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THE EFFECT OF CYCLE LENGTH, INTERSTIMULUS INTERVAL AND PROBABILITY OF REINFORCEMENT IN "AUTOSHAPING/AUTOMAINTENANCE"

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THE EFFECT OF CYCLE LENGTH, INTERSTIMULUS INTERVAL AND PROBABILITY OF REINFORCEMENT IN "AUTOSHAPING/AUTOMAINTENANCE."

by

CARLOS BRUNER-ITURBIDE

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ABSTRACT

The Effect of Cycle Length, Interstimulus Interval and Probability of Reinforcement in "Autoshaping/Automaintenance."

by

Carlos Bruner-Iturbide

Adviser: Professor Thom Verhave

The study evaluated the effects of some variables well known in "operant" experiments in a "classical" conditioning situation. The Pavlovian situation employed was "Autoshaping/Automaintenance" ("A/A") in pigeons. The variables investigated were those of the "intruded stimulus" paradigm: T cycle length, S^N-S^R interval and $p(S^R)$.

Nine homing pigeons served as subjects. S^R consisted of three-sec access to mixed grain. S^N was a four-sec change, from green to red, in the color of the key.

All birds were first placed in the typical "autoshaping" situation, which was replicated in the present study by setting the variables of the "intruded stimulus" paradigm to the following values: T=64 sec; S^N-S^R= 4 sec and $p(S^R)$=1.00. The birds were then separated into three matched groups. Afterwards, T was reduced to 32 and 16 sec in groups B and C, respectively, while group A remained at T=64 sec. With T set at these values as a

group parameter, the following manipulations were instituted:

(a) With $p(S^R)$ constant at 1.00 in all groups, the S^N-S^R interval was gradually increased from 4 sec to 3/4 of the T value in each group.

(b) With a constant S^N-S^R=4 sec in all groups, $p(S^R)$ was decreased from 1.00 to .03 in geometric steps in each group.

(c) At a constant S^N-S^R=8 sec in all groups, $p(S^R)$ was again decreased from 1.00 to .03 in geometric steps in each group.

The results of the study were divided into two different groups of data: those relevant to "intruded stimulus" experiments (1 to 6 below) and those relevant to other "A/A" studies (7 to 9 below).

1. Patterns of responding within the T cycle. All pigeons responded more frequently during S^N than during the rest of the cycle, in all procedures of the study.
2. Number of responses per S^N. Increasing S^N-S^R and decreasing $p(S^R)$ at S^N-S^R=4 and 8 sec produced monotonic decrements in the number of responses per S^N. Longer values of T produced more frequent responding during S^N.
3. S^N rate. The rate in S^N was a monotonically decreasing function of lengthening S^N-S^R and decreasing $p(S^R)$ in all groups. Rates during S^N were a direct function of the value of T.

4. <u>Post-S^N Pause.</u> Longer values of T produced more post-S^N responding. Group C responded infrequently after S^N. In groups A and B, lengthening S^N-S^R produced longer PS^NP's. Decreasing $p(S^R)$ produced very short PS^NP's but did not cause systematic changes in the value of PS^NP.

5. <u>Overall rate.</u> Given that most responding during the T cycle occurred during the 4-sec S^N period, these functions were similar to those for the S^N rate.

6. <u>Net rate.</u> These were inverted U functions of lengthening S^N-S^R for groups A and B. For group C, net rates were decreasing functions of S^N-S^R. Decreasing $p(S^R)$ at S^N-S^R=4 and 8 sec resulted in monotonic decrements in net rates for all groups. The absolute value of net rate was a direct function of T.

7. <u>Number of S^N's containing one response (R>0).</u> R>0 decreased monotonically as S^N-S^R was lengthened and $p(S^R)$ was decreased. Longer T's favored more responding during S^N.

8. <u>Latency in S^N.</u> The latency in S^N was an increasing function of S^N-S^R and $p(S^R)$. Latency duration was not affected by cycle length.

9. <u>Running rate in S^N.</u> The running rate decreased as S^N-S^R increased; it did not change with values of $p(S^R)$ at S^N-S^R= 4 sec. It decreased with $p(S^R)$ when S^N-S^R=8 sec.

The effects of T, S^N-S^R and $p(S^R)$ were generally similar in "A/A" and in other "intruded stimulus" experiments. In view of this similarity, it was concluded that:

(a) The $R\text{-}S^R$ contingency cannot be a necessary parameter for "operant" conditioning, and therefore there is no procedural basis to distinguish between "operant" and "classical" conditioning.

(b) Since "A/A" is an example of "classical" conditioning, there is no basis to distinguish between the conditioning paradigms in terms of their behavioral outcome.

To John and Alicia

To Maria and David

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Skinner (1938) distinguished between two different response classes: one, "respondent" behavior, which is "elicited" by preceding stimulation and is closely related to the activity of the glands and of the autonomic nervous system; two, "operant" behavior, which is "emitted" rather than "elicited" and is closely related to the skeletal movements of the organism.

Skinner also distinguished between two different conditiong paradigms: type S and type R. Type S conditioning coincides with the procedure of "classical" conditioning, where the reinforcer (S^R) is contingent upon the neutral stimulus (S^N). Type R conditioning is equivalent to "operant" conditioning, where S^R is contingent upon a response.

According to Skinner, type S conditioning is effective only in controlling "respondent" behavior while type R is only effective for conditioning "emitted" behavior.

It seems fair to say that these distinctions are believed to be correct by most contemporary behavior theorists (cf. Rescorla and Solomon, 1967). There are, however, some reasons to doubt the validity of this view. In the sections that follow, some arguments will be made against the distinctions mentioned above.

The distinction between "emitted" and "elicited" behavior

Of the two Skinnerian distinctions, the one between "classical" and "operant" conditioning seems to be strongest. The reason is that while the procedural distinction is an empirical one, the behavioral distinction is mainly conceptual (Schoenfeld, 1972).

It seems particularly valid to distinguish between "emitted" and "elicited" behavior in describing the "unconditioned" behavior of the organism. It should be noted, however, that the subject arrives at the experimental set-up already with a history of conditioning that the experimenter generally ignores. Under these circumstances, to distinguish between "emitted" and "elicited" behavior might reflect more the experimenter's perception of causality in the R-S^R relation than a fundamental property of behavior. It might well be the case that the experimenter designates as "elicited" that behavior which can consistently be produced by specific stimuli in a naive animal. According to this criterion, all other behavior might be classified as "emitted."[1]

Once conditioning has taken place, the same distinction appears inappropriate because all the behavior of the subject is determined by the experimental variables (Sidman, 1960). Once the experiment has begun, all the behavior of the subject is determined by preceding stimulation and therefore may be considered as "elicited."

It is known, for example, that when some "emitted" response is reinforced, the stimuli that are present at the moment of reinforcement acquire control over the response (R) (Skinner, 1938). These stimuli may be presented deliberately by the experimenter (E) or may simply be incidental to the delivery of S^R (e.g., Skinner, 1938; Morse and Skinner, 1957). Furthermore, it is also known that after a history of conditioning, S^R itself acquires the power to "elicit" the response that has been reinforced (e.g., Reid, 1957). This last phenomenon holds even if R has been reinforced in a "superstitious" manner (e.g., Skinner, 1948).[2]

If it is true that the distinction between "elicited" and "emitted" behavior disappears after conditiong has proceeded, then it follows that to distinguish between these response classes in the case of unconditioned behavior is inappropriate as well. In the latter case, the distinction ignores the fact that the same variables that determine the behavior of the subject in the experimental situation have been operating (although in a haphazard way) during the history of the subject (Schoenfeld, 1972).

The distinction between "operant" and "classical" conditioning

There are at least two reasons to doubt that "classical" and "operant" conditioning indeed represent two different conditioning procedures. One is the substantial evidence that shows that visceral/glandular behavior can be conditioned by "operant" procedures and conversely, that skeletal behavior can be conditioned by Pavlovian procedures. These demonstrations suggest that there may be elements in common between both types of procedures. Another reason is the evidence that shows that a response-reinforcer contingency may not be a necessary parameter for "operant" conditioning (e.g., Skinner, 1948) and therefore may not be the basis for distinguishing between the two conditioning procedures.

1. Evidence against the coordination of two conditioning paradigms with two different response classes.

The distinction between "classical" and "operant" conditioning is very often justified by reference to the behavior classes that are susceptible to control by each type of procedure. Skinner stated his belief in the coordination of the two conditioning procedures with different response classes as follows: "Type S (classical conditioning) is possible only in respondent behavior because the necessary S^0 ("eliciting" stimulus) is lacking in operant behavior. . . . Type R (operant conditioning) is possible only in operant behavior because S^1 (the reinforcing stimulus) would otherwise be correlated with a stimulus as well." (Skinner, 1938, p. 109; parentheses by the author).

However, as indicated before, the distinction between "elicited" and "emitted" behavior is not clear. It also forces many behavior scientists to rely on the conditioning paradigm, rather than on the actual behavior, to classify a given response as a member of either class.

A more desirable classification of the response classes susceptible to modification by classical and operant conditioning is the use of anatomical referents to distinguish between such classes. Skinner (1938) and a number of more recent writers (e.g., Rescorla and Solomon, 1967) believe that "elicited" behavior corresponds to the activity of the smooth muscle and glands while "operant" behavior corresponds to the skeletal movements of the organism. In fact, the autonomic-skeletal distinction is typical of all response-class distinctions in relating response classes to conditioning procedures in a one-to-one manner (cf. Rescorla and Solomon, 1967; Hearst, 1975).

(1) The "operant" conditioning of visceral/glandular behavior.

Given that the visceral/skeletal distinction is simpler to test than the distinction between "elicited" and "emitted" behavior, a number of investigations have attempted to condition visceral and glandular behavior using "operant" procedures.

In a summary of the work of Miller and his associates (Miller, 1969), it was reported that through differential reinforcement it was possible to increase or decrease such respondents as salivation in dogs and heart rate in rats. Using rats as subjects, Miller has succeeded in controlling intestinal contractions, rate or urine formation, concentration of blood in the tail and in the pinnae of the ears.

Furthermore, Miller has reported that through differential reinforcement it is possible to differentiate a single autonomic response, without affecting other functions. For example, it is possible to increase or decrease intestinal contractions in rats without affecting heart rate. It is also possible to alter the concentration of blood in the pinna of one ear without changing the volume of blood in the pinna of the other ear.

Finally, Miller has shown that these autonomic changes, achieved through response contingent reinforcement, can be subjected to discriminative control. For example, it is possible to increase or decrease heart rate in the same subject by alternating two different discriminative stimuli.

There are numerous other demonstrations of the operant control of "respondent" behavior (e.g., Jonas, 1973). This evidence is too large to review here but it seems to indicate beyond doubt that it is indeed possible to condition "respondent" behavior by "operant" procedures.

(2) The "classical" conditioning of "operant" behavior.

In his book on classical conditioning, Beecroft (1966) indicated that the Pavlovian conditioning of skeletal behavior was an active research area during the first half of the century. Among the motor responses that were "classically" conditioned were: leg flexion in animals, finger withdrawal in humans and gross activity in both humans and animals. It is not clear why the interest in this area declined after World War II (Beecroft, pp. 34-35). There is, however, a relatively recent demonstration of the "classical" conditioning of a skeletal response that has revived the interest in this type of research. The demonstration in question is "autoshaping/ automaintenance" in pigeons, originally described by Brown and Jenkins (1968).

The term "autoshaping/automaintenance" as used in the present research refers to a variation of Brown and Jenkins' "autoshaping" procedure (i.e., their Experiment 4--The "Fixed Trial Procedure"). It can be briefly described as follows: a food-deprived pigeon, with no experimental history, is placed in an operant conditioning chamber and presented periodically with a briefly illuminated key. Shortly after, food is delivered. The key illumination will be referred to hereinafter as the neutral stimulus of S^N. Under these circumstances, key pecking has no influence whatsoever on the experimental events. This operation has considerable uniformity in its effects:

Schwartz and Gamzu (1977) have recently reviewed the literature dealing with "autoshaping/automaintenance" (designated for brevity hereinafter as "A/A") and concluded that it reliably generates and sustains key pecking in naive pigeons. The pecking occurs at high rates (as much as three responses per second), in the vast majority of subjects, and continues during indefinitely long periods of exposure to the experimental conditions.

Terrace *et al.* (1975) have represented the relevance of "A/A" to behavior theory as follows:

> "One cannot use autoshaping to train keypecks and barpresses, the most widely studied examples of 'arbitrary' operant responses, without questioning the validity of traditional distinctions between operant and classical conditioning. Not only have experiments on autoshaping shown that a nonautonomic response such as the pigeon's keypeck can be readily conditioned by a classical conditioning procedure, but they also question how the law of effect can account for the maintenance of such responses." (Terrace *et al.*, 1975, p. 53)

Most research on the "A/A" phenomenon has attempted to elucidate whether it *truly* represents a "classical" conditioning phenomenon or, as the case might be, the "superstitious-operant" conditioning of a pre-selected response. The question arises, of course, because "superstitious-operant" conditioning and Pavlovian procedures are operationally indistinguishable. It must be said from the outset that, from the point of view of this paper, trying to assign "A/A" to one of two mutually exclusive conditioning paradigms begs the question. It assumes *a priori* that the distinction between "classical" and "operant" conditioning is correct. This point of view is exactly opposite to the one presented here.

Some Pavlovian predictions in the "A/A" situation

There are numerous investigations which have evaluated the effects of Pavlovian manipulations in the "A/A" situation. For example:

Brown and Jenkins (1968) instituted the first controls for pseudoconditioning in "A/A". They found that reverse pairing, S^R-S^N, did not produce responding. The isolated presentation of S^N or S^R, without pairing, did not produce keypecking either. Brown and Jenkins thus concluded that the forward pairing, S^N-S^R, was a sufficient and necessary condition to produce "A/A".

Gamzu and Williams (1971, 1973) showed that if S^R is delivered at a constant frequency, and independently from S^N, "A/A" does not occur. However, differential S^N-S^R pairing, if only occasionally, does result in key pecking. This procedure is analgous to Rescorla's (1967) "truly random control," and was originally proposed as a means to discard pseudoconditioning in Pavlovian experiments. Gamzu and Williams concluded that the acquisition and maintenance of responding in the "A/A" situation was directly related to the "informativeness" of S^N with respect to S^R delivery. The "informativeness" of S^N thus appears to be more important to "A/A" than the mere pairing between S^N and S^R.

Allaway (1971, cited by Hearst and Jenkins, 1975, and by Schwartz and Gamzu, 1977) tested the effect of starting a tone a few seconds before presenting S^N, then letting the tone and S^N end together when food was delivered. Under these circumstances, the pigeons pecked the key very infrequently. However, if the tone precedes and accompanies S^N as before but on some occasions is presented alone and does not end with food, the pigeons do key peck. This demonstration is interpreted to be analogous to one by Egger and Miller (1962) and to show that the "informativeness" of S^N is crucial to the "A/A" phenomenon. Thus Allaway's results seem to agree with those of Gamzu and Williams in showing that the "A/A" phenomenon is a direct function of the "informativeness" of S^N.

In an experiment similar to Allaway's, Wasserman and McCracken (1974) studied the effect of presenting S^N and the food tray illumination simultaneously, before food was delivered. They found that the pigeons exposed to this procedure key pecked less than the pigeons exposed to the regular "A/A" procedure (i.e., where tray illumination is co-terminous with S^R availability). Wasserman and McCracken also found that this decremental effect did not appear if the subjects had previous experience with S^N-S^R pairings. These authors concluded that their results were predictable from the Pavlovian concepts of "overshadowing" and "blocking" (cf. Kamin, 1969).

In addition to the studies described above, where the "informativeness" of S^N is evaluated, there are some studies that have systematically investigated the effects of some temporal variables in the "A/A" situation. In general, the results of this type of experiment have been interpreted as agreeing with Pavlovian principles.

Ricci (1973), for example, found that with a constant "intertrial interval" (ITI) the frequency of responding during S^N was an inverse function of S^N length.

Terrace *et al.* (1975) performed the complementary study. They showed that with a constant S^N, the frequency of response during S^N was a direct function of ITI length.

The findings of Ricci and Terrace *et al.* were replicated later in the research by Perkins *et al.* (1975) which also suggested that the effective variable in these studies was the proportion S^N/ITI. More recent research has verified that the proportion S^N/ITI is negatively related to frequency of response during S^N (Gibbon *et al.*, 1977). The fact that key pecking varies in an orderly way with the duration of S^N relative to ITI has been interpreted as verifying that the "informativeness" of S^N is crucial in "A/A".

Still another study that has manipulated the temporal relations between S^N and S^R is that of Newlin and Lolordo (1976). In this study, frequency of responding during S^N was compared in a "trace" versus a "delay" procedure. It was found that the pigeons key pecked more frequently in the "delay" than in the "trace" procedure, and that in the latter condition responding occurred during the "trace" period at rates even higher than during S^N.

There is one type of study that does not manipulate the temporal relations between S^N and S^R in an explicit manner. Yet it also seems to fall within this research category because its experimental events were studied in a parametric fashion. These studies, reported by Gonzalez (1974) and Perkins *et al.* (1975), examined the effects of presenting S^R intermittently with respect to S^N. Both studies found that a decrease in the percentage of S^N's followed by S^R did not alter the rate of responding during S^N in the range from 100% to 50%. Further decrements in S^R percentage produced monotonic decrements in the rate of responding.

There is still another group of studies that has tested Pavlovian predictions in the "A/A" situations. These studies have examined the possibility that the form of the response in "A/A" may depend on the type of consummatory response elicited by S^R. This is, of course, a prediction based on the principle of "stimulus substitution" or signalization (Pavlov, 1927).

Jenkins and Moore (1973), for example, found that in the "A/A" situation, food-deprived pigeons given grain as S^R responded to the key with movements resembling eating. Alternatively, water-deprived pigeons given water as the S^R developed response topographies similar to drinking movements. There is a substantial literature for this phenomenon that cannot be reviewed here. In their recent review of the literature on "A/A", Schwartz and Gamzu (1977) concluded the following: "The overwhelming impression derived from these data is that the autoshaped response usually bears a remarkable resemblance to the response elicited by the reinforcer." (Schwartz and Gamzu, 1977, p. 16).

Finally, there are data that have been interpreted by some authors as evidence, although not conclusive, that the contingency between S^N and S^R plays a more important role in "A/A" than the "superstitious-operant" contingency, R-S^R. The first experiment of this kind was done by Williams and Williams (1969, see also Herrnstein and Loveland, 1972). Briefly, the experiment was as follows: the pigeons were exposed to the unconditional S^N-S^R pairing but with the provision that S^R would be omitted if the key was pecked during S^N. Under this procedure, all the pigeons responded during S^N although, with the omission contingency, the pigeons lost about half of the scheduled S^R's.

Williams and Williams thus concluded that the accidental conjunction of R and S^R could not play an important role in "A/A". By exclusion, the Pavlovian contingency, S^N-S^R, would be the crucial variable to obtain the phenomenon. It is important to notice, however, that this interpretation of the Williams and Williams experiment has been the object of considerable debate and that the persistence of responding under the omission contingency does not necessarily mean that the "superstitious" reinforcement of R is inconsequential in "A/A" (e.g., Hursh, Navarick and Fantino, 1974).

In view of the evidence discussed in this section, a number of authors have concluded that "A/A" does indeed represent the "classical" conditioning of an instrumental response (e.g., Schwartz and Gamzu, 1977; Moore, 1973; Skinner, 1971). Skinner, for example, has stated: "The process (autoshaping) seems more accurately described as the classical conditioning of a stimulus which elicits a response of phylogenic origin." (Skinner, 1971, p. 752; parenthesis by the author)

It has been shown that "respondent" behavior can be conditioned by "operant" procedures. It has also been shown that "instrumental" behavior can be conditioned by Pavlovian procedures. Both demonstrations seriously question the coordination of these two different conditioning paradigms with "respondent" and "instrumental" behavior, as initially suggested by Skinner. It can thus be concluded that there is no basis to distinguish between "operant" and "classical" conditioning in terms of the types of response they are capable of modifying.

2. The role of the R-S^R contingency in "operant" conditioning.

The strongest reason to make a distinction between classical and operant conditioning is the procedural differences involved in each of these paradigms. Skinner (1938) proposed the following criterion to distinguish between "classical" (type S) and "operant" (type R) conditioning: "The fundamental distinction rests upon the term with which the reinforcing stimulus is correlated. In type S it is the stimulus, in type R, the response." (Skinner, 1938, p. 109)

According to this definition, one difference between "classical" and "operant" conditioning is that in the former, S^R occurs independently from R while in the latter, S^R depends upon the previous occurrence of R. It seems that this apparently irreconcilable operational difference between the two conditioning paradigms has been the main difficulty for any one-factor theory of conditioning (Schoenfeld, 1966, 1972).

Although Skinner had made the R-S^R dependency (or contingency) the mark of operant conditioning, he saw the need to review that definition in 1948. The type of data that led Skinner to this reformulation was the folfolowing. Some pigeons were exposed to the periodic presentation of S^R, every 15 sec, but the occurrence of S^R was independent of their behavior. As a result of this procedure, it was found that the pigeons exhibited highly stereotyped behavior patterns which although they were different for each subject nevertheless occurred reliably between the consecutive presentations of S^R. Furthermore, when it was possible to record the frequency of one of these behaviors mechanically, the cumulative record thus obtained did not differ from the "scallop" commonly observed in R-contingent fixed interval schedules of reinforcement. Skinner thus concluded that "operant" conditioning could occur without an R-S^R contingency:

> "To say that reinforcement is contingent upon a response may mean nothing more that it follows the response. It may follow because of some mechanical connection or because of the mediation of another organism, but conditioning takes place presumably because of the temporal relation only, expressed in terms of the order and proximity of response and reinforcement." (Skinner, 1948, p. 168)

If it is true that "operant" conditioning can occur without a contingency relationship between R and S^R, then it seems reasonable to infer that in any Pavlovian experiment the conditioning of some "instrumental" (albeit unidentified) response occurs also. Conversely, in the "superstition" experiment some "respondent" conditioning must take place as well since the Pavlovian procedure of "temporal conditioning" (see note 1) is identical to Skinner's situation. This is to say, as Schoenfeld *et al.* (1972) have indicated, it is clear that the same event (such as food) that is said to reinforce an operant response is also said to "elicit" a "respondent." The question then arises as to whether the "respondent" *and* the "operant" are not both being "elicited" and reinforced by S^R (cf. Terrace, 1973).

The similarity between "superstitious-operant" procedures and Pavlovian conditioning has long been acknowledged (e.g., Kimble, 1961). There is, however, a general belief that the R-S^R dependency is a necessary requirement in operant experiments. One reason for this belief has been the apparent inability of E to specify in advance the response that will be conditioned in S^R-independent procedures (e.g., Skinner, 1948). There are reasons to believe, however, that this might not be necessarily the case. Staddon and Simmelhag (1971) have shown that the "superstitious" procedure produces behavioral changes that are quite uniform and predictable among experimental subjects.

Another reason for the belief that a contingency is necessary in "operant" experiments is the generally uniform outcome of experiments that have attempted to "superstitiously" condition behavior while at the same time circumventing the response identification problem posed by S^R-independent procedures. The general strategy of such procedures has been to shift the S^R schedule from an initially R-dependent one to an R-independent schedule. Under these circumstances rate of responding usually decreases and eventually approaches a zero level after such a shift is made (e.g., Skinner, 1938; Lachter, 1971; Lachter, Cole and Schoenfeld, 1971). In view of this evidence it has been generally concluded that the R-S^R contingency may be a requirement for "operant" conditioning because it would at least insure that S^R follows R immediately (e.g., Skinner, 1938; Lachter, 1971). From the point of view of the present study, however, the fact that an R-S^R contingency serves to insure the temporal proximity between R and S^R does not make it a necessary parameter for "operant" conditioning. There is evidence that there are other ways than establishing an R-S^R contingency, to favor, if not insure, the temporal proximity between R and S^R (Skinner, 1938; Brown and Jenkins, 1968).

If an R-S^R contingency is at most a sufficient but not a *necessary* requirement for "operant" experiments, contrary to Skinner's original criterion, then there may be no reason to distinguish between "operant" and "classical" conditioning on procedural grounds. It is becoming increasingly clear that what matters most in conditioning are the temporal relations between responses and stimuli, and these are the same in both paradigms (Schoenfeld *et al.*, 1972). It may well be that "classical" and "operant" conditioning are simply different ways to arrange the same temporal relations between experimental events. In both cases the following sequence is generated: there is a previously neutral stimulus (S^N) which after conditioning determines the occurrence of a response (R) and both S^N and R are followed by a reinforcer (S^R).

3. The role of S^N in "operant" and "classical" conditioning.

In view of the evidence reviewed in this section, it can be concluded that: one, "classical" and "operant" conditioning cannot be distinguished in terms of the response classes that are susceptible to control by each of these procedures. Two, that the operational basis for distinguishing between these two conditioning procedures was seriously weakened when Skinner (1948) demonstrated that "operant" conditioning could occur without an $R\text{-}S^R$ contingency.

There remains the question whether the response functions obtained in "operant" conditioning procedures (i.e., where there is an $R\text{-}S^R$ contingency) are different from the response functions obtained in "classical" conditioning experiments. As Hearst (1975) has indicated: If different processes or mechanisms (or laws) are involved in each of these conditioning paradigms, then certain phenomena should be observed under one procedure and not under the other.

The relevant evidence so far shows, however, that most phenomena that occur in "classical" conditioning experiments also occur in "operant" situations (Kimble, 1961; Schoenfeld, 1966; Hearst, 1975; Terrace, 1973). It is important to notice that most of the phenomena that are common to "operant" and "classical" conditioning are also related to the notion of stimulus control. These include:

extinction, spontaneous recovery, generalization, discrimination, and the effects of several reinforcement schedules.

Terrace (1973) has pointed out that one element common to both "classical" and "operant" conditioning is the control acquired by S^N over the response. This phenomenon is more obvious in "classical" conditioning because E typically detects that conditioning has taken place when S^N begins to control the response that was originally "elicited" by S^R. In the case of "operant" conditioning, the metaphor of the operant as "emitted" and of the procedure as one that permits "free" responding (Ferster, 1953) does not emphasize the role of S^N. There is, however, enough evidence to conclude that even when S^N is not explicit in the experiment, other environmental stimuli, incidental to the conditioning procedure, acquire control over responding (e.g., Eckerman, Lanson and Cumming, 1968).

As discussed previously, if S^R is delivered independently from R, the resulting operations are indistinguishable from those of "classical" conditioning. This being the case, it only remains to be asked if the necessary and sufficient conditions to endow S^N with control over responding are different in each conditioning paradigm. From what is known, they seem to be quite similar in both cases. One fact seems certain: a $R\text{-}S^R$ contingency is not a requirement in the "operant" stimulus control paradigm. This evidence was provided by Morse and Skinner in two different experiments.

Morse and Skinner (1957) found that an incidental stimulus, without any predetermined relation to either R or S^R could acquire control over R. The procedure was as follows: The key pecking response was established in pigeons and maintained with a variable-interval 30-sec schedule. A second schedule presented S^N which was a 4-min change in the illumination of the response key. It occurred once every hour. The presentation of S^N occurred independently from any response. As a consequence of this procedure, S^N acquired control over the frequency of responding that occurred in its presence. For some pigeons, this control consisted in diminutions in the rate of pecking. For other pigeons, the rate increased while S^N was present. Morse and Skinner concluded that the effect of S^N depended on its fortuitous relation to the response being reinforced. If S^N was present when R was reinforced, S^N acquired control over increments in the response rate. Alternately, when R was not reinforced during S^N, the frequency of R decreased when S^N was present.

In a subsequent experiment, Morse and Skinner (1958) showed that it is not necessary for R to procure the S^R in the presence of S^N for S^N to acquire control over the response. The procedure consisted in pairing one S^N with S^R while another S^N occurred in the absence of S^R. The presentation of these stimuli occurred independently from the behavior of the pigeons. In a subsequent phase of the experiment, the pigeons were trained to peck the key. Finally, during extinction, the two S^N's were presented alternately. It was found that when the S^N which had paired with S^R was present, the pigeons pecked more frequently than when they pecked in the presence of the S^N not paired with food. The authors concluded that the mere temporal contiguity between S^N and S^R was sufficient to endow S^N with a degree of control over subsequently established behavior.

It is precisely the fact that stimulus control can occur in an "operant" situation without there being any relation between responding and the delivery of experimental events that made Brown and Jenkins' (1968) explanation of "A/A" as a case of "superstitious-operant" conditioning plausible. The first response perhaps occurs because of a species-specific tendency in pigeons to peck at things they look at. Once the first key peck occurs, it is reinforced by the proximity of S^R. The S^N, in turn, acquires control over R by virtue of its close temporal relationship to R and S^R (cf. Brown and Jenkins, 1968, p. 7). Brown and Jenkins also considered the possibility that "A/A" could actually represent a case of "classical" conditioning. Their doubt, of course, came about because the procedures could not be distinguished on operational grounds. It can be concluded that the necessary and sufficient conditions to endow S^N with control over behavior seem to be largely the same in "operant" and "classical" conditioning. That is, the relative temporal proximity between R, S^N and S^R.[3]

Purpose of this study

As Schoenfeld (1966) and Terrace (1973) have indicated, one possible way to eventually achieve the reduction of the two conditioning paradigms into a single one is to concentrate on the variables that are common to classical and operant conditioning. This approach would involve the demonstration that behavioral measures observed under both procedures are indeed similar functions of similar variables.

It has already been shown that the independent variables most frequently studied in Pavlovian situations have essentially the same effects in "A/A". These demonstrations seem sufficient to justify the claim that "A/A" represents a "classical" conditioning phenomenon. Alternatively, there are very few experiments in the "A/A" literature that have inquired into the generality of those variables, the effects of which are well known in "operant" conditioning research. Should these variables also have the same effect in the "A/A" situation and in a standard "operant" conditioning situation, then the *empirical* support for the "operant-respondent" distinction would be weakened still further.

From the point of view of this study, the use of the "A/A" phenomenon together with the *t*-system (e.g., Schoenfeld, *et al.*, 1972) affords a unique opportunity to to inquire into the effects of variables that are common to both "operant" and "classical" conditioning.

First of all, the use of "A/A" seems advantageous to this purpose because it involves the same response used in "operant" experiments with pigeons. The fact that the rate of responding can be measured in "A/A" is especially important for such a comparison. With few exceptions, most Pavlovian situations would not permit a direct comparison with "operant" procedures in terms of response rates because in the former, the rate of the conditioned response is restrained by the rate at which the eliciting stimulus is delivered (Schoenfeld, 1976).

Secondly, the use of the t-system to define the independent variables to be compared is also advantageous. One clear difference between the independent variables of "classical" and "operant" conditioning experiments is that in the first case, they are completely under the control of E. In the case of "operant" conditioning, however, the behavior of the subject enters into the determination of the variables because of their contingency upon responding (Schoenfeld and Cole, 1975). This difference in the rules that govern the independent variables in each type of procedure makes it difficult to define and use variables that "classical" and "operant" conditioning have in common. By contrast, the t-system defines all conditioning procedures in temporal terms alone. It is this feature of the system which minimizes the contribution of the subject's responding to the rules that determine the delivery of the experimental events. It has been shown that once the contingency requirement is by-passed in many "operant" procedures, they become indistinguishable from Pavlovian ones (e.g., Evra, 1974).

According to these considerations, the present study systematically attempted to widen the body of data that can be compared in the "A/A" situation and in "operant" experiments done within the tradition of the *t*-system.

The *t*-system and the "intruded stimulus" paradigm will be briefly reviewed here because of their relevance to the present investigation. Afterwards, the specific independent variables of this study will be discussed along with some of their expected effects in the "A/A" situation.

The t-system and the "intruded stimulus" paradigm

The *t*-system constitutes an attempt to organize and inter-relate the independent variables of conditioning using only timeas the basic organizing variable. One of the reasons for using time as *the* central variable is the anticipation that "classical" conditioning procedures, already specified in temporal terms, might eventually be included in the *t*-system (cf. Schoenfeld *et al.*, 1972).

The initial objective of the *t*-system was to subsume Skinner's (e.g., Ferster and Skinner, 1957) ratio and interval schedules. This goal was accomplished when these schedules were classified as limiting cases of the variables of the system (e.g., Schoenfeld, Cumming and Hearst, 1956).

Latter investigations sought to integrate other conditioning procedures where, in addition to the schedules of S^R, other stimuli which may or may not differ from S^R were included. One type of procedure that the system endeavored to subsume was the concurrent presentation of S^R and of a neutral stimulus (S^N). The relevance of this operation is, of course, that it represents the generic procedure to endow S^N with discriminative and conditioned reinforcement functions (e.g., Farmer and Schoenfeld, 1966 a and b). A basic paradigm to study the stimulus functions acquired by S^N consists of introducing S^N within a fixed inter-reinforcement interval (IS^RI) (e.g., Skinner, 1938; Pavlov, 1927). Such experiments therefore have become known within the system as "intruded stimulus" research.

