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VARYING PROBABILITY OF REINFORCEMENT AND TEMPORAL LOCATION OF AN INTRUDED STIMULUS IN A TAU REINFORCEMENT SCHEDULE

by

Richard B. Rice

A dissertation submitted to the Graduate
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Abstract

VARYING PROBABILITY OF REINFORCEMENT AND TEMPORAL LOCATION OF AN INTRUDED STIMULUS IN A TAU REINFORCEMENT SCHEDULE

by

Richard B. Rice

Advisor: Professor Thom Verhave

One approach to the analysis of behavior involves the study of the effects of adding a stimulus to a previously established behavioral baseline. This experiment was adapted from such an "intruded stimulus paradigm" by Farmer and Schoenfeld (1966a). Pigeons were conditioned to peck a key on a tau schedule of reinforcement (Schoenfeld and Cole, 1972). Tau, the cycle length, was 60 seconds. Tau^{D} and tau$^{\Delta}$ were alternating components of tau; the durations of these components were 6 and 54 seconds respectively. Each component was correlated with a different probability of reinforcement given the occurrence of a response. During tau^{D} the response key was lighted white; during tau$^{\Delta}$ the key was lighted green. Thus, the tau cycle components formed a multiple schedule. Subjects were assigned to varying probabilities of reinforcement in tau^{D} and tau$^{\Delta}$. The series of probabilities in tau^{D} was either 1.00, 0.40, 0.10, or 1.00, 0.20, 0.05. The probability of reinforcement in tau$^{\Delta}$ was either 0.02 or 0.00 throughout the experiment. For each

probability of reinforcement in tau^D 10 sessions were conducted before the introduction of a six second change in color (S^N) within tau$^\Delta$. Subsequently, 10 sessions were conducted for each of four locations of S^N. During S^N the color on the response key was white, the same as that during tau^D.

As probability of reinforcement in tau^D was decreased, corrected rates increased at each S^N location. At probabilities of reinforcement in tau^D less than one and probability of reinforcement in tau$^\Delta$ equal to 0.00, each series of S^N intrusions produced an inverted U-shaped function of corrected rates in S^N. Corrected rate was recovered at one S^N location for most subjects. Recovery rates confirmed that corrected rate in S^N was a function of temporal location. As probability of reinforcement in tau^D was decreased, corrected rates in tau^D increased at each probability and also increased over the course of 50 sessions at each probability. At probability of reinforcement in tau$^\Delta$ equal to 0.02, corrected rates in tau$^\Delta$ increased throughout the experiment. At probability of reinforcement in tau$^\Delta$ equal to 0.00, corrected rates within tau$^\Delta$ were either minimal or positively accelerated. Responding during S^N and within tau$^\Delta$ appeared to be under separate stimulus control.

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CONTENTS

The design of the present experiment evolved most directly from the "intruded stimulus paradigm" of Farmer and Schoenfeld (1966a, 1966b). In such an experiment an additional stimulus is superimposed upon a previously established baseline. Farmer and Schoenfeld contrasted two approaches to the analysis of behavior with regard to this intruded stimulus. The more traditional approach was to analyze the behavior in terms of multiple functions of the intruded stimulus. In *The Behavior of Organisms* B. F. Skinner (1938) identified several functions of a stimulus, such as elicitation, discrimination, and reinforcement. These functions were derived from Skinner's distinction between two types of conditioning, Type S (respondent) and Type R (operant). Besides the analysis in terms of multiple functions Farmer and Schoenfeld described the effects of the single category "intruded stimulus" in relation to the temporal parameters of the design. They concluded that this latter analysis was sufficient. Schoenfeld and Cole (1972) suggested that the study of the single category "stimulus" was perhaps appropriate because the distinctions among different stimulus functions have become less clear.

The present experiment was based on two theoretical assumptions which are delineated below. (1) The analysis of behavior should proceed in terms of a single category of stimulus function. (2) This stimulus function should be studied in relation to schedule parameters, but not with respect to types of conditioning.

Skinner set forth a distinction between respondent and operant conditioning procedures which had their origins in the work of

I. P. Pavlov and E. L. Thorndike respectively (Keller and Schoenfeld, 1950; Skinner, 1938; Verhave, 1966). A fundamental difference in these procedures was the order of occurrence of the response and reinforcing stimulus. In respondent conditioning, the reinforcing or unconditioned stimulus (UCS) preceded and, as Skinner put it, elicited the unconditioned response (UCR). Conditioning as a process occurred when the conditioned stimulus (CS) was paired with the UCS. Eventually, after a certain number of pairings, the CS presented by itself elicited the conditioned response (CR). In operant conditioning, the occurrence of a response was followed by a reinforcing stimulus and was said to be emitted. Conditioning occurred when the reinforcing stimulus could be shown to affect the subsequent rate of response. In conjunction with the differences between conditioning procedures, Skinner identified a class of behavior which was conditioned exclusively by each procedure. Respondent behavior, correlated with a prior eliciting stimulus, could not be conditioned in an operant procedure; operant behavior, correlated with a posterior reinforcing stimulus, could not be conditioned in a respondent procedure.

Another difference between Skinner's two types of conditioning concerned the function of the stimulus which preceded the occurrence of the response. In respondent conditioning, as stated above, the CS elicited the CR. Although operant behavior was not correlated with an eliciting stimulus, Skinner (1938) discerned that stimulation prior to the operant did affect the strength of the operant and that a so-called "discriminative stimulus" should be incorporated in the basic operant conditioning paradigm. Skinner demonstrated the function of a discriminative stimulus in a schedule of periodic reconditioning (fixed interval). The first bar press response by a rat in the presence of a light (S^D) produced a reinforcement and turned the light off (S^Δ) for a five minute interval. When responding was maintained in S^D and extinguished in S^Δ, a "discrimination" was said to have been established. Besides the differences between the two types of conditioning, it may be noted that the CS in respondent conditioning and the S^D in operant conditioning are both examples of "intruded stimuli." In each instance a "neutral stimulus" acquires a specific function when it is added to a rudimentary schedule of reinforcement.

The two types of conditioning could be distinguished on the basis of the acquisition of specific stimulus functions. Particularly, the eliciting function of the CS was specific to respondent conditioning (Skinner, 1938). Within the field of operant conditioning, major areas of research have been concerned with the acquisition of stimulus functions and with the analysis of behavior in terms of these functions (Honig, 1966). Through Skinner's operant discrimination procedure a neutral stimulus could acquire a discriminative function. In addition, Skinner (1938) reported that a discriminative stimulus could also function as a conditioned reinforcer. An experiment by Dinsmoor (1950) illustrated the relationship between the discriminative and conditioned reinforcing functions. Rats were conditioned on a continuous reinforcement schedule in the presence of a light and then divided into three groups for extinction. One experimental group was used to test the discriminative role of the light (S^D). This group was extinguished in the presence of S^D, but each response produced three seconds of dark (S^Δ). A second experimental group was used to test the conditioned reinforcing role of S^D. This group was extinguished in S^Δ, but each response produced three seconds of S^D. A control group was extinguished in S^Δ. Response totals for the two experimental groups in extinction were not significantly different, but they were greater than response totals for the control group. Dinsmoor concluded that establishing a stimulus as an S^D was sufficient to establish it as a conditioned reinforcer and that the two roles were equivalent in their effectiveness on responding.

Although the discriminative and conditioned reinforcing functions of a stimulus could be established through operant procedures, other research has demonstrated that these functions do not result solely from operant conditioning. Terrace (1966) and Rescorla and Solomon (1967) cited an experiment by Morse and Skinner (1958) in which the function of a discriminative stimulus in an operant procedure was established at least in part through respondent conditioning. The temporal association between S^D and S^R in operant conditioning, similar to the pairing of CS and UCS in respondent conditioning, resulted in the control of S^D over responding. Pigeons were reinforced with food on a non-contingent variable interval schedule in the presence of either a red or green chamber light and were never reinforced in the presence of the alternative color. Then the subjects were trained to peck a key for food on a variable interval schedule in the presence of a white light.

Finally, responding was extinguished while the red and green lights were alternated. During extinction more responding occurred in the presence of the color that was originally paired with food. Terrace (1966) and Rescorla and Solomon (1967) pointed out that the elicitive function of the light affected operant behavior. Since the elicitive function is supposedly specific to respondent conditioning, the distinction between the discriminative and elicitive functions becomes obscured.

Bersh (1951) investigated the establishment of a secondary (conditioned) reinforcer. The duration of the interval between the onset of a neutral stimulus (light) and a reinforcer (food) was systematically varied from zero to ten seconds. Rats were given paired presentations of light and food with a bar-pressing lever unavailable. Subsequently, the bar was made available, and a bar press produced the light. Bar-pressing totals revealed a maximum effectiveness for intervals of 0.5 and 1.0 seconds. A majority of respondent conditioning studies had shown the optimal CS-UCS interval to be 0.5 seconds. Therefore, Bersh supported a Pavlovian conditioning hypothesis of conditioned reinforcement. After reviewing the available literature Kelleher (1966) also concluded that a stimulus was established as a conditioned reinforcer through respondent conditioning. As with the discriminative function in an operant procedure, the conditioned reinforcing function appears to involve the elicitive function. If distinctions among these functions cannot be maintained, then it is reasonable to proceed with a single category of stimulus function.

Since the types of conditioning appear to overlap in the analysis of stimulus functions in an operant procedure, a clear distinction between the types of conditioning must rest upon the discrete classes of operant and respondent behavior. Of course, either procedure can result in a respondent or operant depending upon which part of the behavior stream is observed. The same food pellet can reinforce a preceding bar press response and elicit a salivary response.
The distinction between classes of behavior has been tested by trying to condition respondents through operant procedures. Terrace (1973) reported experiments (DiCara and Miller, 1968; Miller and Carmona, 1967) in which respondents such as salivation and heart rate were conditioned successfully with operant procedures. Thus, Terrace concluded that the types of conditioning could not be distinguished on the basis of discrete response classes.

Although the accumulated evidence challenges the validity of two-factor theory, a better formulation has not been found. The weakening of the distinctions between the two types of conditioning gives added force to the possibility of a single type of conditioning, but there has been no clear way to explain the existing phenomena in simpler terms. Schoenfeld (1966) reviewed Skinner's distinctions between conditioning paradigms and considered a reduction into a single paradigm. He believed that attempts to resolve the differences in paradigms by conditioning respondents through operant procedures were probably futile. If a respondent were conditioned through an operant procedure, then it could be reasoned that the respondent had been mediated by the conditioned operant. In a way which bypasses the complexities of the differences in types of conditioning, Schoenfeld suggested the possibility of the reduction of the two procedures through incorporation into a common system of schedules. The dichotomy in conditioning procedures could be resolved by integrating the common operational parameters. Furthermore, new categories could be used to describe behavior in relation to schedule parameters. Within the operant conditioning framework, the Farmer and Schoenfeld (1966a) experiment demonstrated an analysis of the effects of varying the position of a single category "intruded stimulus" in a fixed interval schedule. Subsequently, other experimenters (Benassi, 1974; Evra, 1974; Martin, 1971) have systematically varied the position of an intruded stimulus in fixed and random interval schedules.

In the Farmer and Schoenfeld (1966a) experiment pigeons were conditioned to peck a key which was lighted white on a 60 second fixed interval schedule of reinforcement. After 60 baseline sessions, the color on the key was changed from white to green (S_1) during the last six seconds of the interval. The placement of S_1 was varied within the fixed interval in blocks of seven sessions each at 10 different locations: 54-59.99, 48-53.99, 42-47.99 seconds, etc. The effects of S_1 showed up as characteristic response patterns within the fixed interval. At placements 6 or 12 seconds before reinforcement response rates were low preceding S_1 and then increased rapidly during S_1. At placements 18 through 60 seconds before reinforcement response rates increased to high levels before and after S_1, but were near zero during S_1. Farmer and Schoenfeld discussed the role of S_1 in terms of Skinner's (1938) categories of stimulus functions. According to those functions, S_1 could act as a conditioned reinforcer for responses which preceded S_1 and a discriminative stimulus for responses during S_1. However, an explanation in terms of conditioned reinforcement seemed unnecessary because Dews (1962) found that a fixed interval scallop continued in spite of interruptions by short S^{Δ} periods. The authors reasoned that the fixed interval baseline was sufficient to account for the increasing rates before and after S_1. In a second experiment Farmer and Schoenfeld (1966a) changed the previous design simply by adding a second intruded stimulus of the same color in the fixed interval. As in the first experiment the location of S_1 (now designated S_1^1) was varied. In addition, the second stimulus (S_1^0) always occurred during the last six seconds of the interval. The results differed from the first experiment in that subjects responded during S_1^1 at each temporal location as well as during S_1^0 and paused or responded at low rates in the absence of these intruded stimuli. Moreover, the amount of responding in S_1^1 decreased as S_1^1 became more temporally remote from S_1^0 and reinforcement.

The design of the present experiment used the same fixed interval length as Farmer and Schoenfeld and also scheduled two six second lights within the fixed interval. Farmer and Schoenfeld scheduled reinforcement following the termination of the light at the end of the fixed interval. But, in the present experiment the light at the end of the interval was paired with reinforcement (Dinsmoor, 1951; Skinner, 1938). One independent variable was the temporal location of S_1^1; the second independent variable was the probability of reinforcement correlated with S_1^0.

Farmer and Schoenfeld's (1966a) purposes for adding a stimulus to a fixed interval schedule stemmed in part from research (Schoenfeld and Cole, 1972; Schoenfeld, Cumming, and Hearst, 1956) which has been based on a system of temporal schedules. Schoenfeld and Cole have summarized the theory and experiments of the t-tau systems which provide an organizational framework of operant procedures for the scheduling of stimuli in time. In operant conditioning schedules of reinforcement have been dichotomized into ratio and interval schedules (Ferster and Skinner, 1957; Skinner, 1938). Schoenfeld and Cole listed two guidelines for basing a system of schedules exclusively on time. First, it was preferable to construct schedule parameters which possessed continuity. It was necessary, therefore, to choose either count or interval schedules. Second, it was preferable to have an independent variable, a schedule of reinforcement, which was not confounded by the dependent variable, the responding of the subject. Time was chosen as the independent variable because it was possible to specify the delivery of a "free" reinforcement by means of a temporal schedule. With a ratio schedule the delivery of a reinforcement was always dependent upon the occurrance of a response. A further reason for choosing a completely temporal specification is particularly relevant to the Farmer and Schoenfeld intruded stimulus paradigm. If the two types of conditioning were someday reduced to one category, then the conditioning procedure would most likely be based on time since the Pavlovian conditioning procedures essentially consist of temporal schedules of stimuli. The Farmer and Schoenfeld (1966a) first intruded stimulus experiment was viewed as an operant procedure because the authors studied the behavior which produced the reinforcement. However, the scheduling of an intruded stimulus and non-contingent reinforcement would be equivalent to Pavlovian trace conditioning.

The t-system has three parameters. First, there is the repeating time cycle designated as t. Second, t is divided into two segments, t^D and t^Δ; the proportion of t^D to t^D plus t^Δ is called $\bar{t}$. Third, the probability of reinforcement is higher in t^D than in t^Δ. Furthermore, in all the t-system experiments reported to date the following conventions have been used: t is fixed in length; t^D and t^Δ are alternated; only the first response in t^D is made eligible for reinforcement; and, the probability of reinforcement in t^Δ is set at zero. In the Farmer and Schoenfeld (1966a) experiment the onset of a new fixed interval did not occur until a reinforcement had been obtained, whereas in the t-system the t^D period can expire without the occurrence of reinforcement. Although the t-system dncorporated the existent interval schedules, it did not accomplish one of the original purposes of the system. Reinforcing the first response in t^D is the same as counting to one. Thus, response count is still part of the t-system. Consequently, the so-called tau system was devised in which the delivery of reinforcement is independent of response count. The parameters of the tau system parallel those of the t-system. The duration of the repeating time cycle is designated as tau. Tau^D and tau$^\Delta$ are alternating segments of tau; the proportion of tau^D to tau^D plus tau$^\Delta$ is called $\overline{\text{tau}}$. Within tau^D and tau$^\Delta$, t^D and t^Δ similarly are alternating segments, and the proportion of t^D to t^D plus t^Δ is called $\bar{t}$. The length of the t^D plus t^Δ interval is made shorter than the minimum interresponse time, and any response which occurs during t^D is reinforced. Thus, the value of $\bar{t}$ determines the probability of reinforcement which by definition is greater in tau^D than in tau$^\Delta$. Reinforcement is not dependent upon response count because any response in the tau cycle is eligible for reinforcement at a given probability.

The tau system was chosen for the present experiment after considering the effects of pairing a light with either t^D or tau^D. Weissman (1961) paired a change in color (S^D) with t^D. The probability of reinforcement in t^D was set equal to 1.00. The first response in t^D procured a reinforcement and terminated S^D. There were no previous tau system experiments in which a cue had been paired with tau^D. If the Weissman procedure were used with the present design, then the duration of the interval between S^D and the intruded stimulus would be dependent upon a response in t^D. However, it was intended that responding within a fixed cycle would be studied as a function of precise intervals between S^D and the intruded stimulus. Possibly the conventions of the t-system could have been altered, but a more immediate solution was found in the tau system because the termination of tau^D is independent of responding.

Two of the previous tau system studies (Snapper, 1962; Vickery, 1971) were also concerned with the variable of probability of reinforcement. Following Vickery's usage, $p(S^R/R \cdot \text{tau}^D)$ refers to the "probability of reinforcement given the occurrence of a response in the tau^D period." Snapper studied the effects of varying $p(S^R/R \cdot \text{tau}^D)$ for each subject from 0.08 to 0.0125. Tau was held constant at 10 minutes; $\overline{\text{tau}}$ was constant at 0.20; and, $p(S^R/R \cdot \text{tau}^\Delta)$ was equal to 0.00. Response rates were generally insensitive to variations in $p(S^R/R \cdot \text{tau}^D)$. Responses per reinforcement (R/S^R) and the post-reinforcement pause (PS^RP) decreased as $p(S^R/R \cdot \text{tau}^D)$ was increased. Given that responses per cycle did not vary, R/S^R would decrease when more reinforcements were obtained at higher probabilities.

Vickery (1971) investigated the effects of changes in cycle length and $p(S^R/R \cdot \text{tau}^\Delta)$. Groups of subjects were scheduled with series of cycle lengths ranging from 10 to 500 seconds in blocks of 36 sessions at each cycle length. In a three-ply multiple schedule, $p(S^R/R \cdot \text{tau}^\Delta)$ equaled 0.00, 0.10, and 0.01 in randomly ordered 500 second components in each session over 144 sessions. For each group $p(S^R/R \cdot \text{tau}^D)$ was equal to either 1.0 or 0.1 throughout the experiment. $\overline{\text{Tau}}$ was held constant at 0.20. When $p(S^R/R \cdot \text{tau}^D)$ was greater than $p(S^R/R \cdot \text{tau}^\Delta)$, increasing cycle length resulted in decreased running rates for the entire cycle. As $p(S^R/R \cdot \text{tau}^\Delta)$ was increased within sessions, running rate in tau^D and tau^Δ increased. For probabilities of reinforcement other than 0.00, running rate increased over 144 sessions.

In the present tau system experiment probability of reinforcement was varied in both tau^D and tau^Δ. Three groups of subjects were scheduled first with $p(S^R/R \cdot \text{tau}^D)$ equal to 1.00 to permit comparison with the data of the Farmer and Schoenfeld (1966a) study. For each group, two other $p(S^R/R \cdot tau^D)$ values, either 0.40, 0.10, or 0.20, 0.05, were arranged in a descending series. Snapper (1962) had used a mixed series of $p(S^R/R \cdot tau^D)$ for individual subjects and found nearly constant rates across probabilities. Other experiments on probability of reinforcement (Brandauer, 1958; Nevin, 1964; Sidley and Schoenfeld, 1964), fixed ratio (Boren, 1961; Ferster and Skinner, 1957), variable ratio (Autor, 1960), and percentage reinforcement (Neuringer, 1968; Zeiler, 1972) have shown that a decreasing series of probabilities over sessions does result in different response rates. Therefore, in the present experiment a decreasing series of $p(S^R/R \cdot tau^D)$ was employed in order to observe the effect of changes in the rate of response in tau^D. Furthermore, two of the groups were scheduled with $p(S^R/R \cdot tau^\Delta)$ equal to 0.00 and one group with 0.02 throughout the experiment. Given the occurrence of a characteristic pattern of responding during the intruded stimulus at temporal locations with $p(S^R/R \cdot tau^\Delta)$ equal to 0.00, the intention was to observe the effect of $p(S^R/R \cdot tau^\Delta)$ at a value equal to 0.02 on this pattern. The main purposes of this study were to explore the effect of varying (1) $p(S^R/R \cdot tau^D)$ and (2) the temporal location of an "intruded stimulus" in tau^Δ on the pattern of responding during the tau^Δ period. Changing the location of the intruded stimulus in tau^Δ may provide further information about the function of that stimulus in the intruded stimulus paradigm.

