response locus R 10, a decrement in response rate is observed for the first ten responses. With imposition of a TO at response locus R 40, a greater decrement affecting the first forty responses was observed. These decreases in response rate, in addition to the temporal properties of the TO (10 sec.), add an additional parameter to completion of a FR sequence of behavior. With the increase in the period of time necessary to complete the FR, a concomitant increase in the ratio pause is observed. The data indicate a positive relationship between the period of time necessary to complete a behavioral chain (TOI) and the pause accompanying typical FR behavior. Post TO responding witnessed a facilitation in rate.

Substitution of a TO at R 20 for three birds in place of the no TO contingency and substitution of a TO at R 30 for the other three birds in place of the no TO contingency resulted in a change in the pause hierarchy.

With replacement of the no TO component with a TO at R 20, a decrement in response rate was now observed for the first 20 responses of the schedule component. This decrement in addition to the duration of the 10 sec. TO increased the TOI for that component. Although the TOI for the TO at R 20 component assumed an intermediate position in the TOI hierarchy between the TO at R 10 component (shortest TOI) and the TO at R 40 component (longest TOI), it generated the shortest ratio pause.

With replacement of the no TO component with a TO at R 30 component, a decrement in response rate was observed for the first 30 responses of the FR sequence. For two birds the TO at R 30 generated both a TOI and pause intermediate to the TO at R 10 and TO at R 40 contingencies. The third bird generated an intermediate duration TOI, although the accompanying pause exceeded the TO at R 40 contingency. A Post TO facilitation in rate was generally observed.

With the change in level of deprivation, the pause appeared to be a more reliable dependent variable with changes in deprivation level, while the pause showed a general increase in duration with an increase in ad lib weight to 88%, and a general decrease in duration with a decrease in ad lib weight to 72%

Further, the duration of the TO appears to have its main effects upon both run rate prior to the TO and the

accompanying ratio pause.

In Experiment II the TOs were imposed at response locus R 30 while the TO durations were of two different values. The no TO component generated the shortest TOI and a concomitantly short ratio pause. With the imposition of a 2.5 sec. TO at R 30 the response sequence prior to the TO showed a moderate decrement in response rate. This reduced rate in addition to the 2.5 sec. TO resulted in a TOI exceeding the no TO component: a longer ratio pause was also observed. With the imposition of a 10 sec. TO component, the response sequence prior to the TO showed a more marked reduction in rate than the 2.5 sec. TO component. The increased TOI resulting from the reduced rate in addition to the 10 sec. TO was accompanied by a ratio pause exceeding the two other components. In both Experiments I and II, the duration of the ratio pause appeared to be a function of TOI, rather than the number of responses emitted.

An analysis of the sequence in which the components were presented also suggests the pause to be a function of both the impending and preceding contingencies. Pausing was shortest in any component schedule when the schedule followed itself, as compared to when it followed either of the other two components.

Discussion

Pausing as a Function of TOI

The inclusion of a period of non-response associated with extinction within the FR sequence resulted in the generation of a pre-response pause hierarchy. The TO locus differentially effected the initiation of the ratio sequence and concomitantly altered the typical FR break-run behavior pattern. These findings suggest corroboration of Ferster and Skinner's (1957) findings that "if a TO is programmed regularly, it will acquire controlling properties from its relation to reinforcing contingencies."

As the pause duration has been observed to be a correlate of ratio "length," the increase in length may come to represent more than the sum of n responses in the FR schedule. Although a number of investigators have reported increasing the ratio requirement by adding successive sequences of responses for reinforcement to be attained (Ferster and Skinner, 1957; Felton and Lyon, 1966; Boren, 1953; Powell, 1968; Laursen, 1972; Sidman and Stebbins, 1954; Schuster, 1959; Premack, 1964; Kaplan, 1956), and have observed the coincident increase in pause duration, similar increases in pause duration have also been observed where ratio response parameters were maintained and the temporal

parameters of the behavioral sequence had been altered. The present study maintained an FR 50 sequence in each component of the multiple schedule. In Experiment I, the TO was imposed for a duration of 10 seconds at one locus in specified components of the multiple schedule, while in Experiment II the locus was maintained at response 30, while the duration of the TO assumed different values. The ratio response requirement was, therefore, maintained while an additional interval with a correlated stimulus had been added to the chain. This link which had been interposed between two appetitive responses within the FR, served to increase the time from initiation of the ratio to reinforcement: this was termed the Time of Involvement (TOI). The TOI included the period of time elapsing from initiation of the ratio (response 1) to subsequent reinforcement upon completion of the ratio. The TOI included the duration of the TO imposed in the behavioral sequence, and any latency from cessation of the TO to resuming of responding in the ratio. The results of this manipulation are not inconsistent with the findings of Kileen (1969), Neuringer and Schneider (1968), and Zeiler (1970, 1972).

Kileen (1969) reported that while birds responding on various FR schedules generated pause durations as a function of FR length, yoked birds generated similar duration pauses while emitting half the responses of the ratio birds, but were responding for the same duration of time until reinforcement. Kileen suggested that pause length varied as a

result of frequency of reinforcement over time, rather than the precise number of responses emitted, as the birds had been equated on the basis of time and not response requirement.

Similarly, Neuringer and Schneider (1968) increased interreinforcement time by imposing blackouts of varying durations after each response on an FR schedule of reinforcement, while maintaining the number of responses at a constant level on the FR schedule of reinforcement. The Es observed an increase in pause duration as a function of interreinforcement time.

Zeiler (1970, 1972) further observed an increase in the ratio pause accompanying a FR schedule when reinforcement was contingent upon responding on the sequence at a low rate. Similarly, a decrease in pause duration accompanied a ratio emitted at a high rate. The interreinforcement time was again correlated with pause duration, as the response criterion was held constant.

In addition, increased pausing has been observed as a function of increases in delay of reinforcement (Skinner, 1938; Morgan, 1972; Azzi, Fix, Keller, and Silva, 1964), while ratio response requirement was maintained.

With imposition of the 10-sec. TOs during all phases of Experiment I, the ratio pause exceeded that generated by the no-TO contingencies. When different duration TOs were imposed in Experiment II, the longer TO generated the longest

ratio pause. As the components of the three-ply multiple schedule maintained identical response requirements, the pause increase may be attributed to the increased TOI for each component.

The imposition of the TO or delays in reinforcement appear to function in a manner analagous to increasing the ratio requirement of the FR schedule. However, increasing the ratio requirement also serves to increase the interreinforcement time or TOI. Ferster and Skinner (1957) suggest that reinforcement is most readily attained when the organism emits the ratio at the highest rate. Emitting a sequence whereby reinforcement is contingent upon the 60th response (FR 60) consumes less time than completing a component with reinforcement contingent upon the 120th response (FR 120). Although the duration of the ratio pause accompanying a first order FR schedule may be a function of the size of FR_n , the size of n also effects the time to complete the ratio. An organism cannot complete the FR sequence "within a shorter period of time than that required to count out the ratio at the highest possible rate" (Ferster and Skinner, 1957, p. 39). This suggests the possibility of the time necessary to complete the ratio as being the determining factor in the duration of a fixed-ratio pause. Pliskoff and Goldiamond (1966) have further suggested that the time during which an organism has been responding on an FR schedule may manifest certain discriminative properties. The E_s observed that discrimination between two ratios was accurate when the response

difference was large, but that S^{delta} responding increased when the ratios differed by fewer responses. It was suggested that the discrimination of the ratios may be a function of the time necessary to complete them. Prior work by Reynolds and Catania (1962) has shown that pigeons are capable of discriminating small differences in stimuli durations.