Among the different strategies used by the *t*-system to integrate "intruded stimulus" situations, the most successful because of its generality has been that of Martin (1971). This approach conceptualizes the delivery of S^N and S^R as governed by different and independent schedules. These schedules are, in turn, defined by the temporal variables of the system. Briefly, the basic programming variables are the following:

(a) The T parameter specifies the duration of a repetitive time cycle.

(b) The p parameter specifies a given probability with which the experimental event occurs at the end of the T cycle.

(c) By combining T and p in each of the schedules, the expression T/p defines the average interval between two consecutive occurrences of the event at which they apply.

The independent and concurrent operation of the S^N and S^R schedules generates three experimental variables that can be used to systematically examine "intruded stimulus" situations.

(a) the S^N-S^R interval, which specifies the temporal position of the stimuli with respect to each other (e.g., Farmer and Schoenfeld, 1966 a and b; Martin, 1971); and

(b) $p(S^N)$ and $p(S^R)$, which specify the probabilities of occurrence of these stimuli within their respective cycles (e.g., Martin, 1971; Evra, 1974).

Since the t-system originated within the context of traditional "operant" conditioning research, the effects of these variables have been explored mainly in those situations where there has been the familiar R-S^R contingency.

The variables of this study

Since the variables of the "intruded stimulus" model are already defined in temporal terms, the typical "A/A" procedure can easily be replicated and used as an experimental starting point to explore the effect of the following manipulations.

1. Lengthening the S^N-S^R interval while holding $p(S^R)$ constant at 1.00.

The S^N-S^R interval is a variable that has never been investigated systematically in the "A/A" situation. The present research sought to provide this information using three values of T as a parameter.

In "intruded stimulus" experiments where there has been a R-S^R contingency, the manipulation of the S^N-S^R interval has had complex but consistent effects. Farmer and Schoenfeld (1966 a and b) have described the effects of lengthening S^N-S^R according to the temporal distribution of responding within a 60 sec T cycle:

> "At short S_1-S^R (≤12 sec) intervals, responding is low throughout most of the interval, then picks up sharply in the presence of S_1. At longer S_1-S^R intervals (from 18 to 30 sec), high rates develop before S_1 onset (but not appreciably higher than those of the baseline fixed interval functions) while rates during S_1's 6-sec presence, instead of remaining high, drop to low or zero levels. After S_1 termination, high rates, comparable to the original baseline levels, terminate in S^R delivery." (Farmer and Schoenfeld, 1966 a, p. 372)

Another study that has systematically manipulated the S^N-S^R interval is that of Martin (1971). In that study it was found that while certain dependent variables were affected by this manipulation, certain other variables were not affected. The variables that showed the effects of lengthening the S^N-S^R interval were:

(a) the average rate of responding during S^N. This variable turned out to be a monotonically decreasing function of lengthening S^N-S^R.

(b) the frequency distributions of the number of responses made during successive S^N's. As the S^N-S^R interval was increased, the number of responses per S^N decreased.

(c) the frequency distributions of PS^NP. Lengthening the S^N-S^R interval produced a corresponding lengthening in the pause following successive S^N deliveries.

In Martin's study, it should be noted that the overall rate during the T cycle, the median PS^RP and the "net" rate of responding (when S^R time, PS^RP, S^N duration and responding and PS^NP were excluded from the rate calculations) were not systematically related to changes in the S^N-S^R interval.

2. Decreasing $p(S^R)$ at two fixed values of the S^N-S^R interval.

The effect of decreasing $p(S^R)$ while S^N and S^R remain contiguous has been investigated in the "A/A" situation in at least two studies (i.e., Gonzalez, 1974 and Perkins et al., 1975). Both studies have shown that rate of responding in S^N is a decreasing function of a decreasing $p(S^R)$. However, just how the function which relates responding to $p(S^R)$ is influenced by different values of T (or the "intertrial intervals") remains to be determined. One part of the present study therefore closely replicated Gonzalez' procedure but includes different values of T as a parameter of the $p(S^R)$ variable.

Given the set of interlocking variables used in the present research, the typical "A/A" situation represents only one extreme of the potential convergence between S^N-S^R and $p(S^R)$. In an attempt to widen the systematic domain outlined here, the effect of $p(S^R)$ was also determined in the present study while S^N was being held temporally separated from the point where S^R was delivered probabilistically. Here again, three values of T were studied as parameters of the $p(S^R)$ variable.

The variables $p(S^N)$ and $p(S^R)$ have been investigated in R-S^R contingent situations by Martin (1971) and Evra (1974). Martin found that whereas the S^N-S^R interval was a powerful variable in "intruded stimulus" experiments, $p(S^R)$ and $p(S^N)$ were relatively inconsequential. In discussing the effects of $p(S^R)$ and $p(S^N)$ on the same variables that were affected by lengthening the S^N-S^R interval, Martin concluded that: "The data show that stimulus probability per se had little or no effect across its range when the phase angle was small . . ." (Martin, 1971, p. 111)

Evra (1974) came to essentially the same conclusion when she compared the effects of "intruding" S^N in different temporal locations in fixed interval (FI) and random interval (RI) schedules. Both Martin and Evra agree that the fact that $p(S^R)<1.00$ does not have a prominent effect in this type of experiment verifies Eckerman's (1969) statement that the discriminative control exerted by S^N is not weakened by making S^R intermittent with respect to S^N.

The conclusion that can be drawn from Martin's and Evra's data is that $p(S^R)$ has a smaller effect than S^N-S^R in "intruded stimulus" experiments.

3. T cycle length as a parameter for the manipulation of the S^N-S^R interval and $p(S^R)$.

The effect of different "intertrial intervals" (ITI) has been documented in the "A/A" literature by two different studies (Terrace *et al.*, 1975; Perkins *et al.*, 1975). Both studies agree that rate in S^N is an increasing function of the value of ITI.

One way to manipulate the "intertrial interval" in the "A/A" situation while using the "intruded stimulus" paradigm is to change the value of T while holding the S^N-S^R interval constant and $p(S^R)=1.00$. There are, however, no "intruded stimulus" studies where the length of

T has been investigated systematically. In the study by Evra (1974), it was found that S^N-S^R exerted its effects relative to the cycle length in both FI and RI schedules, even though they differed in the values of T employed. It is possible, therefore, that $p(S^R)$ will also have different effects depending on the value of the T parameter.

Given that cycle length (T) is a potentially important variable in "intruded stimulus" experiments, it was included in the present research as a parameter of the manipulation of S^N-S^R and $p(S^R)$.

To summarize the purpose of this study: it set out to determine the effects of T, S^N-S^R and $p(S^R)$ in the "A/A" situation. The effects of these experimental variables and their interactions have been more extensively documented in "operant" than in Pavlovian situations, in spite of the fact that these variables are common to both types of procedures. Given that "A/A" can be considered to be an example of "classical" conditioning, the present study attempted to establish their generality in that situation.

FOOTNOTES

[1] For instance, a very long latency between the presentation of a stimulus and the ensuing response might be the basis for categorizing an "elicited" response as "emitted." Just as there are known experimental procedures to turn an "emitted" response into an "elicited" one, there are experimental procedures that can make an "elicited" response appear to be "emitted."

The case can be illustrated by one of Pavlov's experiments concerning "time reflexes": a dog is fed periodically, every 30 min. Once this routine is established, the effect of the procedure is tested by withholding food. As a consequence of this operation, the dog is seen to salivate substantially every 30 min, at about the same time when food would have been delivered. Pavlov aptly described this behavior as a "delayed reflex": "These reflexes appeared <u>spontaneously</u> at the regular intervals of time. . . . In the interval there is not the least sign of any alimentary reaction. When we come to seek an interpretation of these results, it seems pretty evident that the duration of time has acquired the properties of a conditioned stimulus." (Pavlov, 1927, p. 41; underlined by the author)

It seems clear that in a strict sense, this behavior is not "emitted" (i.e., spontaneous) but rather is "elicited" by the experimental events. Yet, it seems reasonable to expect that an observer, unfamiliar with the subjects' experimental history, might well conclude that the response is truly "emitted."

[2] Regarding the power that S^R acquires during conditioning, to elicit the same behavior that it originally reinforced, it is interesting to note one of Skinner's observations during his experiment on "superstitious" conditioning:

> ". . . it was possible to record the extinction of the response when the clock was turned off and the magazine was no longer presented at any time . . . When the clock was again started, the periodic presentation of the magazine (still without any connection whatsoever with the birds' behavior) brought out a typical curve for reconditioning after fixed-interval reinforcement. The record had been essentially horizontal for 20 min prior to the beginning of this curve." (Skinner, 1948, p. 407)

This observation by Skinner shows that the periodic delivery of S^R, even when it occurs independently of the subject's behavior, serves to "elicit" a conditioned response that had been previously eliminated by extinction.

[3] Although the concept of stimulus control has potential value in achieving the reduction in conditioning

paradigms, there seem to be few studies concerning the acquisition of responding in the presence of antecedent stimuli (Terrace, 1973).

In the case of the "A/A" phenomenon, recent research has shown the extent to which the preparatory conditions of the experiment may determine the occurrence of the "first" conditioned response. Since these operations are applied uniformly to all subjects in any "A/A" experiment, it is not surprising that the phenomenon has such generality among pigeons. These investigations have shown that the similarity in hue between the feeder and the response key is a determinant of the speed with which pigeons start key pecking (Sperling, Perkins and Duncan, 1977; Davol, Steinhauer and Lee, 1977). Another determinant of the "first" key peck seems to be the extent of previous magazine training. If magazine training is extensive, the pigeons appear more disposed to peck the key in isolated presentations of S^N, i.e., unaccompanied by food (Steinhauer, Davol and Lee, 1976; Downing and Neuringer, 1976).

METHOD

Subjects

Nine female homing pigeons, one to three years of age, served as subjects in this investigation. The birds were obtained commercially from a member of the local colombophilus association and had no prior experimental history. After observing their *ad libitum* weight for approximately eight weeks, they were reduced to 80%. Thereafter, they were maintained at that same weight level throughout the course of the entire investigation.

Apparatus

The procedures of the present study were programmed automatically by means of standard laboratory solid state equipment (BRS/LVE). The data were collected and processed by a microcomputer (Radio Shack's TRS-80) coupled with a commercially available interface system (LVB).

All pigeons were tested in the same conditioning cubicle (BRS/LVE Mod. No. SEC-002) which was installed in a room separate from the programming equipment as a precaution against undesirable noises. Only the central key of the intelligence panel (BRS/LVE Mod. No. PIP-014) was functional in recording pecks and presenting color stimuli. A lateral pressure of 25 grams or more was sufficient to activate the response microswitch. Following the recommendation of Ferster and Skinner (1957), the drop pan of the cubicle was raised about three cms. to compensate for the small size of these birds. A masking noise was provided through the intelligence panel's speaker, at a level deemed sufficient, to further reduce outside auditory disturbances.

Procedure

Experimental sessions were conducted daily (seven days a week) and the birds were always run in the same order. The following procedural features remained the same throughout this research:

(a) Each experimental session was initiated by a food delivery and the simultaneous illumination of the response key and the houselight.

(b) Each session consisted of 50 $S^N(T_R)$ and $S^R(T_R)$ cycles.

(c) In each group T_N and T_R were always of the same length, i.e., $T_N=T_R$. For brevity's sake, T from here on will designate the length of both cycles.

(d) The reinforcing event (S^R) which occurred on a probabilistic basis at the end of cycle T_R consisted of three seconds access to the lighted food tray which contained a grain mixture.

(e) The "intruded" S^N event occurred invariably at the end of the T_N cycle, i.e., $p(S^N)=1.00$. S^N consisted of the illumination of the response key by a red light for four seconds. In the absence of S^N, the response key remained illuminated green.

(f) In order to evaluate the effects of each experimental condition of the study, a temporal criterion was preferred over a behavioral definition of stability (see Schoenfeld, Cole *et al.*, 1972, for a brief account of the disadvantages of a response dependent definition of stability and its converse, transition). Ten individual sessions were allotted to observe the effects of each experimental condition of the study. Previous research had shown that this number of sessions was sufficient to observe a trend, if not the terminal values, for most of the variables observed here.

There were three successive phases to the research:

1. *Autoshaping of the response to S^N and shortening the T cycles.*

Once all subjects had been "magazine trained" with the houselight on and the key darkened, they were exposed to the following "autoshaping" procedure: cycle length (T) was fixed at 64 sec, $p(S^R)$ at 1.00 and the synchrony between the cycles was arranged such that the offset of the four sec S^N coincided with the onset of S^R, i.e., S^N-S^R=4 sec.

All pigeons were kept on this schedule for ten sessions. Next, they were ranked according to their average overall rate of key pecking during the last five sessions. The three subjects with the highest average rate were classified as "fast" responders, the following three as "intermediate" and the last three as "slow" responders. Three groups of subjects were then formed by randomly assigning one pigeon from a given category to each of the groups, hereinafter referred to as A, B, and C.

From session 11 through 20, cycle length (T) was reduced from 64 to 32 sec and from 64 to 16 sec for groups B and C, respectively. The variable $p(S^R)$ remained fixed at 1.00 and S^N-S^R at 4 sec for all groups. Group A remained at T=64 sec in order to further evaluate the temporal course of responding without any change in conditions.

2. Increasing the S^N-S^R interval.

During this second phase, each group was exposed to a series of longer S^N-S^R intervals while holding $p(S^R)=$ 1.00 and cycle length constant. The cycle length (T) this time differed for groups A, B, and C.

For all animals, the series of S^N-S^R values were generated according to the following criteria:

(a) S^N-S^R values were included that represented fraction (i.e., 1/4, 1/2, and 3/4) of T for each group.

(b) S^N-S^R values were included in groups with longer T's that were also included in groups with shorter T's.

(c) A six-sec S^N-S^R value was included arbitrarily for all groups.

After the completion of each series, one value of S^N-S^R (four sec) was run again for all animals. Table 1 gives a complete listing of all values used as well as their order.

3. Decreasing $p(S^R)$ with S^N-S^R at 4 and 8 sec.

The redetermination of the data at S^N-S^R=4 sec of the preceding phase served as the starting point to study the effects of decreasing $p(S^R)$ for all groups. While a given cycle length remained fixed as the group parameter, $p(S^R)$ was reduced from 1.00 to .03 in geometric steps (see Table 1). S^N-S^R remained fixed at 4 sec for all groups. After the $p(S^R)$ series was completed, $p(S^R)$ was set at 1.00 once again. Simultaneously S^N-S^R was increased from four to eight sec. The value of $p(S^R)$ was decreased once again in geometric steps, from 1.00 to .03. This time S^N-S^R was held constant at eight sec. Again, a redetermination of the data was obtained at $p(S^R)$=1.00 after the completion of the last series.

Figure 1 shows some temporal relations between S^N and S^R during different phases of the study.

TABLE 1

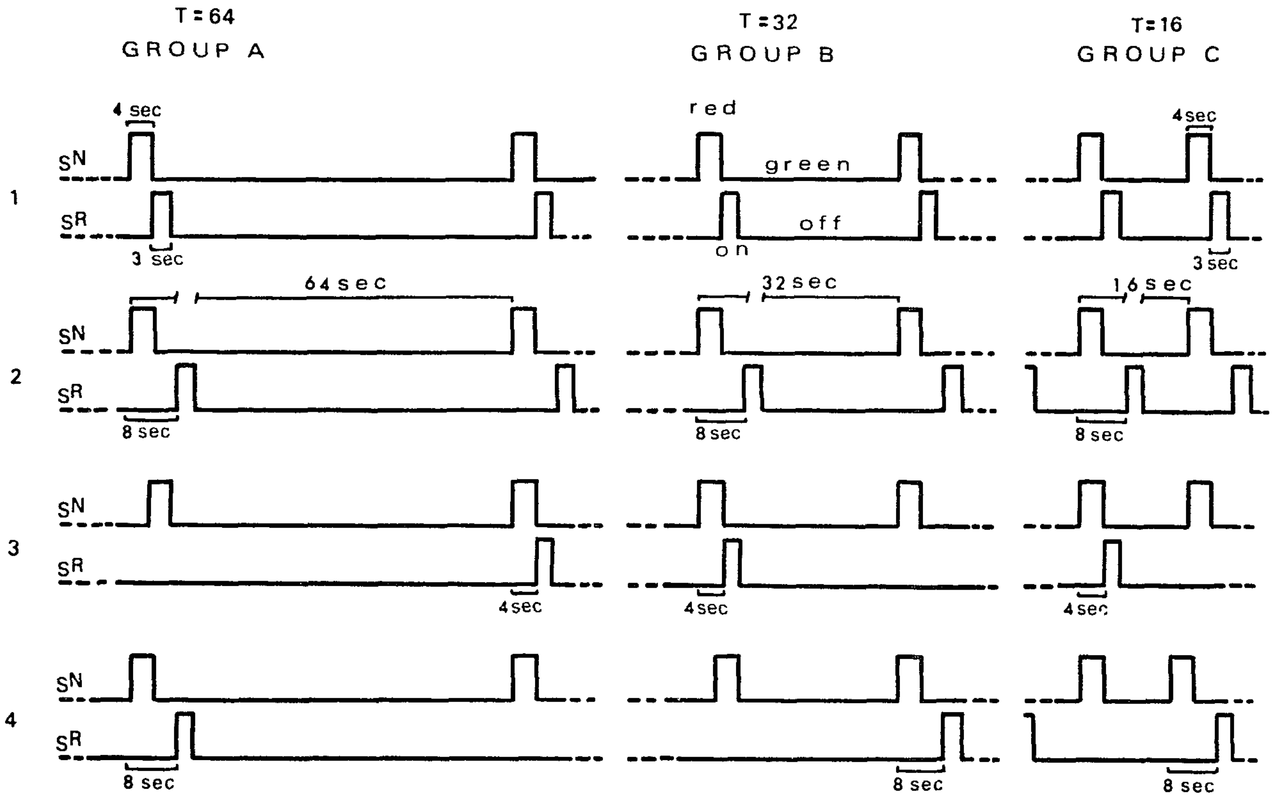
SUCCESSIVE STAGES OF THE EXPERIMENT

Phase 1		Phase 2	Phase 3A	Phase 3B
T=64 sec	S^N-S^R=4	p(S^R)=1.00	S^N-S^R=4 sec	S^N-S^R=8 sec
S^N-S^R=4 sec	p(S^R)=1.00	S^N-S^R (sec)	p(S^R)	p(S^R)
p(S^R)=1.00	T(sec)			
ALL SUBJECTS	(Group A) 64	4 6 8 12 16 24 32 48	1.00 0.50 0.25 0.12 0.06 0.03 1.00	1.00 0.50 0.25 0.12 0.06 0.03 1.00
	(Group B) 32	4 6 8 12 16 24	1.00 0.50 0.25 0.12 0.06 0.03 1.00	1.00 0.50 0.25 0.12 0.06 0.03 1.00
	(Group C) 16	4 6 8 12	1.00 0.50 0.25 0.12 0.06 0.03 1.00	1.00 0.50 0.25 0.12 0.06 0.03 1.00

Figure 1.- The temporal relations between S^N and S^R

This figure illustrates the temporal relations between S^N and S^R which prevailed under the following conditions:

(1) for S^N-S^R=4 sec and $p(S^R)=1.00$
(2) for S^N-S^R=8 sec and $p(S^R)=1.00$
(3) for S^N-S^R=4 sec and $p(S^R)\ 1.00$
(4) for S^N-S^R=8 sec and $p(S^R)\ 1.00$


T=64
GROUP A
T=32
GROUP B
T=16
GROUP C
1
2
3
4
S^N
S^R
4 sec
3 sec
64 sec
8 sec
4 sec
8 sec
red
green
off
on
32 sec
8 sec
4 sec
8 sec
4 sec
3 sec
16 sec
8 sec
4 sec
8 sec

RESULTS

For the purpose of comparing the results of the present study with results obtained in other "intruded stimulus" research, the following dependent variables were used:

(a) The temporal distribution of responding within the S^R cycle. Responding within the S^R cycle was distributed into 32 successive subintervals or bins of equal size for each group. Thus, bin size was 1/32 of the value of T for each group.

(b) The number of responses occurring for each S^N presentation was counted separately.

(c) The rate of responding during S^N. This measure was calculated by dividing the number of key pecks that occurred during S^N by the time that the stimulus was present.

(d) The Post Stimulus Pause (PS^NP). PS^NP was defined as the time elapsed between the offset of S^N and the occurrence of the first response after S^N. Only S^N terminations ending with a response, instead of the following event (i.e., S^R or S^N), qualified as PS^NP's.

(e) The overall rate of responding, defined as the number of responses occurring during the entire T cycle divided by cycle time minus S^R time.

(f) The Post Reinforcement Pause (PS^RP). A

PS^RP was defined as the time elapsed between the offset of S^R and the occurrence of the first response after S^R. As in the case of the definition of PS^NP's, only S^R terminations that were followed by a response, instead of the following experimental event, qualified as PS^RP's.

(g) The residual or net rate. Net rate is defined as the rate of responding when S^R time, PS^RP, S^N duration and S^N responding as well as PS^NP are all excluded from the calculation.

Other "A/A" studies have shown that certain behavioral measures recorded during S^N vary lawfully with a number of experimental operations. Therefore, in the present research the following dependent variables were monitored during S^N, in addition to those mentioned above:

(h) The number of S^N periods that terminated with at least one key peck, hereinafter referred to as $R>0$.

(i) The response latency, defined as the elapsed time between the onset of S^N and the occurrence of the first key peck during S^N. Only S^N presentations that ended with a response entered into the calculation of this variable.

(j) The running rate, defined as the number of key pecks occurring during S^N divided by the elapsed time between the first response in S^N and the offset of S^N.

The results of this research will be presented in two separate sets of data. The first set (Figures 2 to 49) will show the effects of T, S^N-S^R and $p(S^R)$ on those dependent variables that can be compared directly with results obtained in other "intruded stimulus" research.

The second set of data (Figures 50 to 65) shows the effect of T, S^N-S^R and $p(S^R)$ on dependent variables that, although they have not usually been recorded in "intruded stimulus" experiments, are nevertheless relevant to "A/A" studies.

All the data are presented session by session and as group averages and medians, based on the last five sessions of each value of the variables of the study.

I. Dependent variables directly relevant to "intruded stimulus" research.

1. The patterning of responding within the T_R cycle.

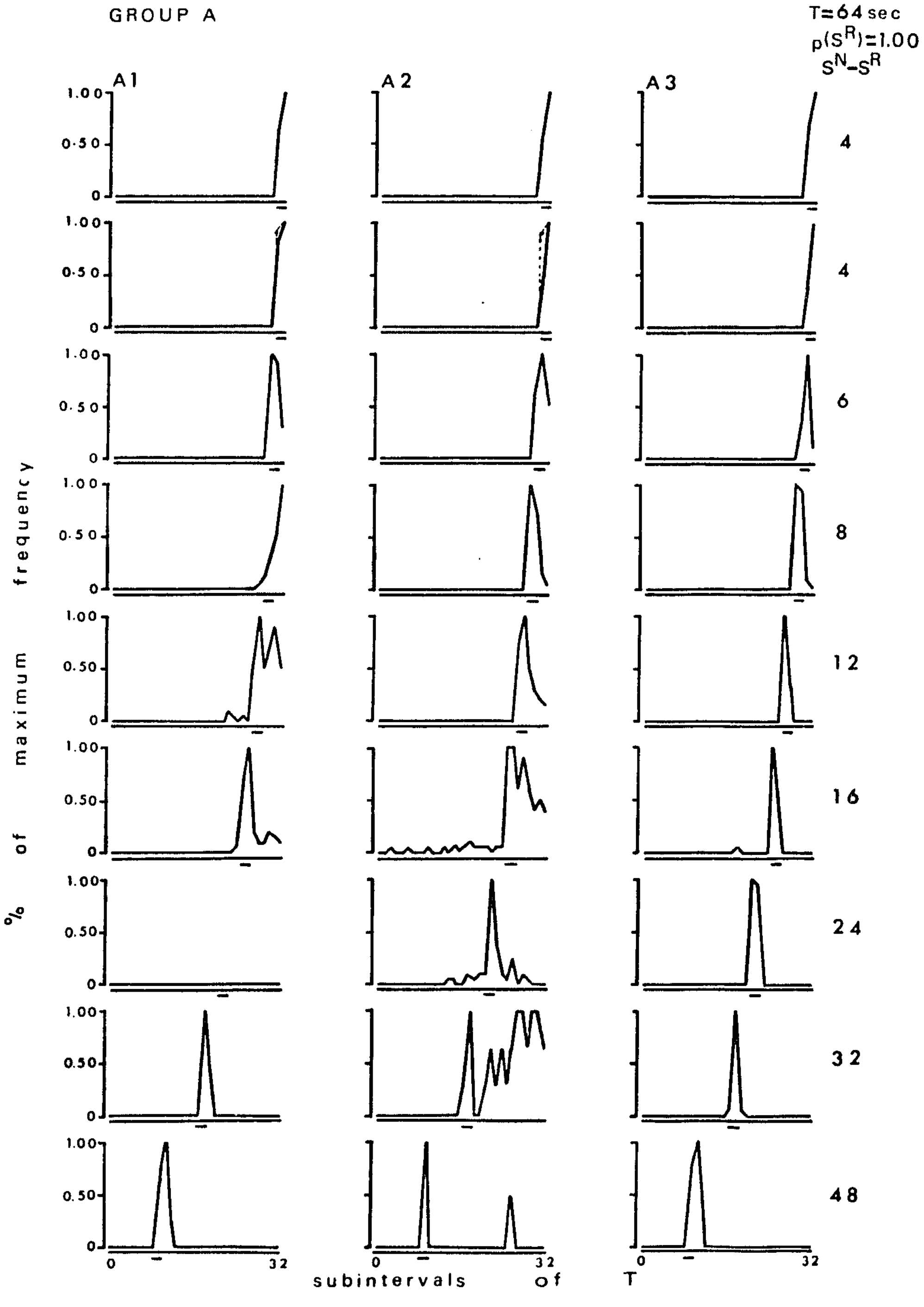
Figures 2 to 10 show the number of responses that occurred in each bin as a fraction of the maximum frequency observed within the entire T cycle. This transformation was made in order to show the response patterns that occurred when the rates of responding were very low relative to the highest rates observed within that phase of the experiment.

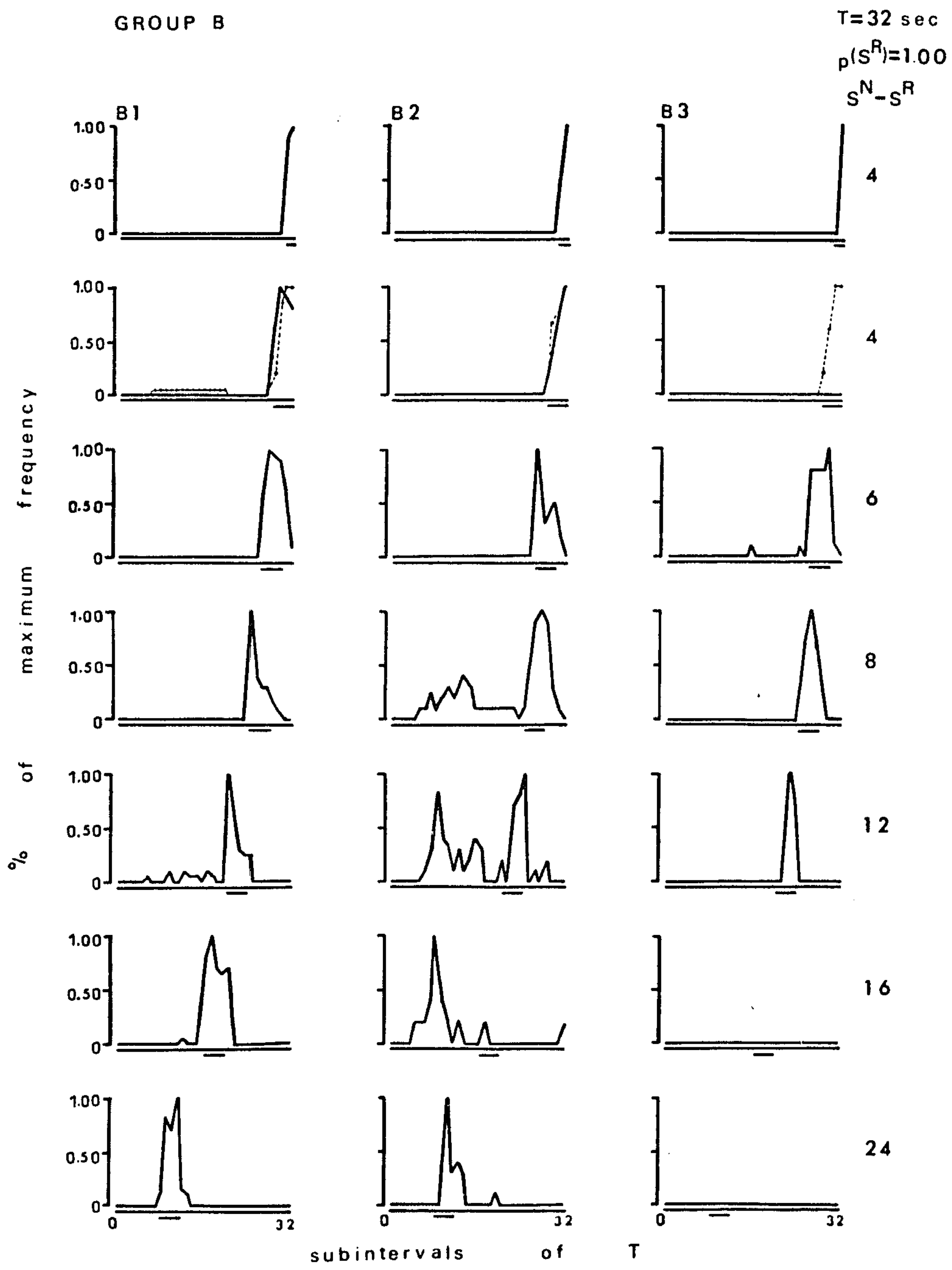
Figures 2 to 10.- Patterning of responding within the T_R cycle

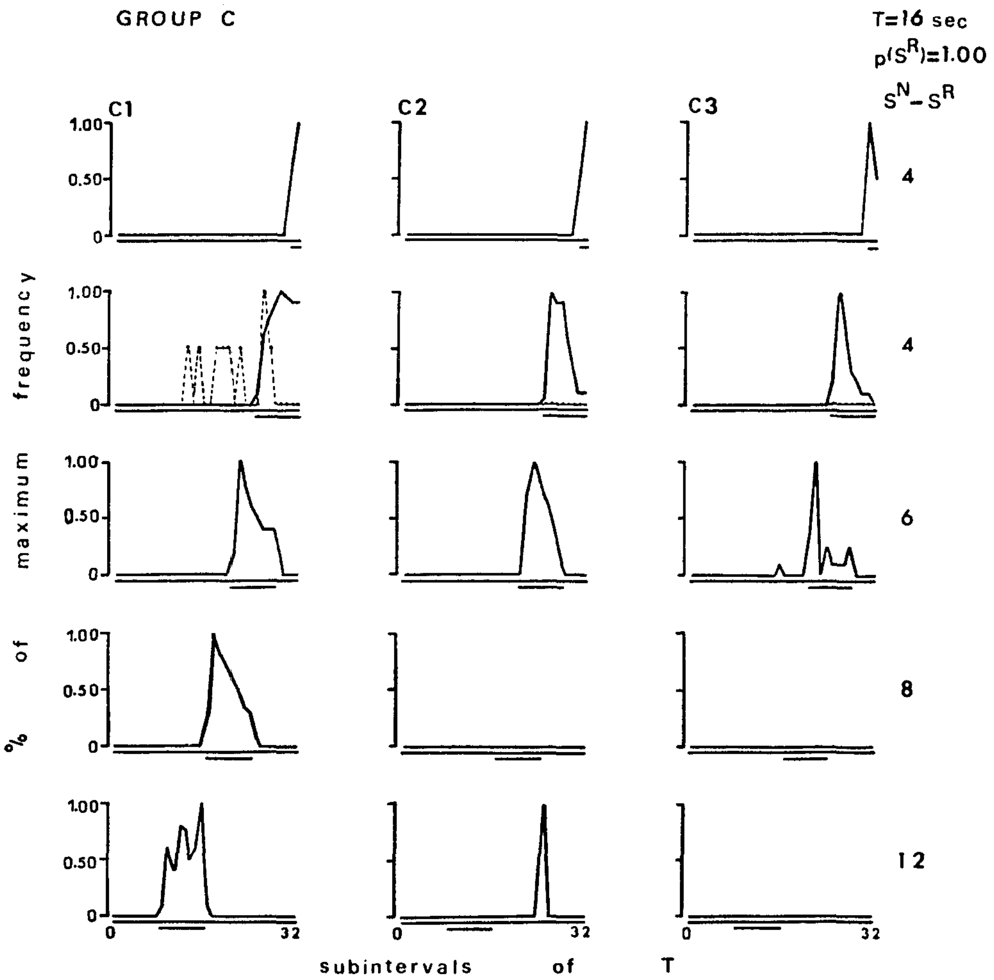
Response rates over thirty-two consecutive subintervals of the T_R cycle are shown as a fraction of the highest rate observed at each experimental point of the study.