METHOD

Subjects:

Nine white Carneaux retired breeder pigeons, approximately four years in age, were obtained from the Palmetto Pigeon Plant in Sumter, South Carolina. The subjects were housed in individual wire cages at the departmental vivarium. Purina Pigeon Grain, grit, and water were provided in unlimited amounts for 15 days, and the median weights from the last five days were selected as *ad libitum* weights. Through the deprivation of grain, the reinforcer, running weights were brought down to 80% of the *ad libitum* weights.

Apparatus:

A Lehigh Valley Electronics Model No. 1519C pigeon chamber with three keys on the work panel was used. The center key directly above the hopper was the operandum; the two side keys remained inoperative throughout the experiment. A 24 VDC power supply operated three General Electric #1820 miniature lamps: one in the houselight fixture above the operandum before and after each session, a second behind the translucent plastic operandum during a session, and a third over the grain hopper during reinforcement access time.

Experimental conditions were programmed with a system of relays, timers, counters, and Lehigh Valley Electronics probability generators. Data were recorded by Sodeco counters and a Gerbrands cumulative recorder.

Procedure:

Pecking responses were shaped to the translucent plastic key which was lighted white. Subjects pecked for 50 reinforcements on a continuous reinforcement schedule for five daily sessions. Reinforcement access time was two seconds.

All subjects were conditioned on the same baseline tau reinforcement schedule in order to assign subjects as equally as possible to groups on the basis of corrected response rates. Tau, the cycle length, was 60 seconds. $\overline{\text{Tau}}$, the proportion of tau^D to tau, was 0.1. These parameter values were held constant throughout the experiment. During tau^D the response key was lighted white; during tau^Δ the key was lighted green. The baseline probabilities of reinforcement were: $p(S^R/R \cdot \text{tau}^D) = 1.00$; $p(S^R/R \cdot \text{tau}^\Delta) = 0.00$. Reinforcement access time continued to be two seconds for the entire experiment and did not interrupt the scheduling of the 60 second cycle. Subjects were maintained on the baseline schedule for ten sessions; each session consisted of 30 cycles. Corrected response rates in tau^D were averaged for sessions eight, nine, and ten, and subjects were ranked according to these rates. The subjects were then assigned to three groups so that the sums of ranks were equal and at the same time so that any subjects who responded significantly in the tau^Δ extinction component were distributed among the three groups.

Table 1 presents the series of $p(S^R/R \cdot \text{tau}^D)$ and one $p(S^R/R \cdot \text{tau}^\Delta)$ for each group. With tau equal to 60 seconds and $\overline{\text{tau}}$ equal to 0.1, each pair of tau^D and tau^Δ probabilities completed the values of the

Table 1

Series of $p(S^R/R\cdot tau^D)$, recovery point $p(S^R/R\cdot tau^D)$, and $p(S^R/R\cdot tau^\Delta)$ for each group.

Group	$p(S^R/R\cdot tau^D)$	Recovery Point	$p(S^R/R\cdot tau^\Delta)$
A	1.00, 0.20, 0.05	0.05	0.00
B	1.00, 0.40, 0.10	1.00	0.00
C	1.00, 0.20, 0.05	0.20	0.02

parameters for one tau reinforcement schedule. Subjects in groups A and B completed one experimental point on the first tau reinforcement schedule during the previously described baseline by which subjects were assigned to groups. Group C was scheduled with $p(S^R/R \cdot tau^\Delta) = 0.02$ throughout the experiment. Preceding the first tau reinforcement schedule in table 1, group C was conditioned for 10 additional sessions in order to ensure responding in tau^Δ at the 0.02 probability. For group C only, the color on the key during tau^Δ was changed from green, which had been correlated with extinction, to red. $p(S^R/R \cdot tau^D)$ continued at 1.00; $p(S^R/R \cdot tau^\Delta)$ was decreased gradually from 1.00 to 0.02.

For each tau reinforcement schedule in table 1, ten 30 cycle daily sessions were conducted before the introduction of a six second change in key color (S^N). Subsequently, 10 sessions were conducted for each of four locations of S^N. The temporal locations of S^N in order of presentation were: 48.0-53.9, 36.0-41.9, 24.0-29.9, 12.0-17.9 seconds. These locations were designated S^1 through S^4 in the same order. The color of S^N on the key was white, the same as that during tau^D.

Assignments for the recovery of one ten session experimental point by each subject were made according to the following rules. First, each group was assigned randomly to one of the three $p(S^R/R \cdot tau^D)$ values in its series with the qualification that each one of the three ordinal positions in these series would be represented by one of the groups. The group assignments for recovery points to $p(S^R/R \cdot tau^D)$ are shown in table 1. Second, in the same manner each subject in a group was assigned randomly to S^1, S^2, or S^3 with the qualification that all three locations of S^N would be replicated. The recovery of experimental points was done immediately after the entire 50 sessions on the $p(S^R/R \cdot tau^D)$ value to which recovery was assigned.

Group C was the only group with reinforcement available in tau^Δ. Since group C could consume many more reinforcements in a 30 cycle session than the other groups, this group was limited to 60 reinforcements per session which approximated the maximum number secured by the other groups and prevented excessive increases in weights above running weights. Therefore, sessions for group C were terminated after 60 reinforcements or 30 cycles.

All response measures were averages of the last three of ten sessions on each experimental point.

RESULTS AND DISCUSSION

Figures one through nine present data for individual subjects in a format similar to Farmer and Schoenfeld (1966a). Corrected rates in responses per second were averaged for successive six second divisions of the tau cycle. To compute corrected rate, reinforcement access time was subtracted from session time. Corrected rate was preferred to running rate for comparison at different probabilities of reinforcement because running rate cannot be computed when the probability is 1.00. For running rate, reinforcement time and $PS^{R}P$ time are subtracted from session time. Theoretically, no time base exists for running rate at the 1.00 probability. In these figures the division between tau^{D} and tau^{Δ} has not been indicated. The first experimental point in each function is corrected rate during tau^{D}; the remaining points are corrected rates during tau^{Δ}. Each dot beneath the abscissa indicates the six second change in color on the response key. Tables two through ten present the numerical values for the tau^{D} and S^{N} corrected rates which are plotted in the figures. In addition, these tables list the average corrected rates for tau^{Δ} with the exception of rates during S^{N}, the average corrected rates during baseline for each S^{N} location in tau^{Δ}, and the range of corrected rates for each of the previously stated measures.

Generally, the corrected rates for the six subjects in groups A and B with $p(S^{R}/R \cdot tau^{D}) = 1.00$ and $p(S^{R}/R \cdot tau^{\Delta}) = 0.00$ did not produce the Farmer and Schoenfeld (1966a) results with respect to response rates during the intruded stimuli. Reference to Farmer and Schoenfeld (1966a) is always to the second experiment in which rates

Figure 1. Corrected rates in responses per second as a function of time within tau cycles for subject A-1. The tau^D probabilities of reinforcement $[p(S^R/R\cdot\text{tau}^D)]$ are shown above each column; the tau^Δ probability of reinforcement $[p(S^R/R\cdot\text{tau}^\Delta)]$ was equal to 0.00 throughout the experiment. The sequence of the experiment proceeded from top to bottom within columns and from left to right across columns. One recovery function (dots) was determined after the sequence within that column. Each function is composed of points at successive six second intervals. The dot below the abscissa at zero seconds indicates the onset of a six second light (S^N) correlated with tau^D; other dots indicate the onset of S^N at 48, 36, 24, or 12 seconds in tau^Δ.

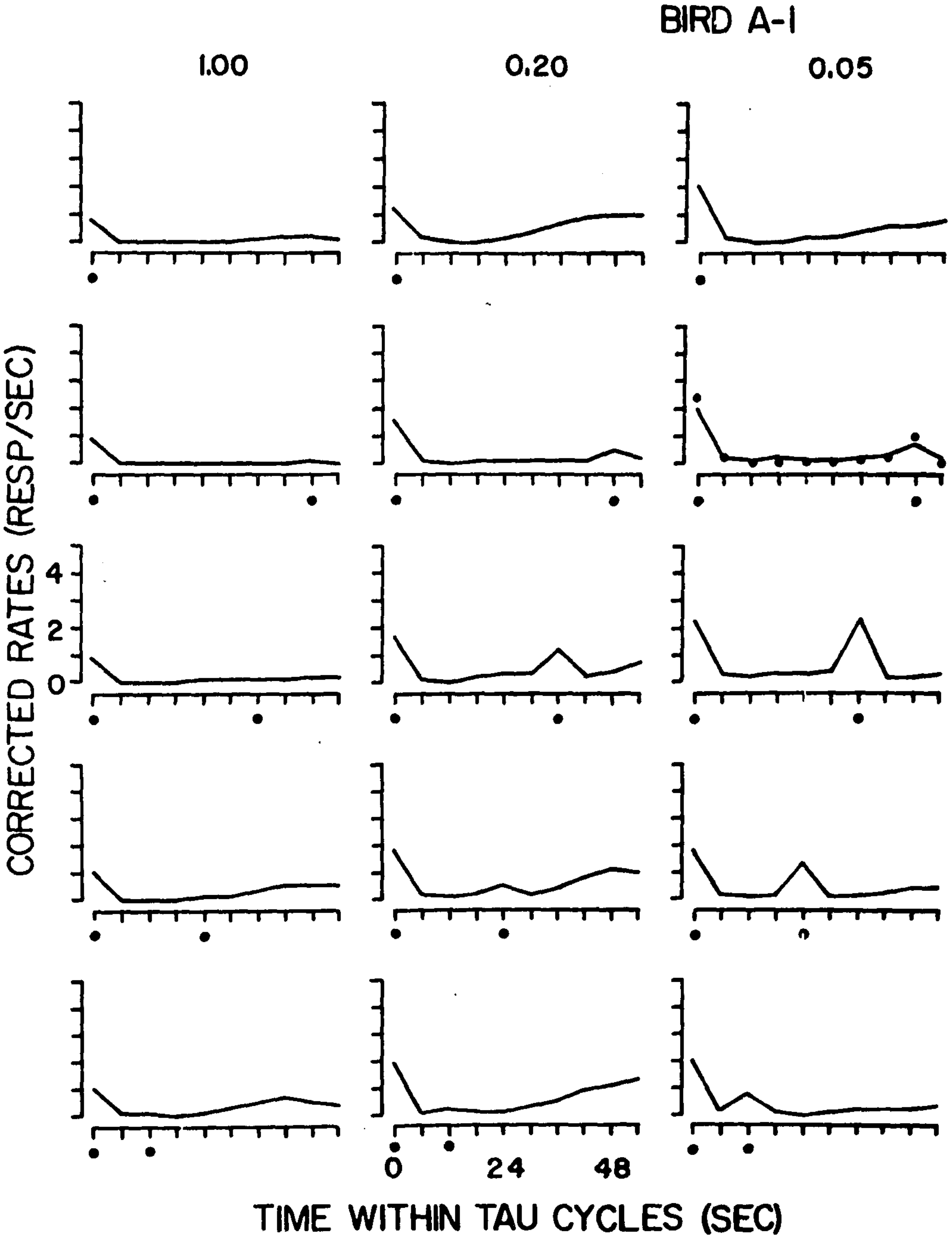

BIRD A-1
1.00
0.20
0.05
CORRECTED RATES (RESP/SEC)
4
2
0
0
24
48
TIME WITHIN TAU CYCLES (SEC)

Figure 2. Corrected rates in responses per second as a function of time within tau cycles for subject A-2. $p(S^R/R \cdot tau^D)$ is shown above each column; $p(S^R/R \cdot tau^\Delta)$ was equal to 0.00 throughout the experiment. The sequence of the experiment proceeded from top to bottom within columns and from left to right across columns. One recovery function (dots) was determined after the sequence within that column. Each function is composed of points at successive six second intervals. The dot below the abscissa at zero seconds indicates the onset of a six second light (S^N) correlated with tau^D; other dots indicate the onset of S^N at 48, 36, 24, or 12 seconds in tau^Δ.

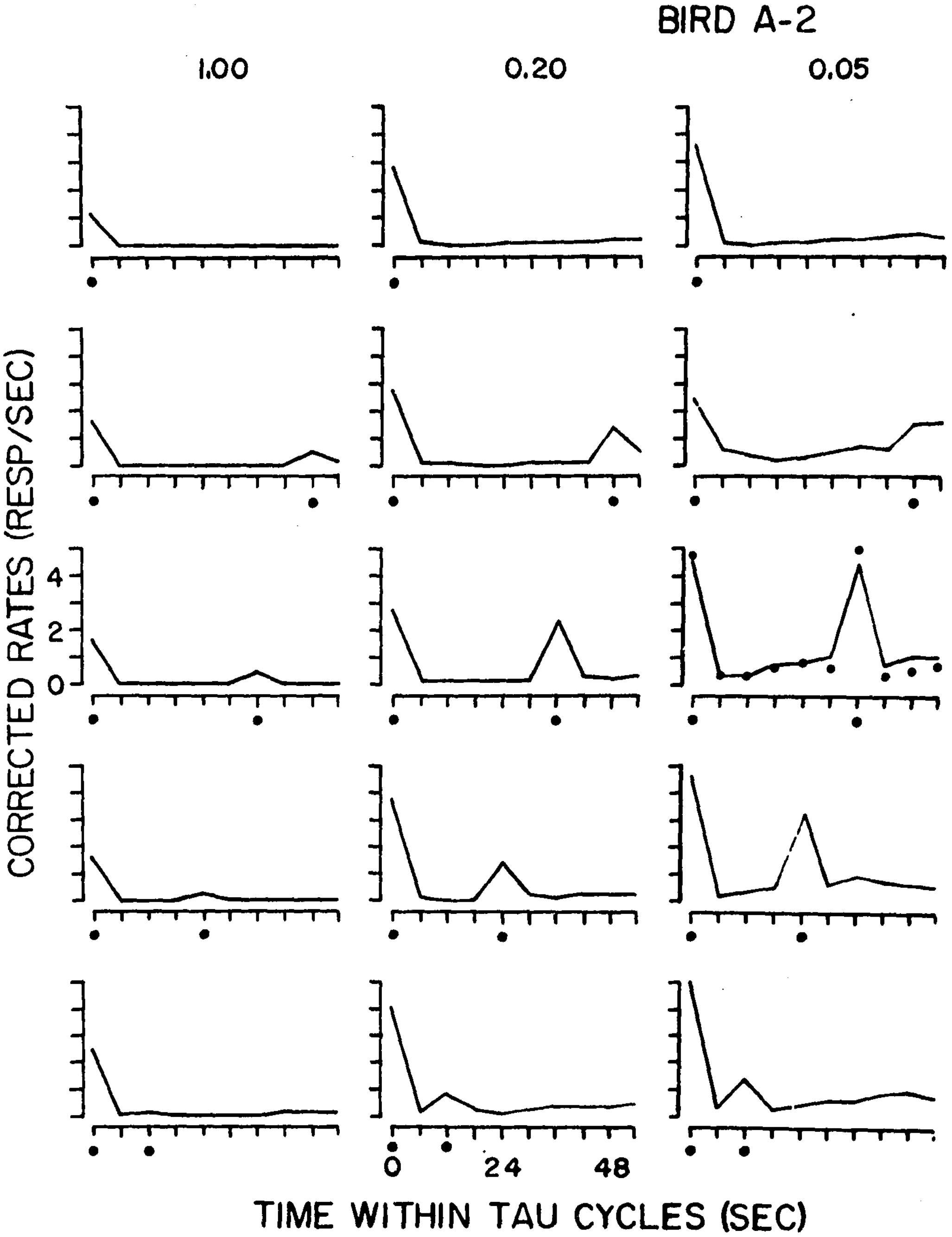

BIRD A-2
1.00
0.20
0.05
CORRECTED RATES (RESP/SEC)
4
2
0
0
24
48
TIME WITHIN TAU CYCLES (SEC)

Figure 3. Corrected rates in responses per second as a function of time within tau cycles for subject A-3. $p(S^R/R\cdot\text{tau}^D)$ is shown above each column; $p(S^R/R\cdot\text{tau}^\Delta)$ was equal to 0.00 throughout the experiment. The sequence of the experiment proceeded from top to bottom within columns and from left to right across columns. One recovery function (dots) was determined after the sequence within that column. Each function is composed of points at successive six second intervals. The dot below the abscissa at zero seconds indicates the onset of a six second light (S^N) correlated with tau^D; other dots indicate the onset of S^N at 48, 36, 24, or 12 seconds in tau^Δ.

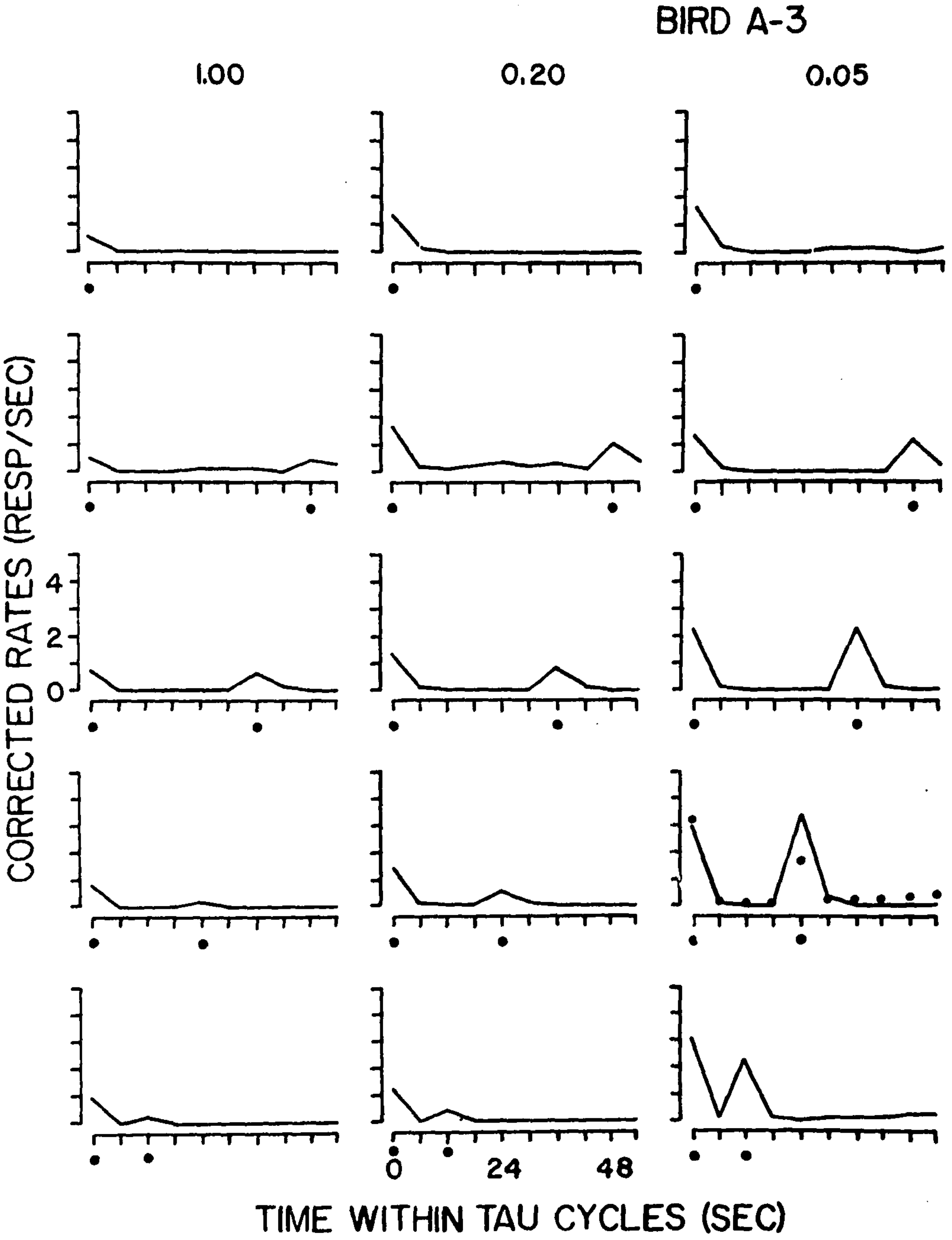

BIRD A-3
1.00
0.20
0.05
CORRECTED RATES (RESP/SEC)
0
2
4
0
24
48
TIME WITHIN TAU CYCLES (SEC)

Figure 4. Corrected rates in responses per second as a function of time within tau cycles for subject B-1. $p(S^R/R \cdot tau^D)$ is shown above each column; $p(S^R/R \cdot tau^\Delta)$ was equal to 0.00 throughout the experiment. The sequence of the experiment proceeded from top to bottom within columns and from left to right across columns. One recovery function (dots) was determined after the sequence within that column. Each function is composed of points at successive six second intervals. The dot below the abscissa at zero seconds indicates the onset of a six second light (S^N) correlated with tau^D; other dots indicate the onset of S^N at 48, 36, 24, or 12 seconds in tau^Δ.