Further, the displacement of reinforcement from the initial responses in the within-ratio sequence as a result of the imposed temporal delay may have weakened the control exerted by grain reinforcement upon responding in the ratio. As a result of this increased interval between initiating the ratio and subsequent reinforcement, a longer interval after a previous reinforcement may become associated with a zero probability of reinforcement. This low probability of reinforcement may exert an inhibitory effect or merely a lack of adequate control in initiating the ratio. Studies indicating that successive increases in response requirement manifest longer ratio pauses may be considered from a different vantage. Successive increases in response requirement also mandate successive increases in time necessary to complete the ratio, in addition to greater displacement from reinforcement, which consequently results in longer pauses.

Differential Locus and Duration of TO:

The pause hierarchy generated by both loci of TO (Experiment I) and duration of TO (Experiment II) cannot be explained solely in terms of adding "an interval of time" to the FR contingency, simply by attaching an additional 2.5 or 10 sec. dro component. It was observed that the extension of the ratio was more than the duration imposed by the experimental contingencies. The schedule of reinforcement generated a response pattern which further increased the duration of time during which the organism was responding in the reinforced sequence. Imposition of a TO at different loci differentially altered the response pattern of the scheduled component. Imposed early in the FR sequence, the TO disrupted a small sequence prior to imposition and cessation of the TO. In Phase A of Experiment I, where the TO was contingent upon R 10, it had the effect of reducing the response rate for the first ten responses; whereas, imposition of the TO late in the sequence (R 40) maintained rate reduction for the first 40 responses of the FR 50 schedule. The low rate of the first 10 responses added to the TOI in addition to the 10-sec. TO. Lower rates for the first 40 responses increased the TOI to a greater extent, as it affected a greater proportion of the FR 50 schedule. This rate reduction, in addition to the duration of the TO greatly increased the TOI. A TOI hierarchy

emerged whereby the no-TO component generated the shortest TOI (no 10-sec. TO and no response rate reduction), while the TO at R 40 component generated the longest TOI. The TO at R 10 generated an intermediate duration TOI. Pause duration was again correlated with TOI and not the number of interreinforcement responses, corroborating the hypothesis suggested by Zeiler (1970, 1972), Kileen (1969), and Neuringer and Schneider (1968), where ratio pause was a function of interreinforcement time. These findings further corroborate the data reported by Barowsky and Mintz (1973), that response suppression prior to imposition of a TO differentially increased the TOI as a function of TO locus.

With the increase of the duration of the TO, the TOI also increased (Experiment II). The no-TO component allowed the ratio to be run off at the highest obtained rate without interruption of the instrumental response chain, while the TO contingencies reliably interrupted the instrumental response chain. The 2.5-sec. TO increased the TOI as a result of the TO duration added to the ratio component, as well as by the pre-TO effect generated by the locus of the TO. The 10-sec. TO also increased the TOI as a result of the TO duration and the concomitant pre-TO rate reduction. The longer TO produced a lower pre-TO rate than did the short TO, corroborating the findings of Kaufman and Baron (1968). The increased TOI was therefore a function of both the duration of the TO imposed, in conjunction with the

rate variations generated by the respective contingencies. This further suggests that the resulting pause varied as a function of the temporal properties of the behavioral chain, as response requirements were constant for all components of the multiple schedules employed. The increase in response pause may therefore be considered to be a function of the delay in reinforcement interposed between initiating the ratio sequence and reinforcement. This delay results from the minimum time necessary to emit the ratio; where a temporal interval is imposed the delay is increased.

With replacement of the no-TO contingencies (Phase A) with either a TO at R 20 or a TO at R 30 (Phase B), a new hierarchy of pausing emerged for each bird. For the birds responding on the TO at R 20 contingency, this component replaced the no-TO component in generating the shortest PreRP. The TO at R 40 maintained the longest PreRP, while the TO at R 10 generated an intermediate duration pause. As pause duration has been suggested to be a function of TOI, and all three components of the multiple schedule now contain the same response and imposed temporal parameters (FR 50: 10-sec. TO), the pause may be expected to be a function of TO locus. This might be expected since a TO imposed further into the FR sequence has been observed to influence a greater sequence of responses preceding it than a TO early in the FR sequence. Thus, the newly imposed contingencies (TO at

R 30) "should" assume intermediate positions in both the pause and TOI hierarchies. This however, does not occur! Two factors may account for this pause inversion in the hierarchy as a function of TO locus.

First, as the TO at R 20 contingency was exteroceptively cued by the stimuli previously associated with the no-TO contingency, residual stimulus control over pause duration and response rate may have been maintained. Second, as a result of the relatively close proximity of the R 10 and R 20 TO loci, the TO at R 20 was affecting only an additional 10 responses in the behavioral chain. A Weber-Fechner type relationship may exist where this influence on an additional ten responses may not have increased the TOI sufficiently to be discriminable by the pigeons. In all three cases where the TO at R 20 was substituted for the no-TO contingency, the difference in TOI between the TO at R 10 and TO at R 20 loci was less than 2.5 sec. The TOI for the TO at R 20 component always exceeded the TOI for the TO at R 10 component, while the TO at R 10 consistently generated longer PreRPs for all birds. Recalling the hypothesis advanced by Pliskoff and Goldiamond (1966) that differences in the time to complete the ratio may be the discriminative properties enabling discrimination between ratios, 2.5 sec. may not be quite a sufficient difference. The study reported by Reynolds and Catania (1962), further do not present evidence of temporal discriminations of less than three seconds in pigeons.

Although pigeons demonstrated the ability to discriminate a 27 second stimulus presentation from a 30 second stimulus presentation, no "finer" discriminations were tested.

With replacement of the no-TO component with the TO at R 30 contingency, the newly introduced contingency generated an intermediate duration pause for two of the birds, and the longest pause in the hierarchy for a third pigeon. However, the new TO locus was consistently preceded by longer pauses than the TO at R 10 contingency. Once again, the adjacency of the TO at R 30 and TO at R 40 loci in the respective TO components, may account for the lack of a clear discrimination as postulated above. With substitution of the "new" TO components (TO at R 20; TO at R 30), the TO loci are discriminable from the previously imposed contingencies when the difference in loci is twenty responses; the effects were variable when the difference in TO loci was only ten responses. The lack of accuracy in discriminating two loci differing by ten responses may be attributable to their adjacency, and the similar TOIs generated.

Probability of Reinforcement as a Function of TO Locus:

In assessing the effects of TO locus within the FR sequence, additional factors warrant further attention. In the FR schedule, as the number of responses is constant for each succeeding reinforcement, "the number of responses emitted since reinforcement or some other arbitrary event is

a discriminable stimulus" (Ferster and Skinner, 1957). The number of responses or time since previous reinforcement therefore may act as a discriminative stimulus signalling emission of succeeding responses, as well as a conditioned reinforcer for the sequence completed. Just after reinforcement, the probability of a subsequent reinforcement is low (or zero) and the probability of a response is also virtually zero. It has been reported that self imposed TOs are initiated when the probability of reinforcement is low (Azrin, 1961; Dardano, 1973), usually during the pause following reinforcement, and that stimuli associated with the initial sequence of a behavioral chain are unfavorable when compared to those stimuli associated more closely with reinforcement (Thomas, 1966). In the latter study, the E observed the S's avoidance of a return to the initial sequence in a behavioral chain from the terminal sequence more closely associated with reinforcement. These data suggest that stimuli associated with an early sequence in the ratio may maintain weaker control over responding. However, as the number of response (or time) since reinforcement maintains discriminative control over responding (Ferster and Skinner, 1957), the probability of reinforcement increases as the organism emits more responses, and concomitantly as time since the previous reinforcement increases. Where the probability of response contingent reinforcement is high, studies report the absence of self imposed TOs. As the TO

removes stimulus associated with reinforcement and prevents response-produced conditioned stimuli by removing the opportunity to respond, the removal of these conditioned stimuli may manifest aversive properties when imposed in the chain at a locus having a higher probability of reinforcement. Ferster (1960) maintains that "TO from a preferred schedule of reinforcement might be more aversive than a timeout from a less preferred schedule of reinforcement." Similarly, TO from responding when the probability of reinforcement is more favorable (relatively high), might be more aversive than a TO from responding when the probability of reinforcement is less favorable (relatively low). The aversiveness of a TO may therefore be a function of its loci, with respect to the probability of reinforcement prevailing when it is imposed. The discriminable probability of reinforcement is considerably higher at R 40 of an FR 50 schedule of reinforcement than it is at R 10 of the same schedule. The imposition of a TO at R 20 may be suggested to assume a locus maintaining an intermediate probability of reinforcement to loci R 10 and R 40. Similarly, a TO at R 30 might be assumed to occupy a locus maintaining a probability of reinforcement intermediate to R 10 and R 40. The TO at R 20 however, may have been imposed at a locus associated with a relatively low probability of reinforcement and consequently indiscriminable from the probability of reinforcement prevailing at the R 10 locus. Imposition of the TO at R 30

assumes a position in the hierarchy exceeding the TO at R 10 for all three pigeons, suggesting that the probability of reinforcement at R 30 is discriminable from that at R 10, and accordingly, exceeds that of R 10. The inconsistencies noted between the hierarchical positions of loci R 30 and R 40 may similarly result from indiscriminable probabilities of reinforcement associated with the two loci.

The aversiveness of the respective loci may be reflected by the respective inhibitory effects upon initiating the FR sequence in each component, as well as the reduced rate of responding in a positively reinforced sequence of behavior. It is of course, a debateable point, whether the longer pauses and reduced rates of response reflect an inhibitory or suppressive consequence of aversive stimulation, or merely instance of notably reduced excitation.

Further, the duration of the removal of stimuli associated with reinforcement has been observed to be a factor (Experiment II). The longer the extinction period or interval associated with non-responding in a period of time associated with a specific probability of reinforcement, the greater the inhibitory effect in initiating the ratio and maintaining a cohesive chain of behavior. This further suggests that removal of the opportunity to respond when the probability of reinforcement is relatively high may be aversive. The response rate is again reduced in the FR prior to cessation of the TO.

Comparison of TO with Shock Punishment:

The TO however, does not appear to be aversive as the term applies to shock contingencies. Comparing the imposition of TO with the imposition of shock, a number of differences become apparent.

As the exteroceptive stimulus signalling the TO contingency marks the location of the TO at a position (temporal or response) within the FR, the period of time or number of responses up to imposition of the TO might act as a conditioned stimulus (CS). Under such a paradigm, an aversive stimulus such as that employed by Estes and Skinner (1941), or a reinforcing stimulus such as employed by Pavlov (Kimble, 1961) would generate a gradient of response rates throughout the interval. The inhibition of delay observed by Estes and Skinner (1941) and Pavlov (Kimble, 1961) was not however observed with the TO. Estes and Skinner (1941) observed this inhibition of delay when a CS imposed upon an FI schedule of reinforcement terminated with an unavoidable shock (US). In the present study, although response rate reduction was a function of the unavoidable TO, no progressive decline was observed up until its imposition. Post-TO responding however, did witness a response facilitation observed in the conditioned emotional response (CER) work reported above. This facilitation, however, may be reconciled by a comparison of the two baseline schedules employed. It is characteristic for response rate to reach asymptote in

the terminal segment of the FI schedule (Ferster and Skinner, 1957; Dews, 1970), which may account for the apparent increase in response rate reported by Estes and Skinner (1941). This occurs where the probability of a response producing reinforcement is higher than early interval responding. The FR schedule typically generates a high response rate throughout. Further, the multiple schedule components employed in a study may produce interactions. While the present study reports a decrease in response rate prior to imposition of the TO in a reinforced sequence, Leitenberg (1966) reports a response facilitation prior to TO imposition, when the other component of the multiple schedule contains a shock contingency.

In addition, comparison of TO locus studies with shock locus studies yield additional differences. Dardano (1964, 1970, 1972) made shock contingent upon responding at different loci within the FR sequence. Consistent with the present findings, response suppression was greatest prior to imposition of the "aversive" stimulus, while post "stimulus" responding was relatively stable. Although these findings are in agreement, comparative pause data reflect differences. The present study observed pause duration to be a function of TO locus; TOs imposed "early" in the FR result in shorter pauses, while TOs at loci more closely associated with reinforcement generated longer pauses. Shock punishment, however, generated the longest pauses when the aversive

stimulus appeared early in the sequence, at a locus more closely associated with initiating the ratio. The shock appears to generate an inhibition in initiating ratio responding. Similar results are reported by Lyon (1964). Lyon imposed CER procedure upon pigeons responding on an FR 150 schedule of reinforcement. If the CS appeared early into the ratio, complete response suppression occurred; whereas, if the CS occurred at "later stages in the run," the birds completed the ratio and then complete suppression followed.

The differential response pattern generated by these two genera of stimuli, shock and TO, may be a function of their respective properties interacting with stimuli generated by the schedule of reinforcement. Electric shock has been observed to suppress response rates at all loci within the FR (Dardano, 1964, 1970, 1972), although the extent of suppression is a function of locus. When employed late in the FR (when the probability of reinforcement is high) least disruption is observed (Lyon, 1964). TO has been observed to adopt a character as a function of locus and FR length. This may suggest that the properties of the two stimuli differentially effect the behavioral sequence as a function of probability of reinforcement prevailing. The properties of electric shock disrupt responding greatest when the probability of reinforcement is low (early ratio responding), while schedule generated behavior is prepotent when the probability of reinforcement is higher, and responding is closely related

to food reinforcement. TO however, may assume a reinforcing character while stimuli signalling a low (or zero) probability of reinforcement prevail (Dardano, 1973; Azrin, 1961; Thompson, 1964; Appel, 1963). This occurs typically when the impending contingency is long and the organism has just received reinforcement for a previous run. The TO assumes aversive properties when imposed at a locus more closely associated with reinforcement. TO imposition at such a position in the FR removes conditioned stimuli which are reinforcing as a result of their relationship to food reinforcement. The dual character assumed by the TO may be a function of the conditioned stimuli at different loci in the FR. "Conditioned stimuli can either be rewarding or aversive, depending upon the manner in which they are related to primary reinforcing contingencies" (Appel, 1963; p. 423). TO further removes the opportunity to respond in the presence of stimuli associated with reinforcement, whereas these stimuli are not removed under shock contingencies.

As shock administration does not preclude responding as in the case of TO, and the terminal sequence is relatively stable and invariant (Pliskoff and Goldiamond, 1966), schedule controlled behavior may be so powerful that it masks the effects of shock when made contingent upon a terminal sequence of behavior.