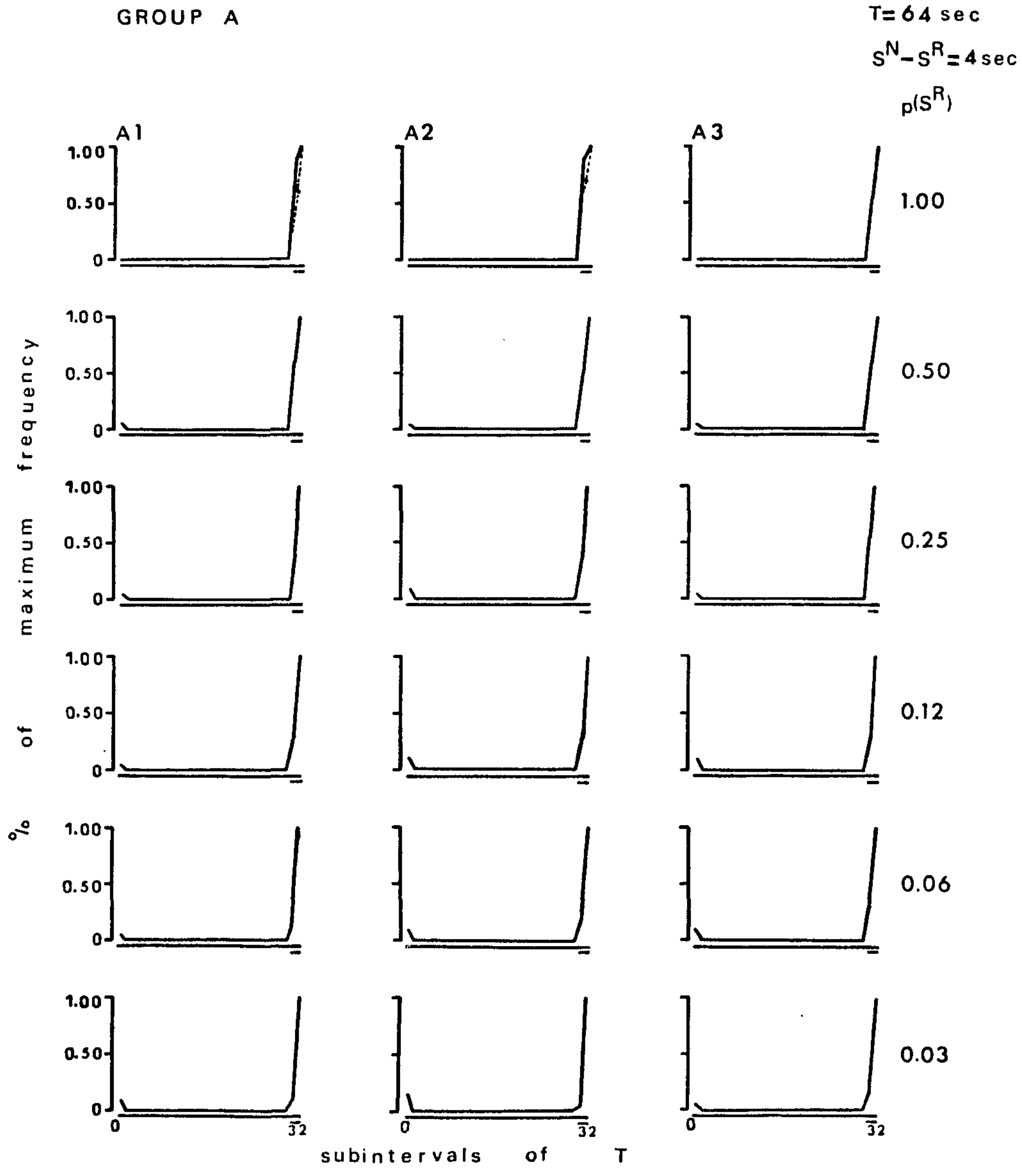
The panels in each figure show responding by the three subjects in a group (columns) at successive values of a given variable (rows). The temporal position of S^N within the T_R cycle is indicated by a line in the abscissa of each panel. The S^R event occurred always at the origin of each function on a probabilistic basis. The T clock stopped during reinforcement thus automatically correcting for S^R time.

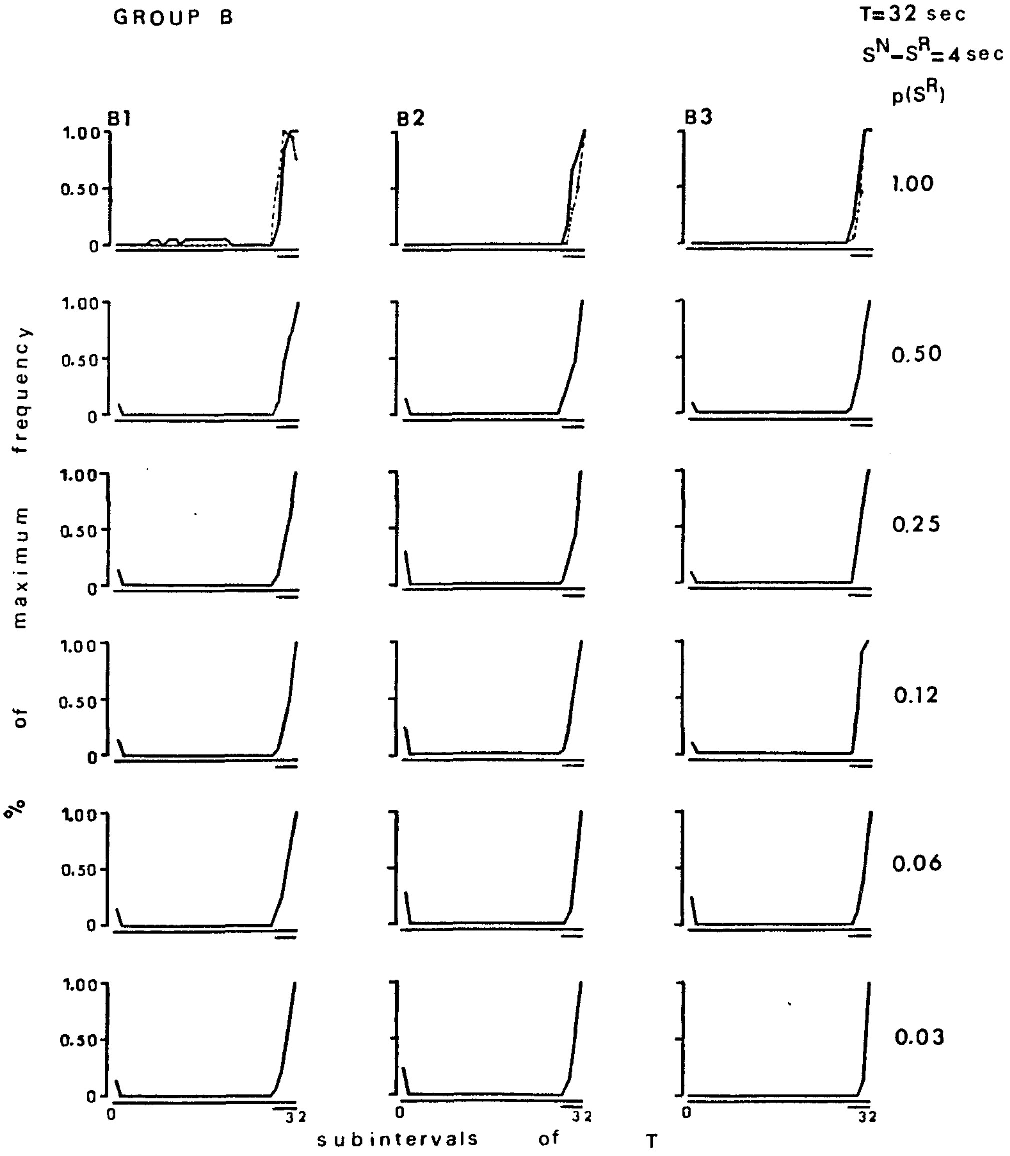
The response rates shown in the bins are the averages of the rates observed during the last five sessions under a given value of the variables. The overlapping broken lines in some panels indicate redeterminations. The first row of panels in figures 2, 3, and 4 show the behavioral patterns obtained with T=64 sec for all subjects.

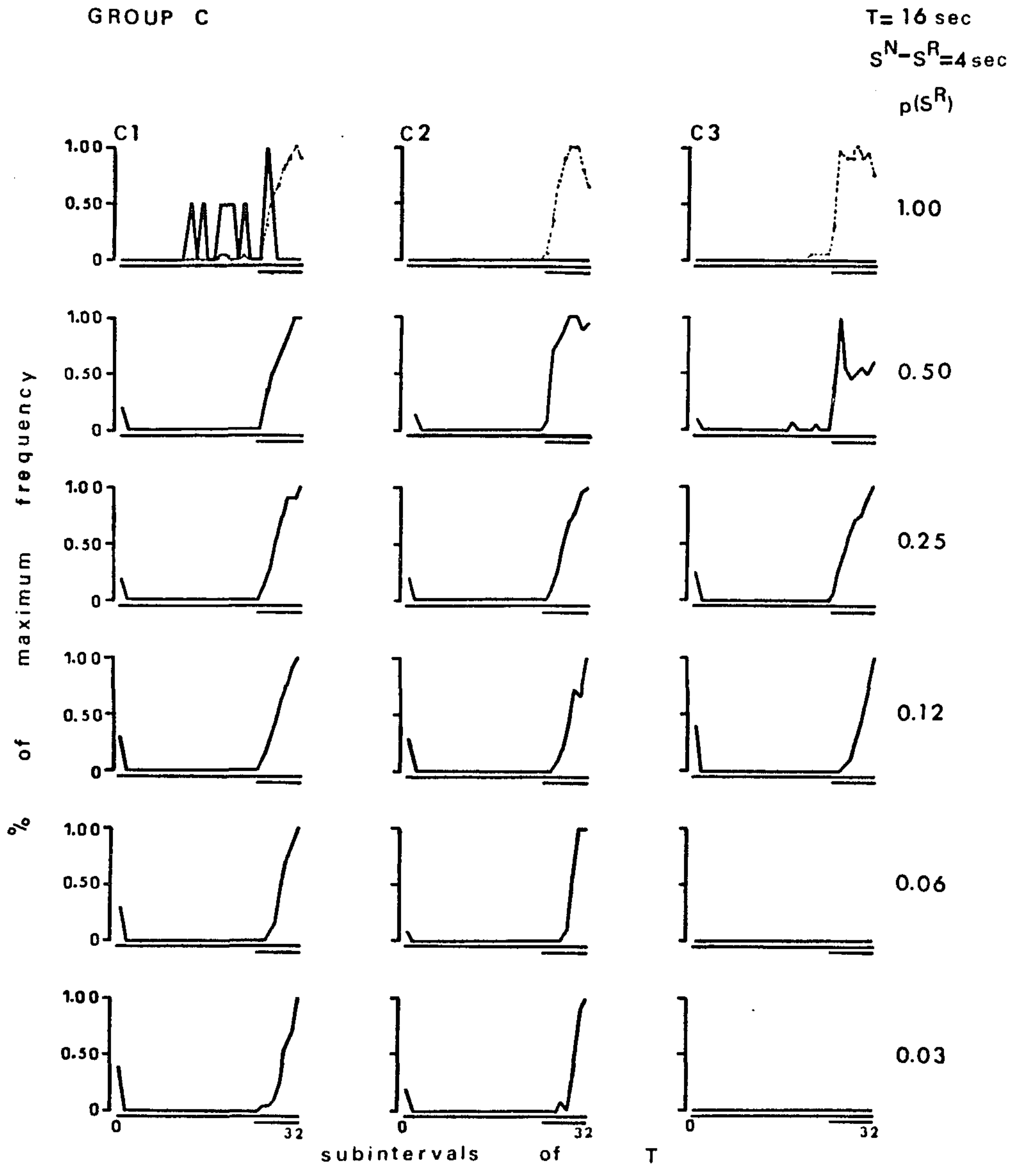

GROUP A
T=64 sec
$p(S^R)=1.00$
$S^N\text{-}S^R$
A1
A2
A3
1.00
0.50
0
4
4
6
8
12
16
24
32
48
% of maximum frequency
0
32
subintervals of T

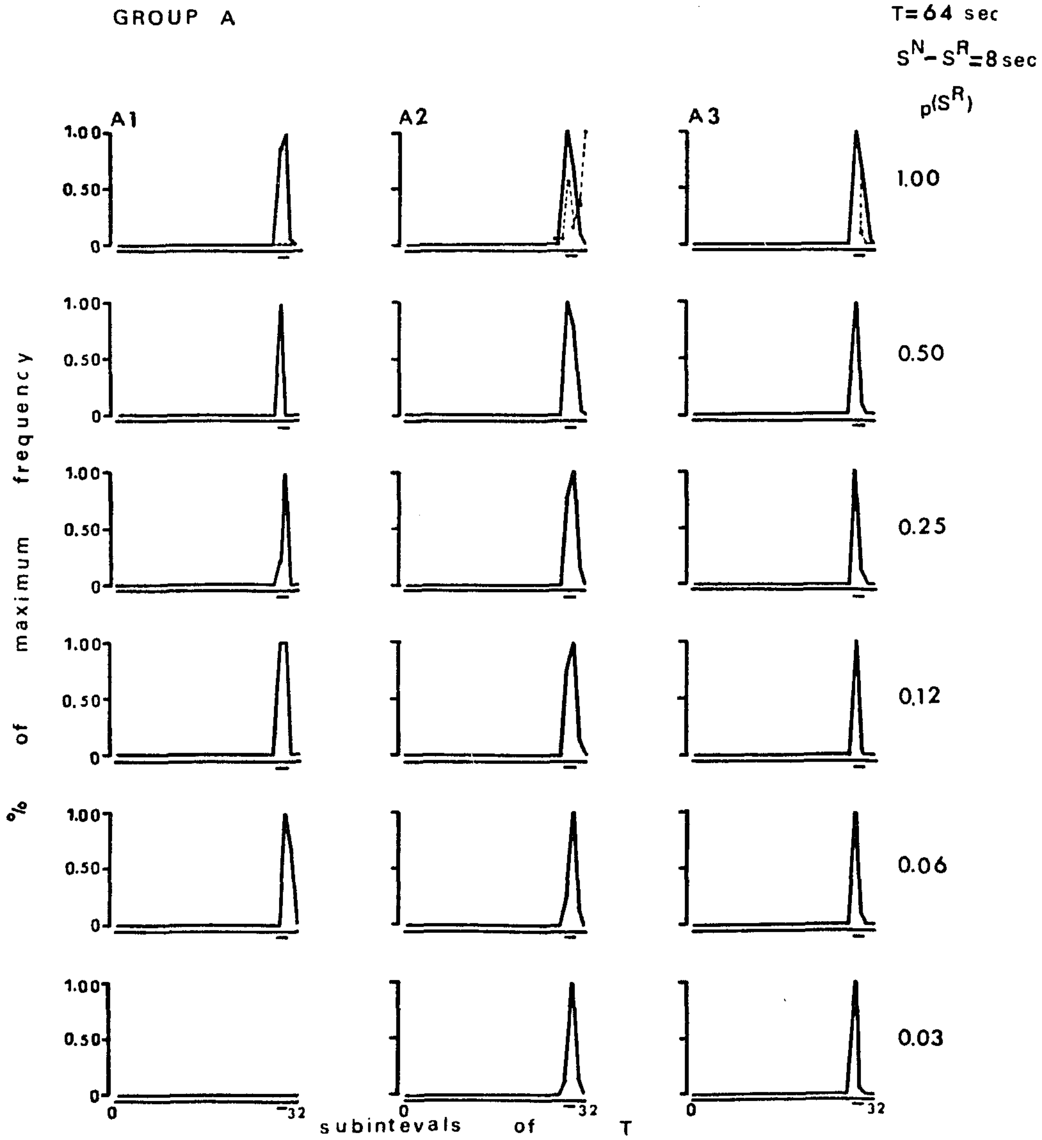

GROUP B
T=32 sec
$p(S^R)=1.00$
S^N-S^R
B1
B2
B3
1.00
0.50
0
4
4
6
8
12
16
24
% of maximum frequency
0
32
subintervals of T

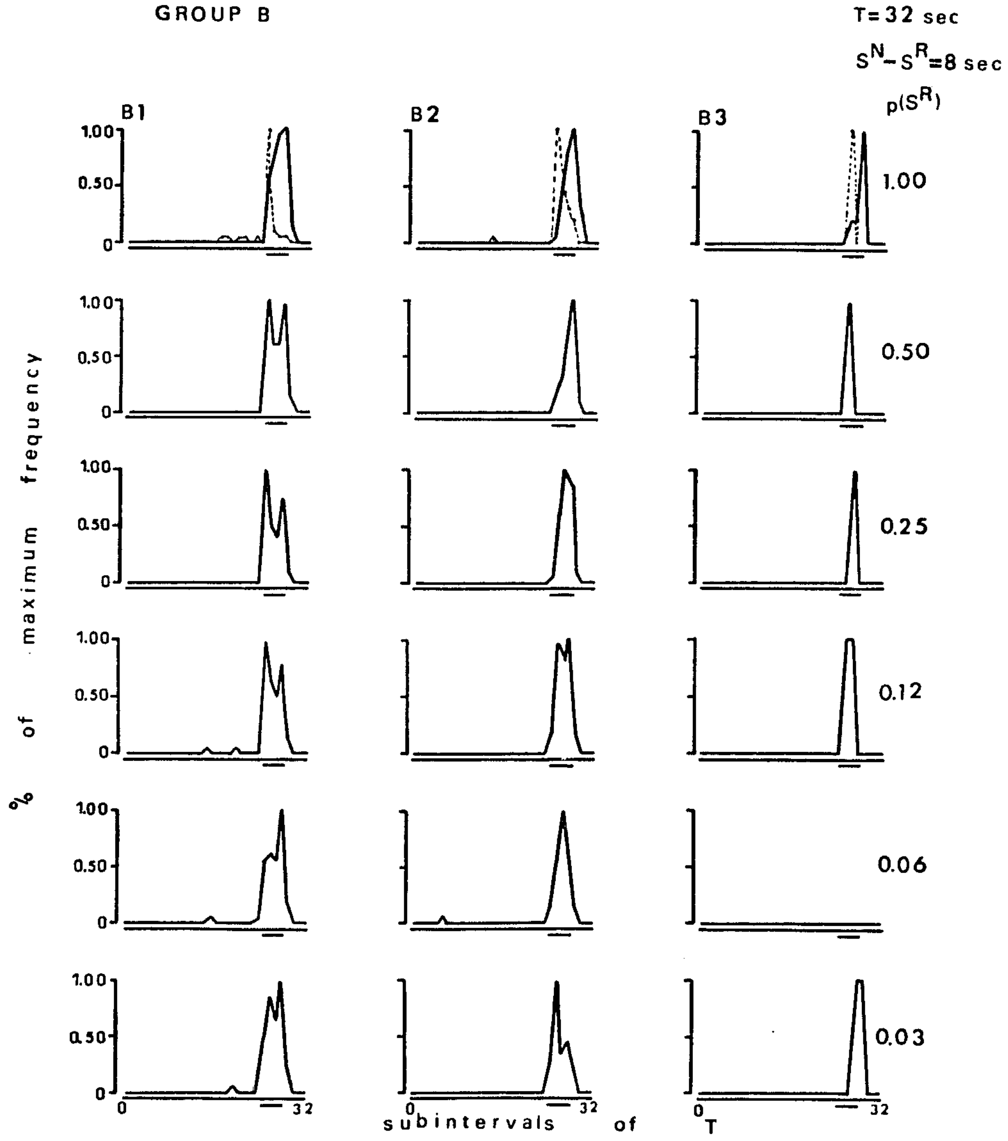

GROUP C
T=16 sec
p(S^R)=1.00
S^N-S^R
C1
C2
C3
1.00
0.50
0
4
4
6
8
12
% of maximum frequency
0
32
subintervals of T

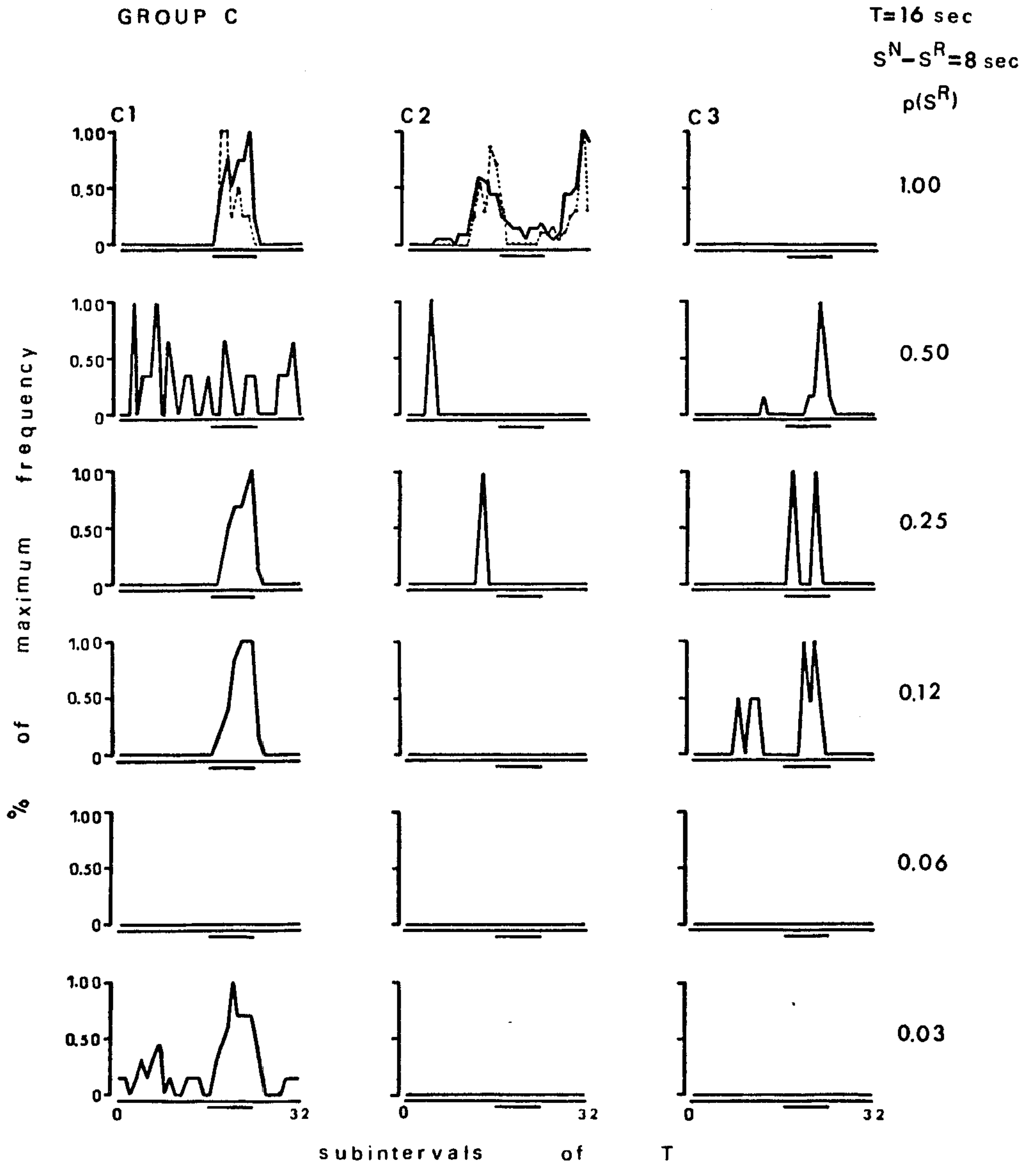

GROUP A
T= 64 sec
$S^N - S^R = 4$ sec
$p(S^R)$
A1
A2
A3
1.00
0.50
0
1.00
0.50
0.25
0.12
0.06
0.03
% of maximum frequency
0
32
subintervals of T


GROUP B
T=32 sec
S^N-S^R=4 sec
p(S^R)
B1
B2
B3
1.00
0.50
0
1.00
0.50
0.25
0.12
0.06
0.03
% of maximum frequency
0
32
subintervals of T


GROUP C
T= 16 sec
$S^N - S^R = 4$ sec
$p(S^R)$
C1
C2
C3
1.00
0.50
0
1.00
0.50
0.25
0.12
0.06
0.03
% of maximum frequency
0
32
subintervals of T


GROUP A
T=64 sec
S^N- S^R=8 sec
p(S^R)
A1
A2
A3
1.00
0.50
0
1.00
0.50
0.25
0.12
0.06
0.03
% of maximum frequency
0
32
subintevals of T


GROUP B
T=32 sec
S^N–S^R=8 sec
p(S^R)
B1
B2
B3
1.00
0.50
0
1.00
0.50
0.25
0.12
0.06
0.03
% of maximum frequency
0
32
subintervals of T


GROUP C
T=16 sec
S^N–S^R=8 sec
p(S^R)
C1
C2
C3
1.00
0.50
0
1.00
0.50
0.25
0.12
0.06
0.03
% of maximum frequency
0
32
subintervals of T

Figures 2, 3, and 4 show the individual patterns of responding that resulted from increasing the S^N-S^R interval. The first row of panels in these figures shows the performance of each subject during the matching procedure.

When S^N-S^R=4 sec (both during the matching procedure and when T was shortened from 64 to 32 and 16 sec), most responding within the T_R cycle was concentrated during the 4-sec S^N period. Responding also occurred between the termination of S^R and the onset of S^N but at much lower rates and only for some of the pigeons. There seemed to be no significant change in the pattern of responding when T was decreased for groups B and C. There was, however, a slight tendency to decelerate responding just before S^R delivery, which was more prominent in group C than in group B.

As the S^N-S^R interval was increased, responding remained concentrated during S^N. Responding also occurred before and after S^N but at much lower rates. The effect of the group parameter, T, became more evident as the S^N-S^R interval was increased. First, longer values of T seem to be associated with a tendency to continue responding after S^N offset. In two of the subjects in group A, for instance, responding continued after S^N offset at values of the S^N-S^R interval from six to ±16 sec until S^R was delivered. In general, however, these post S^N rates rarely exceeded the rate of responding during S^N. All subjects in group C appeared to "track" (i.e., respond only when S^N was present) S^N throughout the range of S^N-S^R values. Group B was somewhat intermediate, between A and C, in rates of responding after S^N offset. Another difference among groups was that animals with shorter values of T stopped responding altogether at the same values of S^N-S^R where animals with longer T's continued responding. A third difference among the groups was that longer values of T appears to favor a more complete recovery of the response pattern obtained at S^N-S^R=4 sec.

Figures 5, 6, and 7 show the pattern of responding within the T_R cycle as a function of decreasing values of $p(S^R)$. S^N-S^R=4 sec served as the parameter value for all three groups of subjects.

The patterns of responding that resulted from this manipulation were largely similar for all the groups, and they were not significantly altered by decreasing the value of $p(S^R)$. In general, these response patterns resembled those obtained when S^N-S^R=4 sec for each group, i.e., most responding was concentrated during the 4 sec S^N period. The effect of the group parameter (T) was less visible here than before. Nevertheless, longer values of T appeared to reinstate responding faster (after it had been eliminated in some instances by long S^N-S^R intervals) than shorter T's.

Figures 8, 9, and 10 show the effect of decreasing $p(S^R)$ while holding S^N-S^R constant at 8 sec.

As in the preceding $p(S^R)$ series, the response patterns obtained with groups A and B were not significantly affected by reductions in the value of $p(S^R)$. They were also generally similar in both groups. Responding was concentrated again during the 4 sec S^N. In groups A and B, responding occurred rather infrequently during the rest of the cycle. In group C, responding occurred throughout the entire cycle, and only in some instances does it appear to be affected by S^N. The fact that group C differed so much from groups A and B during this last manipulation seems to indicate that longer values of T favored better control of the pattern of responding by the 4 sec S^N.

2. The number of responses per S^N.

Figures 11 to 19 show responses per S^N distributed according to their frequency of occurrence relative to the maximum frequency obtained at a given value of a variable. These data were also transformed into a relative measure in order to show very low frequencies. The total number of responses that occurred within an S^N period is shown in the panels of the figures to facilitate absolute comparisons.

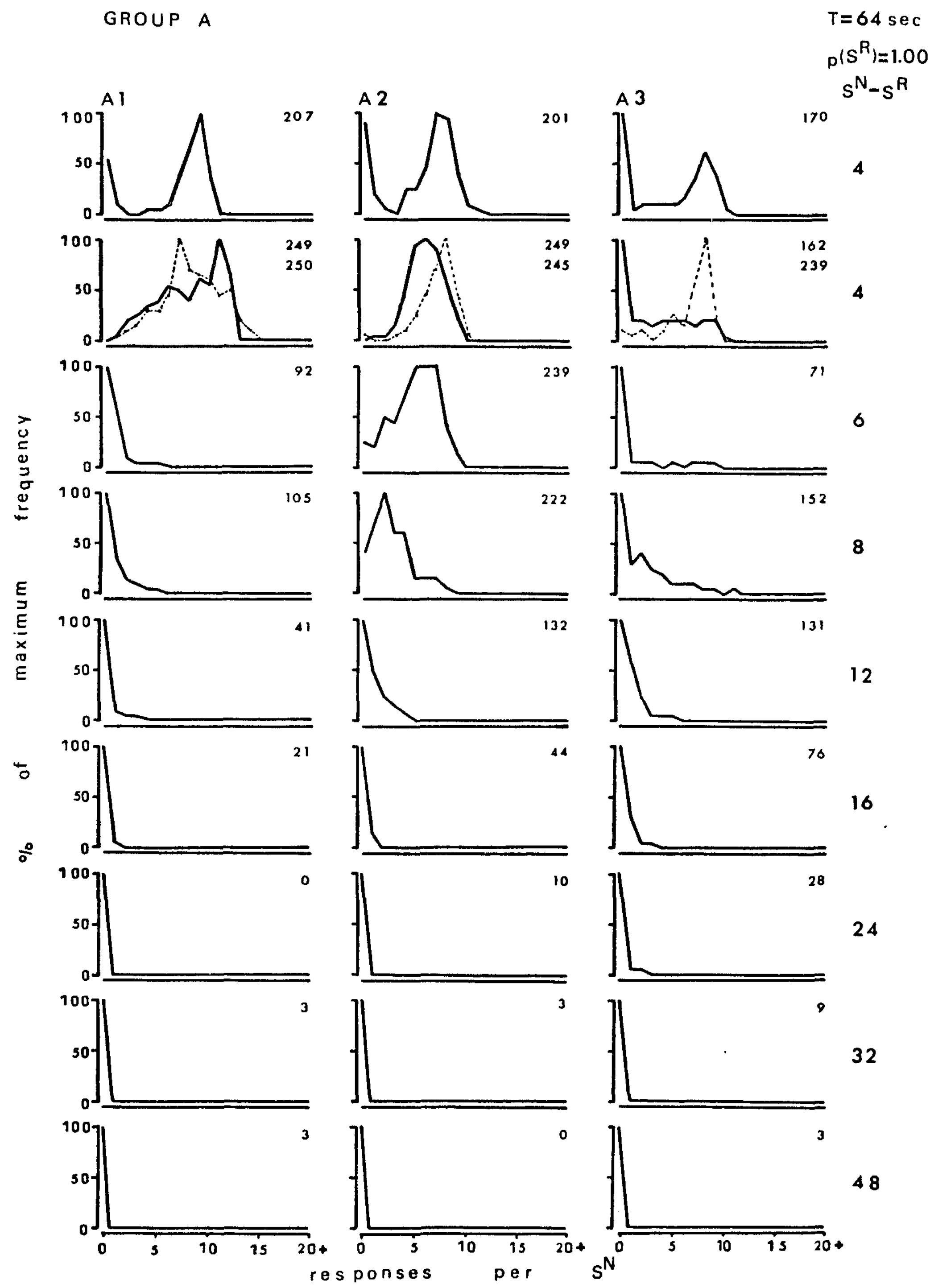
Figures 11 to 13 show individual frequency distributions when the S^N-S^R interval was increased. The first row of panels represents the effect of the matching procedure.