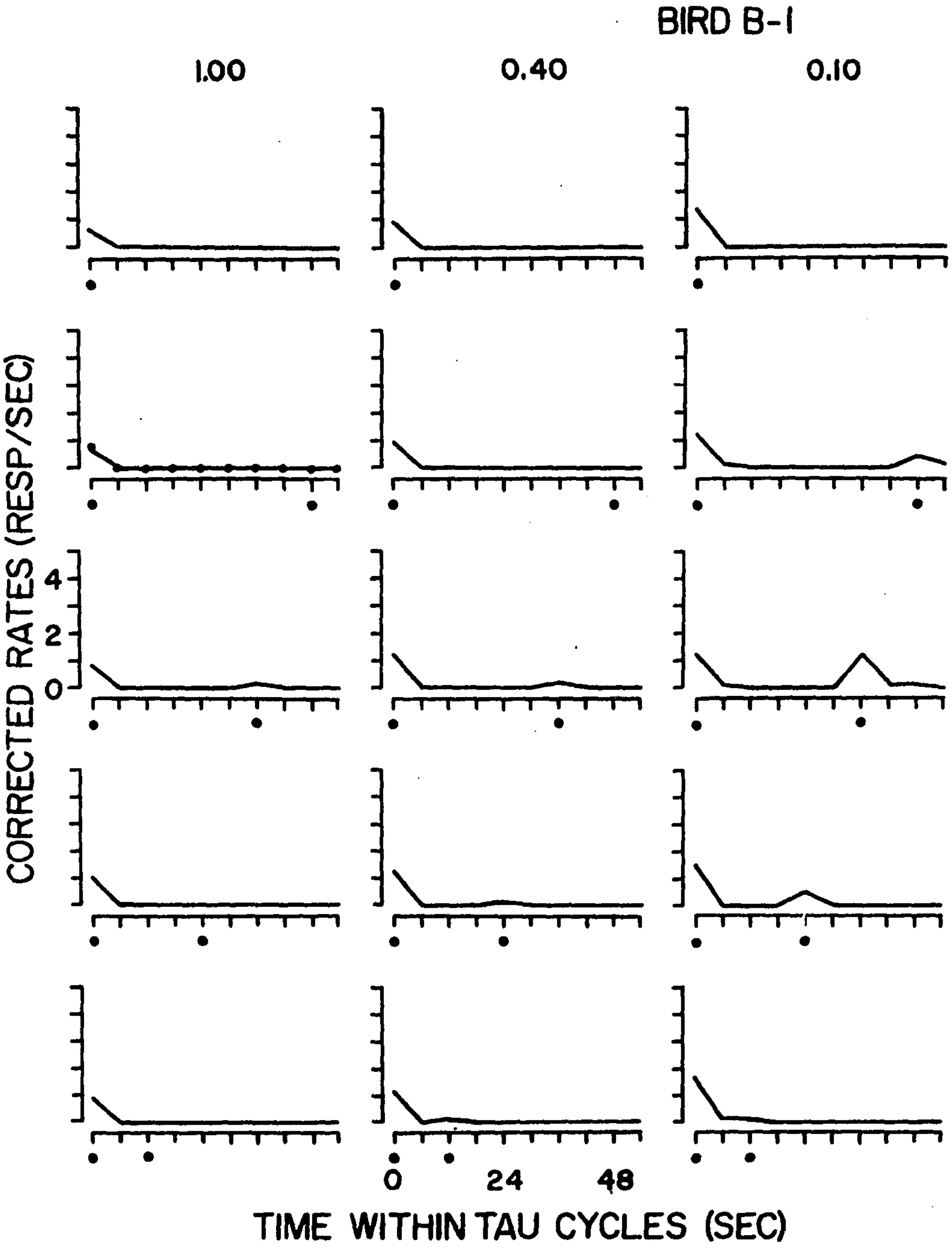

BIRD B-1
1.00
0.40
0.10
CORRECTED RATES (RESP/SEC)
4
2
0
0
24
48
TIME WITHIN TAU CYCLES (SEC)

Figure 5. Corrected rates in responses per second as a function of time within tau cycles for subject B-2. $p(S^R/R \cdot tau^D)$ is shown above each column; $p(S^R/R \cdot tau^\Delta)$ was equal to 0.00 throughout the experiment. The sequence of the experiment proceeded from top to bottom within columns and from left to right across columns. One recovery function (dots) was determined after the sequence within that column. Each function is composed of points at successive six second intervals. The dot below the abscissa at zero seconds indicates the onset of a six second light (S^N) correlated with tau^D; other dots indicate the onset of S^N at 48, 36, 24, or 12 seconds in tau^Δ.

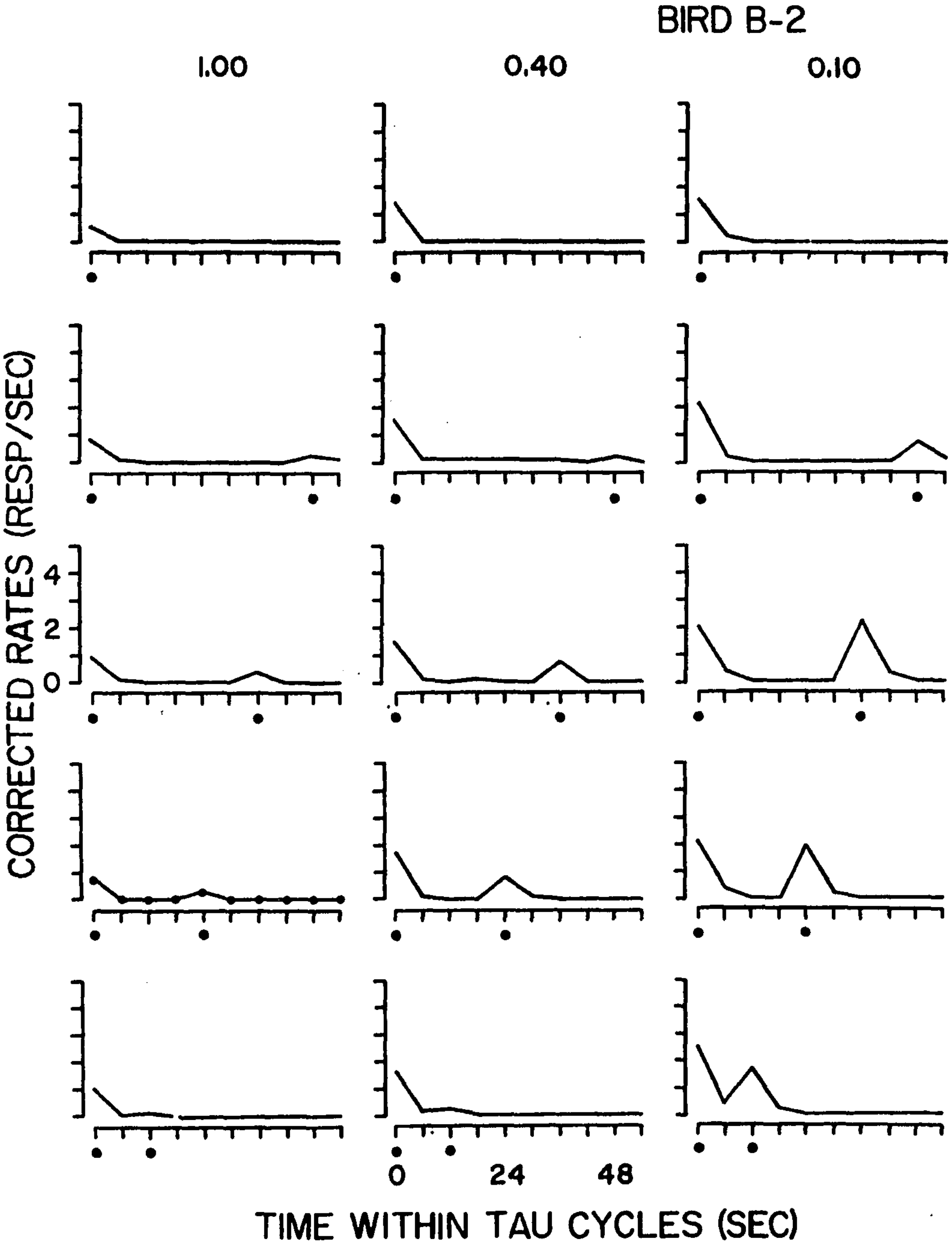

BIRD B-2
1.00
0.40
0.10
CORRECTED RATES (RESP/SEC)
4
2
0
0
24
48
TIME WITHIN TAU CYCLES (SEC)

Figure 6. Corrected rates in responses per second as a function of time within tau cycles for subject B-3. $p(S^R/R \cdot tau^D)$ is shown above each column; $p(S^R/R \cdot tau^\Delta)$ was equal to 0.00 throughout the experiment. The sequence of the experiment proceeded from top to bottom within columns and from left to right across columns. One recovery function (dots) was determined after the sequence within that column. Each function is composed of points at successive six second intervals. The dot below the abscissa at zero seconds indicates the onset of a six second light (S^N) correlated with tau^D; other dots indicate the onset of S^N at 48, 36, 24, or 12 seconds in tau^Δ.

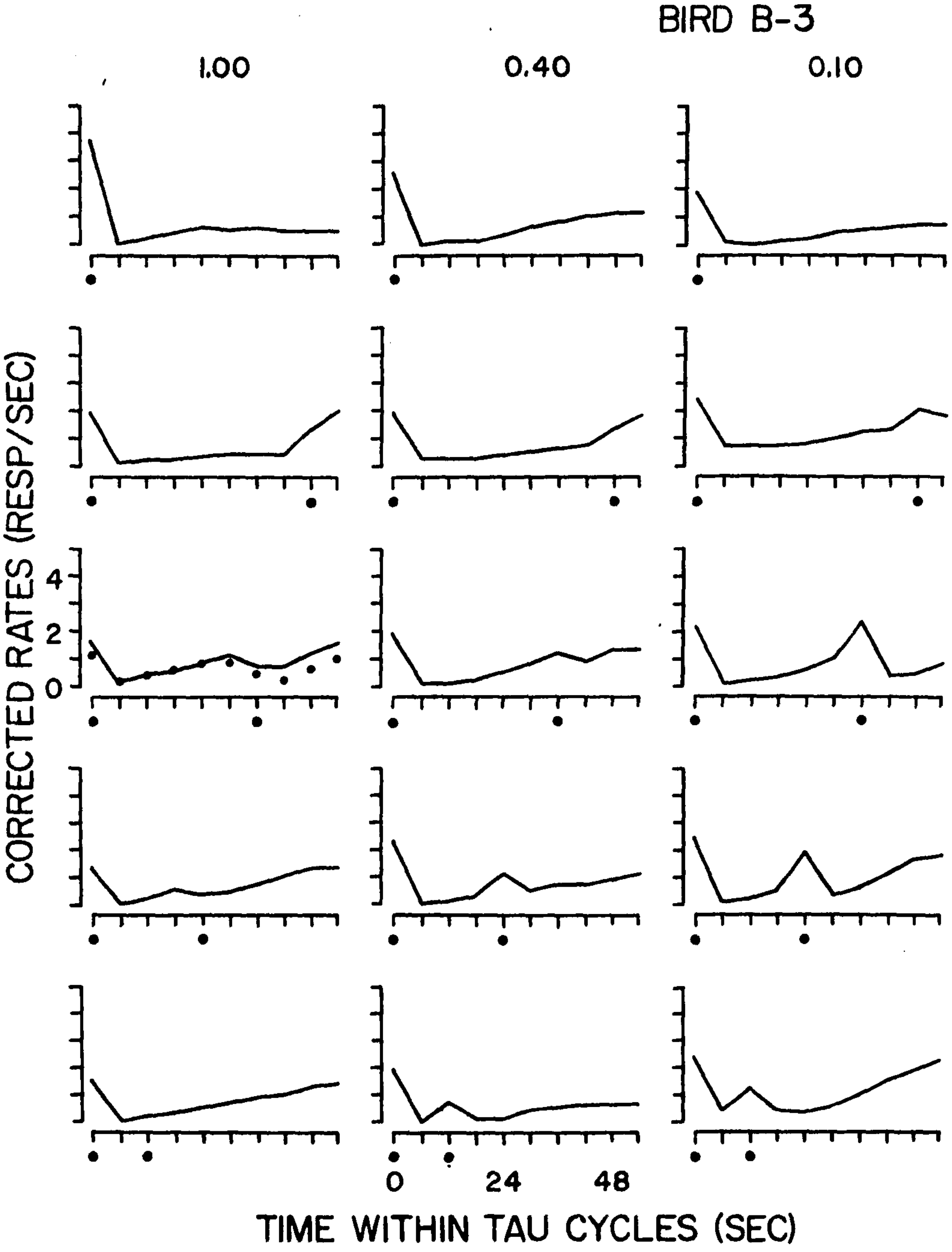

BIRD B-3
1.00
0.40
0.10
CORRECTED RATES (RESP/SEC)
4
2
0
0
24
48
TIME WITHIN TAU CYCLES (SEC)

Figure 7. Corrected rates in responses per second as a function of time within tau cycles for subject C-1. $p(S^R/R \cdot tau^D)$ is shown above each column; $p(S^R/R \cdot tau^\Delta)$ was equal to 0.02 throughout the experiment. The sequence of the experiment proceeded from top to bottom within columns and from left to right across columns. One recovery function (dots) was determined after the sequence within that column. Each function is composed of points at successive six second intervals. The dot below the abscissa at zero seconds indicates the onset of a six second light (S^N) correlated with tau^D; other dots indicate the onset of S^N at 48, 36, 24, or 12 seconds in tau^Δ.

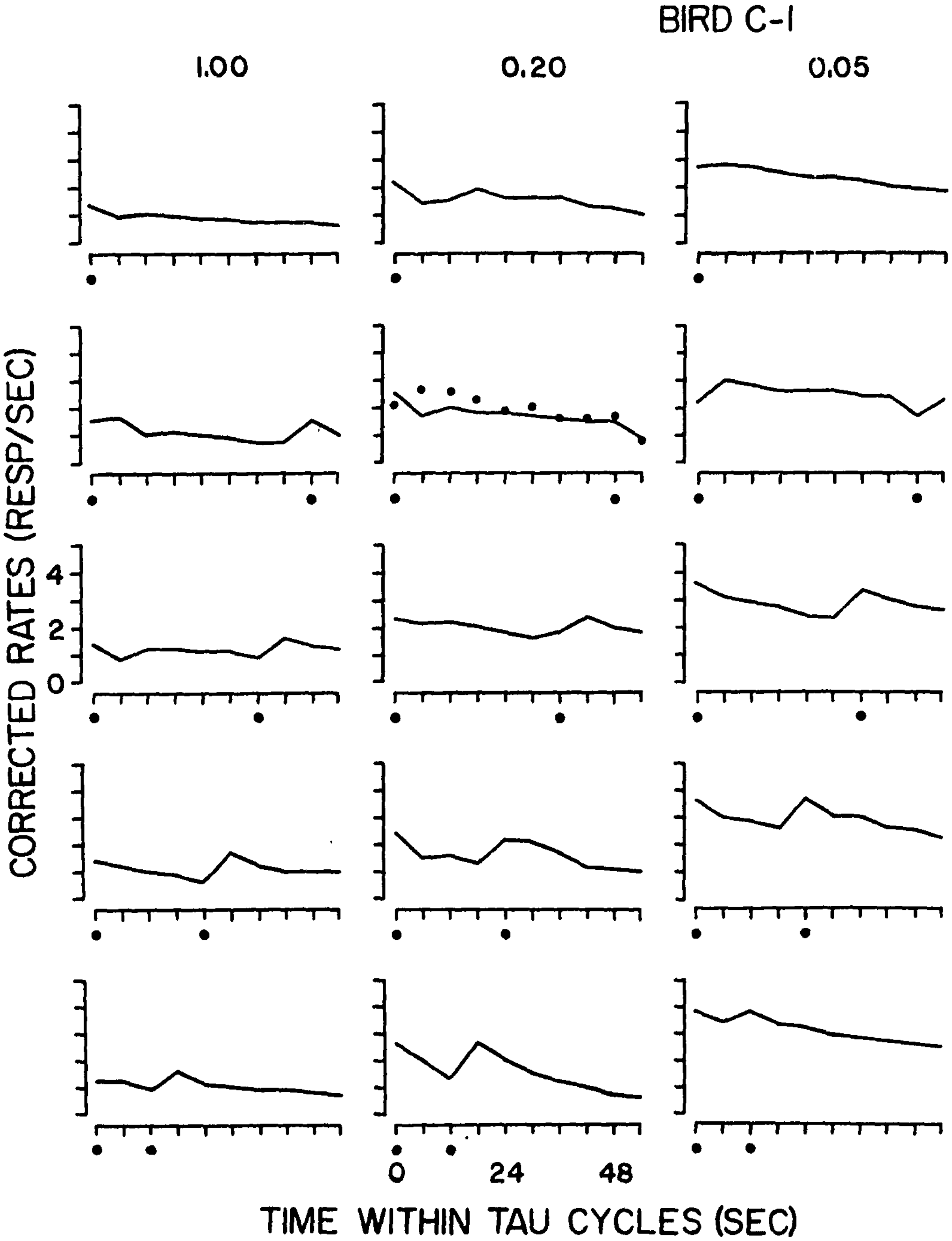

BIRD C-1
1.00
0.20
0.05
CORRECTED RATES (RESP/SEC)
4
2
0
0
24
48
TIME WITHIN TAU CYCLES (SEC)

Figure 8. Corrected rates in responses per second as a function of time within tau cycles for subject C-2. $p(S^R/R \cdot tau^D)$ is shown above each column; $p(S^R/R \cdot tau^\Delta)$ was equal to 0.02 throughout the experiment. The sequence of the experiment proceeded from top to bottom within columns and from left to right across columns. One recovery function (dots) was determined after the sequence within that column. Each function is composed of points at successive six second intervals. The dot below the abscissa at zero seconds indicates the onset of a six second light (S^N) correlated with tau^D; other dots indicate the onset of S^N at 48, 36, 24, or 12 seconds in tau^Δ.

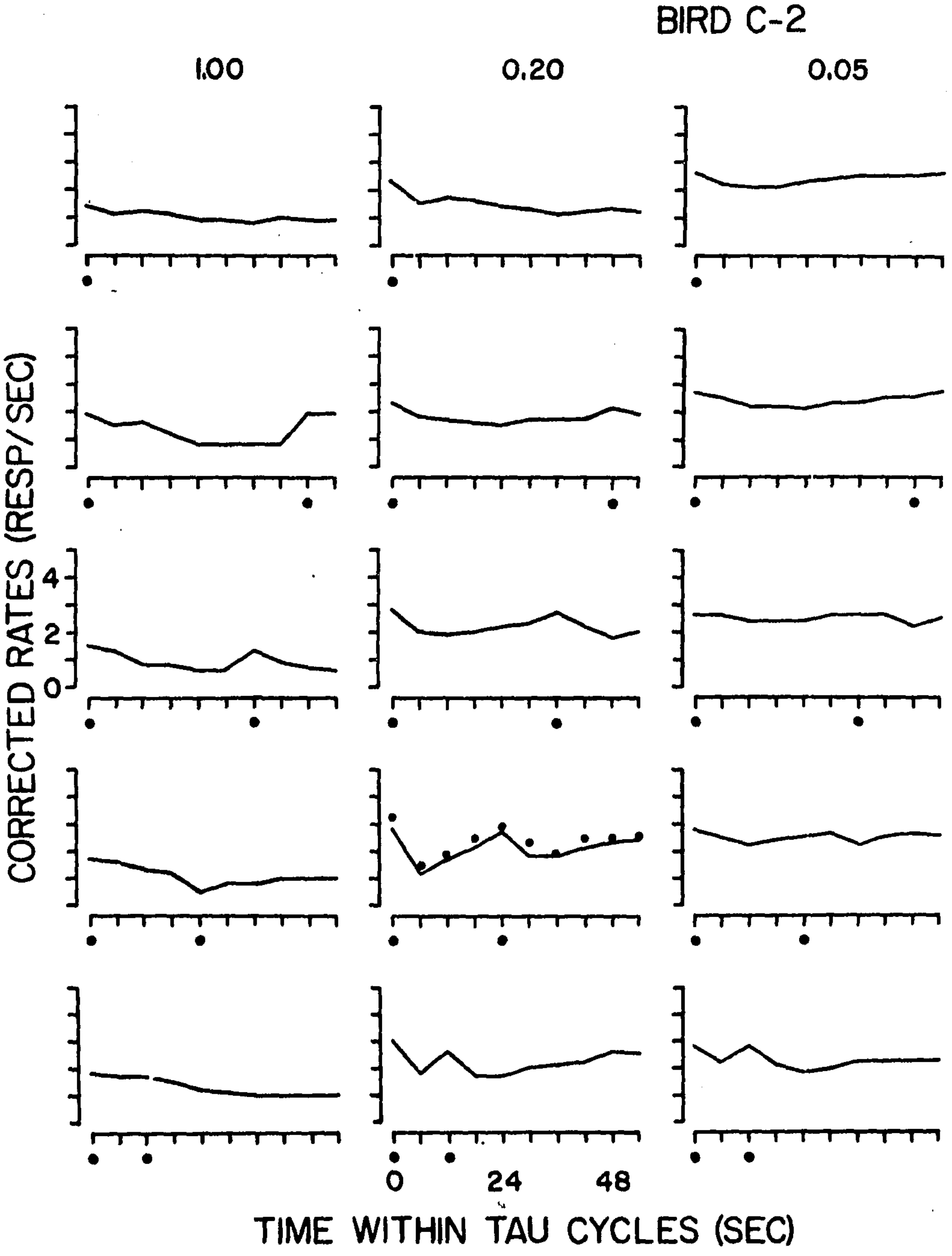

BIRD C-2
1.00
0.20
0.05
CORRECTED RATES (RESP/SEC)
4
2
0
0
24
48
TIME WITHIN TAU CYCLES (SEC)

Figure 9. Corrected rates in responses per second as a function of time within tau cycles for subject C-3. $p(S^R/R\cdot tau^D)$ is shown above each column; $p(S^R/R\cdot tau^\Delta)$ was equal to 0.02 throughout the experiment. The sequence of the experiment proceeded from top to bottom within columns and from left to right across columns. One recovery function (dots) was determined after the sequence within that column. Each function is composed of points at successive six second intervals. The dot below the abscissa at zero seconds indicates the onset of a six second light (S^N) correlated with tau^D; other dots indicate the onset of S^N at 48, 36, 24, or 12 seconds in tau^Δ.