TO as a Correlated Stimulus:

The darkening of the response key may further function as a correlated stimulus, signalling completion of successive links in a chained schedule of reinforcement. Under such a paradigm, the initial component of the chain is emitted at a relatively lower response rate than succeeding chained components (Jwaideh, 1973). Comparison of the TO contingencies with the no TO component in the multiple schedule may therefore be analagous to a comparison of a chained schedule with a tandem schedule of reinforcement. The TO at R 10 component (Expt. 1) could conceivably be interpreted as a chain FR 10: dro 10 sec: FR 40, the TO at R 40 component a chain FR: dro 10 sec: FR 10, while the no TO component would be a tandem FR_x:FR_y, where $x + y = 50$. Similarly, the contingencies in Expt. I Phase B may be designated as a chain FR 10: dro 10 sec: FR 40, chain FR 40: dro 10 sec: FR 10, and chain FR 20: dro 10 sec: FR 30 for three birds, and a chain FR 10: dro 10 sec: FR 40, chain FR 40: dro 10 sec: FR 10, and chain FR 30: dro 10 sec: FR 20, for the other three birds. The contingencies of the three-ply multiple schedule in Expt. II may be similarly represented as a chain FR 30: dro 2.5 sec: FR 20, chain FR 30: dro 10 sec: FR 20, and a tandem FR_x : FR_y, where $x + y = 50$.

Under such contingencies where the length of the links in the chained schedule differed in value, Sheldon (1971) reported that pausing was shortest when the initial link was

short. However, pausing was even shorter in the tandem schedule of the same value. The present study indicates that the shorter initial first component of the chain FR 10: dro 10 sec: FR 40, (FR 50 TO at R 10 contingency) does generate a shorter ratio pause than the FR 40: dro 10 sec: FR 10 (TO at R 40 component). The 10=sec. dro link present in the components containing the TO precludes comparison with the tand FRx: FR y schedule, as no temporal link had been interposed on the no-TO component. As with chained schedules, pausing was primarily confined to initiating the first link.

The importance of the temporal parameters in such an analysis becomes evident in Expt. II, where the TO duration is varied. The tand FR 30: FR 20 generates the shortest pause and least response rate reduction early in the ratio, while the first link of the three link chain FR 30: dro : FR 20 generates a lower response rate. Reduction in response rate in the initial link is further a function of the dro value in the second link of the chained schedule. As Ferster and Hammer (1965) have suggested, an interval with a correlated stimulus effectively adds a link to a schedule of reinforcement. This is observed in the differential pausing in the presence of the stimuli signalling the reinforcement contingencies. Differential pausing is an indication of a discrimination (Ferster and Skinner, 1957). In the present study, the 2.5-sec. TO (or dro) component generated a shorter pause than the 10-sec. (dro) component. Observed as a

chain of behavior, each succeeding change in stimuli correlated with a sequence more closely associated with reinforcement functions as a conditioned reinforcer for the links completed. Therefore, in the chain FR 30: dro n-sec: FR 20, each link is under the control of the succeeding link, which is ultimately under the control of food reinforcement. Further, the value of response produced conditioned stimuli, is a function of their relationship with food reinforcement. The second and final links of the 10-sec. dro component may maintain weaker control over the initial response sequence (FR 30) than the 2.5-sec. dro component, as it removes the initial sequence from a more favorable position with respect to food reinforcement.

The post-TO response facilitation may further be viewed as a property of the chained schedule, as the terminal sequence is more closely correlated with reinforcement, or it may merely result from the properties inherent in the FR schedule where the rate is relatively invariant and stable. Further, the facilitation may be the result of the TO acting as a stimulus signalling no further interruptions in the response sequence, and further responding will terminate with reinforcement. Dardano (1964) renders this a possible reason for the relatively stable response rates observed in pigeons after termination of a shock in a FR schedule of reinforcement. Still another analysis may suggest similarities between the response facilitation and Amsel's (1958)

frustrative non-reward hypothesis. Subsequent to an unreinforced sequence of runway behavior, rats increased their run rate on the following trial. The initial sequence in the present study may lay in the initial response sequence terminating with a TO. Subsequent to the TO, the rate facilitation is observed, as Amsel (1958) observed an increase in running rate. Compensatory responding typical of post US presentation in CER procedures may further resemble the post TO facilitation, although the differences between CER and TO loci have already been noted.

Schedule Interactions: The Pre-response Pause as a Function of the Preceding Contingency:

The pause generated by each scheduled contingency has been observed to be a function of the ratio run immediately preceeding it. Studies reporting behavioral contrast and schedule interactions (Herrnstein and Brady, 1958; Reynolds, 1959, 1961a, 1961b, 1961c; Shettleworth and Nevin, 1965; Brethower and Reynolds, 1962; Sadowsky, 1973; Catania, 1961; Powell, 1969; Kileen, 1969) have presented findings which suggest that these interactions result from the relative differences in reinforcement density. In the FR schedule, the pause duration has been observed to be a function of the magnitude of reinforcement.

Mintz, Mourer, and Weinberg (1966) ran pigeons on an FR schedule of reinforcement where the first 125 responses were not reinforced. Following completion of the 125

responses, successive responses up to four could be reinforced on a CRF contingency. Mintz, et al. observed that the greater the number of reinforcements for a given ratio cycle, the shorter the pause and the higher the run rate which followed.

Powell (1969) corroborates the pause findings in a procedure which maintained the ratio requirements while varying the magnitude of reinforcement. Pigeons were run on multiple fixed ratio schedules where the duration of reinforcement was of two different values. In the presence of a white key, the pigeon received 2.5 sec. access to grain, while in the presence of a red key, completion of the same valued ratio schedule produced 4.0 sec. access to grain reinforcement. Over a series of ratio values ranging from FR 70 to FR 40 (in a descending series), the PRP was consistently shorter for all birds with 4.0 sec. access to grain. The response rate was however, sensitive to the magnitude of reinforcement.

Interactions and behavioral contrast in multiple FR schedules have also been reported as a function of FR length. Schuster (1959) has reported that latencies prior to initiating the ratio run on a mult FR are a function of both the ratio requirement of the impending contingency and the ratio just completed. On a two-ply multiple FR schedule, FR 20: FR 20, pausing prior to each component was similar. However, an increase in one component to FR 40 while the

other was maintained at FR 20, decreased the latency to the FR 20 component and increased the latency to the FR 40 contingency. Similarly, if the FR value of one component is reduced while the other is maintained, latencies prior to the second component increase significantly. Clearly, altering the "response" requirement in one component has been observed to effect pause duration of components maintained at their original values. Reports of such findings have been numerous with relation to comparing response rates in one schedule component by altering the reinforcement contingency of a second component. Reynolds (1961b) ran pigeons on two series of multiple schedules. The first series was a VI FR, where the VI was held constant and the FR component was varied. A second mult VI FR was employed where the FR was maintained at a constant value while the VI was varied over a series of values.

In the first multiple schedule, increasing or extinguishing the FR component decreased the reinforcement frequency in the FR component. The number of reinforcements on the VI, however, was held constant. The relative frequency of reinforcement therefore increased and resulted in a two-fold increase in response rate on the VI schedule. In the second series of multiple schedules, an increase in the VI interval decreased the reinforcement density for that component. Concomitantly, while the absolute amount of reinforcement on the FR component was maintained, the relative

density of reinforcement was increased, with respect to the VI contingency. The increase in reinforcement density systematically decreased the pause prior to initiating each ratio. "The average value of the pause decreased from 40 secs to 17 secs, as the relative frequency of reinforcement in the ratio component" systematically increased (Reynolds, 1961a).

The organism appears to make successive comparisons between relative reinforcement frequencies in the components of a multiple schedule. While the FR schedule was maintained in the second series of multiple schedules (Reynolds, 1961a) the increased response rate which also occurred resulted in a decreased TOI. As reinforcement frequency (over time) has been observed to effect pause duration (Kileen, 1969; Reynolds, 1961a) the alteration of pause duration as a function of ratio length may therefore be a function of the relative amount of time consumed responding in each component before reinforcement is produced. The relative density of reinforcement may therefore determine pause duration in multiple FR schedules.