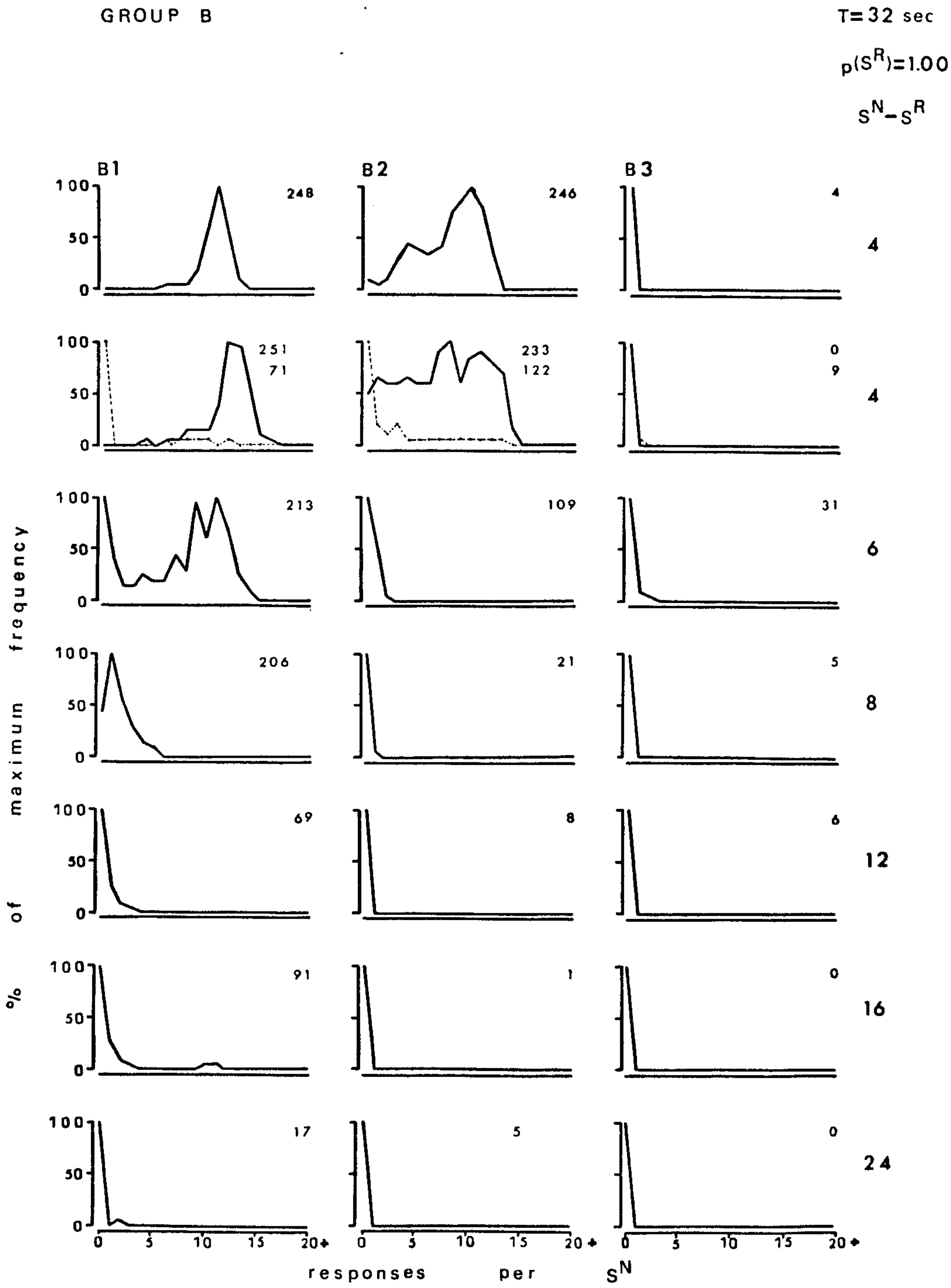
Figures 11 to 19.- Relative frequency distributions of the number of responses per S^N

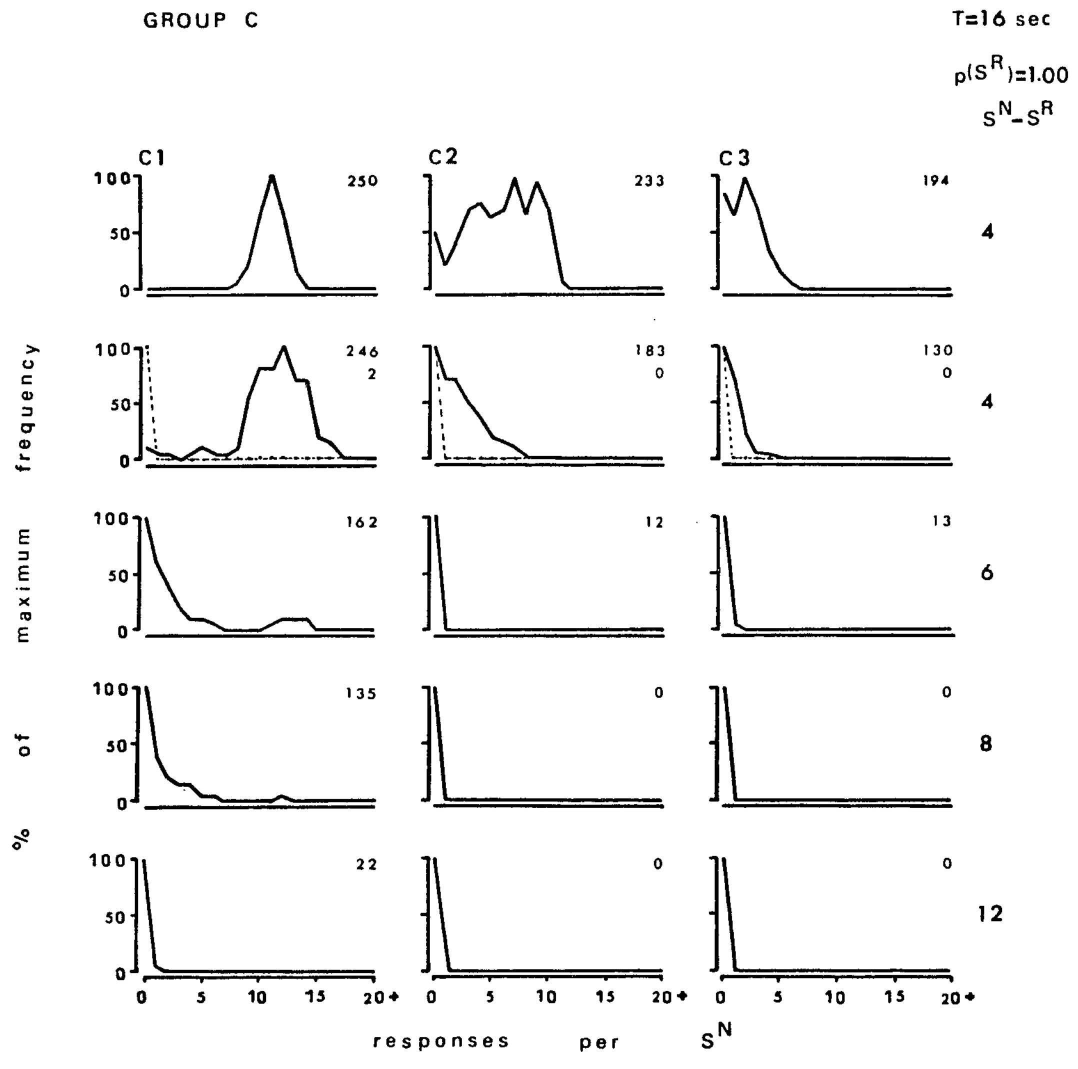
The number of responses per 4-sec S^N are shown according to their frequency of occurrence relative to the maximum frequency observed at each experimental point.

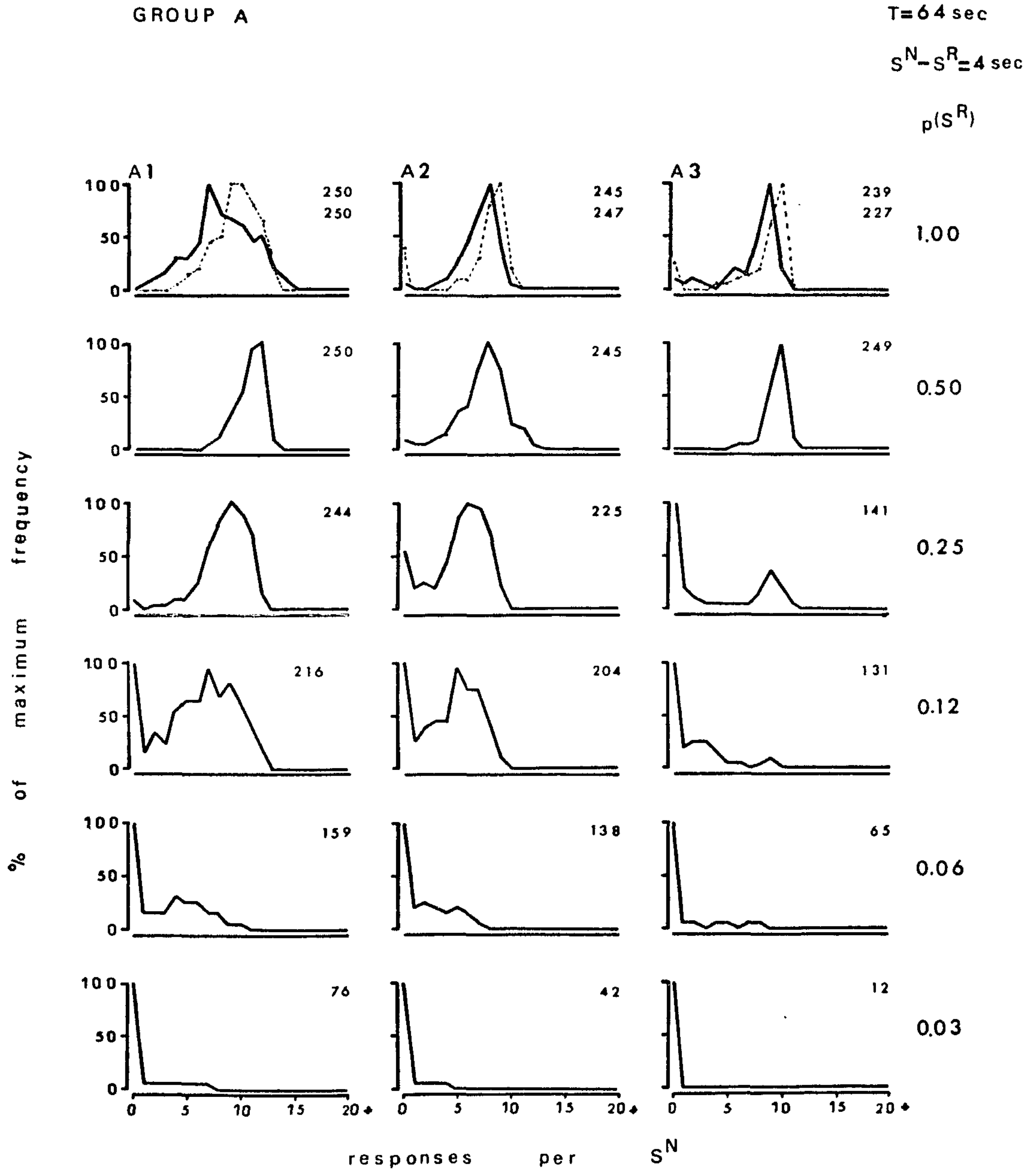
The panels in each figure show frequency distributions for each of three subjects in a group (columns) under successive values of a given variable (rows).

The data shown in these figures represent the last five sessions under a given value of each variable. The broken lines in some panels indicate redeterminations. The total number of responses that occurred at each value of the variables is shown in the upper right corner of each panel. The first row of panels in figures 10, 11, and 12 show the frequency distributions obtained at T=64 sec for all subjects.

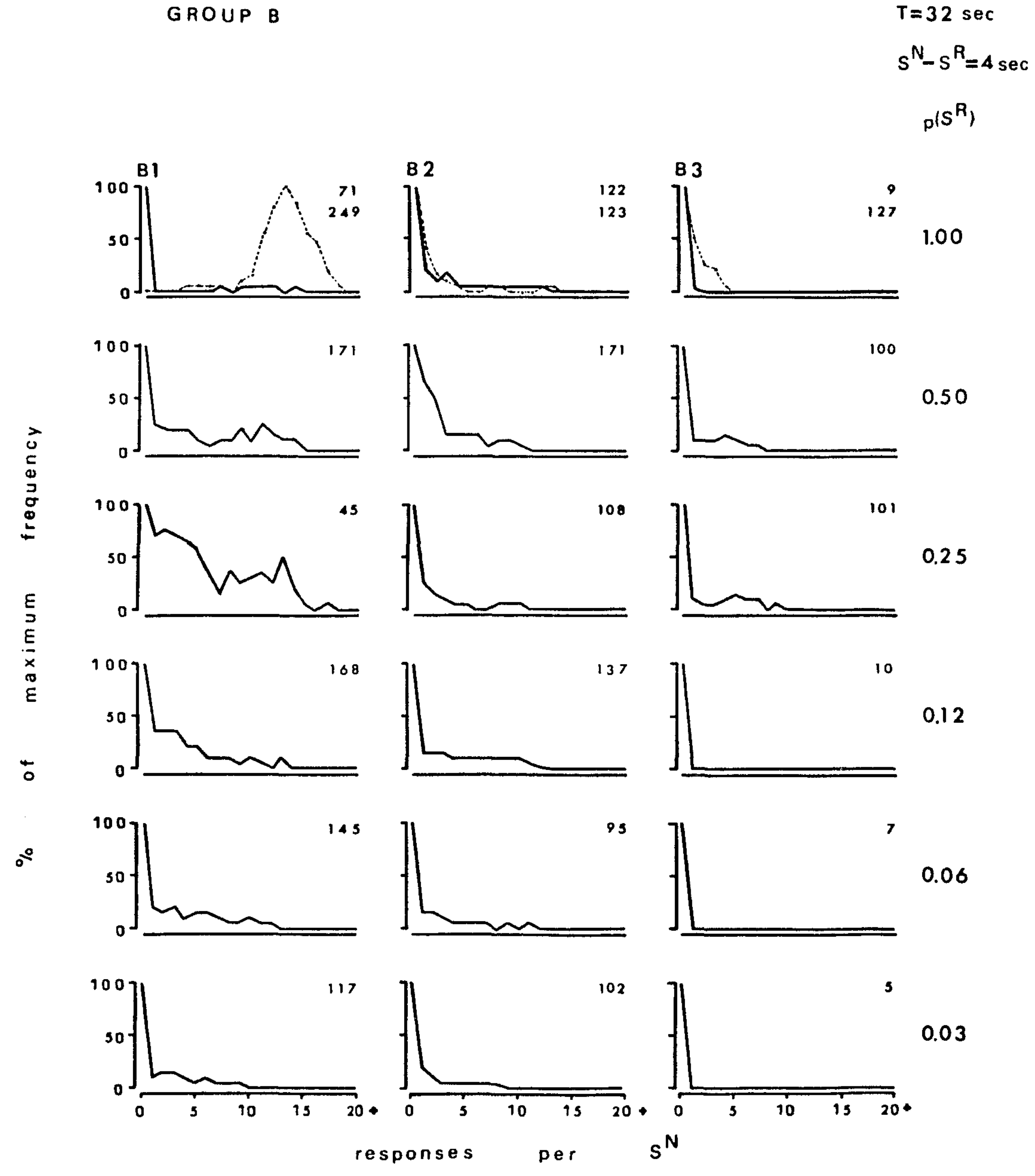

GROUP A
T=64 sec
p(S^R)=1.00
S^N-S^R
A1
A2
A3
100
50
0
207
201
170
4
249
250
249
245
162
239
4
92
239
71
6
105
222
152
8
41
132
131
12
21
44
76
16
0
10
28
24
3
3
9
32
3
0
3
48
0
5
10
15
20+
% of maximum frequency
responses per S^N

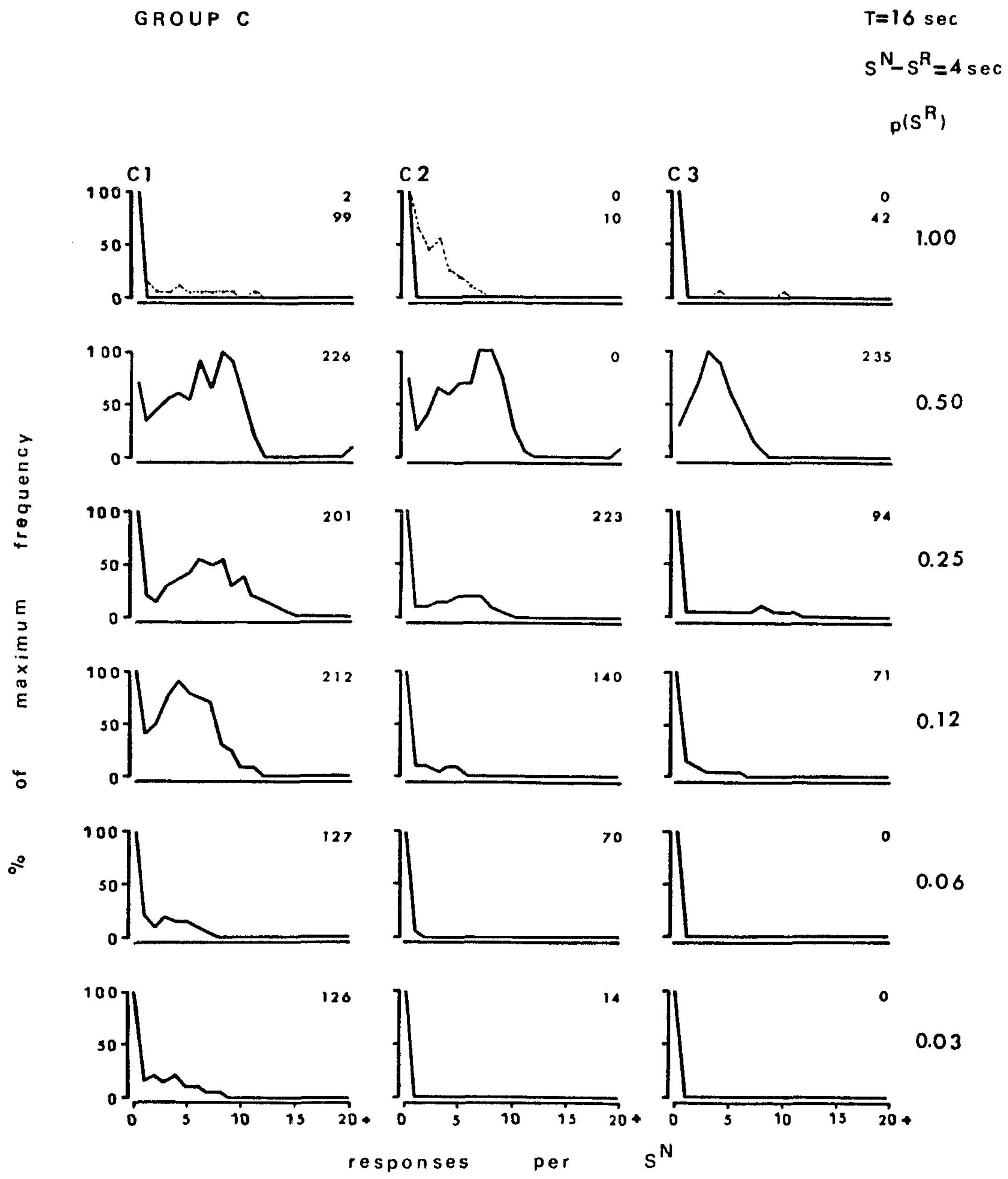

GROUP B
T=32 sec
p(S^R)=1.00
S^N–S^R
B1
B2
B3
100
50
0
248
246
4
251
71
233
122
0
9
213
109
31
206
21
5
69
8
6
91
1
0
17
5
0
4
4
6
8
12
16
24
% of maximum frequency
0
5
10
15
20+
responses per S^N

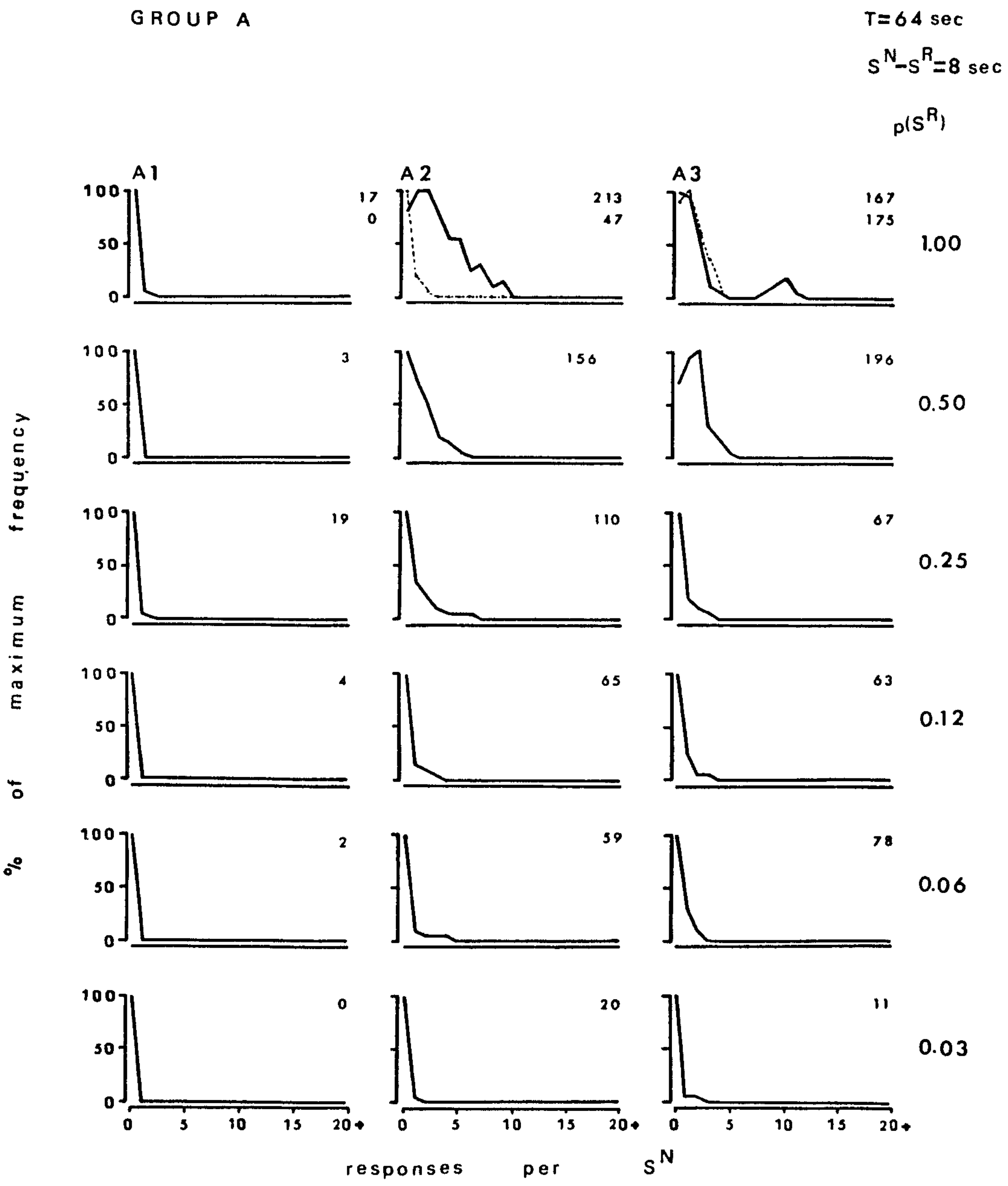

GROUP C
T=16 sec
$p(S^R)=1.00$
S^N-S^R
C1
C2
C3
100
50
0
250
233
194
4
246
2
183
0
130
0
4
162
12
13
6
135
0
0
8
22
0
0
12
0
5
10
15
20+
% of maximum frequency
responses per S^N



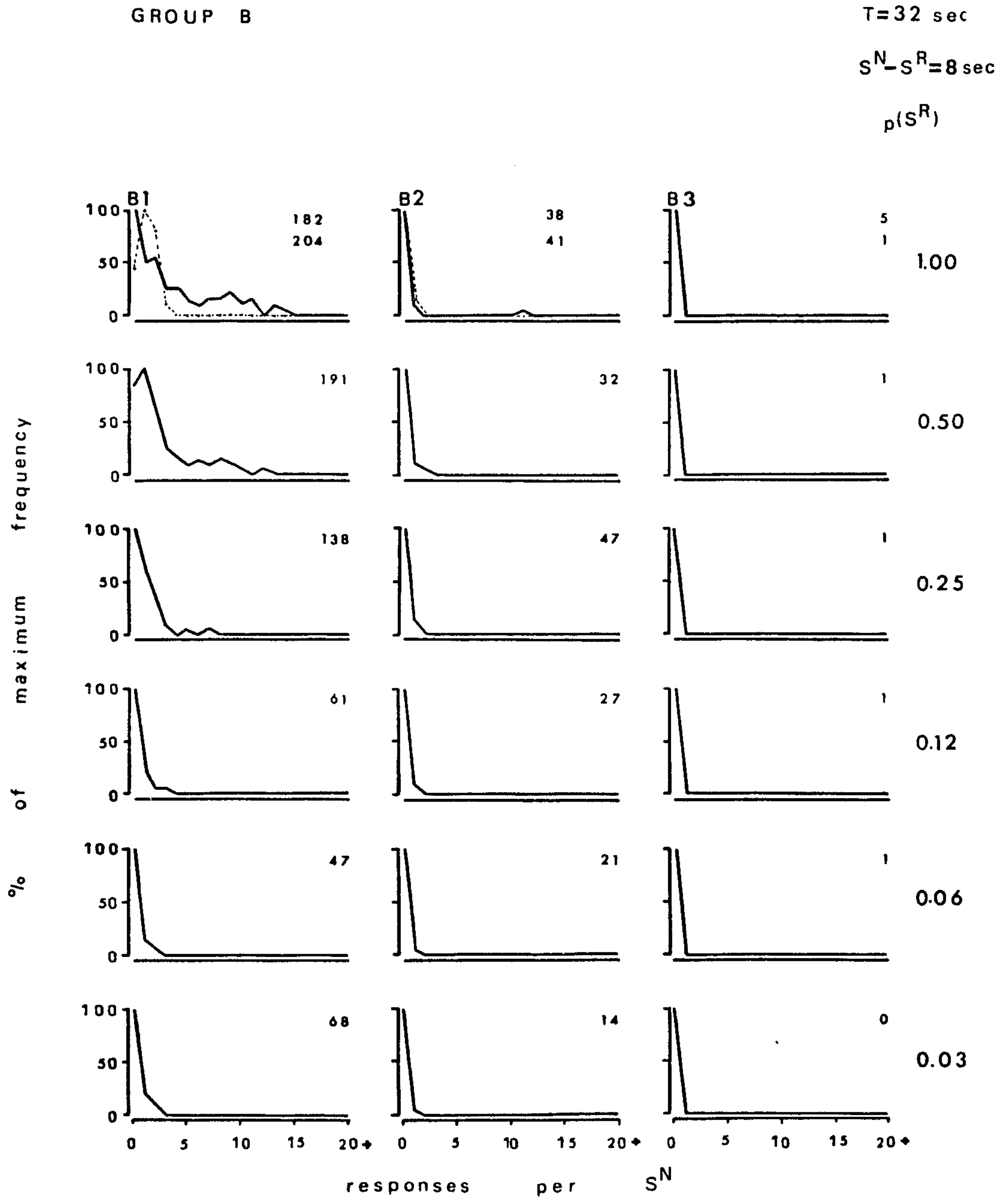
GROUP A
T=64 sec
S^N–S^R=4 sec
p(S^R)
A1
A2
A3
100
50
0
250
250
245
247
239
227
1.00
250
245
249
0.50
244
225
141
0.25
216
204
131
0.12
159
138
65
0.06
76
42
12
0.03
0 5 10 15 20+
% of maximum frequency
responses per S^N

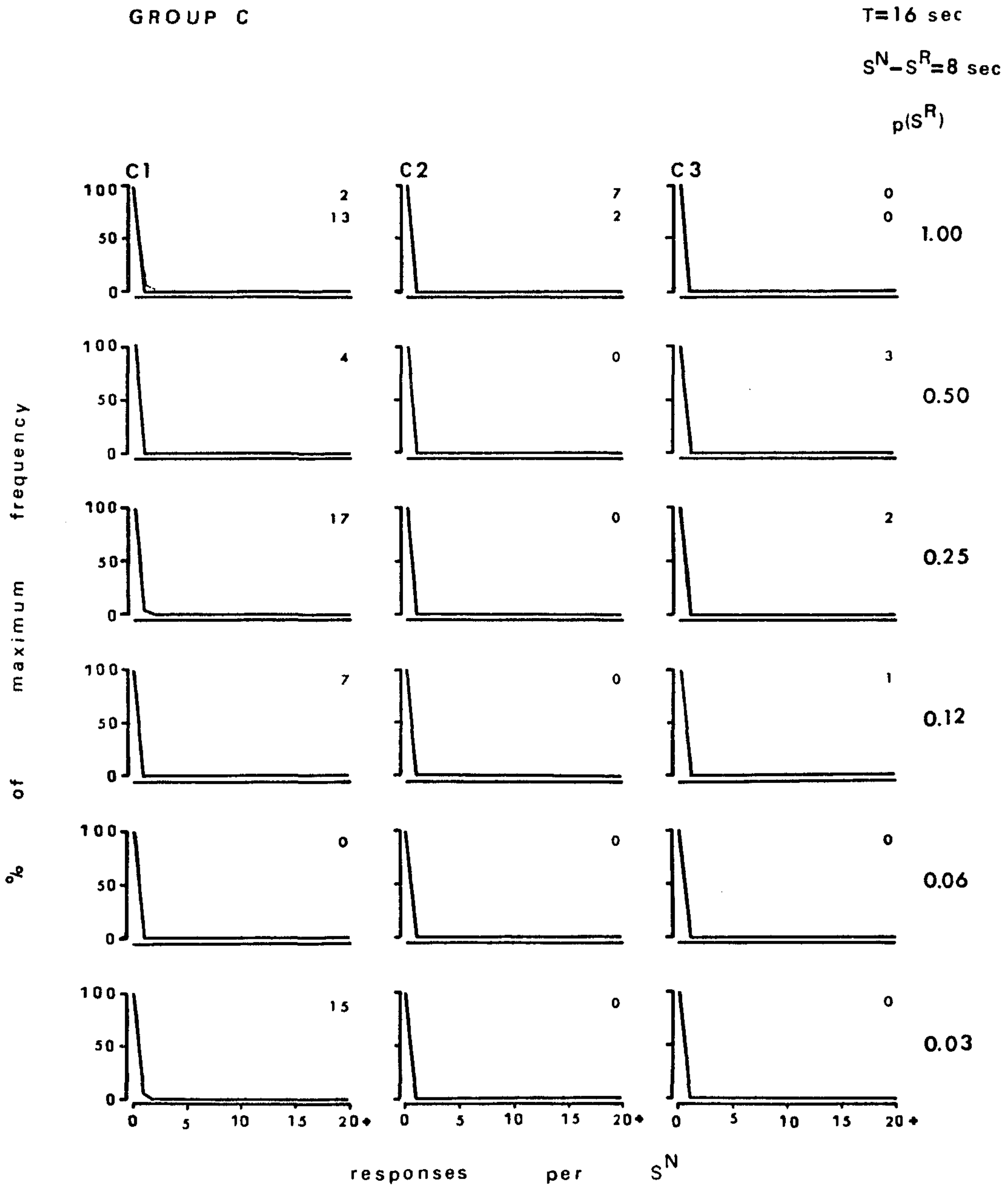

GROUP B
T=32 sec
$S^N - S^R = 4$ sec
$p(S^R)$
B1
B2
B3
100
50
0
71
249
122
123
9
127
1.00
171
171
100
0.50
45
108
101
0.25
168
137
10
0.12
145
95
7
0.06
117
102
5
0.03
0
5
10
15
20+
% of maximum frequency
responses per S^N


GROUP C
T=16 sec
$S^N - S^R = 4$ sec
$p(S^R)$
C1
C2
C3
1.00
0.50
0.25
0.12
0.06
0.03
2
99
0
10
0
42
226
0
235
201
223
94
212
140
71
127
70
0
126
14
0
100
50
0
0
5
10
15
20+
% of maximum frequency
responses per S^N



GROUP A
T=64 sec
S^N-S^R=8 sec
$p(S^R)$
A1
A2
A3
100
50
0
17
0
213
47
167
175
1.00
3
156
196
0.50
19
110
67
0.25
4
65
63
0.12
2
59
78
0.06
0
20
11
0.03
0
5
10
15
20+
% of maximum frequency
responses per S^N


GROUP B
T=32 sec
S^N-S^R=8 sec
p(S^R)
B1
B2
B3
100
50
0
182
204
38
41
5
1
1.00
191
32
1
0.50
138
47
1
0.25
61
27
1
0.12
47
21
1
0.06
68
14
0
0.03
% of maximum frequency
0
5
10
15
20+
responses per S^N


GROUP C
T=16 sec
S^N-S^R=8 sec
$p(S^R)$
C1
C2
C3
1.00
0.50
0.25
0.12
0.06
0.03
2
13
7
2
0
0
4
0
3
17
0
2
7
0
1
0
0
0
15
0
0
100
50
0
0
5
10
15
20+
% of maximum frequency
responses per S^N

The number of responses per S^N did not seem to change as a consequence of shortening T in groups B and C. As will be shown shortly, however, the effect of different values of T became more prominent as parameter values for the manipulation of S^N-S^R and $p(S^R)$.