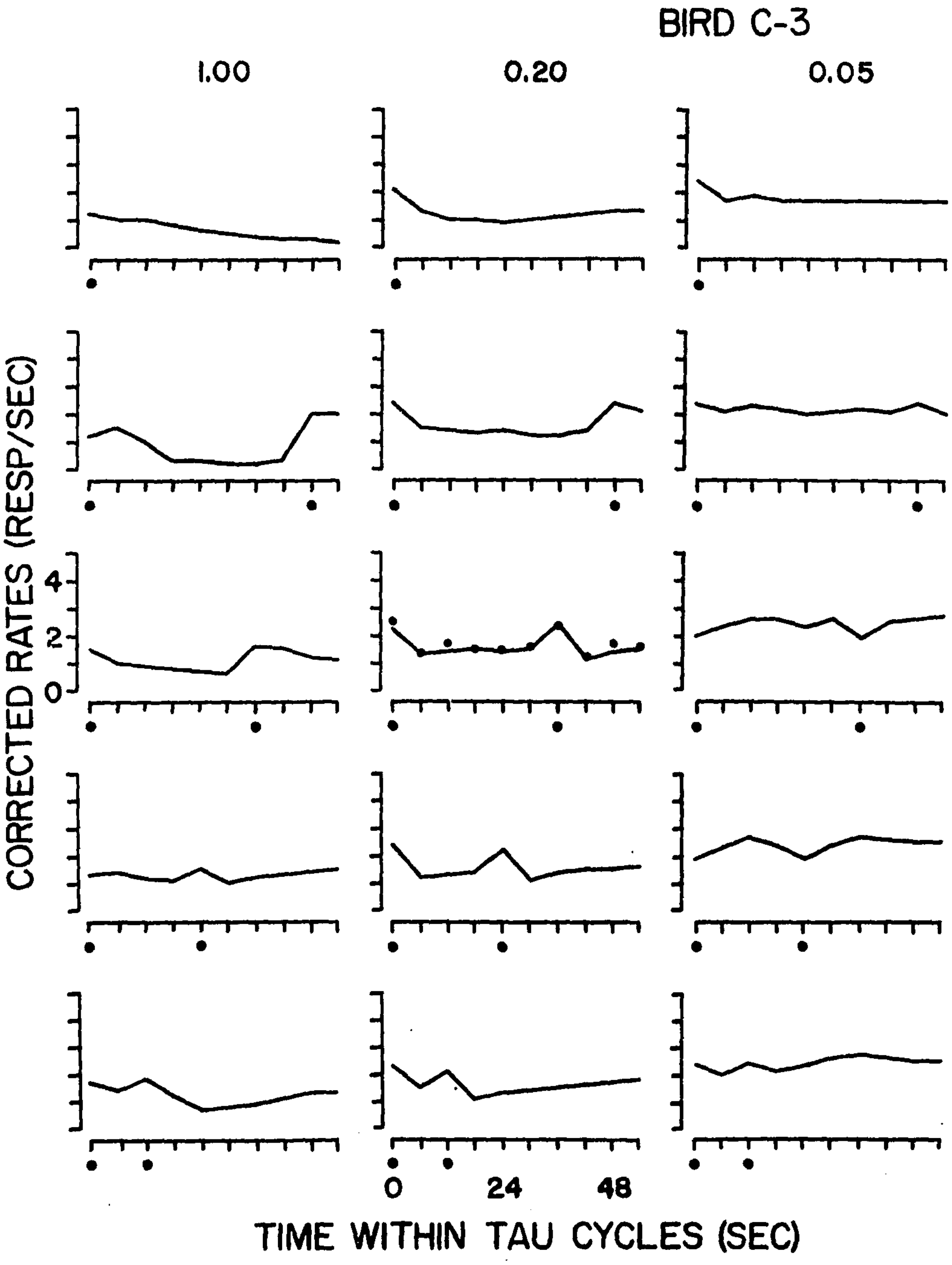

BIRD C-3
1.00
0.20
0.05
CORRECTED RATES (RESP/SEC)
4
2
0
0
24
48
TIME WITHIN TAU CYCLES (SEC)

Table 2

Mean corrected rates and range of corrected rates in responses per second during tau^{D}, tau^{Δ}, S^{N}, and S^{N} location during baseline as a function of $p(S^{R}/R\cdot \mathrm{tau}^{D})$ and S^{N} location for subject A-1.

$p(S^{R}/R\cdot \mathrm{tau}^{D})$	S^{N} Location	tau^{D}		tau^{Δ}		S^{N}		S^{N} Baseline	
1.00	Baseline	0.84	0.82-0.85	0.08	0.05-0.11				
	1	0.85	0.80-0.86	0.01	0.01-0.01	0.05	0.02-0.07	0.18	0.11-0.24
	2	0.90	0.84-0.95	0.08	0.05-0.10	0.13	0.05-0.17	0.14	0.10-0.24
	3	1.03	0.95-1.15	0.24	0.21-0.27	0.10	0.09-0.11	0.03	0.02-0.05
	4	1.03	0.96-1.15	0.33	0.32-0.35	0.08	0.05-0.13	0.01	0.00-0.01
0.20	Baseline	1.20	1.12-1.36	0.47	0.38-0.52				
	1	1.54	1.37-1.70	0.10	0.07-0.12	0.48	0.33-0.63	0.97	0.85-1.18
	2	1.56	1.46-1.72	0.28	0.25-0.30	1.19	1.03-1.36	0.72	0.66-1.01
	3	1.81	1.79-1.84	0.48	0.43-0.53	0.46	0.27-0.68	0.16	0.08-0.25
	4	1.86	1.83-1.92	0.52	0.51-0.53	0.22	0.09-0.47	0.01	0.00-0.02
0.05	Baseline	1.96	1.84-2.12	0.32	0.32-0.33				
	1	2.04	1.83-2.21	0.16	0.08-0.22	0.70	0.39-1.08	0.63	0.47-0.73
	2	2.21	2.12-2.30	0.26	0.21-0.33	2.25	2.19-2.33	0.35	0.31-0.37
	3	1.82	1.66-1.91	0.19	0.18-0.20	1.32	0.89-1.69	0.16	0.14-0.18
	4	2.00	1.85-2.16	0.15	0.13-0.17	0.79	0.53-1.26	0.01	0.00-0.03
	Recovery								
	1	2.51	2.26-2.81	0.07	0.06-0.08	0.98	0.74-1.12	0.63	0.47-0.73

Table 3

Mean corrected rates and range of corrected rates in responses per second during tau^D, tau^Δ, S^N, and S^N location during baseline as a function of $p(S^R/R \cdot tau^D)$ and S^N location for subject A-2.

$p(S^R/R \cdot tau^D)$	S^N Location	tau^D		tau^Δ		S^N		S^N Baseline	
1.00	Baseline	1.10	0.94-1.28	0.00	0.00-0.00				
	1	1.63	1.62-1.64	0.01	0.01-0.02	0.45	0.38-0.49	0.00	0.00-0.01
	2	1.64	1.48-1.72	0.01	0.00-0.01	0.35	0.30-0.42	0.00	0.00-0.01
	3	1.57	1.39-1.80	0.02	0.01-0.03	0.24	0.18-0.32	0.00	0.00-0.00
	4	2.44	2.32-2.57	0.03	0.02-0.04	0.10	0.05-0.13	0.00	0.00-0.00
0.20	Baseline	2.81	2.61-2.93	0.09	0.07-0.10				
	1	2.74	2.59-2.83	0.12	0.11-0.14	1.35	0.99-1.71	0.15	0.12-0.17
	2	2.66	2.29-2.91	0.14	0.11-0.19	2.30	2.14-2.48	0.11	0.08-0.14
	3	3.72	3.48-4.07	0.14	0.12-0.16	1.44	1.10-1.72	0.06	0.04-0.08
	4	3.96	3.78-4.27	0.22	0.17-0.26	0.80	0.47-1.34	0.02	0.00-0.03
0.05	Baseline	3.49	2.77-3.99	0.20	0.19-0.21				
	1	2.38	2.09-2.56	0.62	0.49-0.73	1.50	1.42-1.66	0.38	0.33-0.48
	2	4.48	4.30-4.75	0.69	0.57-0.82	4.35	4.21-4.60	0.24	0.21-0.28
	3	4.64	4.50-4.84	0.54	0.51-0.57	3.23	2.70-3.89	0.14	0.12-0.18
	4	5.01	4.94-5.06	0.56	0.44-0.66	1.18	1.04-1.27	0.01	0.01-0.02
	Recovery								
	2	4.79	4.63-5.03	0.54	0.51-0.56	4.96	4.59-5.24	0.24	0.21-0.28

Table 4

Mean corrected rates and range of corrected rates in responses per second during tau^D, tau^{Δ}, S^N, and S^N location during baseline as a function of $p(S^R/R\cdot\text{tau}^D)$ and S^N location for subject A-3.

$p(S^R/R\cdot\text{tau}^D)$	S^N Location	tau^D	tau^{Δ}	S^N	S^N Baseline
1.00	Baseline	0.54 0.48-0.59	0.01 0.00-0.01		
	1	0.49 0.34-0.73	0.08 0.04-0.13	0.41 0.23-0.71	0.00 0.00-0.01
	2	0.73 0.58-0.81	0.01 0.01-0.01	0.64 0.51-0.74	0.00 0.00-0.00
	3	0.76 0.70-0.79	0.01 0.00-0.01	0.20 0.16-0.27	0.01 0.01-0.02
	4	0.92 0.91-0.94	0.00 0.00-0.01	0.17 0.10-0.27	0.00 0.00-0.01
0.20	Baseline	1.32 1.19-1.43	0.01 0.00-0.01		
	1	1.62 1.46-1.78	0.22 0.14-0.36	0.95 0.67-1.18	0.01 0.01-0.01
	2	1.33 1.09-1.48	0.03 0.01-0.06	0.84 0.66-1.02	0.00 0.00-0.00
	3	1.36 1.31-1.41	0.03 0.02-0.04	0.50 0.43-0.57	0.00 0.00-0.00
	4	1.24 1.12-1.37	0.01 0.01-0.02	0.40 0.36-0.46	0.00 0.00-0.00
0.05	Baseline	1.61 1.34-1.75	0.06 0.04-0.09		
	1	1.28 1.04-1.45	0.05 0.03-0.07	1.05 0.89-1.28	0.04 0.01-0.06
	2	2.15 1.99-2.39	0.04 0.03-0.05	2.22 1.97-2.42	0.06 0.01-0.13
	3	2.85 2.53-3.22	0.05 0.04-0.05	3.25 3.07-3.57	0.03 0.00-0.06
	4	2.99 2.81-3.27	0.11 0.07-0.15	2.21 2.07-2.47	0.03 0.00-0.06
	Recovery				
	3	3.18 3.00-3.33	0.20 0.18-0.22	1.63 1.44-1.86	0.03 0.00-0.06

Table 5

Mean corrected rates and range of corrected rates in responses per second during tau^{D}, tau$^{\Delta}$, S^{N}, and S^{N} location during baseline as a function of p(S^{R}/R·tau^{D}) and S^{N} location for subject B-1.

p(S^{R}/R·tau^{D})	S^{N} Location	tau^{D}		tau$^{\Delta}$		S^{N}		S^{N} Baseline	
1.00	Baseline	0.59	0.51-0.64	0.01	0.00-0.01				
	1	0.62	0.54-0.77	0.00	0.00-0.00	0.04	0.03-0.06	0.02	0.01-0.03
	2	0.84	0.76-0.90	0.01	0.01-0.01	0.10	0.08-0.14	0.01	0.00-0.01
	3	0.98	0.97-1.00	0.01	0.01-0.02	0.02	0.00-0.04	0.00	0.00-0.01
	4	0.89	0.85-0.93	0.01	0.01-0.01	0.03	0.01-0.05	0.00	0.00-0.00
	Recovery								
	1	0.81	0.67-0.93	0.01	0.00-0.01	0.04	0.01-0.06	0.02	0.01-0.03
0.40	Baseline	0.94	0.82-1.08	0.01	0.01-0.01				
	1	0.85	0.83-0.88	0.00	0.00-0.01	0.03	0.03-0.04	0.01	0.00-0.02
	2	1.23	1.13-1.31	0.01	0.01-0.02	0.22	0.10-0.38	0.01	0.00-0.01
	3	1.17	1.04-1.29	0.01	0.01-0.01	0.12	0.01-0.23	0.01	0.01-0.01
	4	1.11	1.04-1.23	0.01	0.01-0.01	0.06	0.03-0.13	0.00	0.00-0.00
0.10	Baseline	1.28	1.14-1.38	0.01	0.01-0.01				
	1	1.24	1.23-1.26	0.02	0.02-0.02	0.42	0.30-0.49	0.01	0.00-0.01
	2	1.23	0.88-1.51	0.05	0.04-0.06	1.23	0.86-1.62	0.02	0.01-0.02
	3	1.51	1.49-1.55	0.02	0.02-0.02	0.50	0.34-0.73	0.01	0.00-0.01
	4	1.61	1.54-1.66	0.01	0.01-0.02	0.07	0.02-0.09	0.00	0.00-0.01

Table 6

Mean corrected rates and range of corrected rates in responses per second during tau^{D}, tau$^{\Delta}$, S^{N}, and S^{N} location during baseline as a function of p(S^{R}/R·tau^{D}) and S^{N} location for subject B-2.

p(S^{R}/R·tau^{D})	S^{N} Location	tau^{D}		tau$^{\Delta}$		S^{N}		S^{N} Baseline	
1.00	Baseline	0.51	0.43-0.56	0.01	0.00-0.01				
	1	0.76	0.69-0.87	0.04	0.04-0.04	0.22	0.07-0.33	0.01	0.00-0.01
	2	0.89	0.86-0.94	0.01	0.01-0.02	0.39	0.33-0.47	0.00	0.00-0.01
	3	0.79	0.72-0.90	0.00	0.00-0.00	0.32	0.31-0.33	0.01	0.00-0.01
	4	1.03	1.00-1.10	0.01	0.01-0.01	0.13	0.08-0.18	0.01	0.00-0.01
	Recovery								
	3	0.74	0.69-0.79	0.01	0.01-0.01	0.30	0.26-0.38	0.01	0.00-0.01
0.40	Baseline	1.44	1.34-1.58	0.01	0.00-0.01				
	1	1.47	1.29-1.66	0.07	0.05-0.09	0.18	0.11-0.25	0.00	0.00-0.01
	2	1.44	1.28-1.60	0.03	0.03-0.04	0.73	0.61-0.91	0.01	0.00-0.02
	3	1.73	1.66-1.80	0.02	0.01-0.02	0.75	0.56-0.93	0.01	0.00-0.02
	4	1.61	1.46-1.80	0.01	0.01-0.02	0.18	0.13-0.22	0.01	0.01-0.02
0.10	Baseline	1.51	1.31-1.66	0.02	0.02-0.03				
	1	2.11	2.07-2.16	0.05	0.04-0.06	0.68	0.58-0.80	0.00	0.00-0.00
	2	1.96	1.77-2.27	0.09	0.07-0.10	2.21	1.92-2.64	0.01	0.01-0.01
	3	2.13	1.99-2.28	0.07	0.05-0.10	1.94	1.64-2.27	0.01	0.00-0.02
	4	2.54	2.35-2.69	0.07	0.06-0.10	1.74	1.38-2.34	0.00	0.00-0.01

Table 7

Mean corrected rates and range of corrected rates in responses per second during tau^D, tau^Δ, S^N, and S^N location during baseline as a function of $p(S^R/R\cdot tau^D)$ and S^N location for subject B-3.

$p(S^R/R\cdot tau^D)$	S^N Location	tau^D	tau^Δ	S^N	S^N Baseline
1.00	Baseline	3.72 3.55-3.83	0.42 0.34-0.51		
	1	1.90 1.61-2.25	0.50 0.40-0.56	1.33 1.26-1.38	0.52 0.40-0.67
	2	1.58 1.39-1.77	0.74 0.71-0.76	0.66 0.60-0.73	0.57 0.53-0.66
	3	1.32 1.23-1.43	0.69 0.60-0.76	0.26 0.21-0.34	0.55 0.47-0.67
	4	1.45 1.30-1.61	0.78 0.73-0.81	0.23 0.21-0.27	0.21 0.16-0.32
	Recovery 2	1.08 1.03-1.15	0.56 0.52-0.59	0.36 0.31-0.39	0.57 0.53-0.66
0.40	Baseline	2.60 2.49-2.71	0.59 0.55-0.62		
	1	1.87 1.79-1.92	0.63 0.57-0.74	1.30 1.24-1.41	1.13 1.06-1.22
	2	1.94 1.71-2.10	0.63 0.52-0.72	1.22 1.10-1.33	0.82 0.74-0.93
	3	2.33 2.21-2.45	0.54 0.41-0.62	1.09 0.99-1.19	0.29 0.17-0.43
	4	1.85 1.69-1.99	0.38 0.31-0.44	0.72 0.60-0.93	0.05 0.01-0.08
0.10	Baseline	1.82 1.61-1.97	0.37 0.33-0.42		
	1	2.37 2.30-2.41	1.01 0.86-1.16	2.02 1.86-2.15	0.69 0.64-0.73
	2	2.14 1.97-2.33	0.46 0.43-0.49	2.26 2.19-2.34	0.50 0.34-0.61
	3	2.41 2.30-2.51	0.77 0.65-0.91	1.91 1.72-2.14	0.22 0.17-0.26
	4	2.32 2.20-2.46	1.00 0.85-1.08	1.19 0.97-1.44	0.03 0.00-0.07

Table 8

Mean corrected rates and range of corrected rates in responses per second during tau^{D}, tau^{Δ}, S^{N}, and S^{N} location during baseline as a function of $p(S^{R}/R\cdot\mathrm{tau}^{D})$ and S^{N} location for subject C-1.