TO has also been observed to occasion behavioral contrast when employed in the negative component of a multiple schedule. Reynolds (1961b) presented a two-component VI TO multiple schedule to pigeons. The TO which "immediately produced a near zero rate of responding, also resulted (sic) in an increase in the rate of responding in the other component." Sadowsky (1973) further assessed the effects of a

TO procedure in producing behavioral contrast. The E subjected six pigeons to a multiple VI 1 TO procedure. During the positive condition (cued by a green light), responding was reinforced on the VI 1 schedule of reinforcement; while the TO contingency was cued by extinguishing the key light and responses were accordingly not reinforced. The TO procedure resulted in a reduced rate of responding in the presence of the darkened key light, while generating a substantial rate increase under the VI 1 contingency.

In the present study, with imposition of a TO at various loci (Experiment I) or various durations (Experiment II), schedule interactions are suggested. As the TO added an additional temporal factor to each component, the density of reinforcement was not merely a function of FR value and how rapidly the organism could emit the ratio. The TOs generated a TOI hierarchy which modified the reinforcement density for each component. The reinforcement density was therefore a function of the TOI.

The no-TO component generated the shortest TOI and therefore maintained the highest reinforcement density. Maintaining the highest reinforcement density, the shortest pause was generated. As the TO components later in the ratio generated lower response rates (in general) and therefore greater TOIs, these components were reinforced under lower reinforcement densities. As indicated by Reynolds (1961a, 1961b) and Schuster (1959), increases or decreases in reinforcement density resulted in pause changes in the other

components of the multiple schedule. Further, the "comparison" of these scheduled components by the organism may be the result of response patterns generated by the terminal response sequence, as suggested by Pliskoff and Goldiamond (1968).

The shortest pause within a contingency resulting from repetition of a scheduled component still requires further explanation. Repetition of the "late" TO component appears in agreement with the model presented. A schedule which is reinforced under the lowest density of reinforcement produced the longest pause. Presenting such a contingency after a component maintaining relatively higher densities of reinforcement would appear similar to Schuster's (1959) decreasing the ratio requirement in one component and observing a concomitant increase in pause duration of a component maintained at its original value. However, with such an analysis, the shortest pause might be expected to occur when a schedule of relatively higher density of reinforcement follows a schedule of a lower density of reinforcement. Therefore, it would be expected that the no-TO component would generate the shortest pause when it followed the late TO component. Similarly, the early TO components would be expected to generate the shortest pause when it also followed the late TO component, which was not the case.

The pause relationship which is exhibited suggests a possible "recency model." Under this model, the pause is

atypically shorter for a scheduled component when the organism has just received reinforcement under similar stimulus conditions.

Ratio Strain:

The reduction in reinforcement density which resulted from the increased time of involvement may have precipitated the ratio strain observed.

Boren (1953) observed that with increased ratio requirements and magnitude of reinforcement maintained at levels prevailing at CRF and small ratio values, longer pauses and a number of breaks were observed in FR responding. The breaks after reinforcement were extremely long, and when responding was initiated it did not follow the typical FR pattern. Rather than a stable response rate, a number of breaks in responding would occur, separated by short bursts of responses. This phenomenon termed "ratio strain" almost never occurred at lower ratios.

Ferster and Skinner (1957) also reported disruption of the typical FR behavior pattern on the FR component of a Multiple FI 5 FR 275 schedule of reinforcement.

While FR strain is not common at low FR values, Verhave (1959) observed its occurrence in an adjusting FR schedule for TO from an avoidance schedule at ratio values as low as FR 33. After pretraining on a schedule where TO from avoidance was obtained by CRF responding, the ratio

requirement to remove the avoidance schedule by imposing a TO was increased in a stepwise fashion. The Ss were thus required to respond on an adjusting ratio schedule. Subsequent to a TO, the ratio for obtaining a succeeding TO was increased by one response. If 5 minutes passed however, since a TO was produced by ratio responding, the FR contingency was reduced by one response. Monitoring of the ratio stepper yielded maintenance of the ratio schedules peculiar to each rat. Strain was observed to occur at low ratio values. Verhave observed that "very fine control exists between FR schedule length and performance. An increase from FR 35 to FR 36 may produce enough of an increase in straining during the next FR run to bring the schedule down to FR 35 again" (p. 253). Similar findings are reported by Verhave (1963).

Ratio strain has traditionally been associated with high response requirements for FR contingent reinforcement. The long duration pausing indicative of strain has, however, been observed as a result of temporal delays imposed upon relatively low valued ratio schedules. Azzi, Fix, Keller, and Silva (1964), exposed rats to successively longer delays in reinforcement on a CRF (FR 1) schedule of reinforcement. Increases in the cued delays in reinforcement from 1 to 20 secs, systematically produced longer ratio pauses.

Ferster and Hammer (1965) employed a discrimination procedure in which responses during S^D periods resulted in

the deflection of a needle on a response meter. A certain number of deflections produced reinforcement. However, interposed between the S^D periods were cued periods during which responses did not advance the needle position (S^{delta}), but rather delayed further the onset of the S^D and produced a blackout. These delays interposed between S^D periods weakened the behavior severely, and increased numbers of pellets for reinforcement were necessary to maintain minimal responding. With increasing the time from initiation of responding to reinforcement and thereby delaying reinforcement, concomitant increases in pausing were observed. Pauses of one day in duration accompanied delays of a similar duration (24 hours).

With the imposition of a pre-TO stimulus, during which a lowered response rate avoided the TO on an FR schedule, Ferster, Appel, and Hiss (1962), reported extreme response curvature and ratio strain. The stimuli further suppressed responding most effectively when the "disposition to respond was low," early in the ratio.

The strain observed in the present study may therefore have resulted from the relatively lowered density of reinforcement which occurred as a result of increased TOI. Observation of the PreRP/TOI functions suggest that as TOI increases (while the access to reinforcement remains at 3 secs), pausing increases, as does "broken" ratio responding. The response requirement is maintained, however, and only

the temporal parameters are extended. Ratio strain may be the result of insufficient reinforcement over time, and therefore lowered density of reinforcement. This low density resulted from the increased time from initiation of the ratio to the subsequent reinforcement which terminates the behavioral sequence. The extremely long pre-response pausing may further suggest a phenomenon "akin" to extinction. As the pause is "so" displaced from grain reinforcement, it may be under the weakest control of the stimuli associated with reinforcement. This is not inconsistent with the hypothesis suggested by Boren (1953). Boren suggested that the unitary features of the FR response sequence proposed by Skinner (1938), are not applicable to longer FR schedules. Both the break after reinforcement and the subsequent ratio run are not necessarily reinforced as a unit. The length of the FRs presently employed, further exceed the response contingency expressed by their ratio values, as a "correlated stimulus interposed" between initiating the ratio and reinforcement has been added. Strain may be enhanced in the longer ratios as a result of the greater number of unreinforced responses, as well as the time necessary to complete the sequence. In the present study, strain may have resulted from the increased time to complete the ratio, as a result of the schedule and response-produced delays. These delays result in an insufficient amount of reinforcement.

Changes in Deprivation:

Studies reporting changes in motivation have rather consistently reported their effects to be confined to the pause associated with ratio responding, while leaving the within-ratio sequence virtually undisturbed (Sidman and Stebbins, 1961; Ferster and Skinner, 1957). These findings refer to simple FR schedules, while studies involving imposed periods of TO or punishment report a variety of changes.