Lengthening the S^N-S^R interval produced, in all groups, a steady decrease in the number of responses during S^N. The decremental effect of longer S^N-S^R intervals on responses per S^N was much more severe when T=16 sec (group C) than when T=64 sec (group A). Group B was, again, somewhat intermediate between A and C in this respect. Longer values of T seemed again to be positively related to the speed (i.e., within 10-day samples) with which frequency distribution of responses per S^N were recovered after lengthening the S^N-S^R interval.

Figures 14 to 16 show the same variable as a function of decreasing $p(S^R)$, holding S^N-S^R constant at 4 sec. Decreasing $p(S^R)$ also produced a general decrease in the number of responses during S^N. This effect, however, was less dramatic than when S^N-S^R was lengthened. Cycle length, T, was again associated with slower rates of change in this dependent variable. It seems that longer values of T favored higher rates of responding at most values of the $p(S^R)$ variable. Longer values of T once more seemed to facilitate the recovery of the original distributions obtained at $p(S^R)=1.00$.

Figures 17 to 19 show the effect of decreasing

$p(S^R)$ holding S^N-S^R constant at 8 sec. In groups A and B, decreasing $p(S^R)$ again caused decrements in the number of responses per S^N. This response decrement seemed more pronounced in group B than A. Group C responded quite infrequently during this $p(S^R)$ series.

3. The rate of responding during S^N.

Figure 20 shows a general view of the experimental domain outlined in this research and the relations between average S^N rate and the variables of the study. Figure 21 shows the same functions superimposed on common axes to facilitate inter-group comparisons. Figures 20 and 21 show S^N rate averaged across the three subjects in each group. Figures 22 to 24 show individual data.

In general, there seems to be good agreement between the group and the individual data. Although in some instances numerical values are quite different among subjects, the form of the function is generally similar. In view of the similarity between group data and individual functions, the following analysis will be based on the group functions.

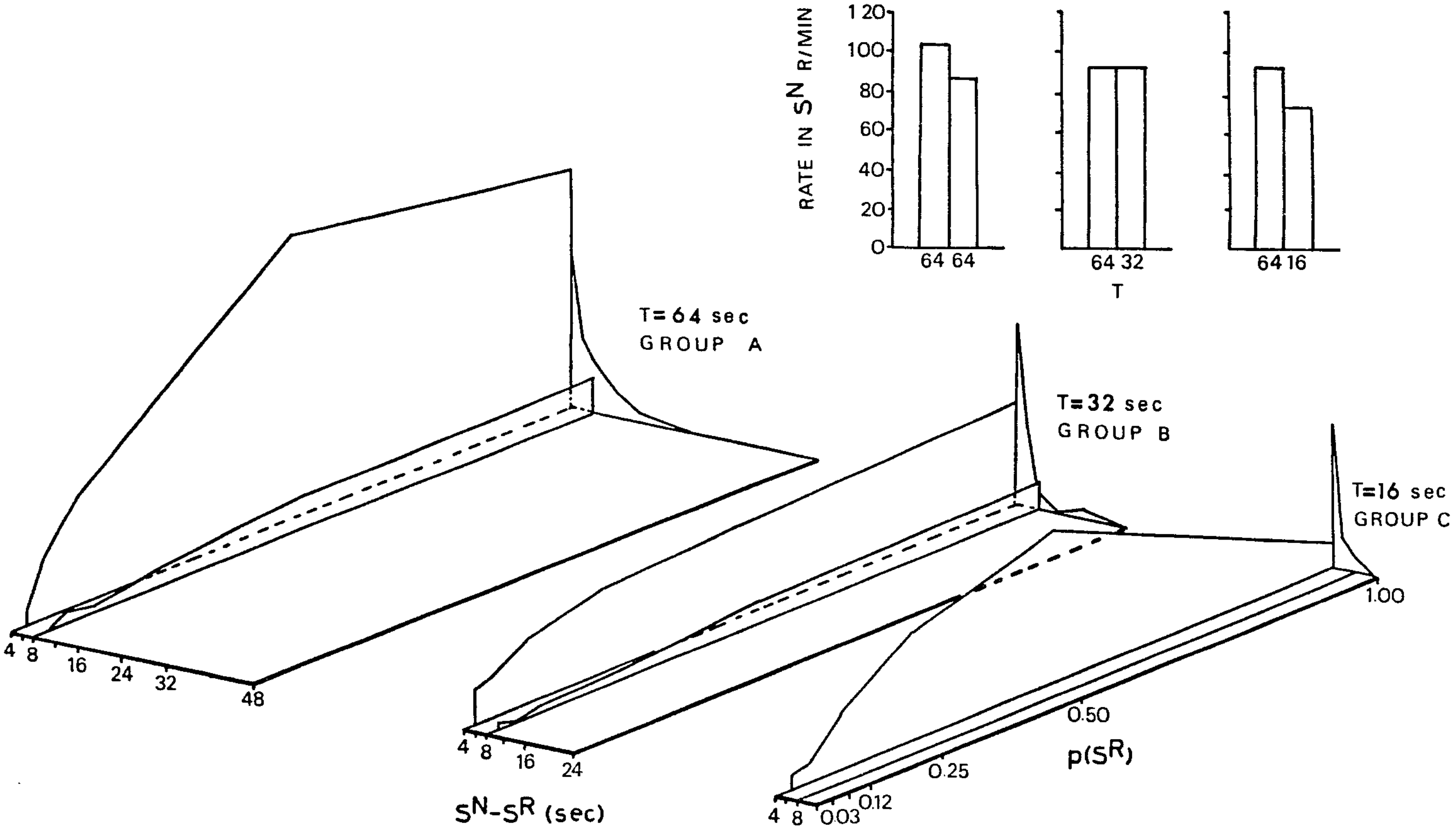
Most of the responding that occurred during the matching phase occurred during the 4 sec S^N. This accounts for the fact that although overall rate in the T cycle served as the matching variable, the groups were also matched for their rates of responding during S^N. The bar-graph in figure 20 shows that rates of responding during

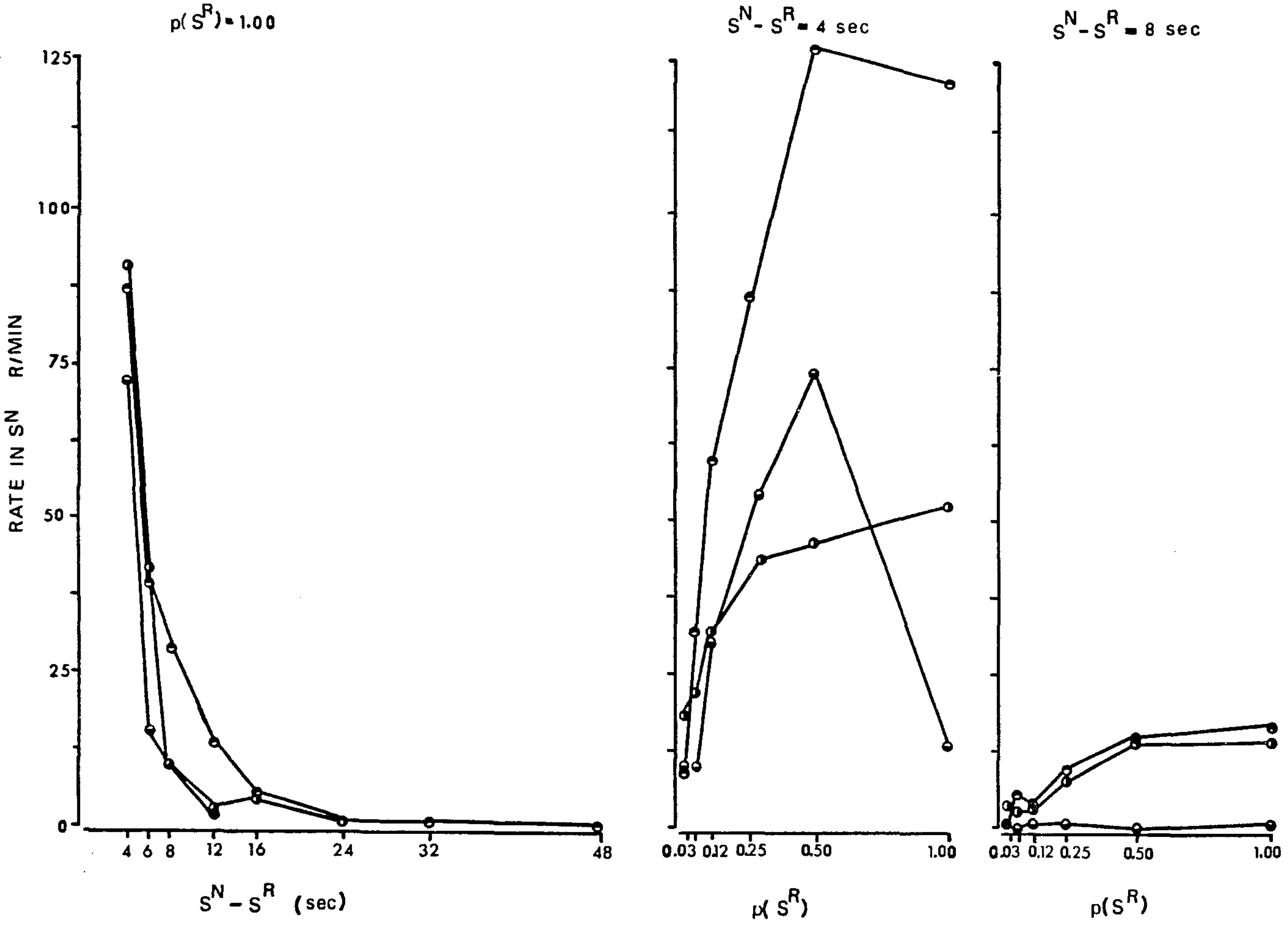
Figures 20 and 21.- Averaged rate of responding during S^N (group data)

Figures 20 and 21 show the averaged rate of responding during S^N for all experimental conditions. The data are averages of the rates of the three subjects in each group over the last five sessions for each procedure. Figure 20 shows mean rate in S^N as a function of S^N-S^R and $p(S^R)$. The bargraph in the right corner of the figure shows averaged rate in S^N as a function of holding T constant at 64 sec for an additional 10-session period and of shortening the value of T from 64 to 32 and 16 sec. The ordinate scale of the three dimensional figure is the same as in the bargraph. Each surface of the figure shows the performance of a different group of subjects for which the group parameter T was held constant. The points at which the $p(S^R)$ and S^N-S^R functions intersect are the averages of two redeterminations at $p(S^R)=1.00$.

Figure 21 shows the same data plotted on two dimensional coordinates. The meaning of the symbols is as follows:

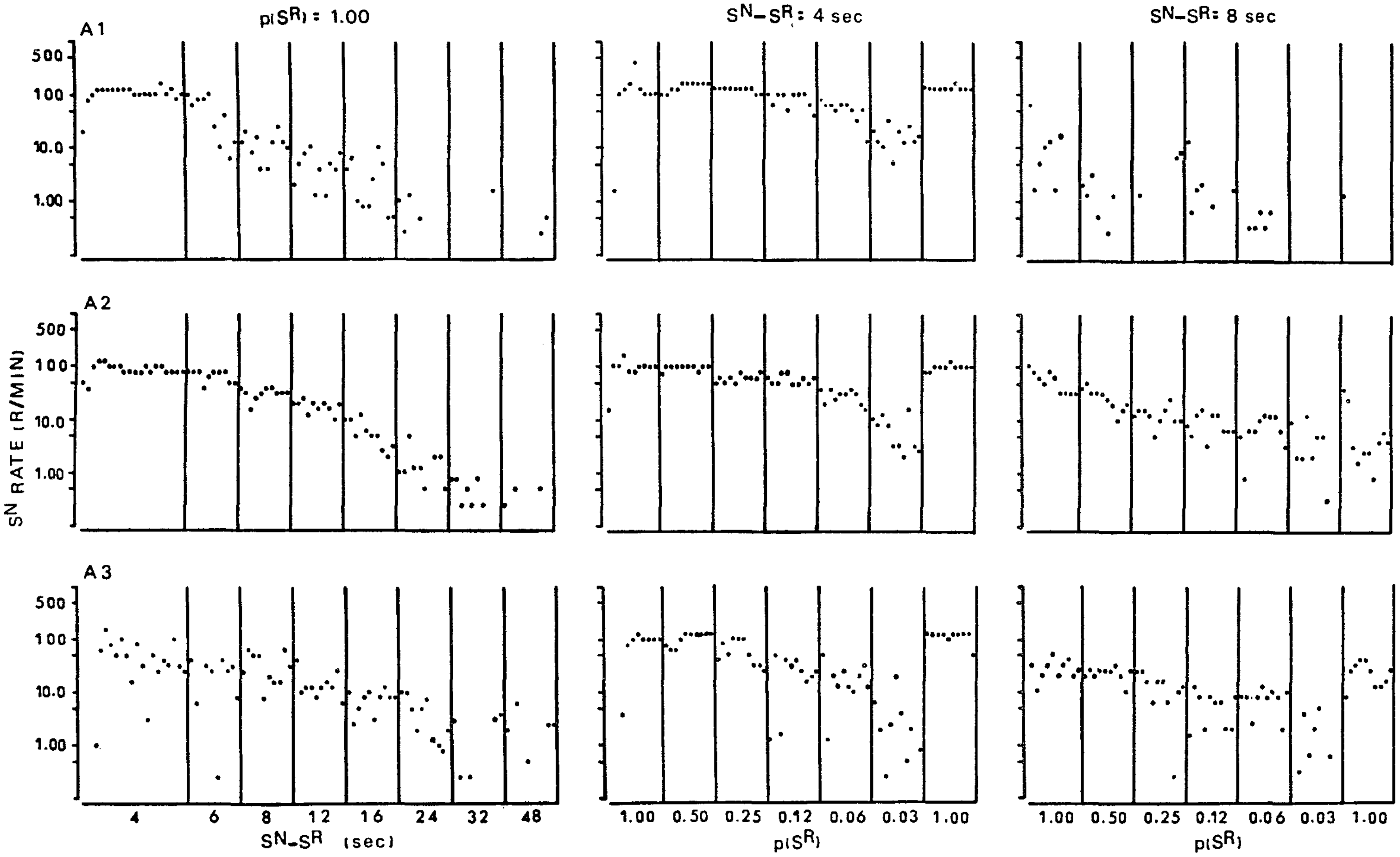
◓ indicates group A (T=64 sec)
◑ indicates group B (T=32 sec)
◒ indicates group C (T=16 sec)

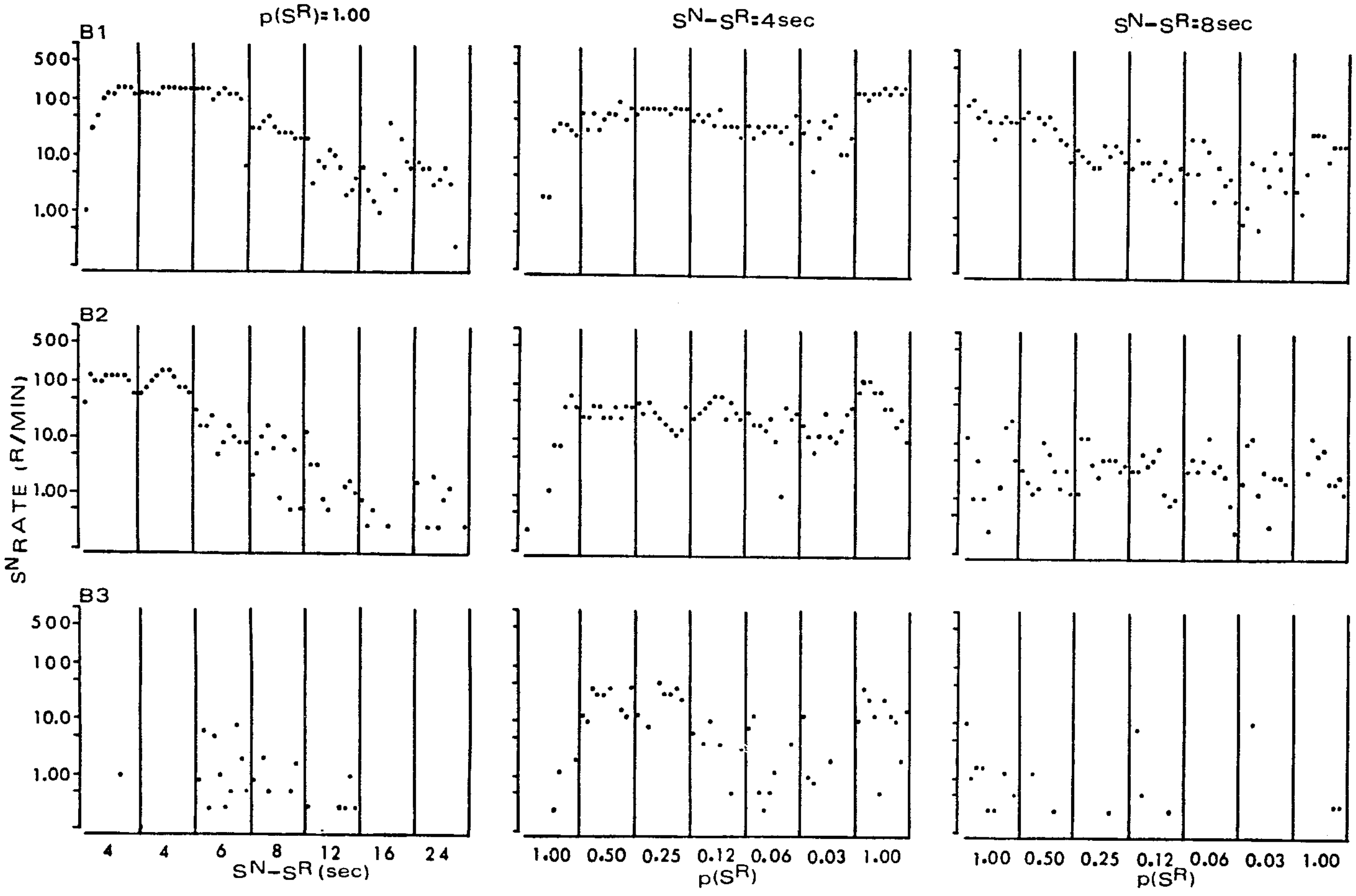

RATE IN S^N R/MIN
120
100
80
60
40
20
0
64 64
64 32
64 16
T
T=64 sec
GROUP A
T=32 sec
GROUP B
T=16 sec
GROUP C
4
8
16
24
32
48
4
8
16
24
S^N-S^R (sec)
4
8
0.03
0.12
0.25
0.50
1.00
$p(S^R)$

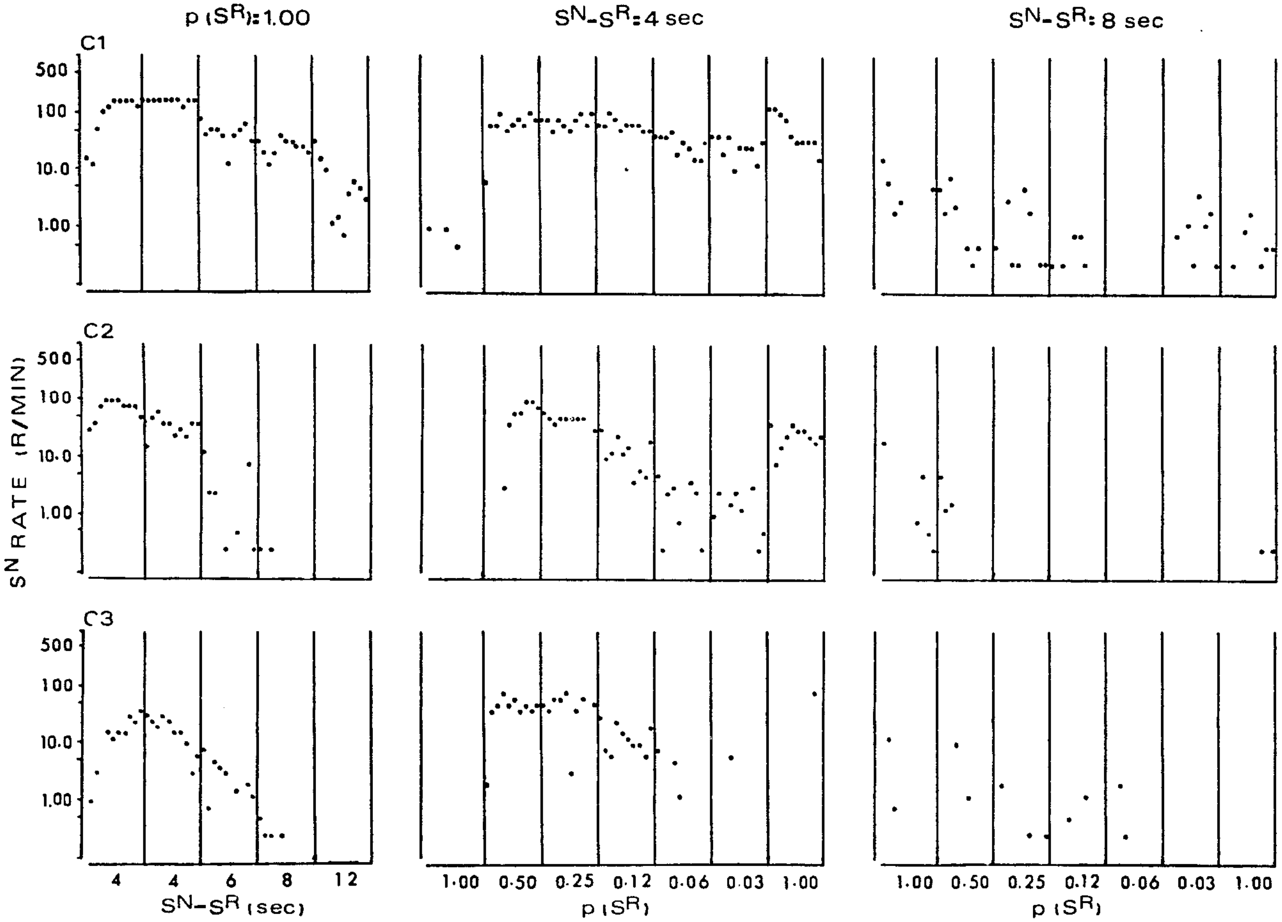

$p(S^R) = 1.00$
$S^N - S^R = 4$ sec
$S^N - S^R = 8$ sec
RATE IN S^N R/MIN
125
100
75
50
25
0
4
6
8
12
16
24
32
48
$S^N - S^R$ (sec)
0.03
0.12
0.25
0.50
1.00
$p(S^R)$
0.03
0.12
0.25
0.50
1.00
$p(S^R)$

Figures 22 to 24.- Daily rates of responding during S^N

Daily rate of responding during S^N are shown on a logarithmic ordinate. Sessions without responding have not been plotted in these figures. The first panel in each figure shows the effect of the matching procedure while the successive panels separate blocks of ten consecutive sessions, when the value of a given variable was in effect.


p(S^R) = 1.00
S^N–S^R: 4 sec
S^N–S^R: 8 sec
A1
A2
A3
500
100
10.0
1.00
S^N RATE (R/MIN)
4
6
8
12
16
24
32
48
S^N–S^R (sec)
1.00
0.50
0.25
0.12
0.06
0.03
1.00
p(S^R)
1.00
0.50
0.25
0.12
0.06
0.03
1.00
p(S^R)


p(S^R)=1.00
S^N-S^R:4sec
S^N-S^R:8sec
B1
B2
B3
S^NRATE (R/MIN)
500
100
10.0
1.00
4
4
6
8
12
16
24
S^N-S^R (sec)
1.00
0.50
0.25
0.12
0.06
0.03
1.00
p(S^R)


p (SR)=1.00
SN-SR=4 sec
SN-SR: 8 sec
C1
C2
C3
SN RATE (R/MIN)
500
100
10.0
1.00
4
4
6
8
12
SN-SR (sec)
1.00
0.50
0.25
0.12
0.06
0.03
1.00
p (SR)

S^N were similar for the three groups after the matching procedure was used. It also shows that except for a small decrease in rate in groups A and C, neither holding the value of T constant over a twenty-session period nor decreasing T from 64 to 32 sec and from 64 to 16 sec caused systematic changes in response rate during S^N.

Figures 20 and 21 show the rates of responding during S^N as a function of S^N-S^R, $p(S^R)$ and T.

Rate of responding during S^N was a monotonic and decreasing function of the S^N-S^R interval for all groups. The rate of responding was generally higher and approached zero more slowly in group A, while the rate was lower and approached zero more rapidly in group C. The rate of responding in group B was intermediate between A and C, at least with respect to absolute rate.

Rate in S^N seemed to be a decreasing function of decreasing $p(S^R)$, at both values of S^N-S^R (4 and 8 sec). Although in groups A and B these functions appear to be monotonically decreasing ones, in group C the function obtained with S^N-S^R=4 sec as a parameter of $p(S^R)$ had a maxima at $p(S^R)=.50$. This difference suggests a slower recovery of the original values for this group. That is, ten sessions under S^N-S^R=4 sec and $p(S^R)=1.00$ were probably not enough to recover the higher rates originally observed under the same conditions.

In all groups, rate or responding during S^N was higher when S^N-S^R was four sec than when S^N-S^R was eight sec for all values of $p(S^R)$.

During the two decreasing series of values of $p(S^R)$, rates of responding during S^N were higher in group A than in group B, which in turn generally had higher rates than group C. It seems that longer values of T favor higher rates of responding and slower rates of decay in the functions that relate rate in S^N to the increments in the S^N-S^R interval, which now served as a parameter for the manipulation of $p(S^R)$. Longer values of T also seemed to facilitate the recovery of high rates of responding after such high rates had been lowered by either lengthening S^N-S^R or decreasing $p(S^R)$.

4. The relative frequency of responding during S^N.

The frequency of responding during S^N relative to the frequency of responding during the T cycle (responses in S^N divided by total responding) is a measure that has not been reported in "intruded stimulus" research. It was nevertheless considered important to calculate it for the present experiment in view of the possible involvement of T in the determination of different frequencies of responding in the absence of S^N.

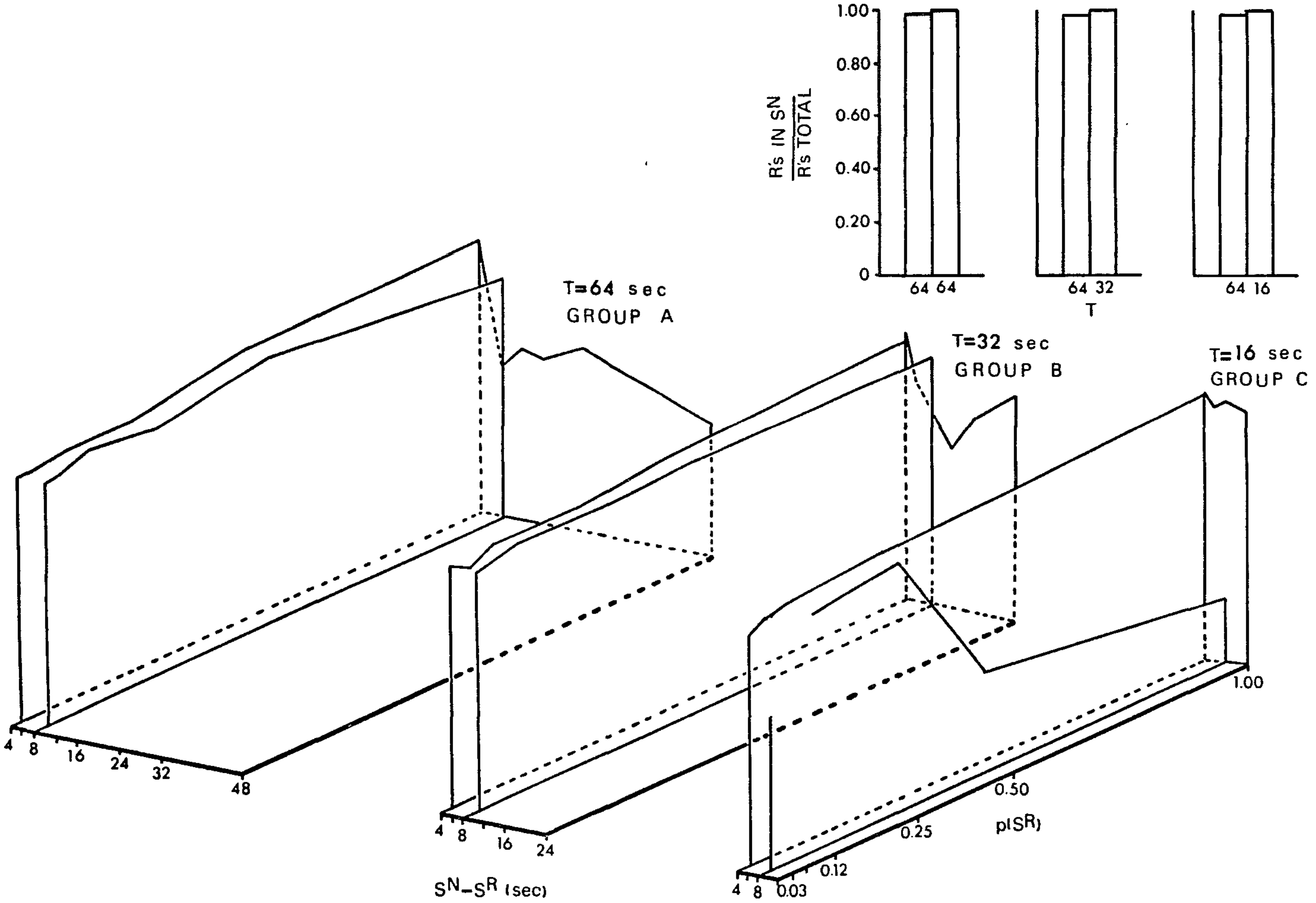
Given the difference in cycle length among the three groups of subjects, a relative measure based on rate would have probably been more desirable over raw frequencies. This last measure, however, was preferred over rate since it seems to exaggerate any trend in the

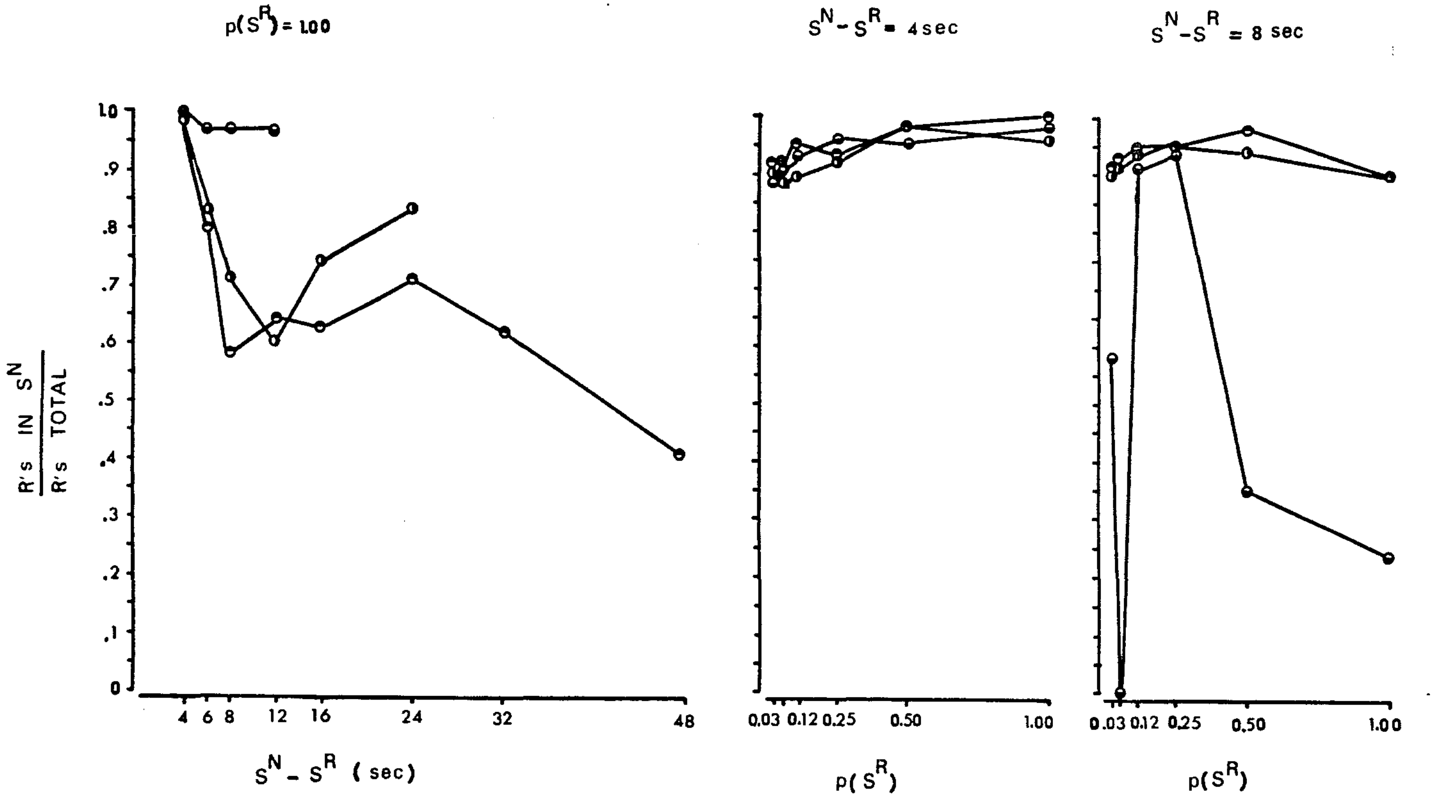
Figures 25 and 26.- Relative frequency of responding during S^N (group data)

Figures 25 and 26 show the frequency of responding during S^N as a fraction of total responding for all experimental conditions. The data for these figures are averages of the three subjects in each group over the last five sessions of each procedure. Figure 25 shows the relative frequency of responding during S^N as a function of S^N-S^R and $p(S^R)$. The bargraph on the right corner of the figure shows this dependent variable as T was held constant at 64 sec and the effect of changing the values of T from 64 to 32 and 16 sec. The ordinate scale of the three dimensional figure is the same as in the bargraph. Each surface of the figure shows the performance of a different group of subjects for which the group parameter T was held constant. The points of intersection between $p(S^R)$ and S^N-S^R functions are the averages of two redeterminations at $p(S^R)=1.00$.