$p(S^{R}/R\cdot\mathrm{tau}^{D})$	S^{N} Location	tau^{D}	tau^{Δ}	S^{N}	S^{N} Baseline
1.00	Baseline	1.30 1.24-1.40	0.72 0.67-0.88		
	1	1.48 1.27-1.77	0.98 0.86-1.06	1.49 1.15-1.71	0.69 0.54-0.92
	2	1.42 1.28-1.57	1.18 1.17-1.19	0.85 0.74-1.00	0.72 0.63-0.76
	3	1.43 1.11-1.74	1.10 0.92-1.28	0.64 0.54-0.77	0.76 0.62-0.92
	4	1.24 1.05-1.46	1.02 0.97-1.07	0.94 0.67-1.23	1.00 0.85-1.16
0.20	Baseline	2.24 2.08-2.39	1.42 1.35-1.52		
	1	2.48 2.34-2.69	1.63 1.51-1.69	1.51 1.42-1.57	1.15 1.10-1.19
	2	2.32 2.29-2.35	1.91 1.69-2.07	1.79 1.67-1.96	1.58 1.49-1.68
	3	2.42 2.28-2.56	1.44 1.32-1.58	2.18 2.04-2.34	1.59 1.44-1.68
	4	2.60 2.50-2.65	1.44 1.30-1.59	1.33 1.12-1.61	1.45 1.35-1.63
	Recovery				
	1	2.14 2.02-2.46	1.92 1.74-2.02	1.71 1.69-1.80	1.15 1.10-1.19
0.05	Baseline	2.73 2.50-2.94	2.27 2.20-2.36		
	1	2.22 2.00-2.55	2.61 2.59-2.65	1.70 1.64-1.77	1.89 1.84-1.97
	2	3.57 3.38-3.76	2.69 2.32-2.92	3.30 3.11-3.47	2.18 2.08-2.36
	3	3.61 3.30-4.07	2.70 2.53-2.81	3.72 3.51-4.08	2.25 2.13-2.39
	4	3.81 3.74-3.87	2.92 2.87-2.98	3.80 3.52-4.17	2.74 2.55-2.88

Table 9

Mean corrected rates and range of corrected rates in responses per second during tau^{D}, tau^{Δ}, S^{N}, and S^{N} location during baseline as a function of $p(S^{R}/R\cdot\text{tau}^{D})$ and S^{N} location for subject C-2.

$p(S^{R}/R\cdot\text{tau}^{D})$	S^{N} Location	tau^{D}	tau^{Δ}	S^{N}	S^{N} Baseline
1.00	Baseline	1.40 1.04-1.62	0.97 0.84-1.08		
	1	1.86 1.68-1.96	1.16 1.09-1.25	1.90 1.80-2.01	0.89 0.79-0.96
	2	1.45 1.32-1.52	0.78 0.75-0.83	1.29 1.12-1.38	0.81 0.76-0.89
	3	1.70 1.55-1.95	1.04 0.95-1.21	0.54 0.46-0.60	0.88 0.83-0.98
	4	1.76 1.66-1.83	1.18 0.96-1.30	1.67 1.40-1.95	1.16 0.91-1.33
0.20	Baseline	2.25 2.15-2.35	1.35 1.27-1.43		
	1	2.32 2.18-2.43	1.69 1.57-1.83	2.07 1.95-2.14	1.30 1.21-1.49
	2	2.75 2.59-2.84	1.95 1.85-2.07	2.72 2.53-2.84	1.14 1.04-1.30
	3	2.77 2.53-2.96	1.93 1.68-2.17	2.65 2.49-2.81	1.38 1.35-1.44
	4	2.95 2.82-3.11	2.06 1.98-2.11	2.62 2.50-2.76	1.66 1.47-1.83
	Recovery 3	3.20 2.89-3.36	2.20 2.18-2.25	2.86 2.76-2.94	1.38 1.35-1.44
0.05	Baseline	2.57 2.48-2.67	2.33 2.26-2.39		
	1	2.74 2.60-2.94	2.35 2.30-2.45	2.48 2.39-2.60	2.52 2.47-2.58
	2	2.64 2.50-2.71	2.46 2.41-2.52	2.61 2.44-2.80	2.46 2.40-2.55
	3	2.80 2.65-3.03	2.43 2.37-2.47	2.53 2.41-2.67	2.26 2.12-2.35
	4	2.81 2.56-2.97	2.11 2.02-2.15	2.75 2.48-2.94	2.05 1.98-2.20

Table 10

Mean corrected rates and range of corrected rates in responses per second during tau^D, tau^Δ, S^N, and S^N location during baseline as a function of $p(S^R/R \cdot tau^D)$ and S^N location for subject C-3.

$p(S^R/R \cdot tau^D)$	S^N Location	tau^D	tau^Δ	S^N	S^N Baseline
1.00	Baseline	1.22 1.02-1.34	0.55 0.40-0.66		
	1	1.15 1.10-1.19	0.71 0.59-0.95	2.01 1.95-2.06	0.28 0.25-0.34
	2	1.51 1.11-2.15	0.98 0.93-1.05	1.61 1.43-1.70	0.44 0.24-0.57
	3	1.25 1.13-1.37	1.29 1.19-1.48	1.54 1.38-1.63	0.55 0.23-0.77
	4	1.67 1.44-1.82	1.08 1.03-1.18	1.84 1.68-2.01	1.04 0.89-1.14
0.20	Baseline	2.14 2.07-2.25	1.12 1.04-1.20		
	1	2.39 2.16-2.59	1.42 1.39-1.47	2.37 2.27-2.48	1.26 1.11-1.42
	2	2.23 2.19-2.27	1.39 1.36-1.41	2.38 2.29-2.50	1.09 1.00-1.15
	3	2.35 2.29-2.45	1.37 1.20-1.48	2.18 2.01-2.27	0.93 0.83-1.05
	4	2.27 2.07-2.42	1.48 1.43-1.54	2.08 2.01-2.20	0.96 0.80-1.16
	Recovery 2	2.52 2.46-2.57	1.49 1.38-1.59	2.44 2.37-2.51	1.09 1.00-1.15
0.05	Baseline	2.39 2.36-2.43	1.70 1.67-1.73		
	1	2.43 2.26-2.52	2.12 2.07-2.16	2.39 2.31-2.50	1.69 1.61-1.74
	2	2.00 1.64-2.24	2.51 2.43-2.58	1.89 1.68-2.14	1.69 1.64-1.71
	3	1.85 1.50-2.10	2.51 2.45-2.60	1.85 1.70-1.98	1.70 1.47-1.83
	4	2.39 2.28-2.55	2.43 2.42-2.43	2.39 2.26-2.50	1.85 1.73-1.95

during S_1^1 decreased as the interval between S_1^1 and S^R lengthened. The tables show that subjects A-2 and B-3 were the only subjects who produced the Farmer and Schoenfeld finding, while the other four subjects exhibited a pattern of higher rates in either S^2 or S^3 than in S^1 and S^4. This pattern of higher S^N rates in the middle of tau^Δ, an inverted U-shaped function, subsequently emerged as the most characteristic pattern of responding during S^N in the experiment.

Each subject in group C with $p(S^R/R \cdot tau^D) = 1.00$ and $p(S^R/R \cdot tau^\Delta) = 0.02$ showed a consistent pattern of responding for the series of S^N placements. Corrected response rates were higher in S^1 and S^4 than in S^2 and S^3. Thus, the efect of $p(S^R/R \cdot tau^\Delta) = 0.02$ was to invert the function of S^N rates produced by four out of the six subjects in groups A and B.

With $p(S^R/R \cdot tau^D)$ less than 1.00 and $p(S^R/R \cdot tau^\Delta) = 0.00$, subjects in groups A and B demonstrated extremely consistent patterns of response rates for each series of S^N placements. Each of the six subjects in these groups was given a series of S^N placements at two $p(S^R/R \cdot tau^D)$ less than 1.00. Corrected response rates were highest during S^2 or S^3 in 11 out of 12 of these individual series. Furthermore, as $p(S^R/R \cdot tau^D)$ was decreased over three values for each subject, the highest S^N corrected rate for each series of placements increased directly for five out of the six subjects.

For group C the pattern of corrected response rates for the series of S^N placements did not remain constant when $p(S^R/R \cdot tau^D)$ was decreased. Whereas all three subjects had shown highest rates in S^1 and S^4 with $p(S^R/R \cdot tau^D) = 1.00$, all three inverted this pattern with $p(S^R/R\cdot\text{tau}^D) = 0.20$ and displayed the highest rates in S^2 or S^3. However, neither the same function of S^N corrected rates not the consistency among subjects was maintained by group C when $p(S^R/R\cdot\text{tau}^D)$ was decreased to 0.05. At this probability, C-1 rates increased regularly with successive placements; C-2 rates increased irregularly with successive placements; and, C-3 rates reverted to the pattern with $p(S^R/R\cdot\text{tau}^D) = 1.00$, with highest rates in S^1 and S^4.

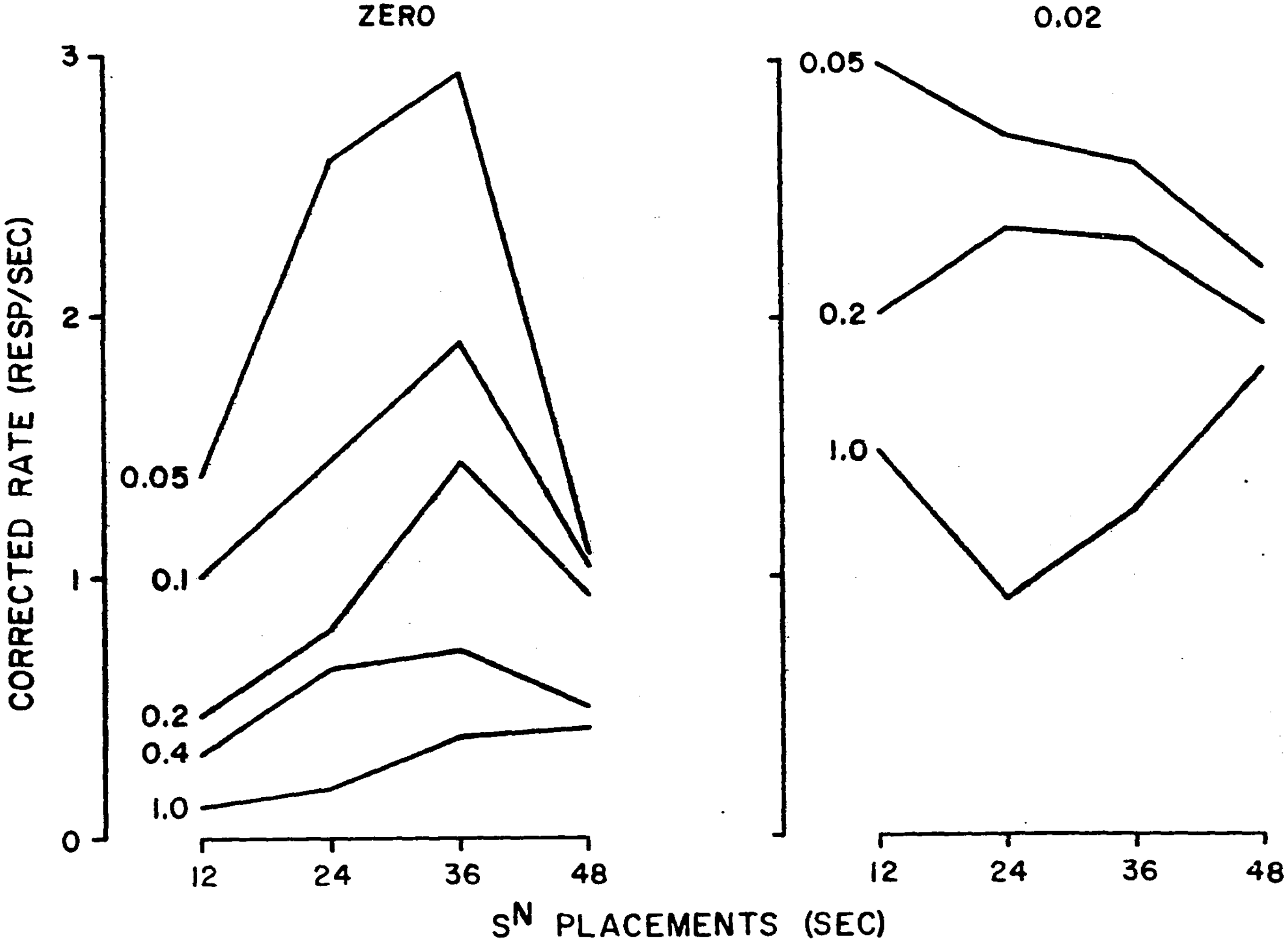
Generally, each function of S^N corrected rates at different probabilities of reinforcement was similar for individual subjects in groups A and B and dissimilar for subjects in group C, but a summary statement about group C must take into account the specific probabilities of reinforcement which were scheduled. With $p(S^R/R\cdot\text{tau}^D) = 0.20$ group C did produce the inverted U-shaped function of S^N corrected rates displayed by groups A and B on that probability. When group C was scheduled with 0.05, the probabilities of reinforcement in tau^D and tau^Δ were sufficiently close, 0.05 and 0.02 respectively, that response rates became more uniform during tau^D and all S^N locations. Other $p(S^R/R\cdot\text{tau}^D)$ values between 1.00 and 0.05 could be explored in order to determine the possibility of obtaining additional inverted U-shaped functions of S^N rates.

The recovery of experimental points at various $p(S^R/R\cdot\text{tau}^D)$ and S^N locations by individual subjects confirmed the finding that rate in S^N was a function of temporal location within the tau cycle. Inspection of the recovery functions in figures one through nine and of the corrected rates in tables two through ten shows a recovery of corrected rates for seven out of nine subjects. Subjects A-1, B-1, B-2, B-3, and C-1 produced recovery rates ranging inbetween the previous rate at that S^N location and the preceding or following S^N in the series. For subjects A-2 and C-3 the highest S^N rate occurred originally at the recovery S^N location, and in both of these cases the recovery rate was higher than the original rate. Recovery rates for A-3 and C-2 only did not confirm the original functions of S^N corrected rates.

Figure 10 presents the mean corrected rates during S^N for each group. In the left panel for groups A and B, data for six subjects were combined at $p(S^R/R \cdot tau^D) = 1.00$. At lower probabilities the data were the averages of three subjects: 0.20 and 0.05 for group **A**, 0.40 and 0.10 for group B. With $p(S^R/R \cdot tau^D) = 1.00$ the corrected rates for combined groups show a direct decrease with successive S^N placements. As stated previously, only two out of six individual subjects exhibited this pattern. With $p(S^R/R \cdot tau^D)$ less than 1.00, the group averages concur with an analysis of individual subjects. In summary, decreasing $p(S^R/R \cdot tau^D)$ resulted in increasing rates at all S^N locations and proportionately higher rates at S^N locations in the center of the tau^Δ component. For $p(S^R/R \cdot tau^D)$ less than 1.00, each series of S^N intrusions resulted in an inverted U-shaped function of S^N corrected rates.

In the right panel of figure 10 mean corrected rates during S^N are presented for group C. With $p(S^R/R \cdot tau^D) = 1.00$ and 0.20 the group functions duplicate the functions which were found for all three subjects. With $p(S^R/R \cdot tau^D) = 0.05$, the group function does not accurately represent the individual subjects. Thus, decreasing $p(S^R/R \cdot tau^D)$ resulted in higher rates at each S^N location, but no

Figure 10. Corrected rate during a six second light (S^N) presented within tau^Δ as a function of $p(S^R/R \cdot \text{tau}^D)$ and temporal location of S^N. $p(S^R/R \cdot \text{tau}^\Delta)$ is shown above the left panel for groups A and B and above the right panel for group C. Data for $p(S^R/R \cdot \text{tau}^D) = 1.00$ in the left panel are the averages of six subjects, combining groups A and B; all other data are the averages of three subjects.


ZERO
0.02
CORRECTED RATE (RESP/SEC)
3
2
1
0
0.05
0.1
0.2
0.4
1.0
0.05
0.2
1.0
12
24
36
48
12
24
36
48
S^N PLACEMENTS (SEC)

orderly relationship was found between decreasing probability of reinforcement and the functions of S^N corrected rates.

The preceding description of corrected rates in S^N was carried out under the assumption that behavior should be analyzed with reference to a single category "stimulus." According to Skinner's (1938) terminology, S^N could have been labeled as a "discriminative stimulus" because it set the occasion for an operant response. Skinner clearly distinguished between the stimulus functions of discrimination and elicitation. Only respondent behavior was elicited. However, further research (Morse and Skinner, 1958; Rescorla and Solomon, 1967; Terrace, 1966) has demonstrated that a "discriminative stimulus" appears to involve the function of elicitation. Since these functions are not individually distinct, it seems more accurate to refer to a single stimulus function. While the term "discrimination" may be inappropriate for the function of a stimulus, "discrimination" does mean to show differential responding in the presence of different stimulus situations. In the present experiment, the different rates in S^N and tau^Δ illustrate a discrimination. Also, the differential responding as a function of S^N location within tau^Δ illustrates a "temporal discrimination" (Skinner, 1938).

If the rationale for a single category "stimulus" has validity, then it must be applicable to the categories of "intruded stimulus" and "reinforcer." In the present experiment, statements about the intruded stimulus (S^N) and the reinforcer (S^R) may suggest discrete categories. There are two factors which may create the impression of a dichotomy in stimulus function; the properties of these stimuli and the response-contingencies. The intruded stimulus has been called a "neutral stimulus" because it supposedly has no demonstrable effect on behavior before it is added to a behavioral baseline (Farmer and Schoenfeld, 1966a). However, light or food may not be described as "neutral" or "reinforcing" without regard to the properties of that stimulus in a particular situation. If the intensity of the light were increased, it might not be "neutral." Similarly, if the duration of access time to food were decreased, it might not be effective as a "reinforcer." Thus, the descriptive categories "intruded stimulus" and "reinforcer" refer to stimulus properties which exhibit continuity.

The intruded stimulus and reinforcer also differed in the matter of response-contingency. In Skinner's (1938) operant conditioning procedure the delivery of reinforcement was contingent upon the occurrence of a response which was specified in advance. The operant procedure for noncontingent reinforcement was viewed as the special case of "superstitious" conditioning (Skinner, 1948). A temporal system of schedules, such as the t-tau systems (Schoenfeld and Cole, 1972), can incorporate the procedure for either response-contingent or noncontingent intrusion of any stimulus. In the present tau system experiment S^R was response-contingent, and S^N was noncontingent. In other similar experiments Farmer and Schoenfeld (1966b) intruded a response-contingent light, and Benassi (1974) intruded noncontingent food. Moreover, since the probability of response-contingent and/or noncontingent reinforcement may be varied for a particular locus in time, response-contingency and noncontingency represent the extremes of operational continua (Evra, 1974; Lachter, Cole, and Schoenfeld, 1971).

Although six subjects were scheduled with $p(S^R/R \cdot tau^D) = 1.00$ and $p(S^R/R \cdot tau^\Delta) = 0.00$ for the purpose of comparison with the Farmer and Schoenfeld (1966a) experiment, the failure to produce the Farmer and Schoenfeld results with respect to response rates during S^N does not detract from the reliability of the present findings which were confirmed through intragroup replication and the recovery of experimental points. The different patterns of S^N rates, therefore, must result from the differences in procedures. The present design departed from the Farmer and Schoenfeld paradigm in more than just one feature; for example, the initial baselines were different, and Farmer and Schoenfeld did not pair the intruded stimulus at the end of the interval with reinforcement. Consequently, it is impossible to attribute the differences in results to any one change in procedure.

One factor which may have influenced the rate of responding in S^N was the subjects' temporal discrimination (Skinner, 1938) of the 60 second cycle. Zeiler (1972) studied the effects of varying percentage reinforcement (PR) on response rates in a fixed interval schedule. Intervals were terminated with either reinforcement or a timeout stimulus. At PRs ranging from 10% to 90%, subjects often responded during timeout and throughout the next interval. In a second experiment, a 10 second blackout followed each interval. With the blackout the characteristic fixed interval scallop occurred for PRs ranging from 7% to 100%. Thus, the blackout may have maintained the subjects' temporal discrimination of the fixed interval. In the Farmer and Schoenfeld (1966a) experiment each cycle terminated with reinforcement. The responding during S_1^1 at different temporal placements resembled segments of a fixed interval scallop. Since S_1^1 changed only in its temporal location within the fixed interval, the subjects' differential responding exhibited a temporal discrimination. Tables two through seven of the present experiment show that subjects in group A with $p(S^R/R \cdot tau^D) = 0.05$ and in group B with $p(S^R/R \cdot tau^D) = 0.10$ produced corrected rates which did not offer evidence of a temporal discrimination between S^2 and tau^D. While this finding is based on a comparison of corrected rates, further analysis of the temporal discrimination of S^N within the tau cycle could also take into account the effect of PS^RP on response rates.