Azrin and Holz (1966) report that increased deprivation substantially reduces the suppressing effects of shock level.

Holz and Azrin (1963) observed that at 80% of the ad lib weight, a 60 cps shock delivered at 0.075 sec. will reduce response rate to 50% of its pre-shock level. However, when body weight was increased to 102%, responding was reduced to 10% and at 109% it was completely eliminated.

With increases in motivation, Azrin, Holz, and Hake (1963) report a corollary increase in response rate. At 85% of ad lib weight, responding was almost completely eliminated when a 160 volt shock was delivered to pigeons. However, as weight was reduced by 5% increments to 60%, responding maintained a stable rate and recovered to the pre-shock level. Azrin, et al. also report that shock intensity while altering the degree of response rate reduction, did not alter the uniform pattern typical of FR behavior.

With changes in deprivation, FR-TO procedures yield additional findings. Employing an adjusting ratio schedule, Dardano (1973) observed that the number of self imposed TOs were related to body weight and the number of progressive ratio steps completed. The E observed that the higher the body weight, the fewer the self imposed TOs delivered, while the greater the number of progressive ratio steps completed, the greater the number of TOs.

Kaufman and Baron (1968) observed a change in IRT distribution with changes in deprivation. When the third response of an FR 3 schedule produced a TO, reduction in ad lib weight from 80% to 70% produced a decrease in the $R_2 - R_3$ IRT for two of three birds. The third pigeon showed no change. With an increase from 80% to 90%, all three birds generated significantly longer $R_2 - R_3$ IRTs.

The results of the present study appear consistent with the findings of Sidman and Stebbins (1954), and Ferster and Skinner (1957). Although changes in motivation are accompanied most consistently by changes in the duration of the ratio pause, it is not definitive that "the degree of satiation alters only the probability of occurrence of the first response in the run, but has no effect upon discrimination responsible for stable state" (p. 116). As the local response rates have in addition indicated their susceptibility to alteration under the procedure employed, the analysis of schedule and procedural interactions are more accurately

suggested by Morse (1966), that,

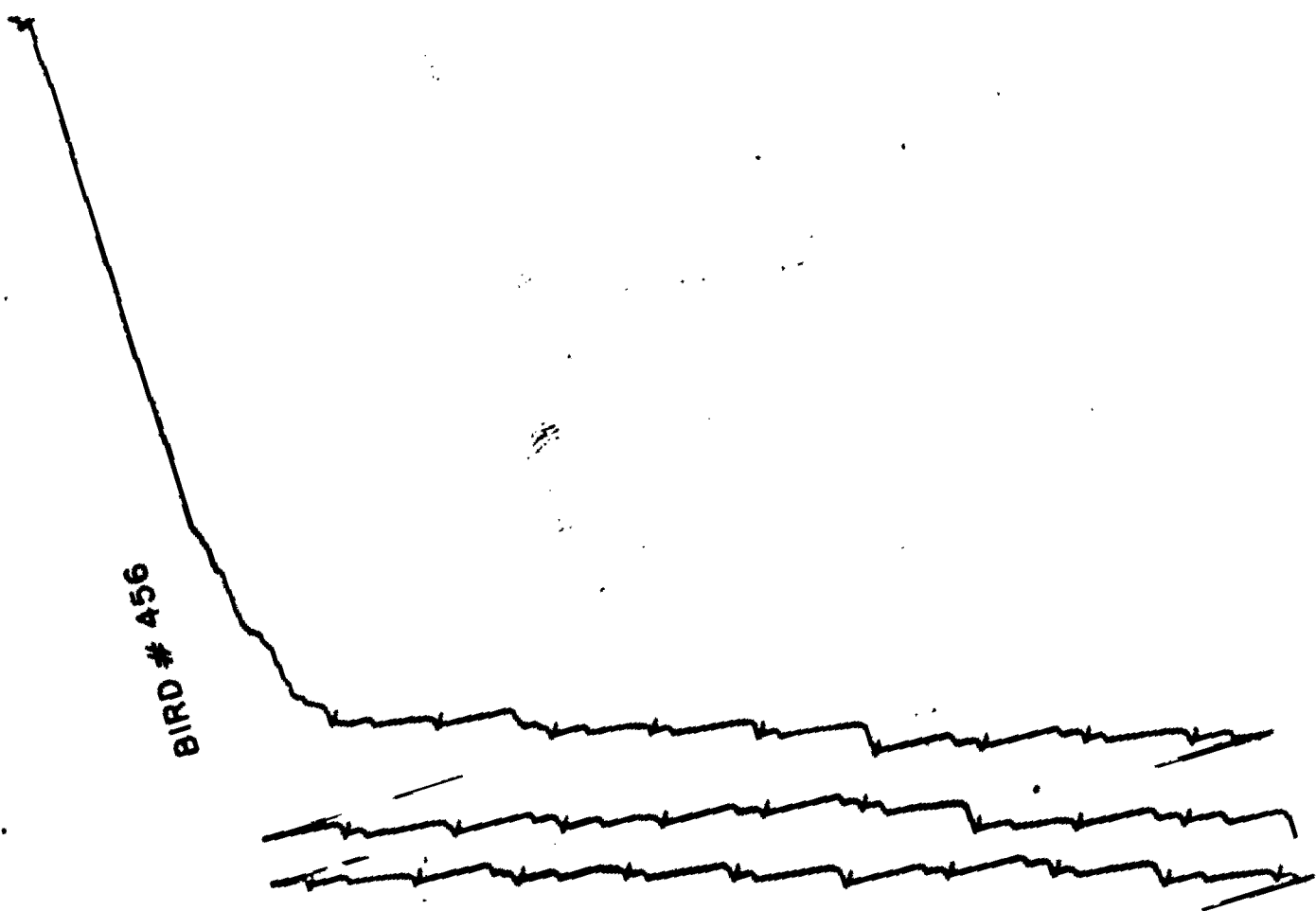
It has been found...that the effects of deprivation...depend upon the controlling schedule and has [sic] different effects with different schedules. In other words, schedule controlled behavior is so powerful that it overshadows the effects of traditional psychological variables.

(Honig, 1966, p. 59)