Figure 26 shows the same data on two dimensional coordinates. The meaning of the symbols is as follows:

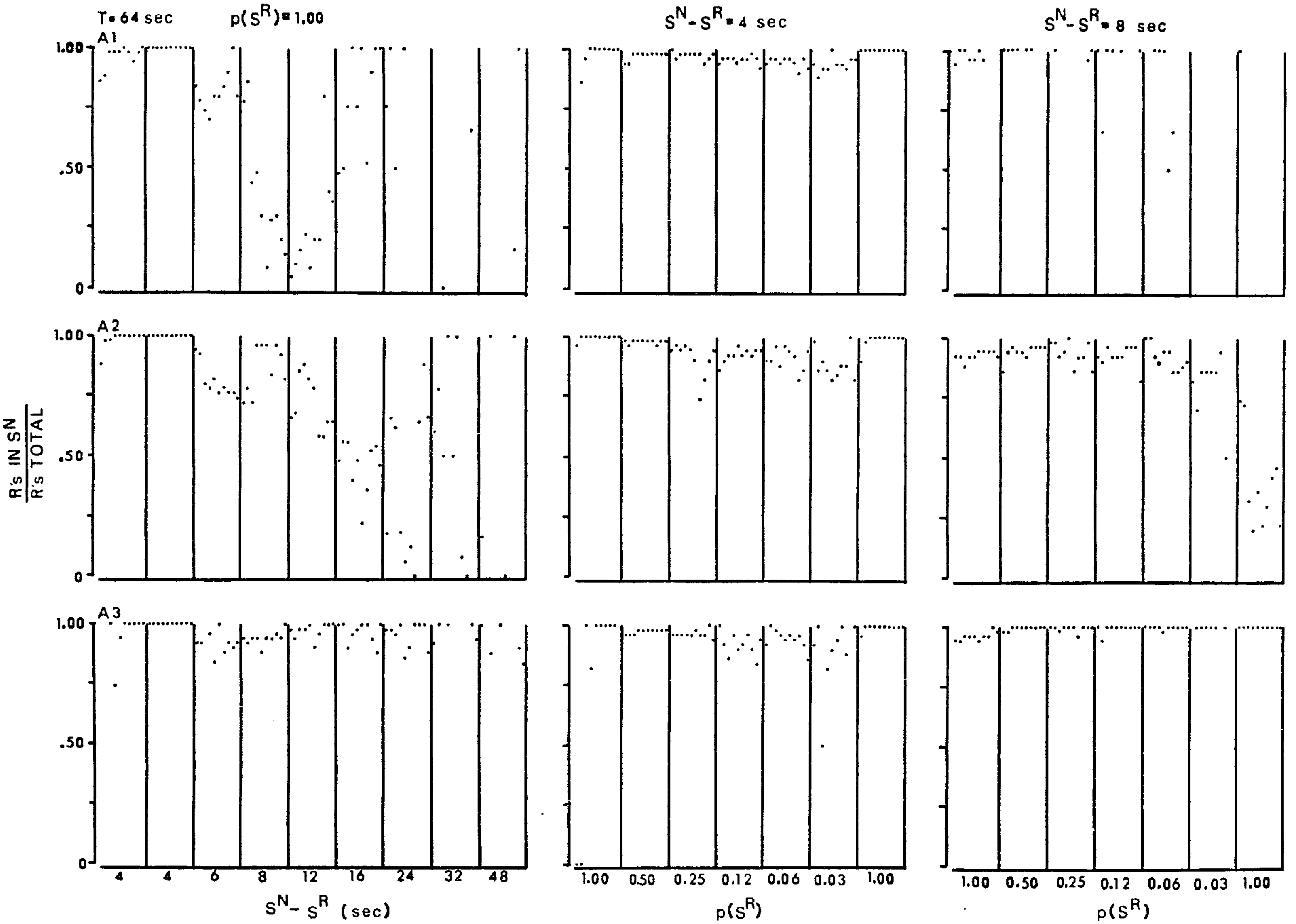
◓ indicates group A (T=64 sec)
◑ indicates group B (T=32 sec)
◒ indicates group C (T=16 sec)

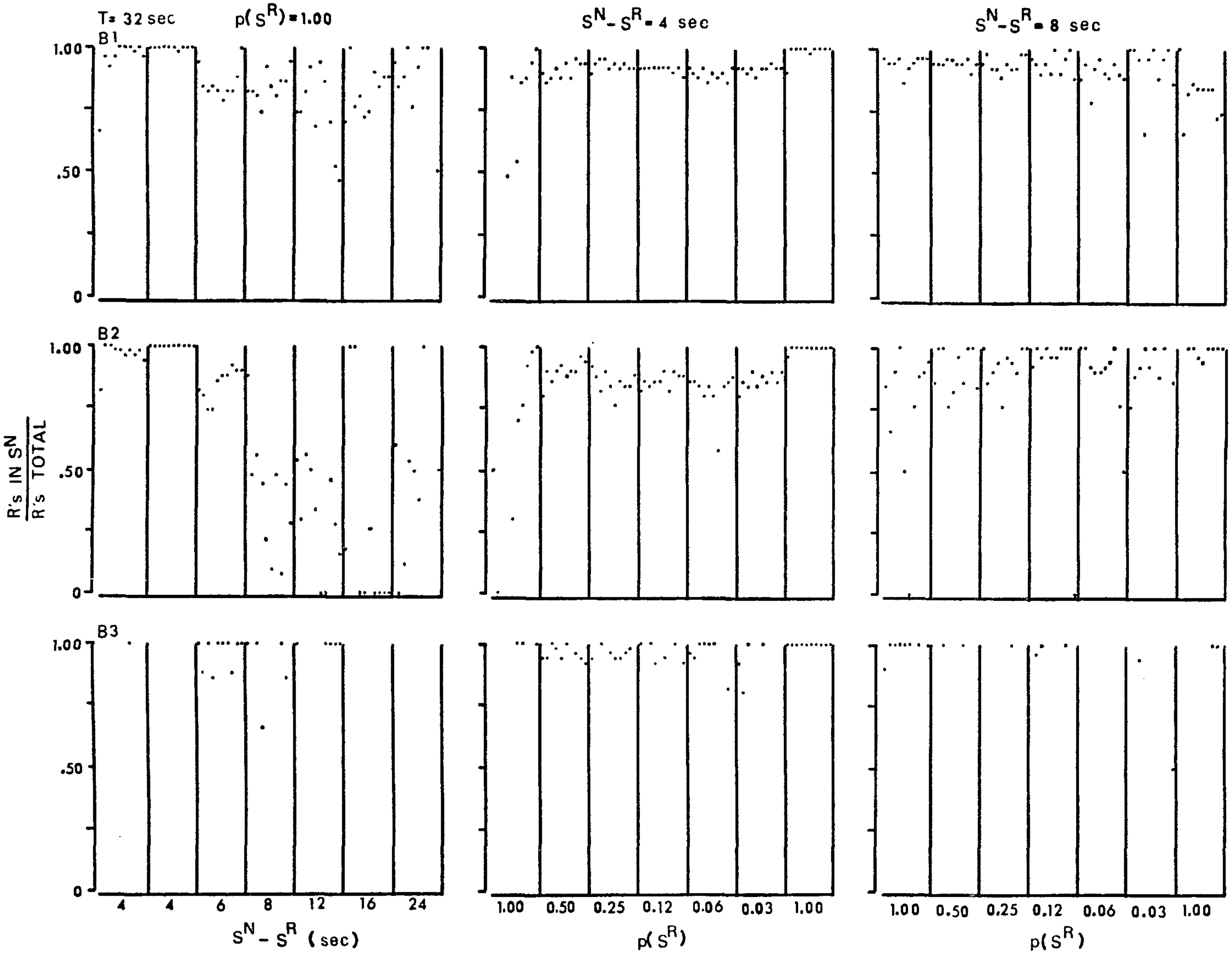

1.00
0.80
0.60
0.40
0.20
0
R's IN S^N / R's TOTAL
64 64
64 32
64 16
T
T=64 sec
GROUP A
T=32 sec
GROUP B
T=16 sec
GROUP C
4
8
16
24
32
48
4
8
16
24
S^N–S^R (sec)
4
8
0.03
0.12
0.25
0.50
1.00
p(SR)

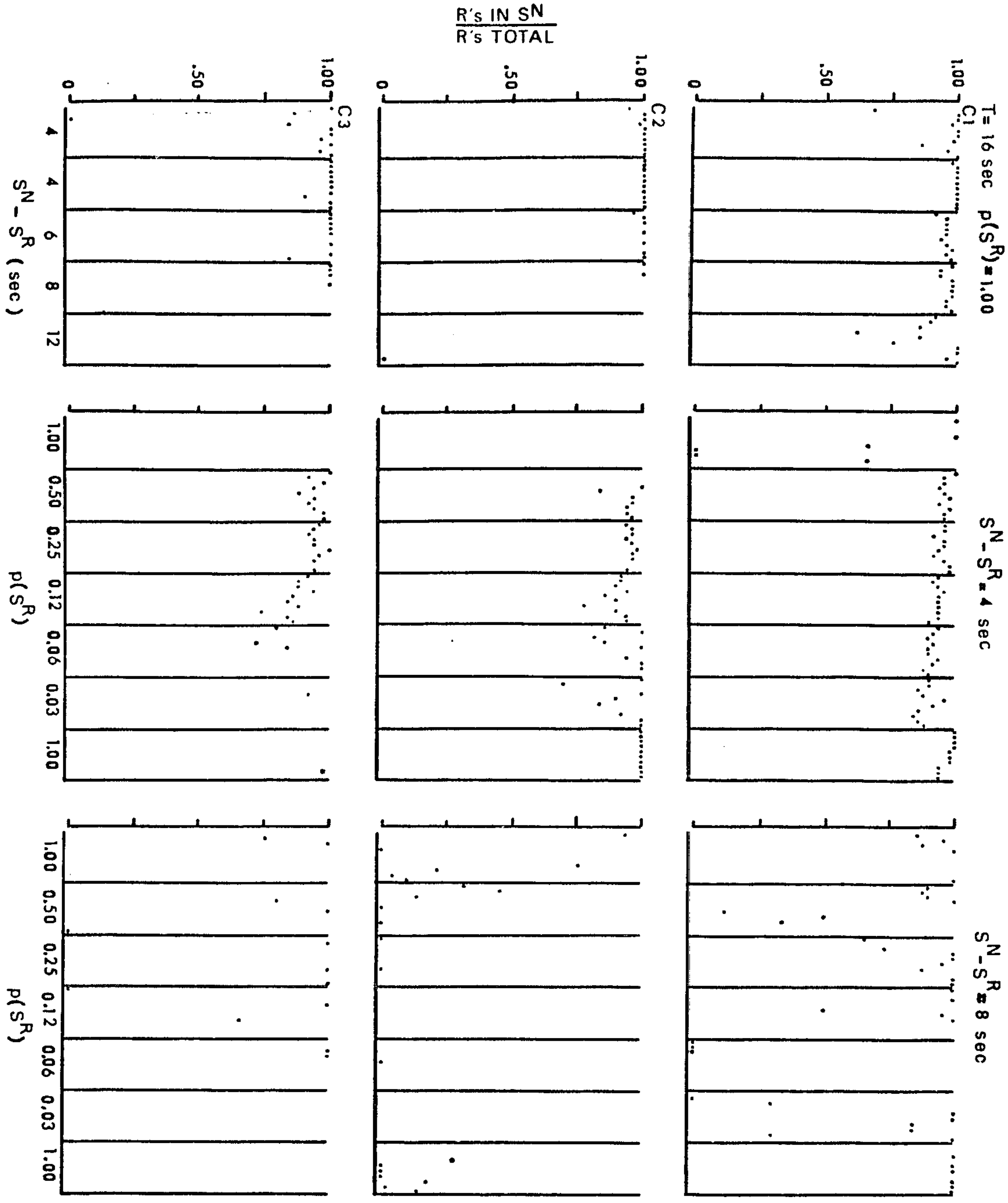

$p(S^R) = 1.00$
$S^N - S^R = 4$ sec
$S^N - S^R = 8$ sec
R's IN S^N / R's TOTAL
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
4
6
8
12
16
24
32
48
$S^N - S^R$ (sec)
0.03
0.12
0.25
0.50
1.00
$p(S^R)$
0.03
0.12
0.25
0.50
1.00
$p(S^R)$

Figures 27 to 29.- Daily relative frequency of responding during S^N

R's in S^N divided by total R's is shown on a daily basis throughout the entire study. The first panel in these figures shows the effects of the matching procedure while the successive panels separate blocks of ten consecutive sessions when the value of a given variable was in effect. Sessions without responding have not been plotted in these figures.


T= 64 sec
p(S^R)= 1.00
S^N-S^R= 4 sec
S^N-S^R= 8 sec
A1
A2
A3
1.00
.50
0
R's IN S^N / R's TOTAL
4
4
6
8
12
16
24
32
48
S^N- S^R (sec)
1.00
0.50
0.25
0.12
0.06
0.03
1.00
p(S^R)


T= 32 sec
p(S^R)=1.00
S^N - S^R = 4 sec
S^N - S^R = 8 sec
B1
B2
B3
1.00
.50
0
R's IN S^N / R's TOTAL
4
4
6
8
12
16
24
S^N - S^R (sec)
1.00 0.50 0.25 0.12 0.06 0.03 1.00
p(S^R)
1.00 0.50 0.25 0.12 0.06 0.03 1.00
p(S^R)


R's IN S^N / R's TOTAL
1.00
.50
0
C1
C2
C3
T= 16 sec $p(S^R)$=1.00
S^N-S^R=4 sec
S^N-S^R=8 sec
4
4
6
8
12
S^N-S^R (sec)
1.00
0.50
0.25
0.12
0.06
0.03
1.00
$p(S^R)$

dependent variable.

Figures 25 and 26 show the group data whereas Figures 27 to 29 show individual functions.

As can be seen in these figures, there is some disagreement between the individual and the group data. The functions relating relative frequency of responding to S^N-S^R tend to be more variable within and among subjects than the functions relating the same index to $p(S^R)$. The fact that this response index is quite unstable when responding occurs at very low rates may explain, at least partially, the variability among individual functions. Given that the group data appears to show more orderly effects, the description of these results will be based on the latter functions.

The bargraph in the upper right corner of figure 25 shows that during the matching stage virtually all responding occurred during S^N. Responding continued to be concentrated in S^N when cycle length was shortened from 64 to 32 and 16 sec in groups B and C.

Figures 25 and 26 show relative frequency of responding in S^N as a function of S^N-S^R, $p(S^R)$, and T. When the S^N-S^R interval was increased, responding in S^N, relative to total responding, decreased in group A. The same measure seemed to have been affected to a lesser degree in group B and still less in group C. The group parameter (T) therefore appears to be related directly to the magnitude of this response index when the S^N-S^R

interval is increased.

Decreasing $p(S^R)$, under both values of S^N-S^R, 4 and 8 sec, produced slight monotonic decrements in relative S^N responding. This effect seems to be more prominent in groups A and B than in group C. In group C, the function obtained under S^N-S^R=8 sec differs markedly from the same in other groups. In this case, relative S^N responding appears to increase with diminutions in $p(S^R)$. Responding in group C, however, was very infrequent during this procedure, thus possibly deflating the measure at $p(S^R)$=1.00 and .50.

In all groups, relative responding in S^N was higher at all values of $p(S^R)$ when S^N-S^R was four sec than when S^N-S^R was eight sec.

5. The Post-S^N Pause (PS^NP).

Figures 30 to 38 show the effect of the different procedures of the study on the frequency distributions of PS^NP. PS^NP frequency is shown as a fraction of the highest frequency obtained at any given value of a variable. As before, this transformation was done in order to show very low PS^NP frequencies. The number of cases represented in each distribution is indicated in the panels of the figures.

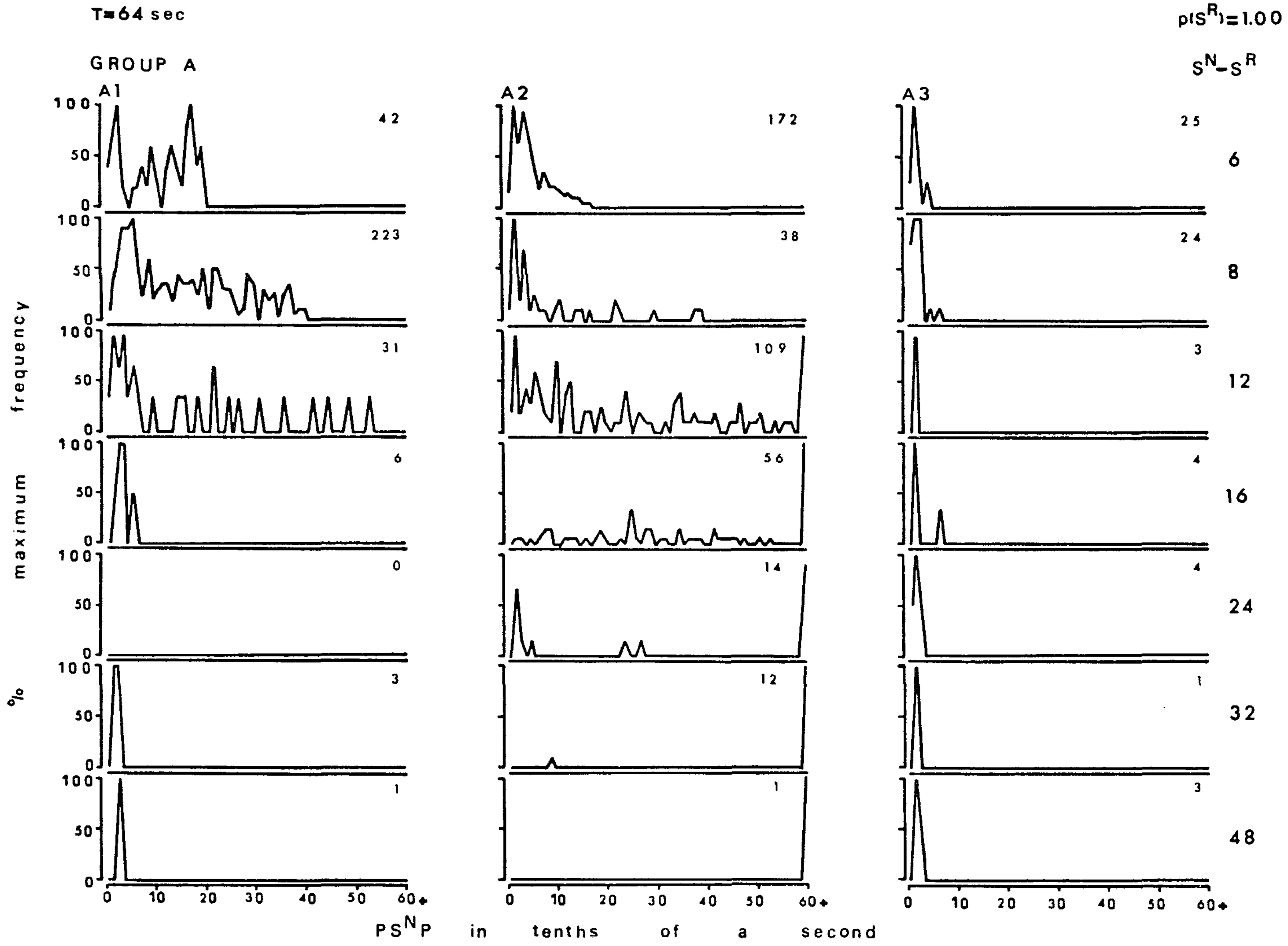
PS^NP occurred in all phases of the study. These pauses were very short, with the mode of the distributions falling in the range from 0 to about .5 sec. The three

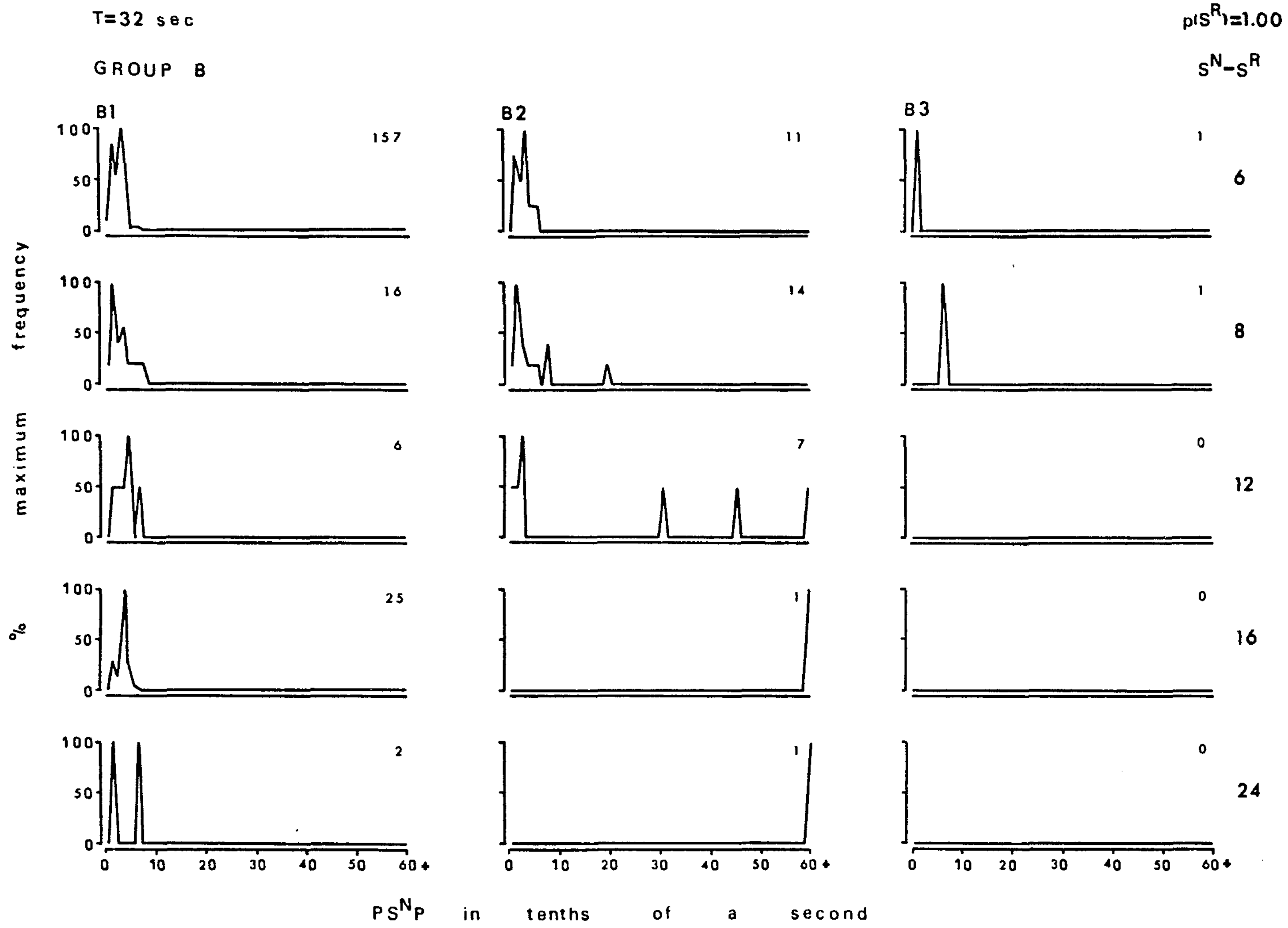
Figures 30 to 38.- Relative frequency distribution of Post-S^N Pause

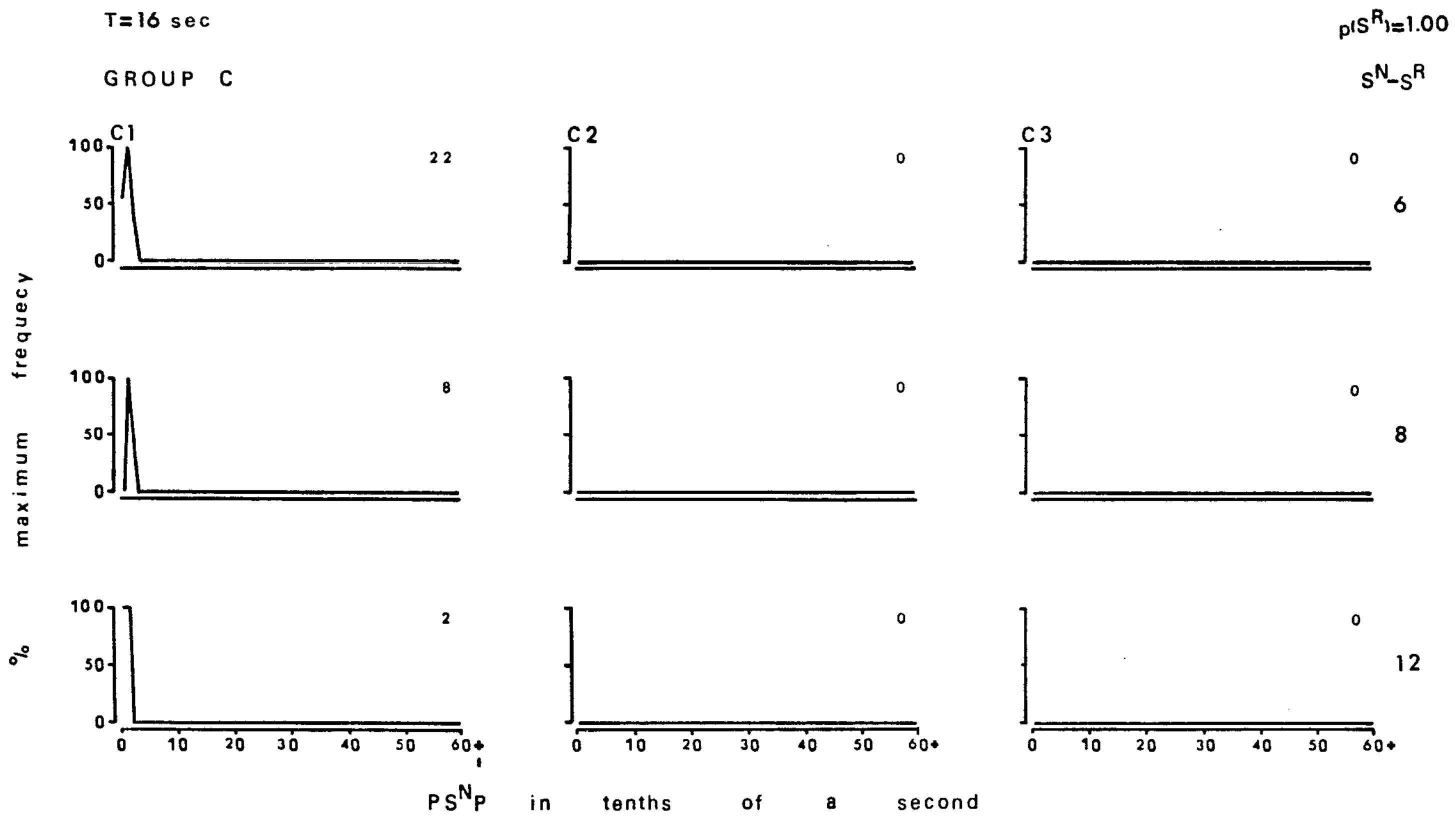
PS^NP frequency is shown as a fraction of the maximum frequency observed at each experimental point.

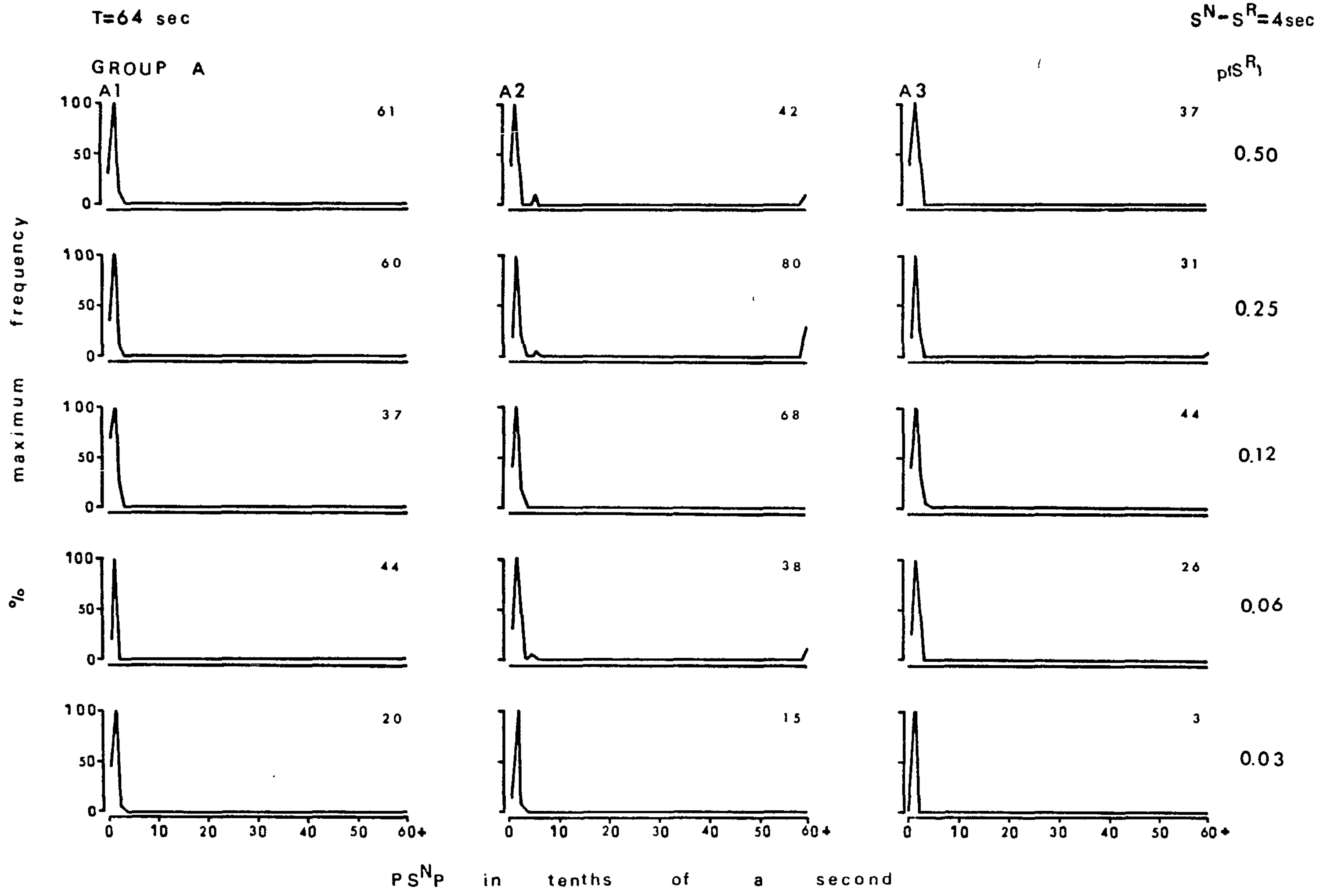
The panels in each figure show frequency distributions for each of three subjects in a group (columns) at successive values of a given variable (rows).