As $p(S^R/R \cdot tau^D)$ was decreased, group A and B mean corrected rates in tau^D increased. Tables two through seven give the corrected rates in tau^D during the final sessions, either S^4 or recovery, for each probability of reinforcement. For each subject corrected rates in tau^D increased at each of the three probabilities. The trend of corrected rates in tau^D over the course of 50 sessions at each value of $p(S^R/R \cdot tau^D)$ was determined by comparing rates during baseline with rates during S^4 or recovery. For four out of six subjects corrected rates in tau^D increased over 50 sessions at each of the three probabilities. Subject A-3 showed an increase in corrected rates in tau^D over 50 sessions for $p(S^R/R \cdot tau^D) = 1.00$ and 0.05, and subject B-3 for only $p(S^R/R \cdot tau^D) = 0.10$. Overall, the individual corrected rates in tau^D increased over 50 sessions for 15 out of 18 of the S^N series. Tables eight through ten present the group C mean corrected rates in tau^D. These rates increased over three $p(S^R/R \cdot \text{tau}^D)$ for subject C-1 only. Subjects C-2 and C-3 produced higher corrected rates in tau^D with $p(S^R/R \cdot \text{tau}^D) = 0.20$ than with 0.05. In 50 sessions on each $p(S^R/R \cdot \text{tau}^D)$ group C corrected rates in tau^D increased in six out of nine series of S^N intrusions.

The inverse relationship between decreasing $p(S^R/R \cdot \text{tau}^D)$ and increasing mean corrected rates in tau^D for groups A and B resulted from at least two aspects of the tau reinforcement schedule: the schedule of decreasing probabilities of reinforcement and the two component multiple schedule in which one of the components was an extinction schedule. In an experiment with random ratio schedules Farmer and Schoenfeld (1967) established that running rate does not vary systematically for probabilities of reinforcement ranging from 0.8 to 0.002. They suggested that rates could be a function of the order of probabilities. All subjects were conditioned first on the 0.002 probability and then on a mixed sequence of higher probabilities. It was found that as the probability of reinforcement was decreased, the PS^RP lengthened. Thus, in a mixed sequence of random ratio schedules, rates in response runs were nearly constant, while PS^RP was inversely related to probability of reinforcement. Since Brandauer (1958) and Sidley and Schoenfeld (1964) had reported differences in corrected rates for a series of probabilities, Farmer and Schoenfeld explained these differences in part as the result of computing corrected rather than running rates. However, the results of the present experiment do not substantiate the Farmer and Schoenfeld (1967) findings. If response rates during runs were constant, and if decreasing probability of reinforcement lengthened PS^RP, then corrected rates should decrease, the opposite of what was found here. Therefore, the sequence of probabilities of reinforcement appears to be one factor which affected the corrected rates. The inverse relationship between probability of reinforcement and corrected rate confirmed several similar findings with fixed ratio (Boren, 1961; Ferster and Skinner, 1957) and random ratio (Brandauer, 1958; Sidley and Schoenfeld, 1964) schedules.

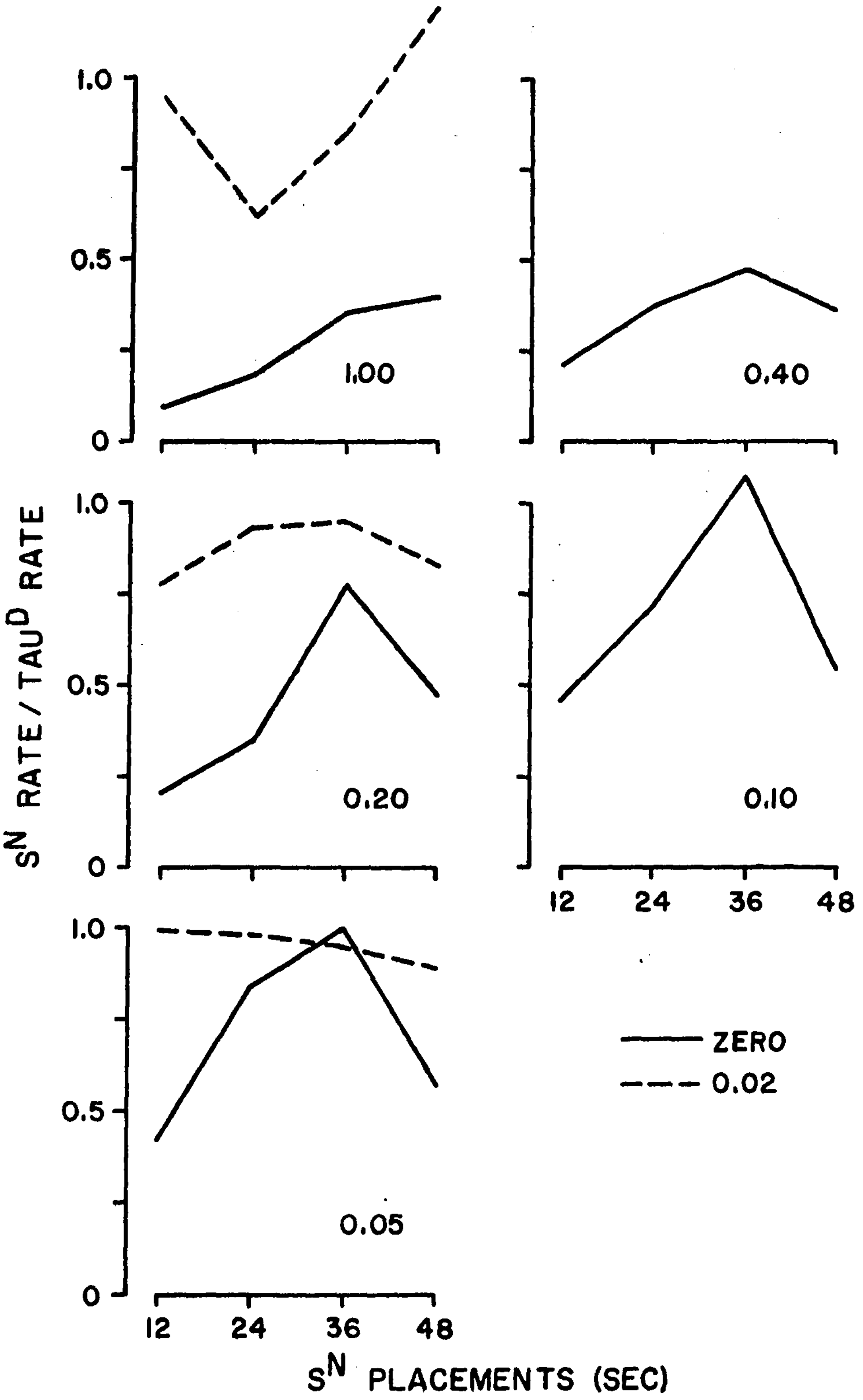
Vickery (1971) also has found differences in response rates for different probabilities of reinforcement in the tau^D and tau^Δ components of a tau reinforcement schedule, but in his experiment the scheduling of a mixed sequence of $p(S^R/R \cdot tau^\Delta)$ values resulted in a direct relationship between probability of reinforcement and response rate. Vickery stated that this sensitivity in response rate to $p(S^R/R \cdot tau^\Delta)$ was a major finding because it contrasted with the Farmer and Schoenfeld (1967) finding about random ratio rates. He cited Morse (1966) who reported that response rate was more sensitive to changes in reinforcement frequency in a multiple schedule. Although Vickery's results with respect to the relationship between probability of reinforcement and response rate were reversed in the present experiment, the sequence in which the probabilities were scheduled may account for the contrary results.

The increase in mean corrected rates in tau^D over the course of 50 sessions at each value of $p(S^R/R \cdot tau^D)$ confirms the data of

Sidley and Schoenfeld (1964) and Vickery (1971), but disagrees with the findings by Eckerman (1966). Sidley and Schoenfeld investigated the effects of extended exposure to random ratio schedules. At probabilities of reinforcement 0.10 and 0.05 subjects were conditioned daily for 10 minutes. Asymptotic rates were obtained after 40 sessions. Eckerman trained subjects to discriminate between alternating random ratio and extinction components. Rates were nearly constant during the random ratio component.

Increasing corrected response rates in tau^D during each series of S^N intrusions may have influenced in turn the functions of S^N corrected rates in figure 10. In an attempt to take into account the effect of increasing corrected rates in tau^D, figure 11 presents the ratio of corrected rate in S^N to corrected rate in tau^D recorded during the same session. This ratio indicates the relative amount of responding during S^N and tau^D. Figure 11 reveals that the increasing corrected rates in tau^D did not affect the characteristic shape of the group functions of S^N corrected rates as shown in figure 10. In figure 11 with $p(S^R/R \cdot tau^D) = 1.00$ and $p(S^R/R \cdot tau^\Delta) = 0.00$, group A and B corrected rates during S^N were less than half of the tau^D rates. As $p(S^R/R \cdot tau^D)$ was decreased for groups A and B, corrected rates during S^N generally increased proportionately to tau^D corrected rates up to $p(S^R/R \cdot tau^D) = 0.10$. At $p(S^R/R \cdot tau^D) = 0.10$ the ratio of S^2 to tau^D corrected rates was slightly higher than 1.0 which points out again that the subjects did not discriminate between S^2 and tau^D. In the left panel of figure 10 corrected rates during S^N for $p(S^R/R \cdot tau^D) = 0.05$ were higher at all locations than for 0.10.

Figure 11. The ratio of corrected rate during a six second light (S^N) presented within tau^Δ to corrected rate during tau^D on the same experimental point as a function of the temporal location of S^N. One $p(S^R/R \cdot tau^D)$ is shown in each pair of coordinates. $p(S^R/R \cdot tau^\Delta)$ is equal to either 0.00 (solid line) or 0.02 (dashed line). Data for $p(S^R/R \cdot tau^D) = 1.00$ and $p(S^R/R \cdot tau^\Delta) = 0.00$ in the upper left panel are the averages of six subjects, combining groups A and B; all other data are the averages of three subjects.


1.0
0.5
0
1.00
0.40
0.20
0.10
0.05
12
24
36
48
S^N RATE / TAU^D RATE
S^N PLACEMENTS (SEC)
ZERO
0.02

In figure 11 a comparison of the 0.10 and 0.05 functions reveals that S^2 and S^4 rates did not increase proportionately to tau^D rates at the lower probability. With $p(S^R/R\cdot tau^D) = 0.05$ the increases in these S^N corrected rates reflected the increase in tau^D rates.

With $p(S^R/R\cdot tau^\Delta) = 0.02$ in the left column of figure 11 the group C ratios of S^N to tau^D corrected rates were closer to 1.0 than group A, except during S^2 with $p(S^R/R\cdot tau^D) = 0.05$. Thus, one effect of $p(S^R/R\cdot tau^\Delta) = 0.02$, compared with extinction, was to increase S^N responding relative to tau^D responding. For group C, individual differences in the function of S^N corrected rates occurred for the first time at $p(S^R/R\cdot tau^D) = 0.05$. Figure 11 shows that for this probability S^N corrected rates were nearly equal to tau^D rates at all locations. Therefore, the group C function dissolved when subjects no longer discriminated between tau^D and temporal locations of S^N.

In figures one through six the corrected response rates within tau^Δ are shown for subjects in groups A and B. Four of the subjects replicated the Farmer and Schoenfeld (1966a) finding that subjects paused when the intruded stimuli were not scheduled. The other two subjects, A-1 and B-3, displayed increasing rates within the tau^Δ component. As $p(S^R/R\cdot tau^D)$ was decreased, no characteristic trend appeared in the amount or pattern of the corrected rates in tau^Δ. Subject B-1 paused throughout; subjects A-3 and B-2 responded during some of the experimental points; subjects A-1, A-2, and B-3 responded during all experimental points with either fairly constant or increasing rates.

For subjects in groups A and B, responding within tau^Δ and during S^N appeared to be under separate stimulus control. The functions of the corrected rates in S^N within the tau^Δ component were maintained whether or not a significant amount of responding occurred in tau^Δ. Likewise, in the case of those subjects where the rates in tau^Δ increased, the S^N intrusions did not permanently interrupt the scallop. Dews' (1962, 1970) experiments which added multiple S^Δ periods to a fixed interval baseline are relevant here. He found that the S^Δ periods interrupted responding during the fixed interval, but that the S^D periods displayed an overall pattern of scalloped responding. Dews suggested that response rates during S^D periods were maintained at increasing strengths throughout the fixed interval because the delay between response and reinforcement decreased. In the present experiment, responding in the tau^Δ extinction component sometimes resembled the scalloping in a fixed interval. One explanation for the maintenance of the scalloping in tau^Δ can be made in terms of the function of a "conditioned reinforcer." The pairing of S^N with tau^D should be sufficient to establish S^N as a conditioned reinforcer (Dinsmoor, 1950); any responding which occurred in tau^Δ would be reinforced adventitiously by the onset of the tau^D light (Skinner, 1948).

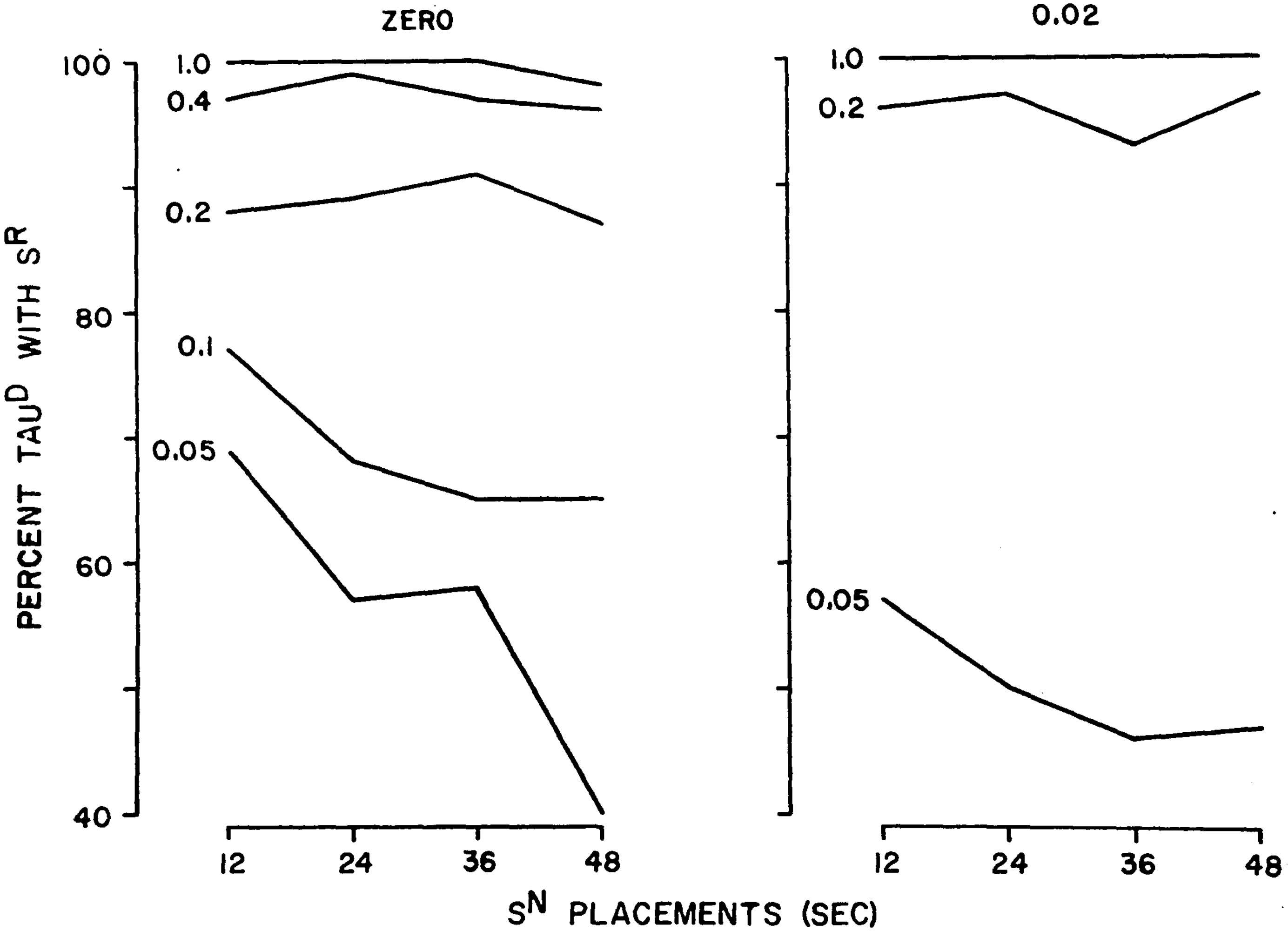
In the above analysis the label "conditioned reinforcer" seems appropriate because S^N may have acquired the capacity to reinforce responding in tau^Δ. But in order to maintain an analysis of behavior in terms of a single category "stimulus," it is necessary to determine whether the function of a conditioned reinforcer is individually distinct. In this regard, the "conditioned reinforcer" may be compared with the function of a "conditioned stimulus" in a respondent procedure. As stated previously, the conditioned reinforcer in operant conditioning appears to be established through the pairing of a neutral stimulus and reinforcer as in respondent conditioning (Bersh, 1951; Kelleher, 1966). Thus, the function of a conditioned reinforcer overlaps with the conditioned stimulus on the basis of the procedure through which it is acquired.

In figures seven through nine corrected rates in tau^{Δ} are shown for the individual subjects of group C. Subject C-1 corrected rates usually decreased over 54 seconds for each experimental point; subject C-2 rates were fairly stable; and, subject C-3 rates often increased. Thus, there was no group trend in the pattern of corrected rates in tau^{Δ}. In tables eight through ten, a comparison of baseline rates in tau^{Δ} with the final rates in tau^{Δ} on each $p(S^{R}/R \cdot tau^{D})$ shows that corrected rates in tau^{Δ} increased during eight of the nine individual series. Also, for subjects C-1 and C-3 corrected rates in tau^{Δ} increased for each value of $p(S^{R}/R \cdot tau^{D})$. Subject C-2 displayed one reversal with $p(S^{R}/R \cdot tau^{D}) = 0.05$, when corrected rate in tau^{Δ} not only decreased within this series, but also decreased from the rate with $p(S^{R}/R \cdot tau^{D}) = 0.20$. Generally, the increases in corrected rates in tau^{Δ} corroborated the same finding for rates in tau^{D} and other experiments with random ratio schedules (Sidley and Schoenfeld, 1964; Vickery, 1971).

Another way of analyzing the effects of intruding S^{N} within tau^{Δ} is to compare S^{N} rates with baseline rates at the same location. Baseline corrected rates at each S^{N} location are listed in tables two through ten. As previously described, the functions of the corrected rates in S^{N} were similar for individual subjects regardless of the pattern of tau^{Δ} responding, except for those in group C at $p(S^R/R \cdot tau^D) = 0.05$. At each S^N location corrected rates during S^N appeared to displace baseline rates. With $p(S^R/R \cdot tau^{\Delta}) = 0.00$, group A and B corrected rates during S^N exceeded the baseline rates at corresponding locations on 68 out of 72 experimental points. Those relatively few instances in which S^N rates were less than baseline rates further illustrate the separate control which S^N and tau^{Δ} had over responding. S^N rates were not compounded with tau^{Δ} rates. For example, subject A-1 on each $p(S^R/R \cdot tau^D)$ often exhibited an accelerating rate in tau^{Δ} and the function of corrected rates in S^N which was typical for this experiment. With $p(S^R/R \cdot tau^D) = 1.00$, corrected rate during S^N was lower than baseline rate at locations S^1 and S^2 and higher at S^3 and S^4. With $p(S^R/R \cdot tau^D) = 0.20$, S^N rate was lower than baseline rate only at location S^1. In these instances a lower intruded stimulus rate simply displaced a segment of the scalloped responding in the tau^{Δ} component.

Figure 12 shows the percentage of tau^D components with at least one reinforcement for each $p(S^R/R \cdot tau^D)$ as a function of S^N placements. Percentage of tau^D with reinforcement could have a singular effect on responding during S^N. Particularly for groups A and B with extinction in tau^{Δ}, the occurrence of at least one reinforcement in each tau^D could be sufficient for the temporal discrimination of the 60 second cycle. In the left panel groups A and B with $p(S^R/R \cdot tau^D) = 1.00$ procured reinforcements in 98% of the tau^D components during S^1 and in 100% of the tau^D components during the other S^N placements. As $p(S^R/R \cdot tau^D)$ was decreased, the

Figure 12. Percent of tau^D with reinforcement as a function of $p(S^R/R\cdot\text{tau}^D)$ and the temporal location of a six second light (S^N) presented within tau^Δ. $p(S^R/R\cdot\text{tau}^\Delta)$ is shown above the left panel for groups A and B and above the right panel for group C. Data for $p(S^R/R\cdot\text{tau}^D) = 1.00$ in the left panel are the averages of six subjects, combining groups A and B; all other data are the averages of three subjects.


ZERO
0.02
1.0
0.4
0.2
0.1
0.05
1.0
0.2
0.05
100
80
60
40
PERCENT TAU^D WITH S^R
12
24
36
48
12
24
36
48
S^N PLACEMENTS (SEC)

percentage of tau^D components with reinforcement decreased directly. According to figure 11, groups A and B failed to discriminate between tau^D and S^2 with $p(S^R/R\cdot\text{tau}^D) = 0.10$ and 0.05; in figure 12 at these $p(S^R/R\cdot\text{tau}^D)$ the percentage of tau^D with reinforcement decreased below 70%.