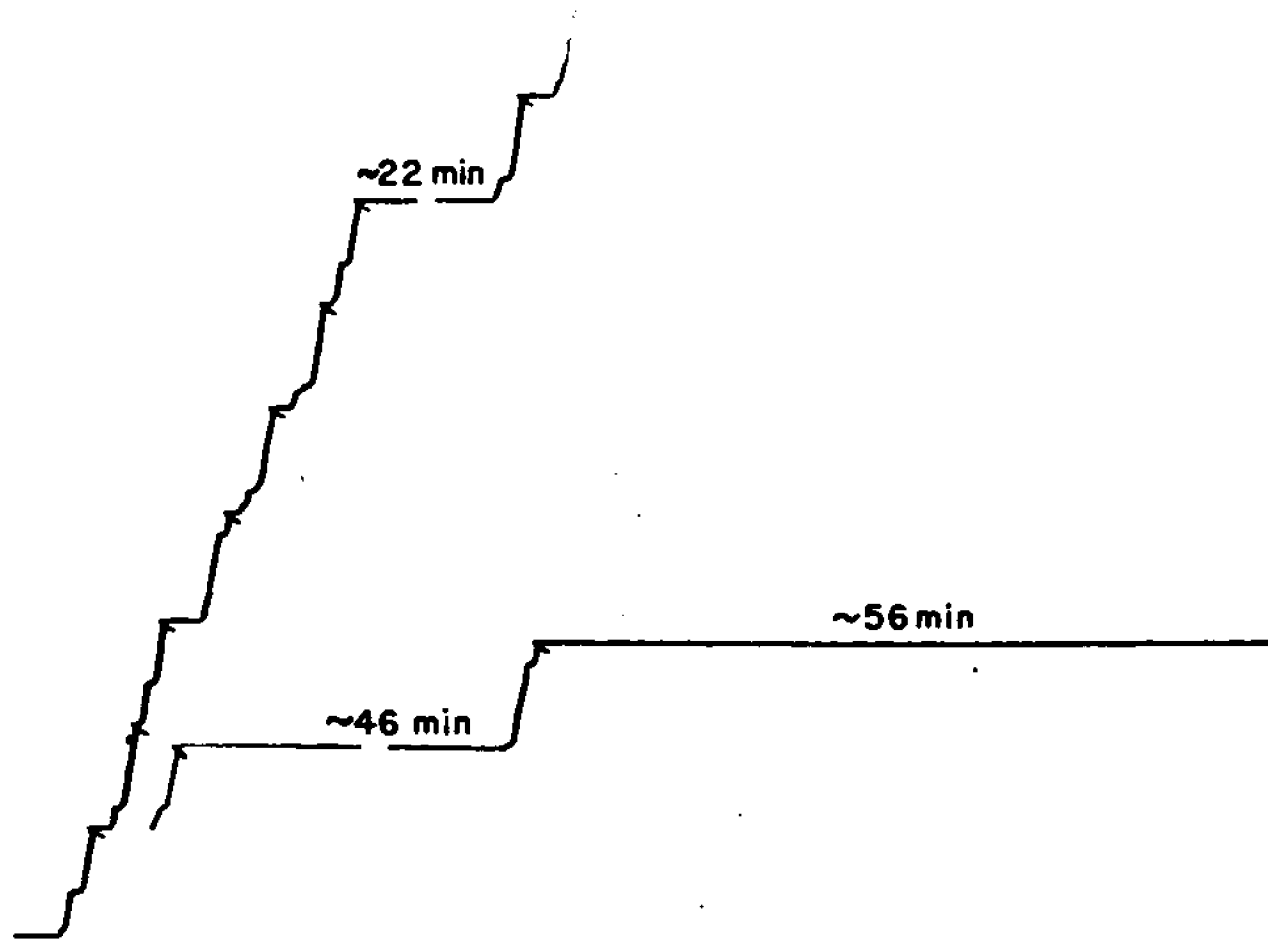
It is suggested that further study focus on the effects of the interruption of FR behavior per se. Contingencies employing multiple TOs within a single FR sequence may allow assessment of the effects of interrupting an instrumental response sequence, when the pause is compared with a contingency containing one TO of equal duration to the sum of the multiple TOs.

Further, the decrement of the response rate prior to imposition of a TO within the FR sequence, and post-TO facilitation, engenders properties similar to those observed when stimulus correlated shock punishment is employed (Dardano, 1964). It is suggested that the operations employed in the assessment of the affects of shock punishment be extended to include TO. The behavioral similarities and differences generated by these two genera of stimuli, TO and electric shock, warrant further study!