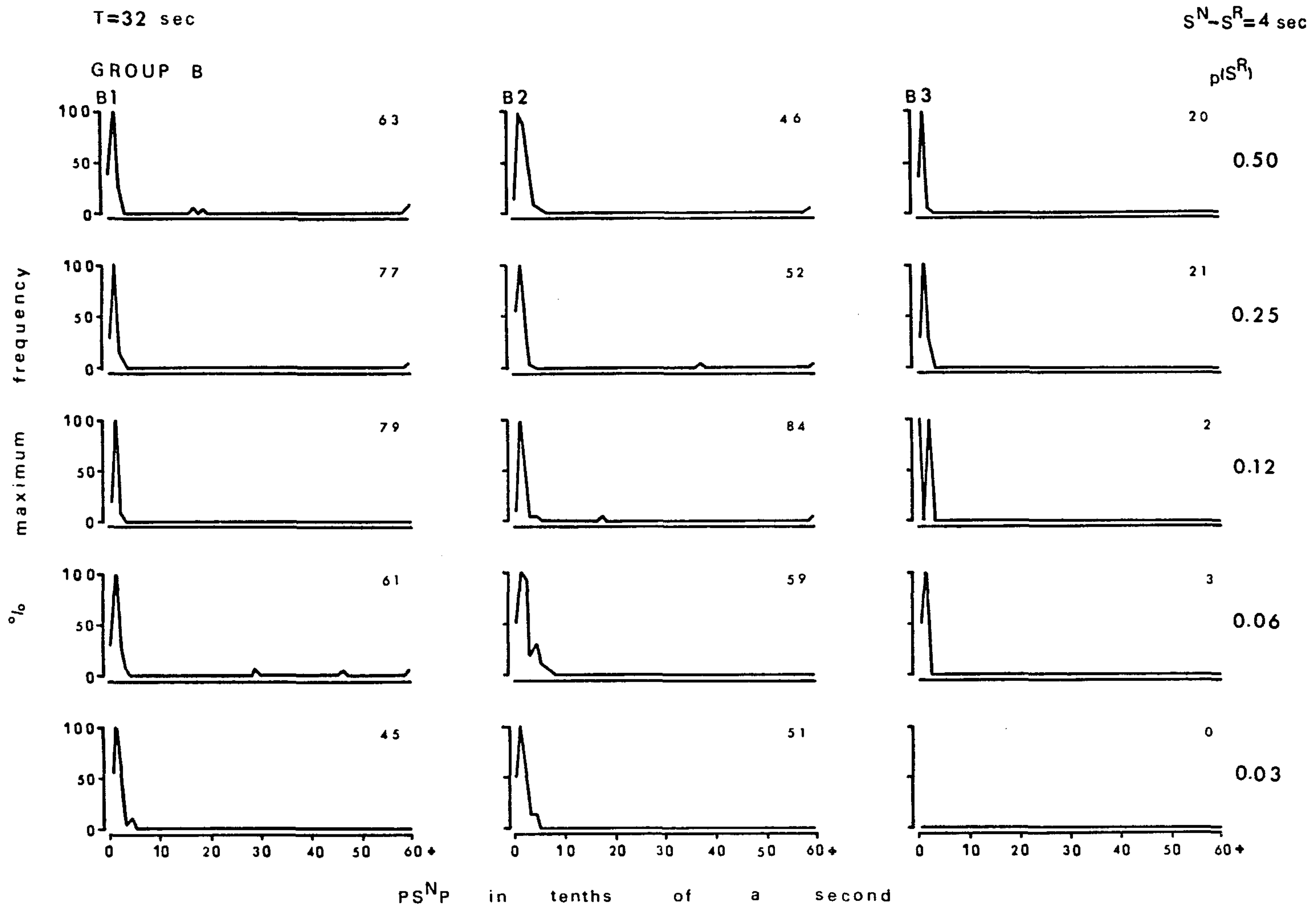
The data shown in these figures represent the last five sessions at a given value of each variable. The broken lines in some panels indicate redeterminations. The number of cases included in each distribution is shown on the upper right corner of each panel.

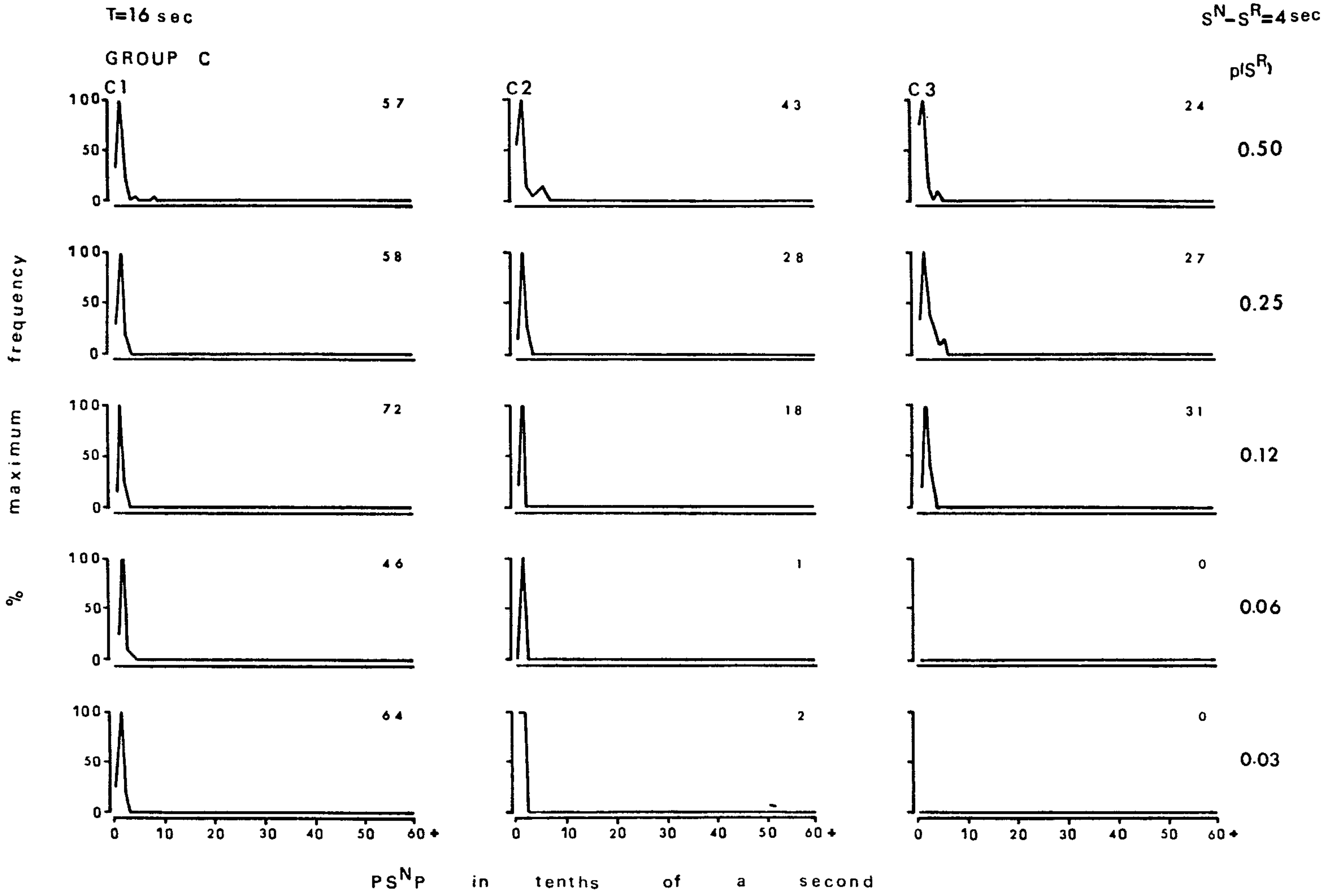

T=64 sec
GROUP A
p(S^R)=1.00
S^N-S^R
A1
A2
A3
% maximum frequency
42
223
31
6
0
3
1
172
38
109
56
14
12
1
25
24
3
4
4
1
3
6
8
12
16
24
32
48
0
50
100
0
10
20
30
40
50
60+
PS^NP in tenths of a second

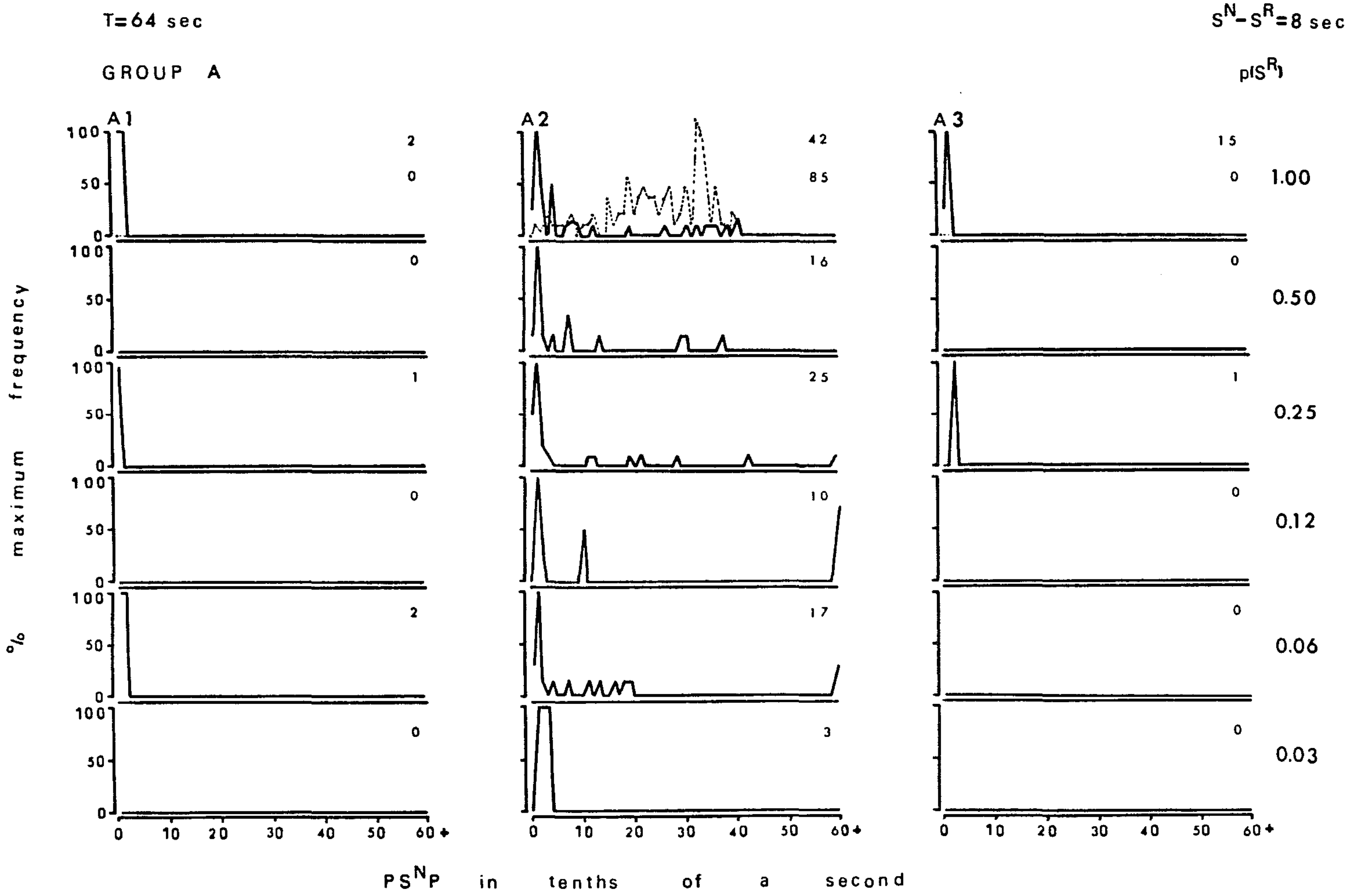

T=32 sec
GROUP B
p(S^R)=1.00
S^N-S^R
B1
B2
B3
157
11
1
6
16
14
1
8
6
7
0
12
25
1
0
16
2
1
0
24
frequency maximum %
100
50
0
0 10 20 30 40 50 60+
PS^NP in tenths of a second

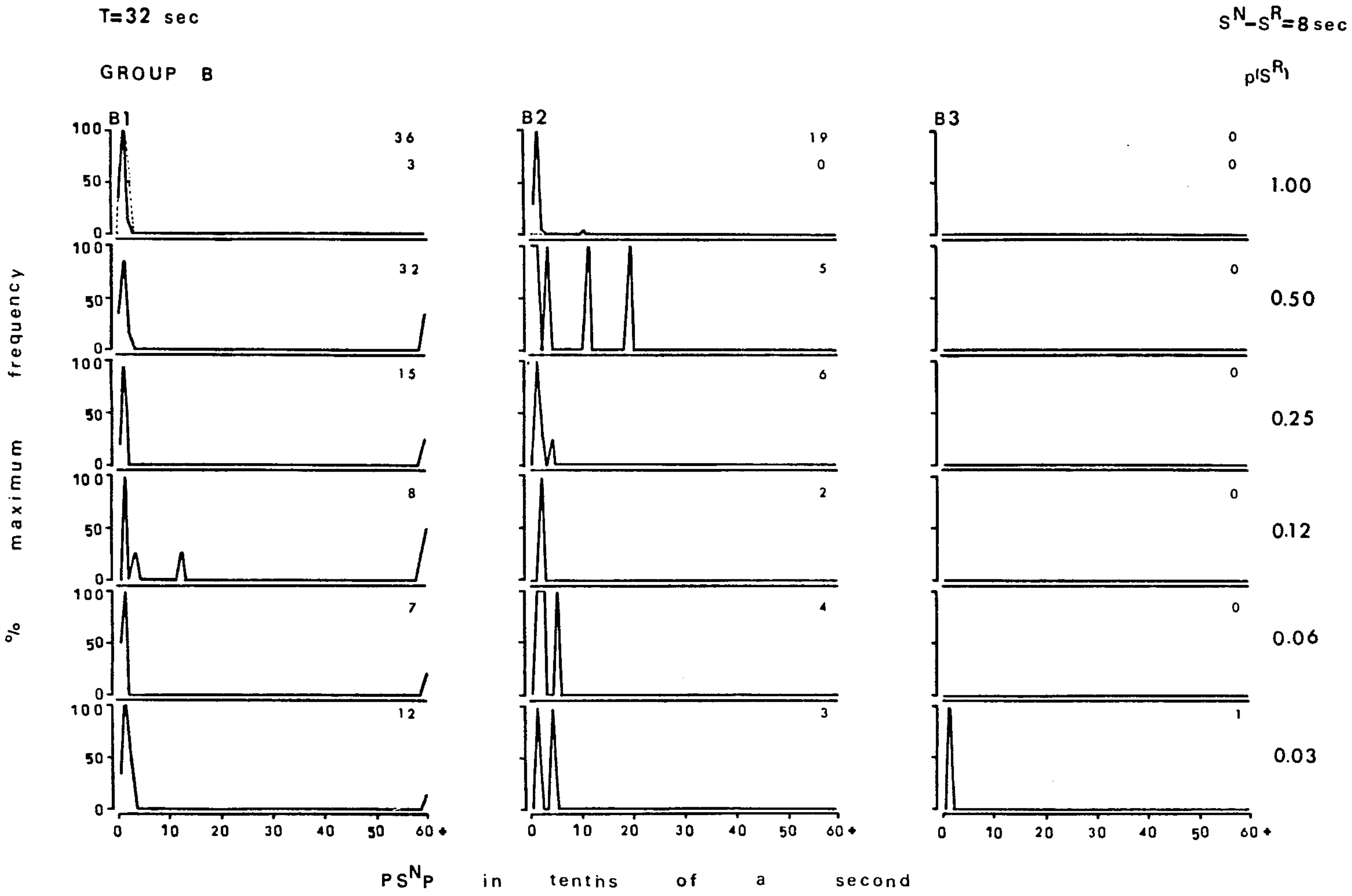

T=16 sec
GROUP C
p(S^R)=1.00
S^N-S^R
C1
C2
C3
100
50
0
22
0
0
6
8
0
0
8
2
0
0
12
% maximum frequecy
0 10 20 30 40 50 60+
PS^NP in tenths of a second

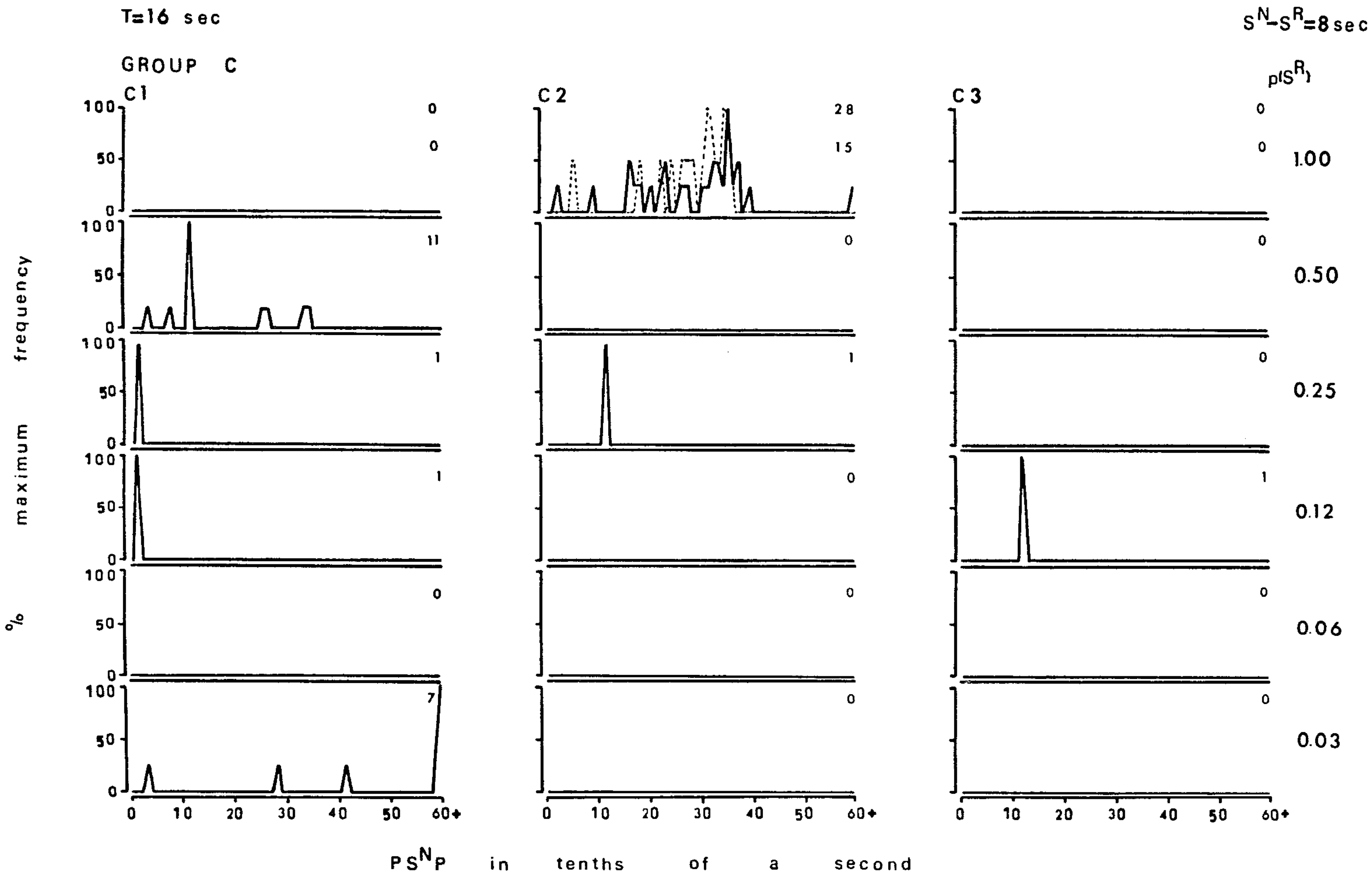

T=64 sec
GROUP A
$S^N-S^R=4sec$
$p(S^R)$
A1
A2
A3
61
42
37
0.50
60
80
31
0.25
37
68
44
0.12
44
38
26
0.06
20
15
3
0.03
100
50
0
% maximum frequency
0
10
20
30
40
50
60+
PS^NP in tenths of a second


T=32 sec
GROUP B
S^N-S^R=4 sec
$p(S^R)$
B1
B2
B3
% maximum frequency
100
50
0
63
46
20
0.50
77
52
21
0.25
79
84
2
0.12
61
59
3
0.06
45
51
0
0.03
0
10
20
30
40
50
60+
PS^NP in tenths of a second


T=16 sec
GROUP C
$S^N - S^R = 4$ sec
$p(S^R)$
C1
C2
C3
100
50
0
57
43
24
0.50
58
28
27
0.25
72
18
31
0.12
46
1
0
0.06
64
2
0
0.03
0
10
20
30
40
50
60+
% maximum frequency
PS^NP in tenths of a second


T=64 sec
GROUP A
$S^N-S^R=8$ sec
$p(S^R)$
A1
A2
A3
100
50
0
% maximum frequency
2
0
0
1
0
2
0
42
85
16
25
10
17
3
15
0
0
1
0
0
0
1.00
0.50
0.25
0.12
0.06
0.03
0
10
20
30
40
50
60+
PS^NP in tenths of a second


T=32 sec
GROUP B
S^N-S^R=8 sec
p(S^R)
B1
B2
B3
100
50
0
36
3
19
0
0
0
1.00
32
5
0
0.50
15
6
0
0.25
8
2
0
0.12
7
4
0
0.06
12
3
1
0.03
% maximum frequency
0 10 20 30 40 50 60+
PS^NP in tenths of a second


T=16 sec
GROUP C
S^N-S^R=8 sec
$p(S^R)$
C1
C2
C3
100
50
0
% maximum frequency
0
0
28
15
0
0
1.00
11
0
0
0.50
1
1
0
0.25
1
0
1
0.12
0
0
0
0.06
7
0
0
0.03
0
10
20
30
40
50
60+
PS^NP in tenths of a second

groups appeared to differ systematically in the tendency to respond after S^N termination. In general, group A responded more frequently after S^N, followed by group B. Group C responded relatively infrequently after S^N offset. This phenomenon was particularly evident during the manipulation of the S^N-S^R interval and when $p(S^R)$ was decreased with S^N-S^R fixed at 8 sec.

Figures 30 to 32 show the effect of lengthening the S^N-S^R interval on PS^NP distribution. Increasing the S^N-S^R interval produced a decrement in the number of PS^NP's in all groups. Also, although the effect was not uniform, it seemed to produce progressively longer PS^NP's in some subjects of groups A and B. This effect seemed more evident when S^N-S^R was increased to about 12-16 sec. Further increments in the value of the variable did not seem to affect the duration of PS^NP's. As indicated before, group C responded infrequently after S^N termination during this procedure.

Figures 33 to 35 show frequency distributions of PS^NP as a function of decreasing $p(S^R)$, holding S^N-S^R constant at 4 sec. This manipulation produced a marked increase in the number of PS^NP's. The effect was particularly noticeable in group C, which responded infrequently after S^N during the manipulation of S^N-S^R. In all groups, PS^NP became shorter than inthe previous procedure and its duration did not seem to have been affected by successive reductions in the value of $p(S^R)$. The number of PS^NP's, however, decreased with decrements in $p(S^R)$.

Decreasing $p(S^R)$ with S^N-S^R constant at 8 sec (see figures 36 to 38) not only also produced progressive decrements in the number of PS^NP's, it also resulted in longer PS^NP's than the preceding $p(S^R)$ series. As in the previous $p(S^R)$ manipulation, reductions in the value of the variable did not seem to affect PS^NP length in a systematic manner.

6. The overall rate of responding.

Rate of responding throughout the entire T cycle is shown in figures 39 to 43. Figures 39 and 40 show overall rate averaged across the three subjects for each group. Figures 41 to 43 show the individual data.

Since there is substantial agreement between the individual and the averaged functions, the description of these results will be based on the group data.

As indicated before, in all groups and experimental conditions most responding occurred during the four sec S^N. Therefore, the functions relating overall rate to S^N-S^R and $p(S^R)$ are similar to those relating rate in S^N to the same variables. The data only appear to differ in the absolute value of the overall rate which depends, as could be expected, on the value of T for each group.

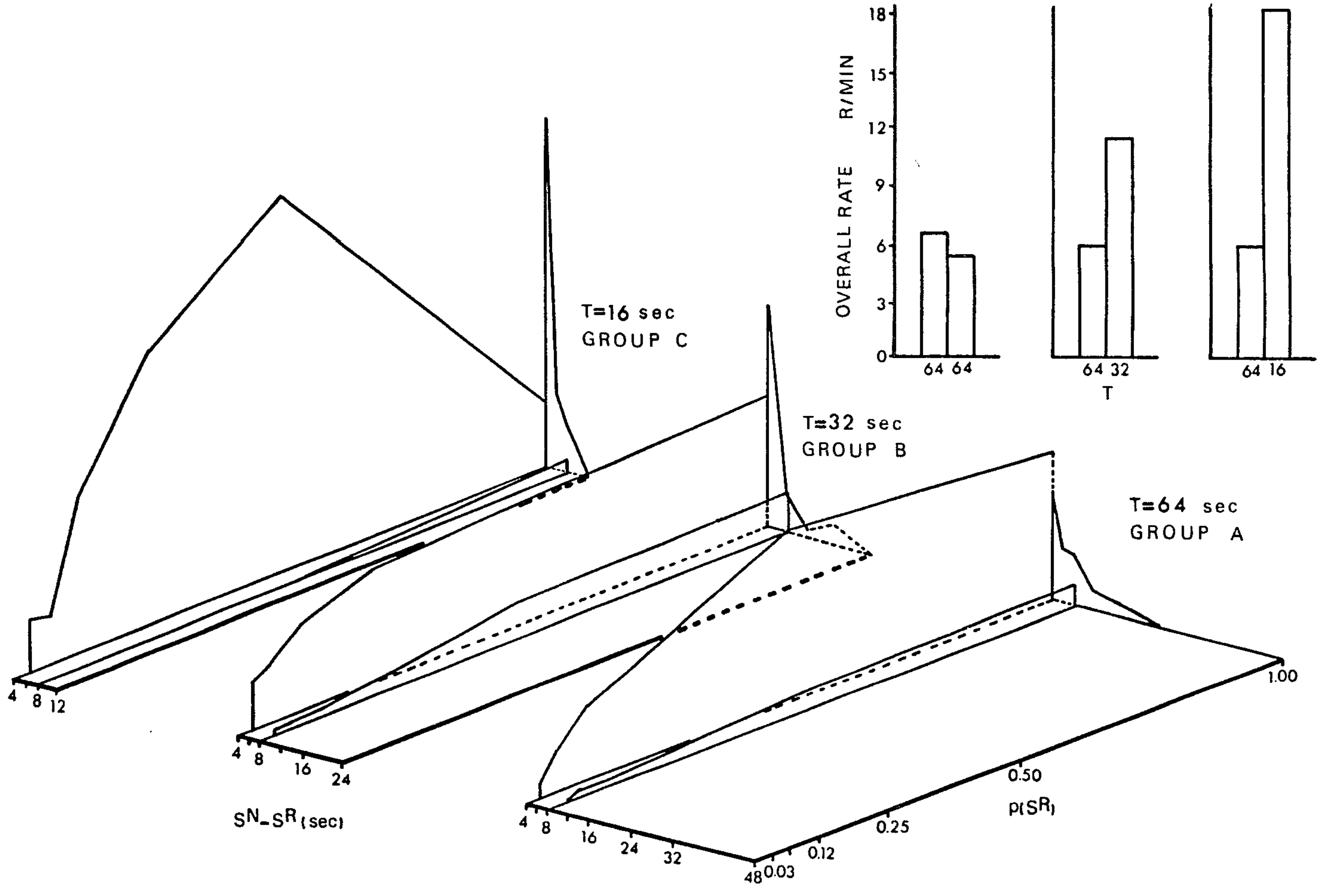
Given that the form of these functions has already been discussed, only a brief account will be given here. Overall rate decreased monotonically in all groups

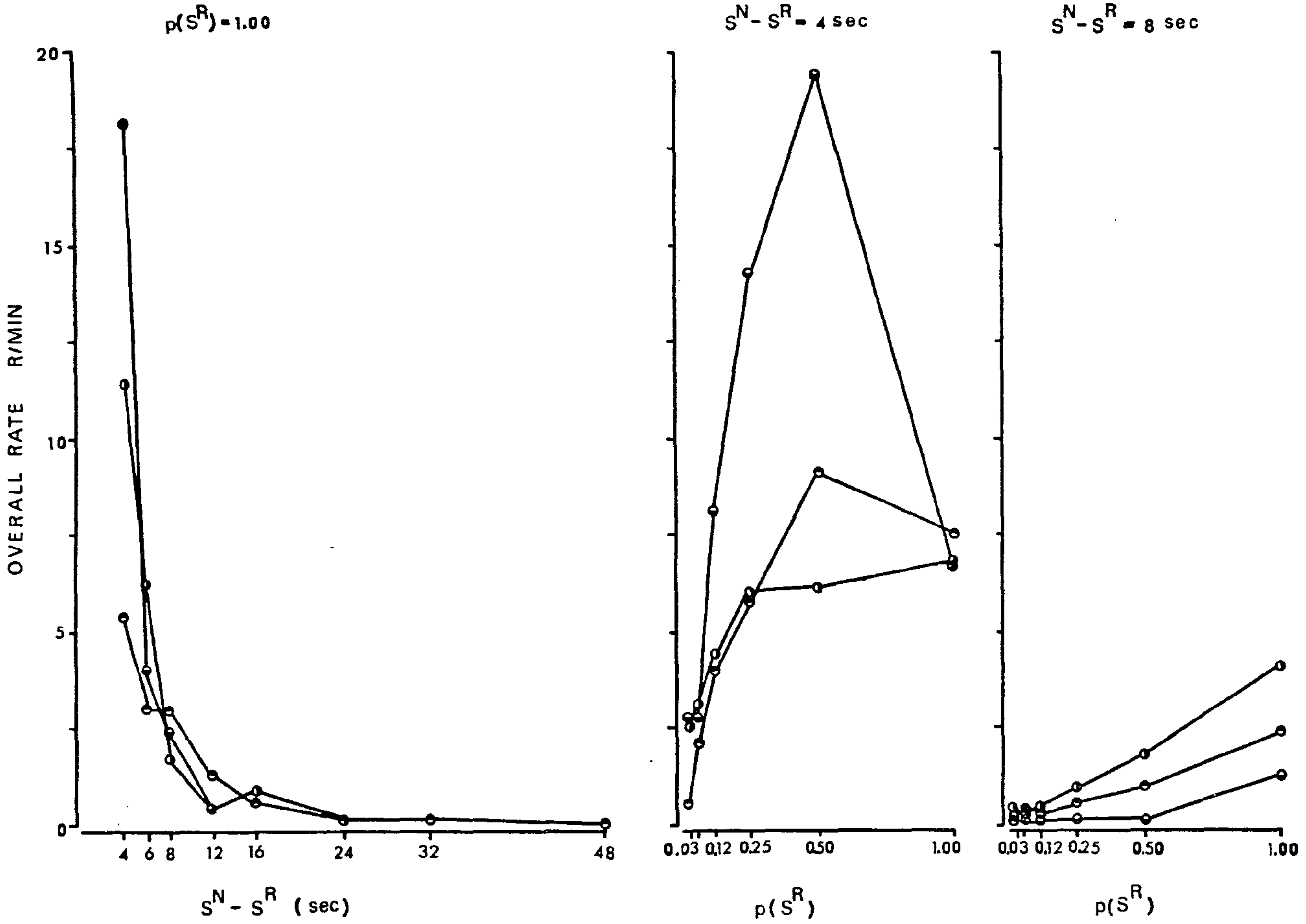
Figures 39 and 40.- Averaged overall rate of responding (group data)

Figures 39 and 40 show the averaged overall rate of responding for all experimental conditions. The data are averages of the overall rate of the three subjects in each group over the last five sessions of each procedure. Figure 39 shows the overall rate of responding as a function of S^N-S^R and $p(S^R)$. The bargraph on the right corner of the figure shows this dependent variable as T was held constant at 64 sec and the effect of changing the values of T from 64 to 32 and 16 sec. The ordinate scale of the three dimensional figure is the same as in the bargraph. Each surface of the figure shows the performance of a different group of subjects for which the group parameter T was held constant. The points of intersection between $p(S^R)$ and S^N-S^R functions are the averages of two redeterminations at $p(S^R)=1.00$.