In figure 12, as $p(S^R/R\cdot\text{tau}^D)$ was decreased, the function changed from a flat to a negative relationship. In the left panel with $p(S^R/R\cdot\text{tau}^D) = 0.10$ and 0.05 and in the right panel with $p(S^R/R\cdot\text{tau}^D) = 0.05$, the percentage of tau^D correlated with reinforcement increased as S^N was relocated from 48 through 12 seconds in tau^Δ. These increases were most likely a function of increasing rates in tau^D throughout the experiment rather than S^N placement. On a random ratio schedule increases in rate result in proportionate increases in reinforcement and in the present experiment a higher percentage of tau^D with reinforcement.

The remaining figures show response measures as a function of increasing $p(S^R/R\cdot\text{tau}^D)$. Direct comparison with previous tau system findings may not always be meaningful because in this experiment tau^D and tau^Δ formed a multiple schedule. Figure 13 shows corrected rate (solid line) and running rate (dots) during S^N as a positively accelerated function of increasing $p(S^R/R\cdot\text{tau}^D)$ for groups A and B. Figure 14 shows the same result for group C. For groups A and B, as the temporal location of S^N was shifted toward the onset of tau^Δ, the difference between corrected and running rate increased. Running rate is nearly superimposed on corrected rate at 48 seconds (S^1); running rate is separated furthest from corrected rate at 12 seconds

Figure 13. Corrected rate (solid line) and running rate (dots) during a six second light (S^N) presented within tau^Δ as a function of $p(S^R/R \cdot tau^D)$ for groups A and B. The onset in seconds for one temporal location of S^N is shown in each pair of coordinates. Data for $p(S^R/R \cdot tau^D) = 1.00$ are the averages of six subjects, combining groups A and B; all other data are the averages of three subjects.

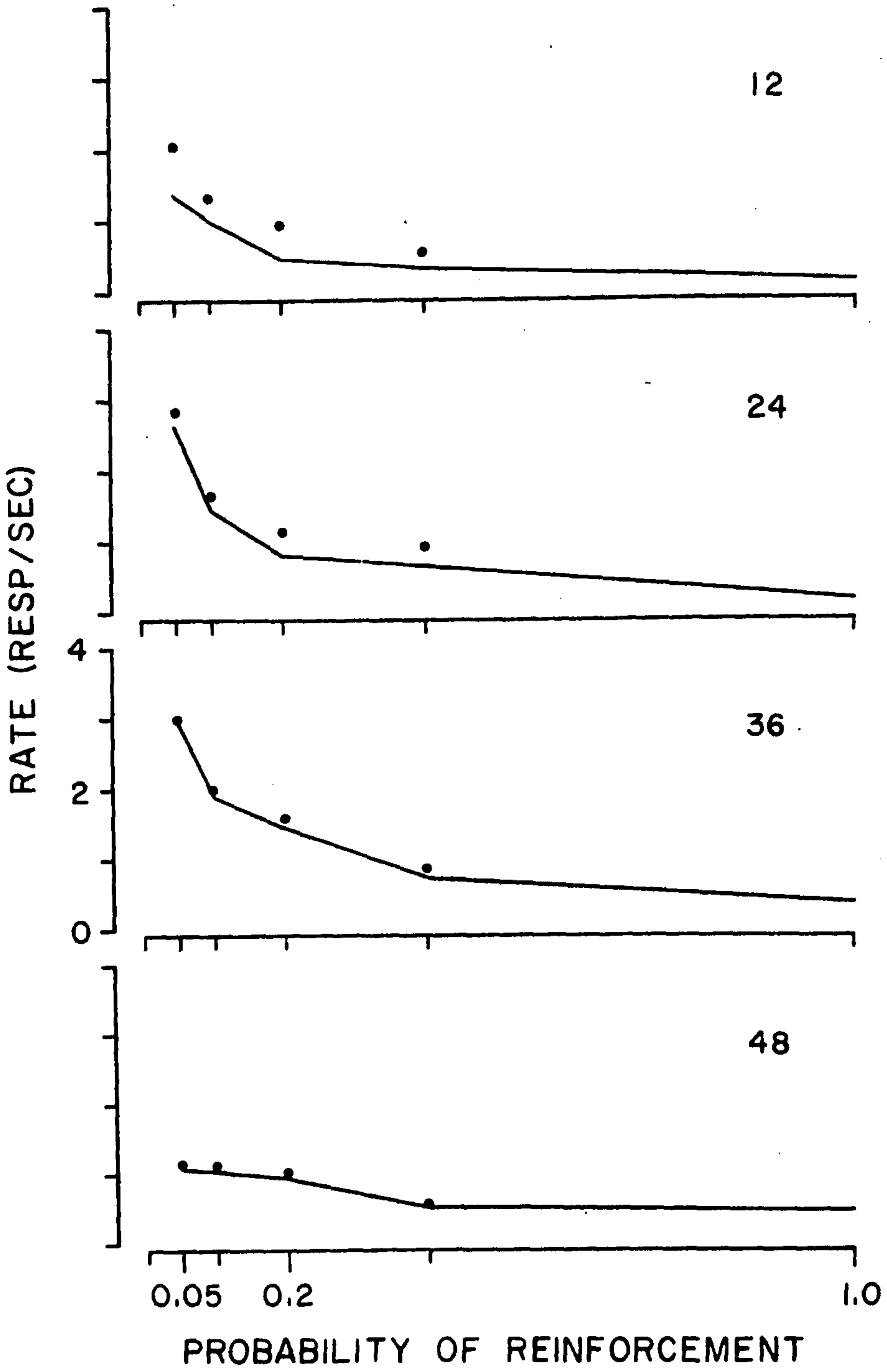
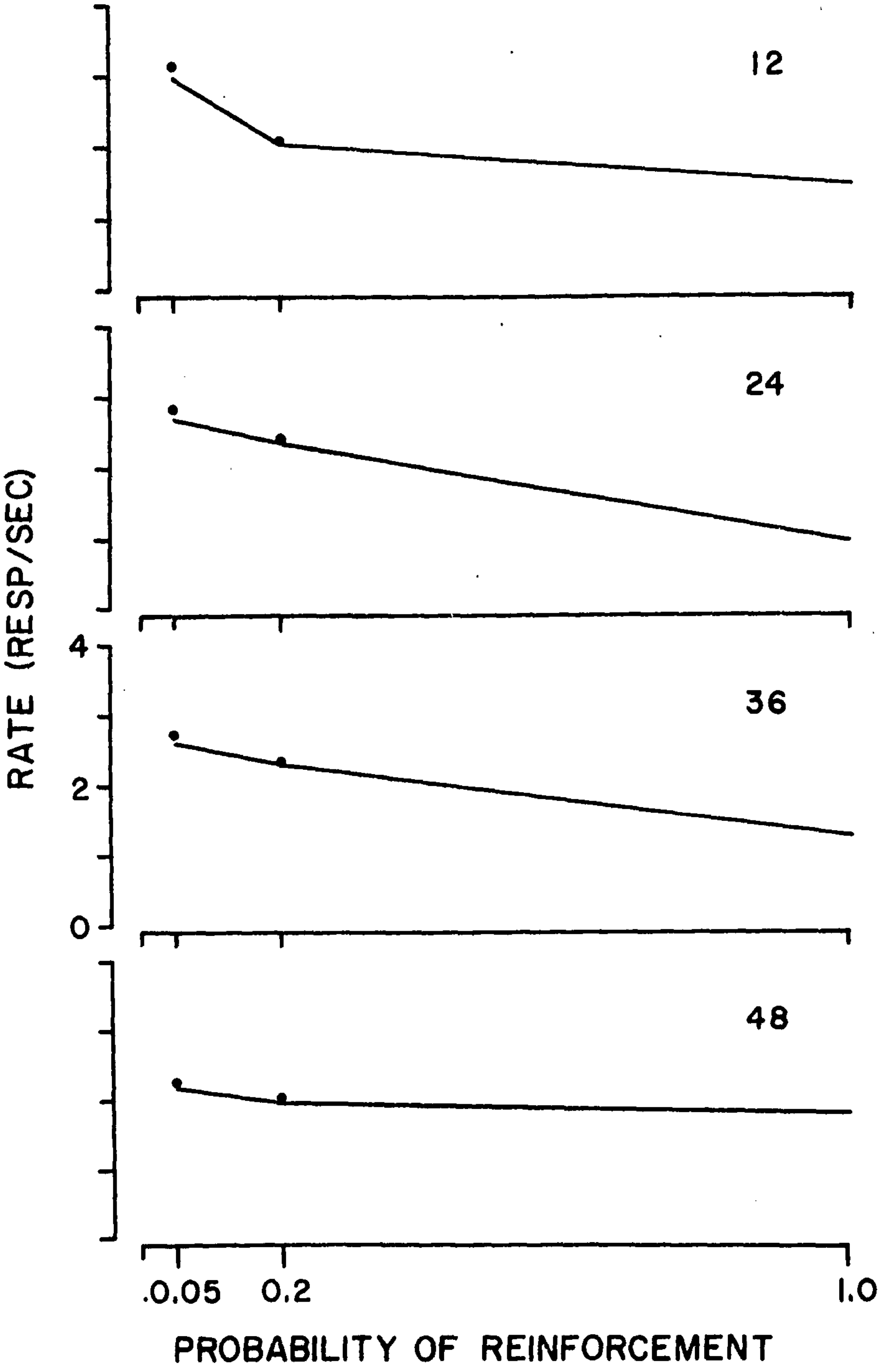

12
24
36
48
4
2
0
RATE (RESP/SEC)
0.05
0.2
1.0
PROBABILITY OF REINFORCEMENT

Figure 14. Corrected rate (solid line) and running rate (dots) during a six second light (S^N) presented within tau$^\Delta$ as a function of p(S^R/R·tau^D) for group C. The onset in seconds for one temporal location of S^N is shown in each pair of coordinates.


12
24
36
48
RATE (RESP/SEC)
4
2
0
.0.05
0.2
1.0
PROBABILITY OF REINFORCEMENT

(S^4). As stated previously, PS^RP accounts for the difference between corrected and running rate. The amount of PS^RP in S^N was related to at least two factors: responding in tau^Δ and S^N. PS^RP extended from tau^D reinforcement time into tau^Δ. The further PS^RP extended into tau^Δ, the more likely it would be terminated by any incidental or accelerated responding in tau^Δ. When PS^RP lengthened from tau^Δ into S^N, those S^N locations with lower rates would accumulate more PS^RP time. For example, subject B-1 occasionally did not respond in S^4 (12 seconds) so that PS^RP extended through S^4. Consequently, for groups A and B the maximum difference between corrected and running rate at 12 seconds may be attributed to its early location within tau^Δ and to its relatively low corrected rate. The minimum difference at 48 seconds may be due solely to location within tau^Δ because corrected rate at 48 seconds was lower than at 24 or 36 seconds.

For group C in figure 14 the differences between corrected and running rates were nearly equal at each S^N location and generally smaller than for groups A and B. The schedule of $p(S^R/R \cdot tau^\Delta) = 0.02$ maintained responding throughout tau^Δ and precluded tau^D PS^RP from extending into S^N. The increment in running rate over corrected rate resulted from PS^RP which originated in tau^Δ.

Figure 15 shows the PS^RP for baseline and S^N as a function of $p(S^R/R \cdot tau^D)$ for groups A and B. Similarly, figure 16 shows PS^RP in tau^D and tau^Δ for group C. PS^RP for tau^D or tau^Δ includes any PS^RP extending beyond that component to the next response. For all groups PS^RP showed no systematic increases or decreases. Several studies

Figure 15. Tau^D post-reinforcement pause (PS^RP) in seconds as a function of $p(S^R/R \cdot tau^D)$ for groups A and B. Baseline or onset in seconds for one temporal location of a six second light (S^N) presented within tau^Δ is shown in each pair of coordinates. Data for $p(S^R/R \cdot tau^D) = 1.00$ are the averages of six subjects, combining groups A and B; all other data are the averages of three subjects.

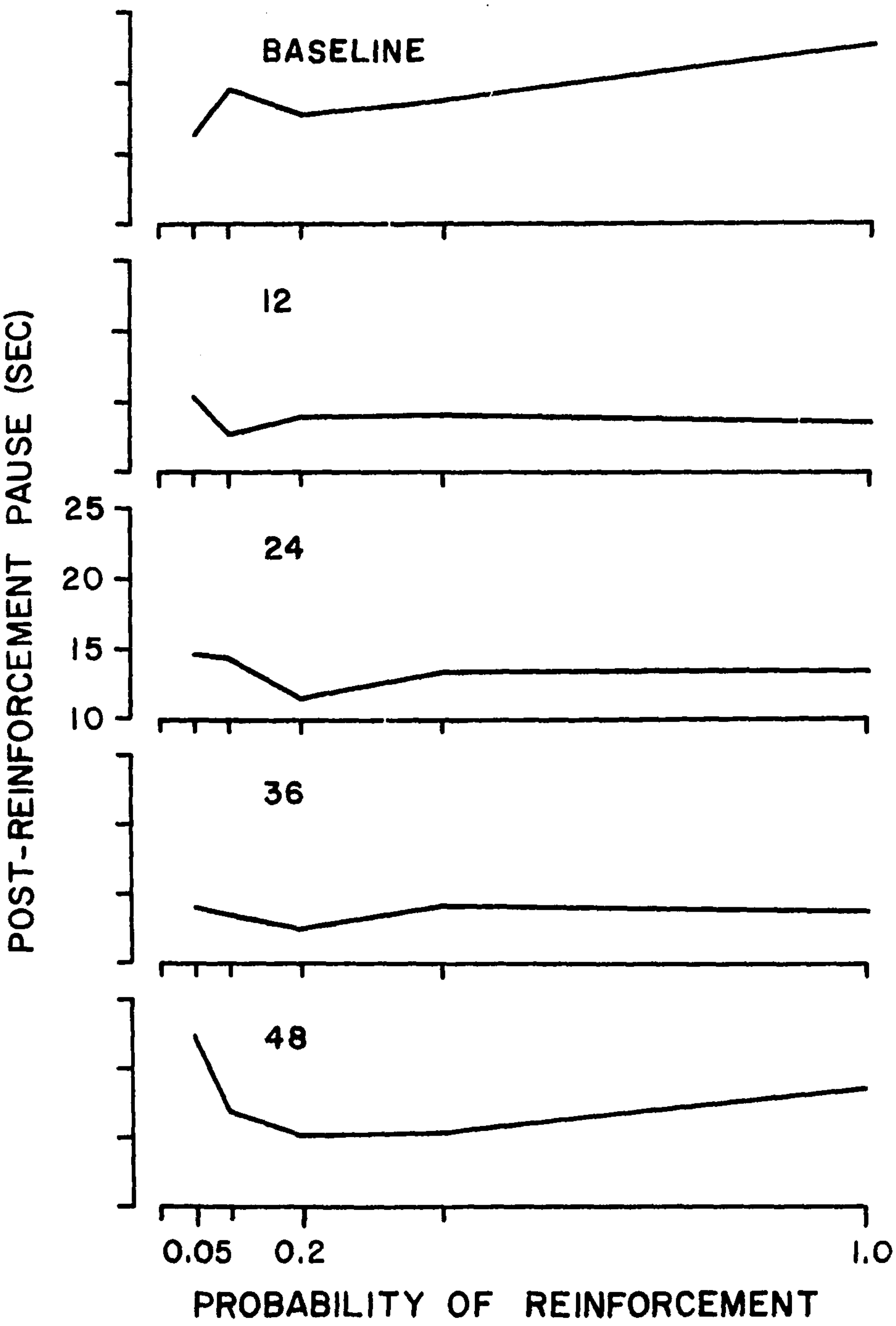
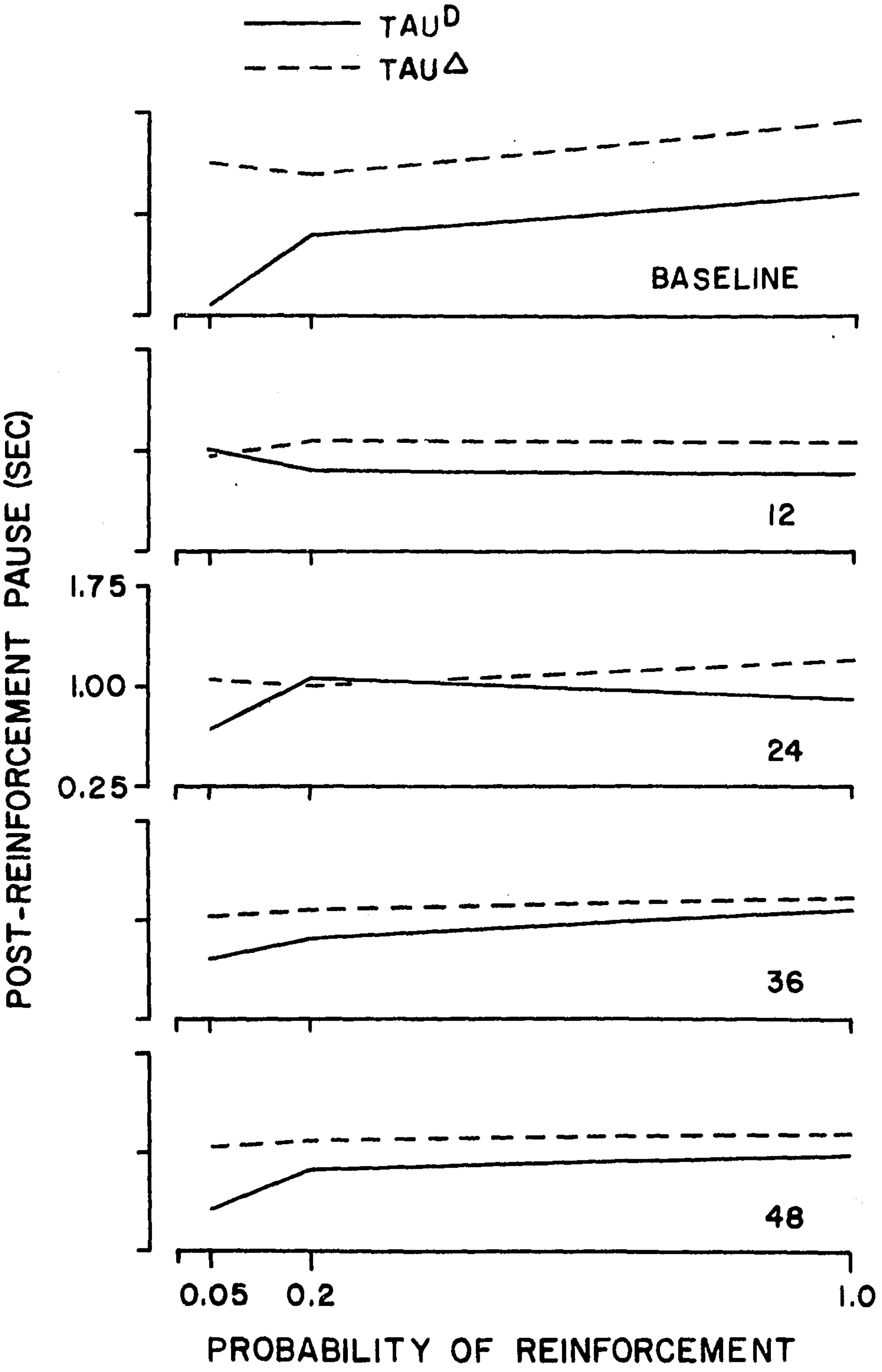

BASELINE
12
24
36
48
POST-REINFORCEMENT PAUSE (SEC)
25
20
15
10
0.05
0.2
1.0
PROBABILITY OF REINFORCEMENT

Figure 16. Tau^D (solid line) and tau^Δ (dashed line) post-reinforcement pause (PS^RP) in seconds as a function of $p(S^R/R\cdot \text{tau}^D)$ for group C. Baseline or onset in seconds for one temporal location of a six second light (S^N) presented within tau^Δ is shown in each pair of coordinates.


TAU^D
TAU$^\Delta$
BASELINE
12
24
36
48
1.75
1.00
0.25
POST-REINFORCEMENT PAUSE (SEC)
0.05
0.2
1.0
PROBABILITY OF REINFORCEMENT

with random ratio schedules (Brandauer, 1958; Farmer and Schoenfeld, 1967; Sidley and Schoenfeld, 1964; Snapper, 1962; Vickery, 1971) reported that increases in probability of reinforcement resulted in decreases in PS^RP, but these studies did not use a multiple schedule. PS^RP was longer for all probabilities during baseline, when no S^N was intruded, and during the S^N location at 48 seconds, when S^N was intruded at the longest temporal separation from tau^D. For group C, tau^Δ PS^RP was usually longer than tau^D PS^RP. This difference was greater during baseline than during any S^N location. Thus, the presence of S^N decreased tau^Δ PS^RP.