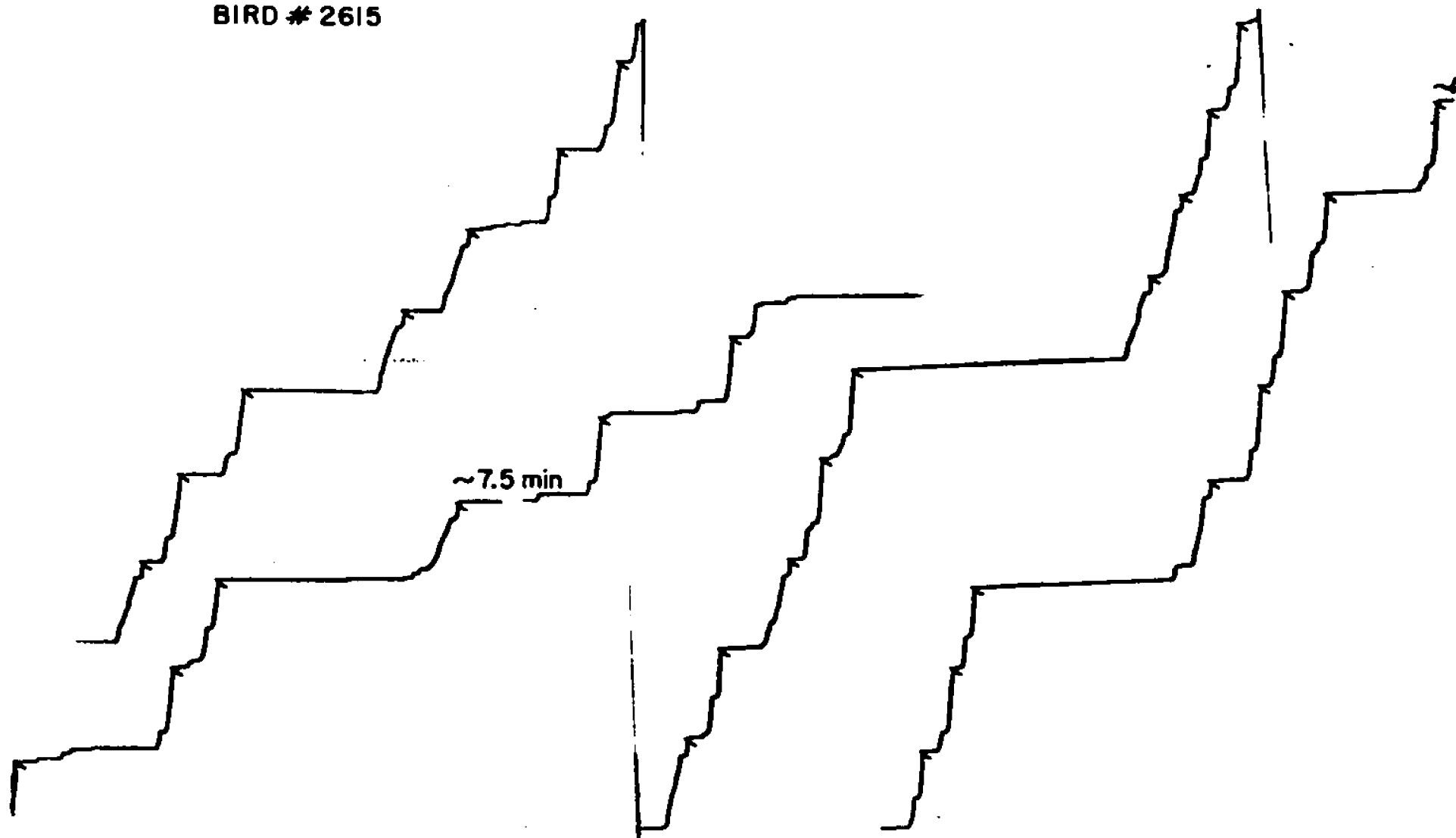
Appendix

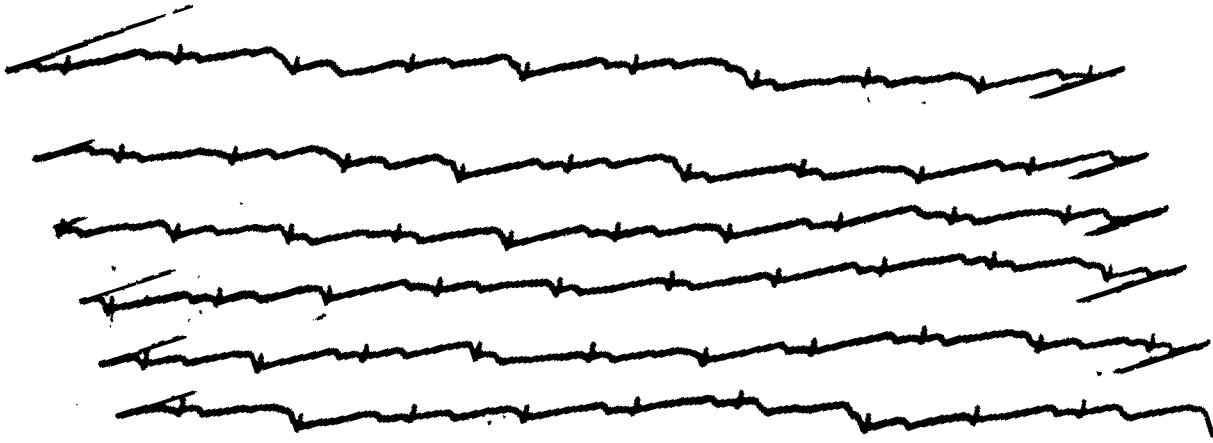


BIRD# 2567

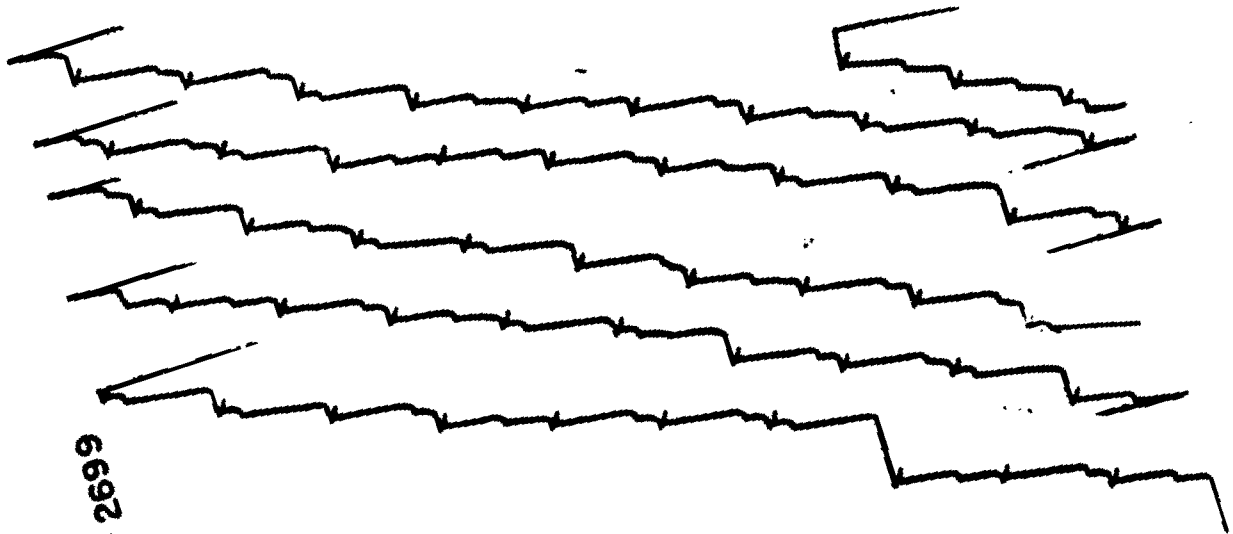


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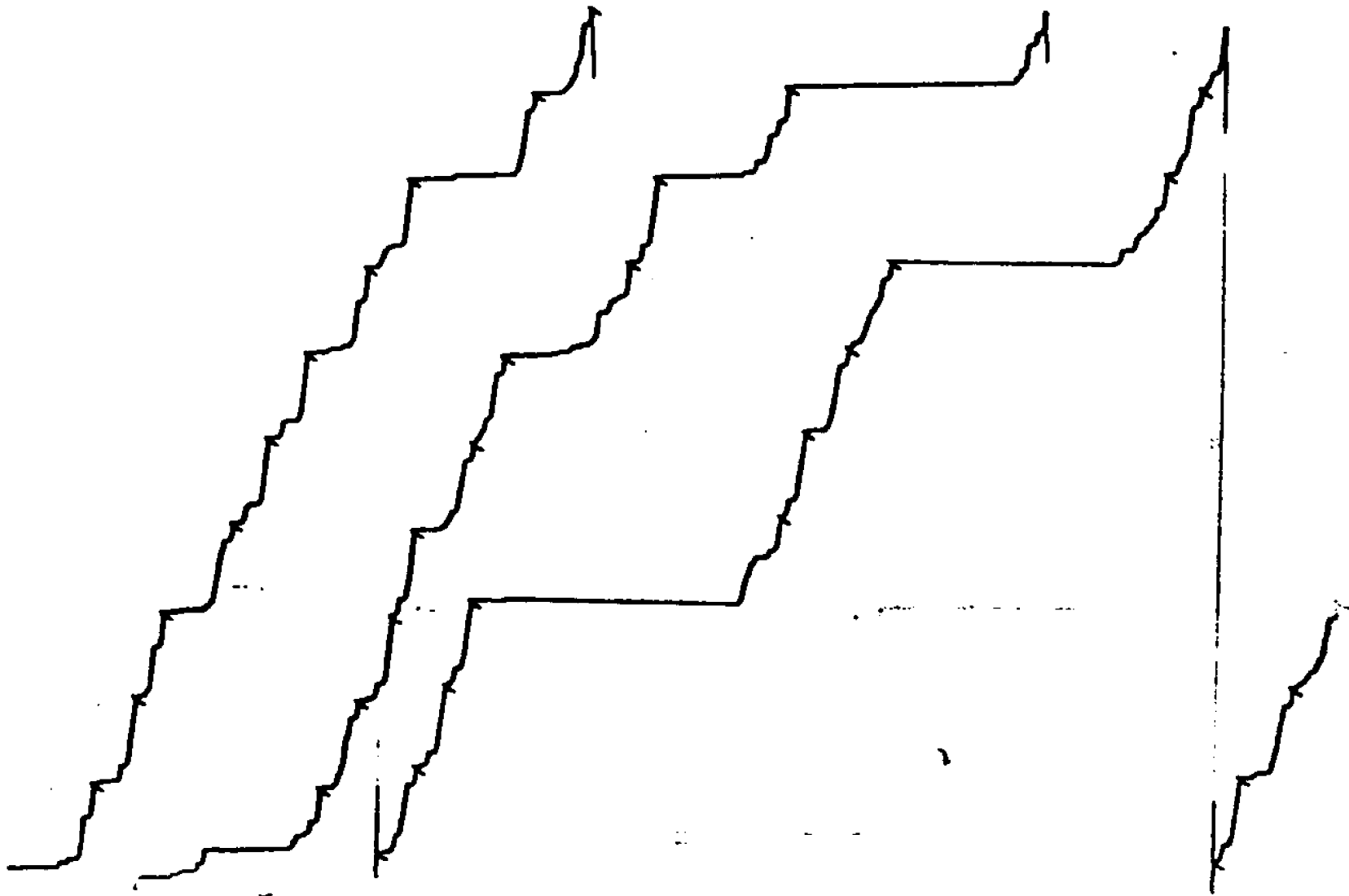


BIRD # 3765



BIRD # 2699

BIRD #3783



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