Figure 17 for groups A and B and figure 18 for group C show R/S^R as a positively accelerated function of increasing $p(S^R/R \cdot tau^D)$. With a random ratio schedule the computation of R/S^R for tau^D alone would simply report the accuracy of the probability generator in delivering reinforcement at a given probability over time. Therefore, R/S^R was computed for the whole cycle to indicate the distribution of responses between tau^D and tau^Δ. For group A with $p(S^R/R \cdot tau^D) = 0.05$ and for group B with $p(S^R/R \cdot tau^D) = 0.10$ the effect of S^N was to increase R/S^R compared to baseline responding. The highest R/S^R occurred at 24 or 36 seconds when corrected rate in S^N was highest. For group C the variation in S^N location had an insignificant effect on the distribution of responses between the tau system components for each $p(S^R/R \cdot tau^D)$.

Figure 19 shows tau^D inter-reinforcement time (IS^RT) as a positively accelerated function of increasing $p(S^R/R \cdot tau^D)$ for groups A and B. Vickery (1971) similarly found that decreasing either

Figure 17. Responses per reinforcement (R/S^R) as a function of $p(S^R/R \cdot tau^D)$ for groups A and B. Baseline or onset in seconds for one temporal location of a six second light (S^N) presented within tau^Δ is shown in each pair of coordinates. R/S^R equals total responses in one session divided by total reinforcements. Data for $p(S^R/R \cdot tau^D) = 1.00$ are the averages of six subjects, combining groups A and B; all other data are the averages of three subjects.

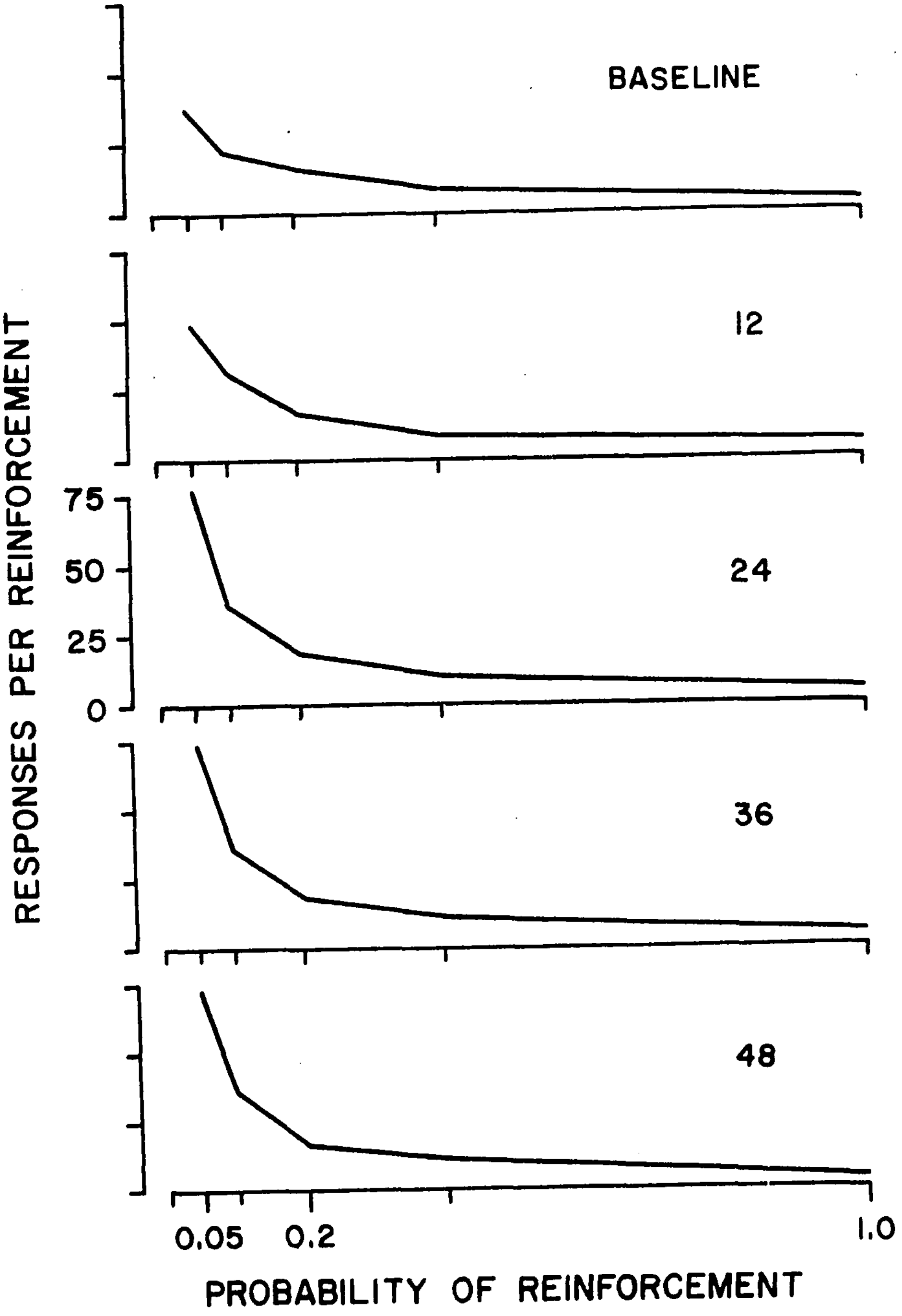

BASELINE
12
24
36
48
75
50
25
0
RESPONSES PER REINFORCEMENT
0.05
0.2
1.0
PROBABILITY OF REINFORCEMENT

Figure 18. Responses per reinforcement (R/S^R) as a function of $p(S^R/R \cdot tau^D)$ for group C. Baseline or onset in seconds for one temporal location of a six second light (S^N) presented within tau^Δ is shown in each pair of coordinates. R/S^R equals total responses in one session divided by total reinforcements.

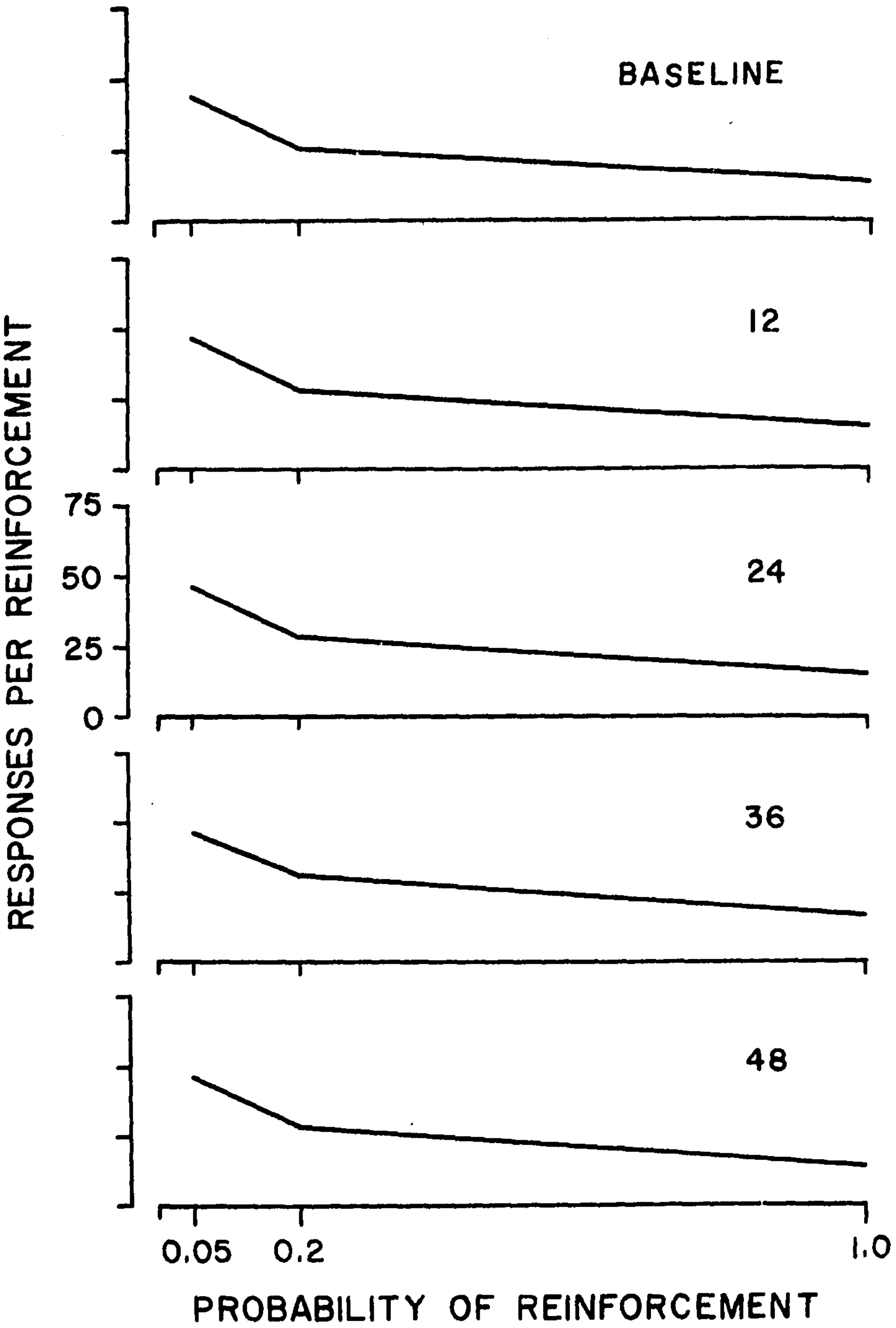
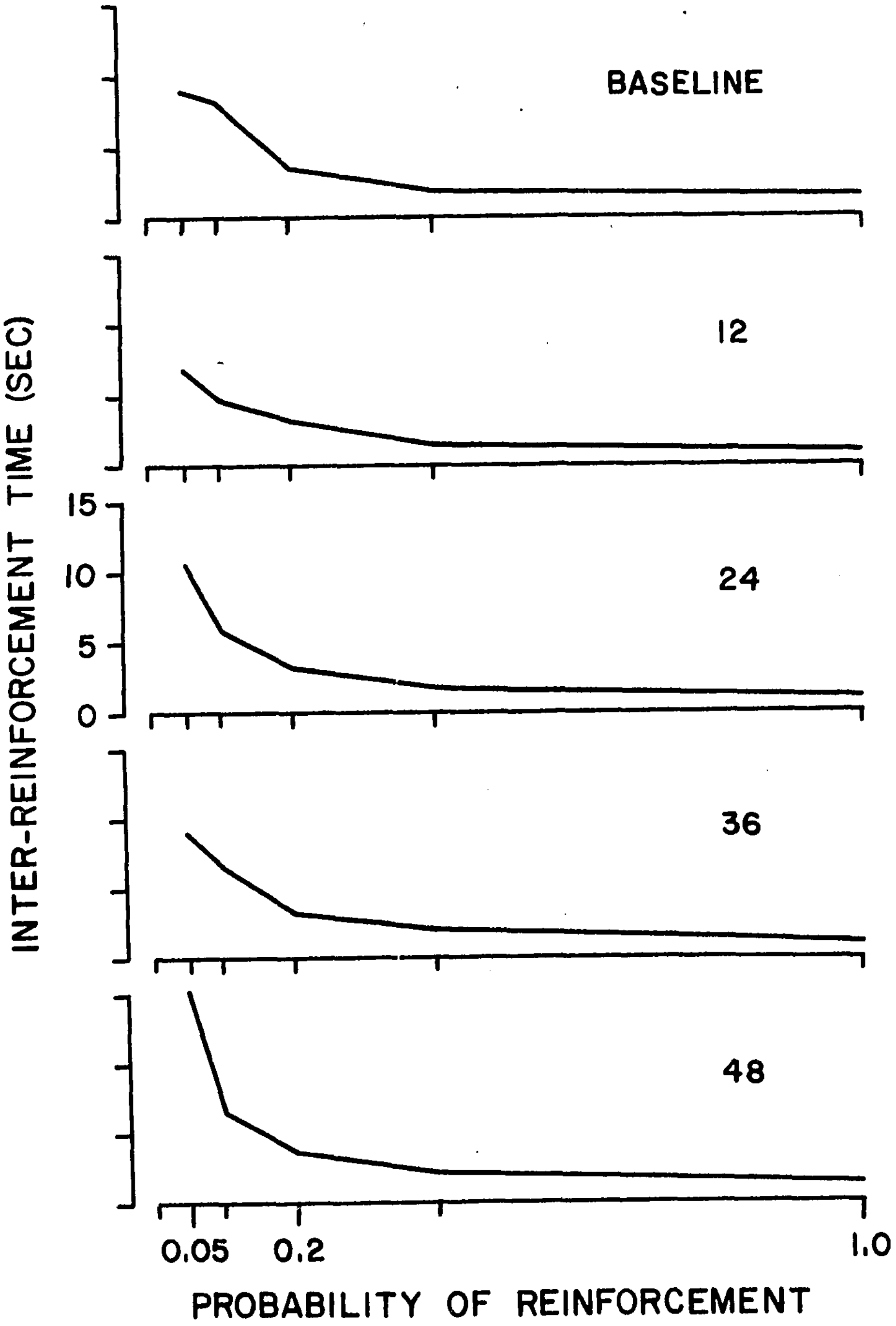

BASELINE
12
24
36
48
RESPONSES PER REINFORCEMENT
75
50
25
0
0.05
0.2
1.0
PROBABILITY OF REINFORCEMENT

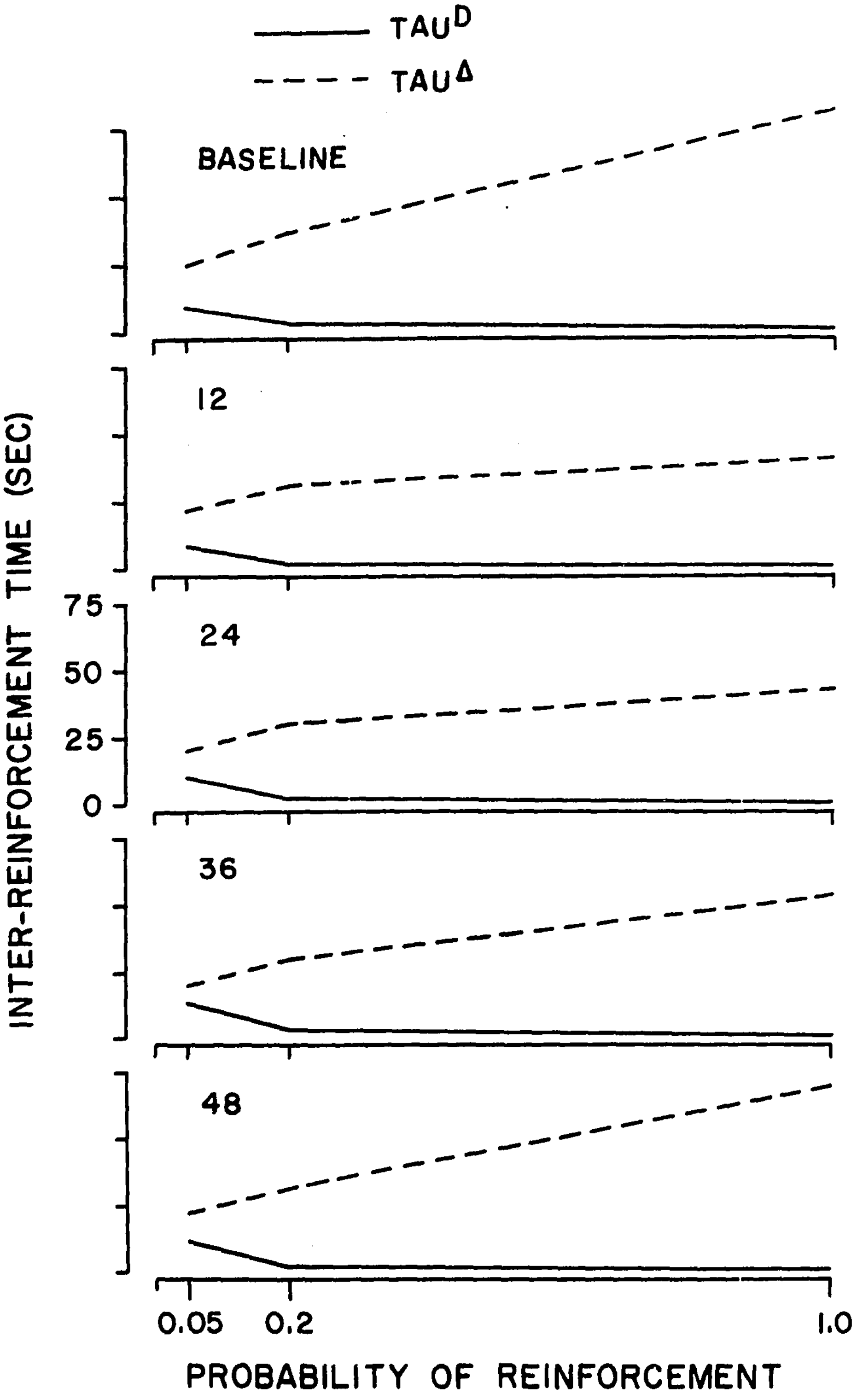
Figure 19. Tau^D inter-reinforcement time (IS^RT) in seconds as a function of $p(S^R/R \cdot \text{tau}^D)$ for groups A and B. Baseline or onset in seconds for one temporal location of a six second light (S^N) presented within tau^Δ is shown in each pair of coordinates. Data for $p(S^R/R \cdot \text{tau}^D) = 1.00$ are the averages of six subjects, combining groups A and B; all other data are the averages of three subjects.


BASELINE
12
24
36
48
15
10
5
0
INTER-REINFORCEMENT TIME (SEC)
0.05
0.2
1.0
PROBABILITY OF REINFORCEMENT

$p(S^R/R \cdot tau^D)$ or $p(S^R/R \cdot tau^\Delta)$ was sufficient to increase IS^RT for the whole cycle. For group C, figure 20 shows tau^D IS^RT as a positively accelerated function and tau^Δ IS^RT as a negatively accelerated function of increasing $p(S^R/R \cdot tau^D)$. Probability of reinforcement in tau^Δ was constant throughout the experiment. Therefore, the negatively accelerated IS^RT function in tau^Δ represents the increase in tau^Δ rates, also reported in tables eight through ten. Variation in S^N location did not affect IS^RT in tau^Δ.

The major findings of this experiment are summarized as follows:
(1) As $p(S^R/R \cdot tau^D)$ was decreased over five values from 1.00 to 0.05 with $p(S^R/R \cdot tau^\Delta) = 0.00$, corrected rates increased at each S^N location and increased proportionately as S^N was moved toward the center of tau^Δ. For $p(S^R/R \cdot tau^D)$ less than 1.00, each series of S^N intrusions resulted in an inverted U-shaped function of corrected rates in S^N. As $p(S^R/R \cdot tau^D)$ was decreased over three values from 1.00 to 0.05 with $p(S^R/R \cdot tau^\Delta) = 0.02$, corrected rates increased at each S^N location, but the functions of corrected rates in S^N were irregular. At each $p(S^R/R \cdot tau^D)$ corrected rates in S^N were recovered. Therefore, corrected rates were a function of temporal location.
(2) As $p(S^R/R \cdot tau^D)$ was decreased with $p(S^R/R \cdot tau^\Delta) = 0.00$ or 0.02, corrected rate in tau^D increased for each $p(S^R/R \cdot tau^D)$ and increased over the course of 50 sessions at each value of $p(S^R/R \cdot tau^D)$.
(3) At $p(S^R/R \cdot tau^\Delta) = 0.00$ corrected rates in tau^Δ were either minimal or positively accelerated. Responding within tau^Δ and during S^N appeared to be under separate stimulus control. At $p(S^R/R \cdot tau^\Delta) = 0.02$ corrected rates in tau^Δ increased throughout the experiment.

Figure 20. Tau^D (solid line) and tau^Δ (dashed line) inter-reinforcement time (IS^RT) in seconds as a function of $p(S^R/R \cdot \text{tau}^D)$ for group C. Baseline or onset in seconds for one temporal location of a six second light (S^N) presented within tau^Δ is shown in each pair of coordinates.


TAU^D
TAU$^\Delta$
BASELINE
12
24
36
48
INTER-REINFORCEMENT TIME (SEC)
75
50
25
0
0.05
0.2
1.0
PROBABILITY OF REINFORCEMENT

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Farmer, J. & Schoenfeld, W. N. Response rates under varying probability of reinforcement. Psychonomic Science, 1967, 7, 173-174.

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