Figure 40 shows the same data plotted on two dimensional coordinates. The meaning of the symbols is as follows:

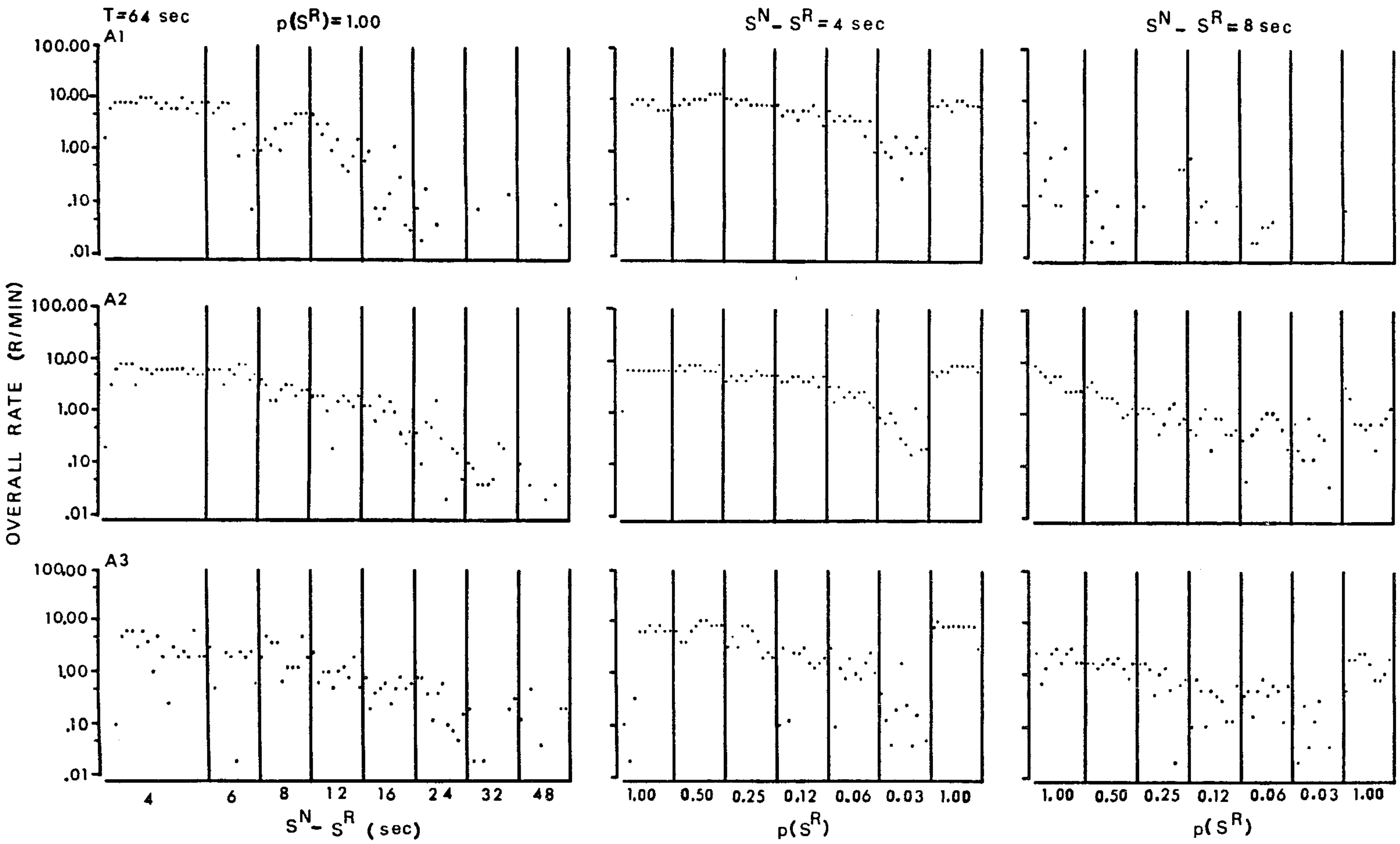
◓ indicates group A (T=64 sec)
◑ indicates group B (T=32 sec)
◒ indicates group C (T=16 sec)

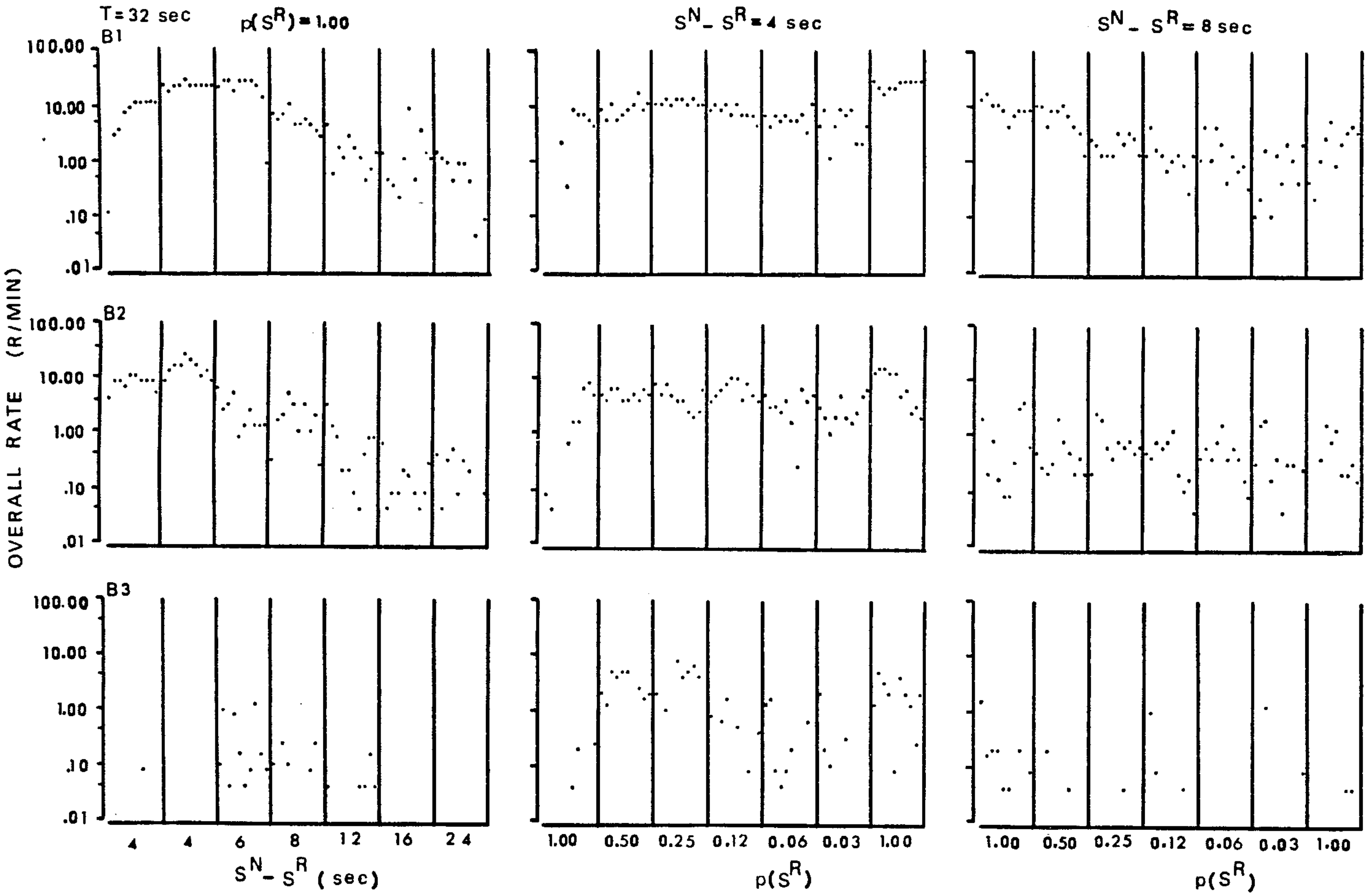

T=16 sec
GROUP C
T=32 sec
GROUP B
T=64 sec
GROUP A
4
8
12
4
8
16
24
SN-SR (sec)
4
8
16
24
32
48
0.03
0.12
0.25
0.50
p(SR)
1.00
OVERALL RATE R/MIN
0
3
6
9
12
15
18
64 64
64 32
64 16
T

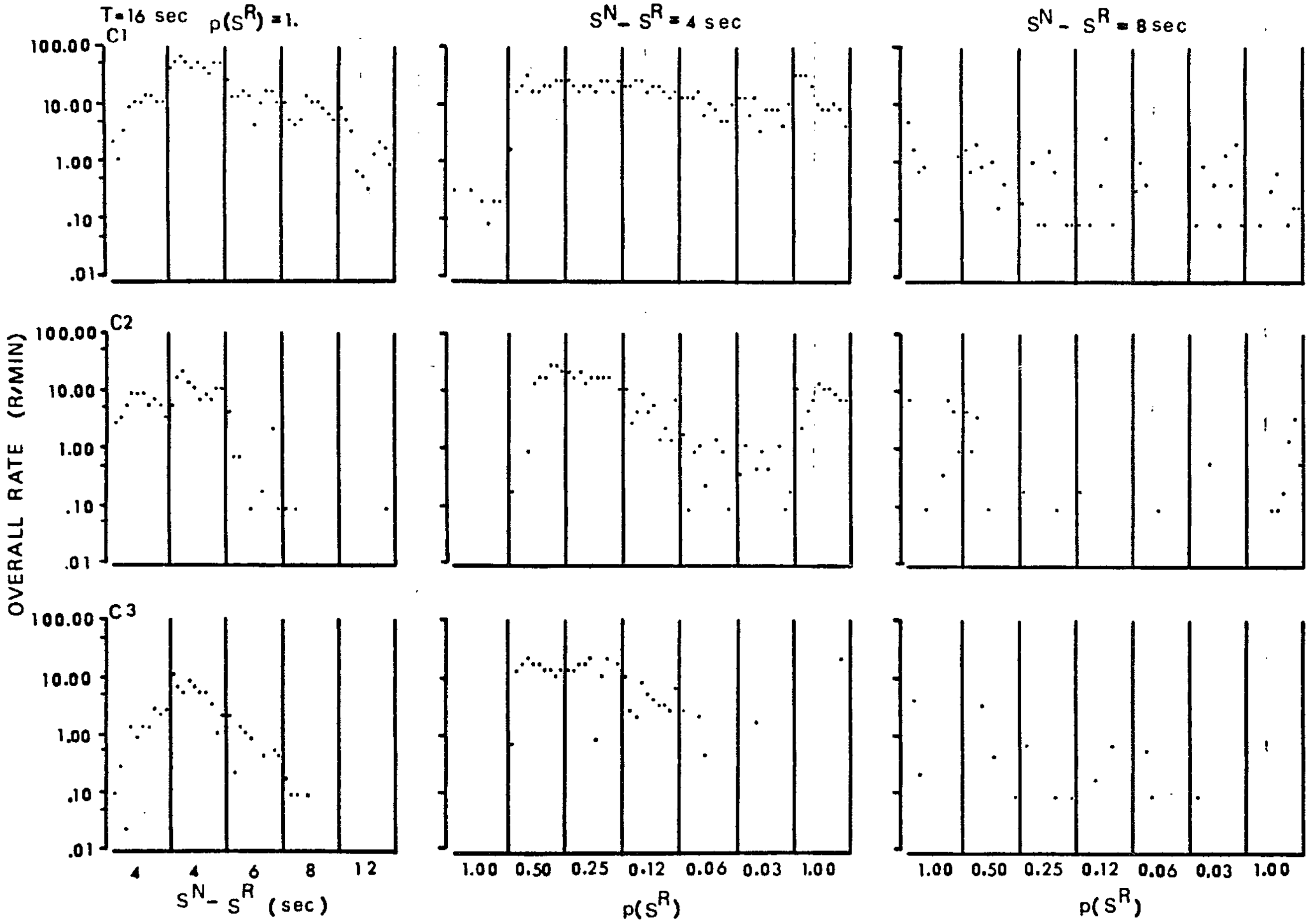

p(S^R) = 1.00
S^N - S^R = 4 sec
S^N - S^R = 8 sec
OVERALL RATE R/MIN
0
5
10
15
20
4
6
8
12
16
24
32
48
S^N - S^R (sec)
0.03
0.12
0.25
0.50
1.00
p(S^R)
0.03
0.12
0.25
0.50
1.00
p(S^R)

Figures 41 to 43.- Daily overall rates of responding

The overall rates of responding of the three individual subjects within each group is shown on a daily basis throughout the entire study. The first panel in each figure shows the effect of the matching procedure. The successive panels separate blocks of ten consecutive sessions, when the value of a given variable was in effect.


T=64 sec
p(S^R)=1.00
S^N- S^R=4 sec
S^N- S^R=8 sec
A1
A2
A3
OVERALL RATE (R/MIN)
100.00
10.00
1.00
.10
.01
4
6
8
12
16
24
32
48
S^N- S^R (sec)
1.00
0.50
0.25
0.12
0.06
0.03
1.00
p(S^R)
p(S^R)


T=32 sec
p(S^R)=1.00
S^N- S^R=4 sec
S^N- S^R=8 sec
B1
B2
B3
OVERALL RATE (R/MIN)
100.00
10.00
1.00
.10
.01
4
4
6
8
12
16
24
S^N- S^R (sec)
1.00
0.50
0.25
0.12
0.06
0.03
1.00
p(S^R)
1.00
0.50
0.25
0.12
0.06
0.03
1.00
p(S^R)


T=16 sec p(S^R)=1.
S^N- S^R=4 sec
S^N- S^R=8 sec
C1
C2
C3
100.00
10.00
1.00
.10
.01
OVERALL RATE (R/MIN)
4
4
6
8
12
S^N- S^R (sec)
1.00
0.50
0.25
0.12
0.06
0.03
1.00
p(S^R)
p(S^R)

as the S^N-S^R interval was lengthened. The rate was higher in group C than in group B, which in turn responded with higher rates than group A. The slope of these decreasing functions was directly related to the value of T.

For groups A and B, overall rate was a decreasing function of decreasing $p(S^R)$ at both values of S^N-S^R, 4 and 8 sec. In the case of group C, when $p(S^R)$ was decreased from 1.00 to .50 with S^N-S^R fixed at 4 sec, overall rate increased. Further decrements in $p(S^R)$ resulted in progressive reductions in rate. In the same group, the $p(S^R)$ function obtained with S^N-S^R fixed at 8 sec seemed a steadily decreasing one.

7. The Post-S^R Pause (PS^RP).

Figure 44 shows median Post-S^R Pause for all subjects and conditions of the study.

Responding after S^R termination occurred very infrequently throughout this research. More often than not, an S^R delivery would be followed by the next S^N than by an intervening response. In general, the "fast" and "intermediate" subjects in each group responded after S^R termination to more values of the independent variables. The "slow" responders rarely pecked within the interval between S^R and S^N. In the case of the "fast" and "intermediate" responders, PS^RP's were more frequent as the S^N-S^R interval was increased than when $p(S^R)$ was decreased, for both S^N-S^R=4 and 8 sec. This last finding is more or

Figure 44.- Median PS^RP

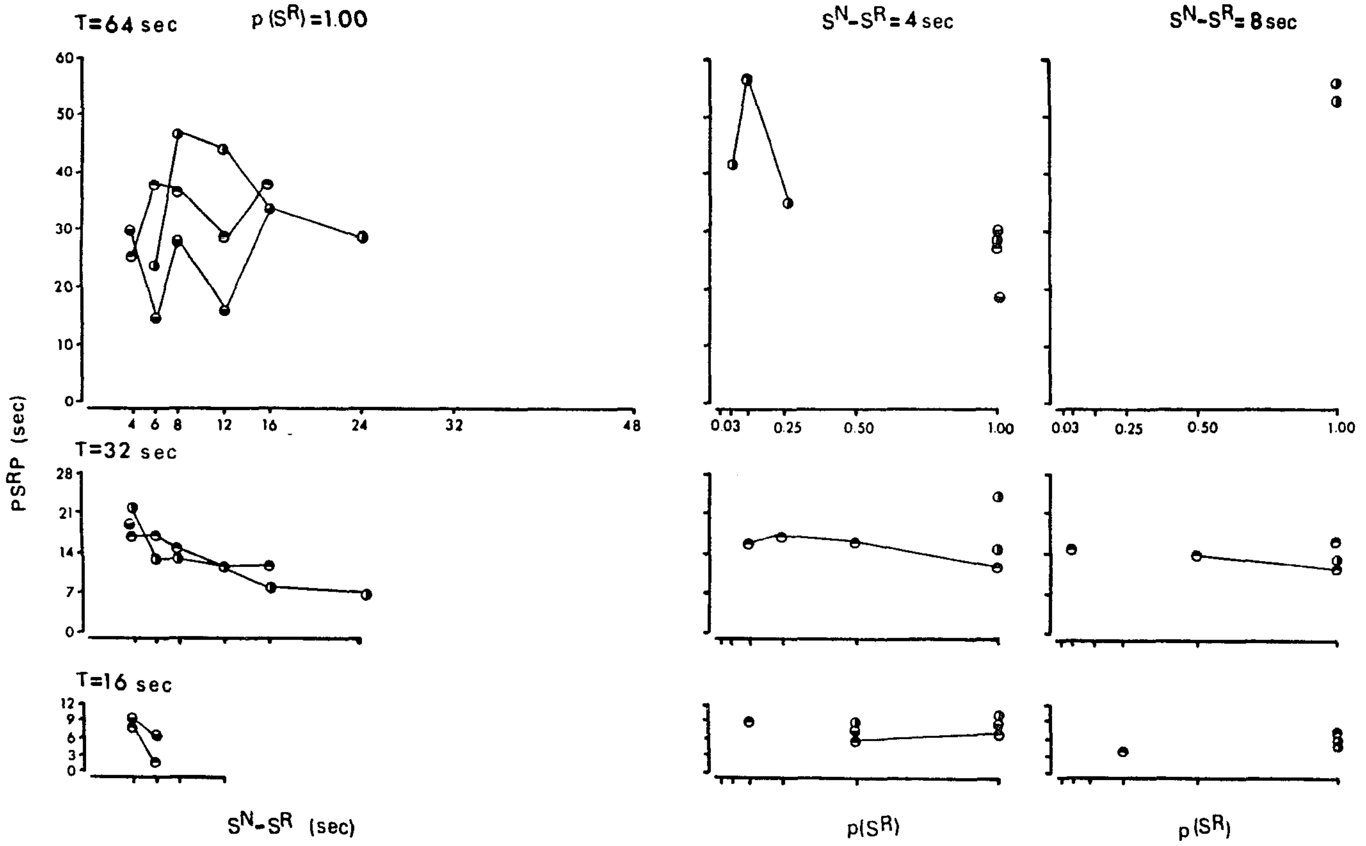
Median PS^RP are shown for each subject in the study within their respective groups. The data are based on the last five sessions of each experimental point. The overlapping symbols on some conditions indicate the effects of the matching procedure (T=64 sec) or redeterminations at $p(S^R)=1.00$. See text (p.) for details concerning the definition of this variable.

The meaning of the symbols is as follows:

◓ indicates a "fast" responder

◑ indicates an "intermediate" responder

◒ indicates a "slow" responder


T=64 sec
p (S^R) = 1.00
S^N-S^R = 4 sec
S^N-S^R = 8 sec
PSRP (sec)
60
50
40
30
20
10
0
4
6
8
12
16
24
32
48
0.03
0.25
0.50
1.00
T=32 sec
28
21
14
7
0
T=16 sec
12
9
6
3
0
S^N-S^R (sec)
p(S^R)
p(S^R)

less to be expected if one considers that the number of "opportunities" to peck after S^R was reduced by decreasing $p(S^R)$.

Due to the paucity of data, it is difficult to assess any trend in these functions. It seems, however, that at least in some cases, the functions relating PS^RP to S^N-S^R and $p(S^R)$ were quite without any trend.

8. The residual or net rates.

Figures 45 and 46 show net rates in terms of the medians for each group. Figures 47 to 49 show the daily net rate for each individual subject within their respective groups.

In general, there seems to be good agreement between individual and group medians. The fact that some subjects did not respond throughout the entire range of a given variable makes it somewhat difficult to describe individual functions. Therefore, the description of these data will be based on the group functions.

The bargraph in the upper right corner of figure 45 shows that net rate increased systematically as a function of shortening the value of T from 64 to 32 and 16 sec.

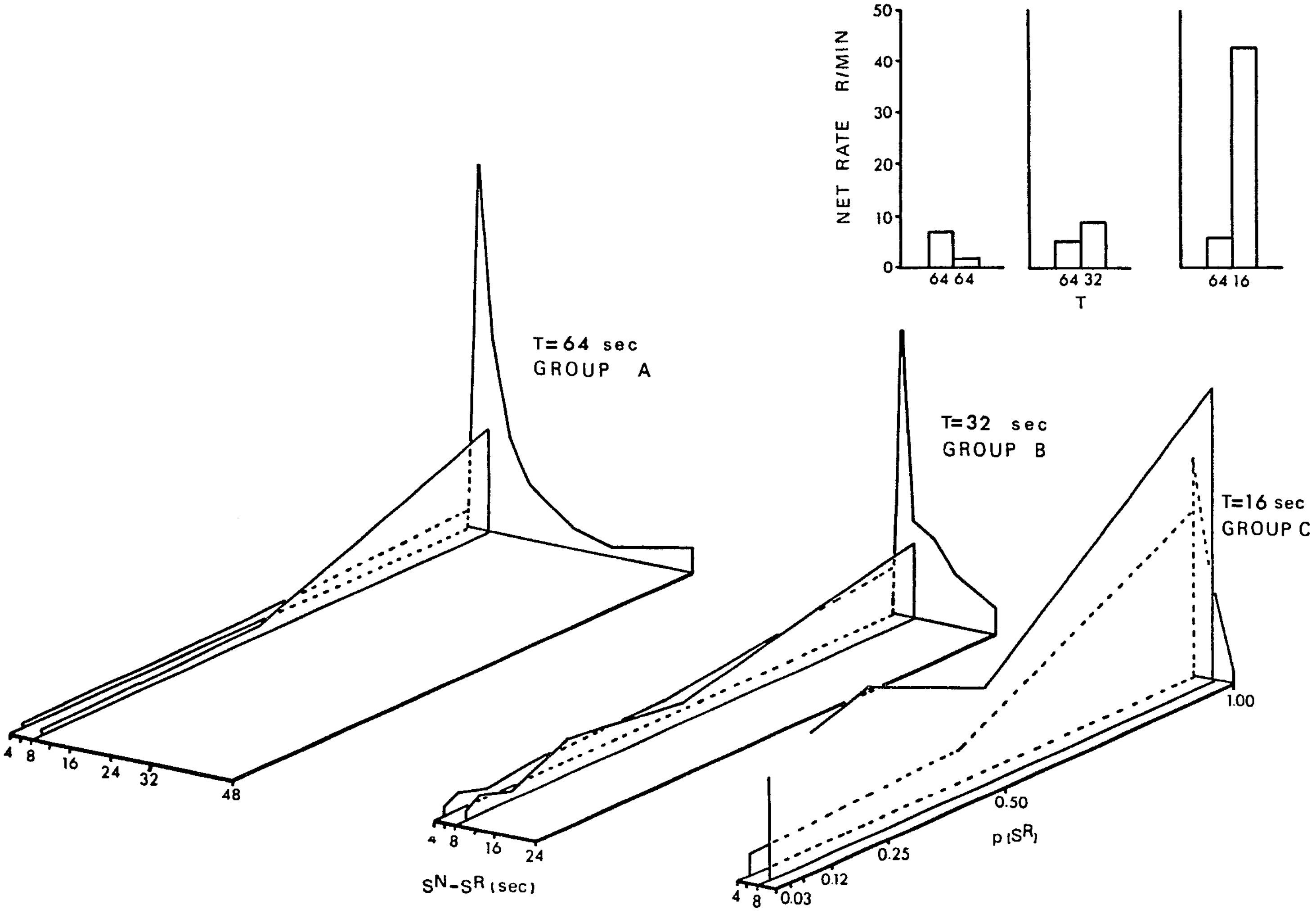
The functions relating net rate to S^N-S^R and $p(S^R)$ at both values of S^N-S^R, 4 and 8 sec, were similar in all groups. Net rate increased rapidly in groups A and B when S^N-S^R was increased from 4 to 6 sec. Further

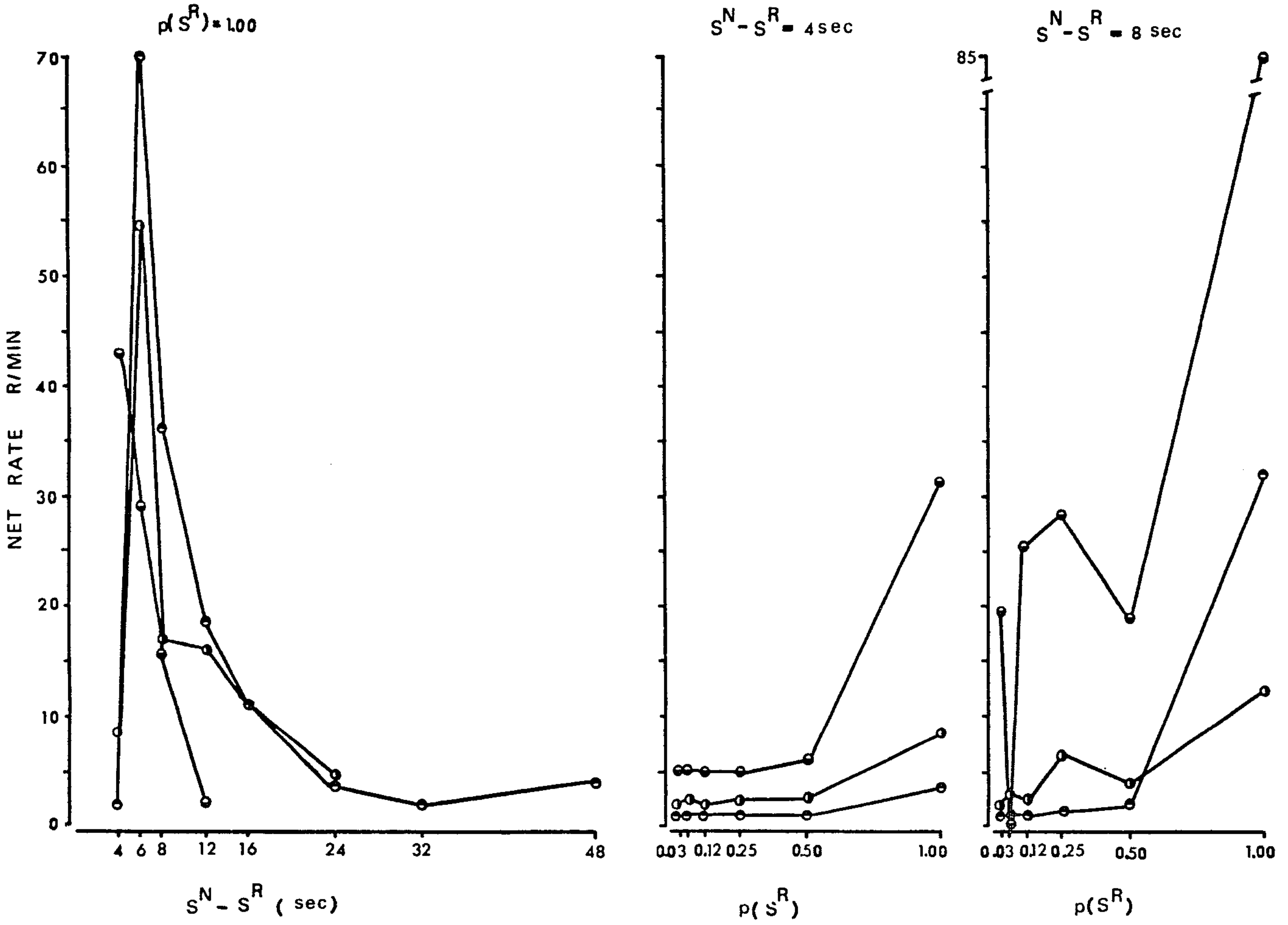
Figures 45 and 46.- Median net rates (group data)

Figures 45 and 46 show group net rates for all experimental conditions. The data are the medians of each group of subjects calculated over the last five sessions of each procedure. The bargraph on the right corner of figure 45 shows median net rates as a function of holding T constant at 64 sec for an additional 10-session period and of shortening T from 64 to 32 and 16 sec. The three dimensional plot in the same figure shows median net rates as a function of S^N-S^R and $p(S^R)$. The ordinate scale is the same as in the bargraph. Each surface of the figure shows the performance of a different group of subjects wherein the group parameter T was held constant. The points of intersection between the $p(S^R)$ and S^N-S^R functions represent the median value of two five-day samples, i.e., based on the redeterminations at $p(S^R)=1.00$.

Figure 46 shows the same data plotted on two dimensional coordinates. The meaning of the symbols is as follows:

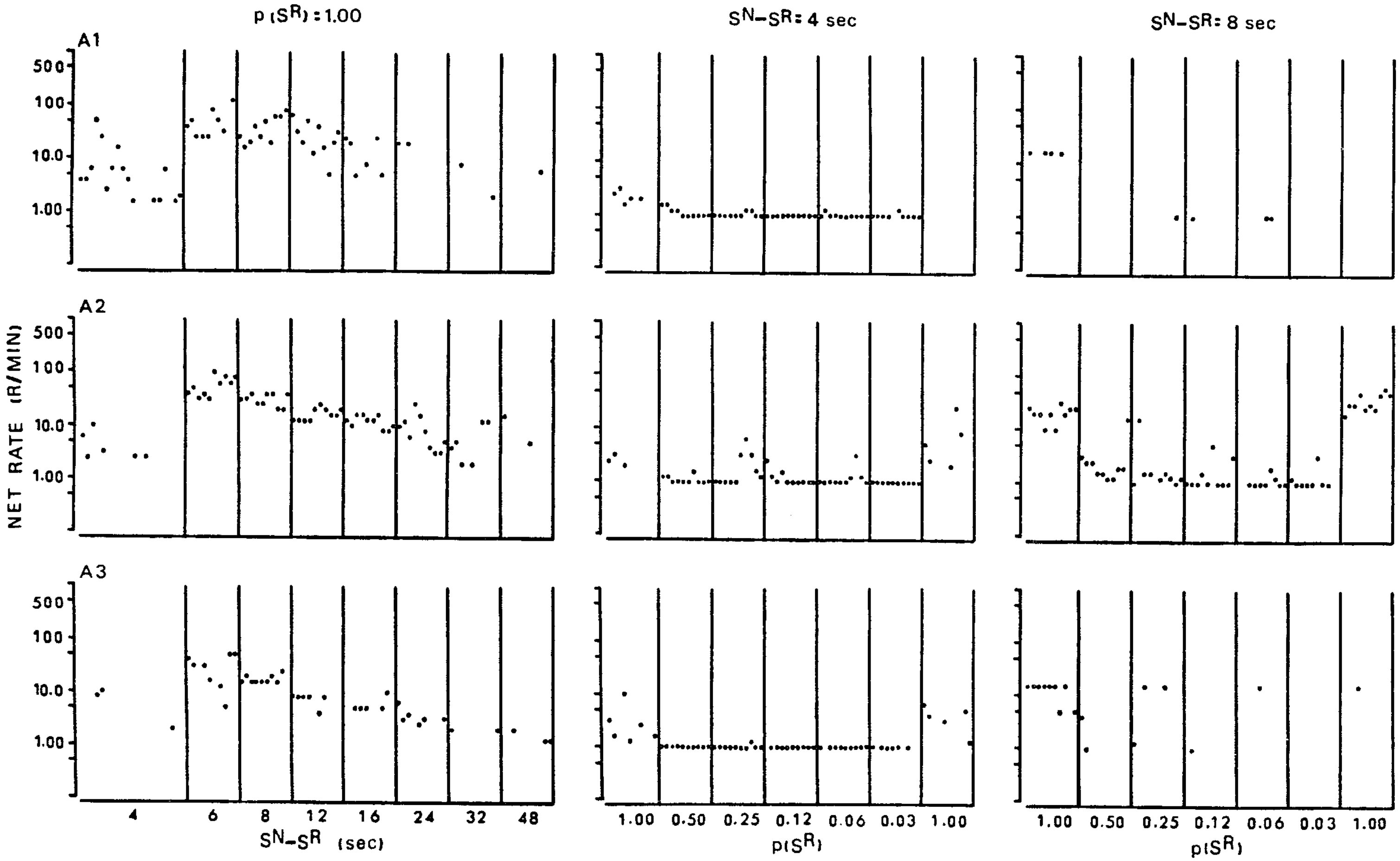
◓ indicates group A (T=64 sec)
◑ indicates group B (T=32 sec)
◒ indicates group C (T=16 sec)

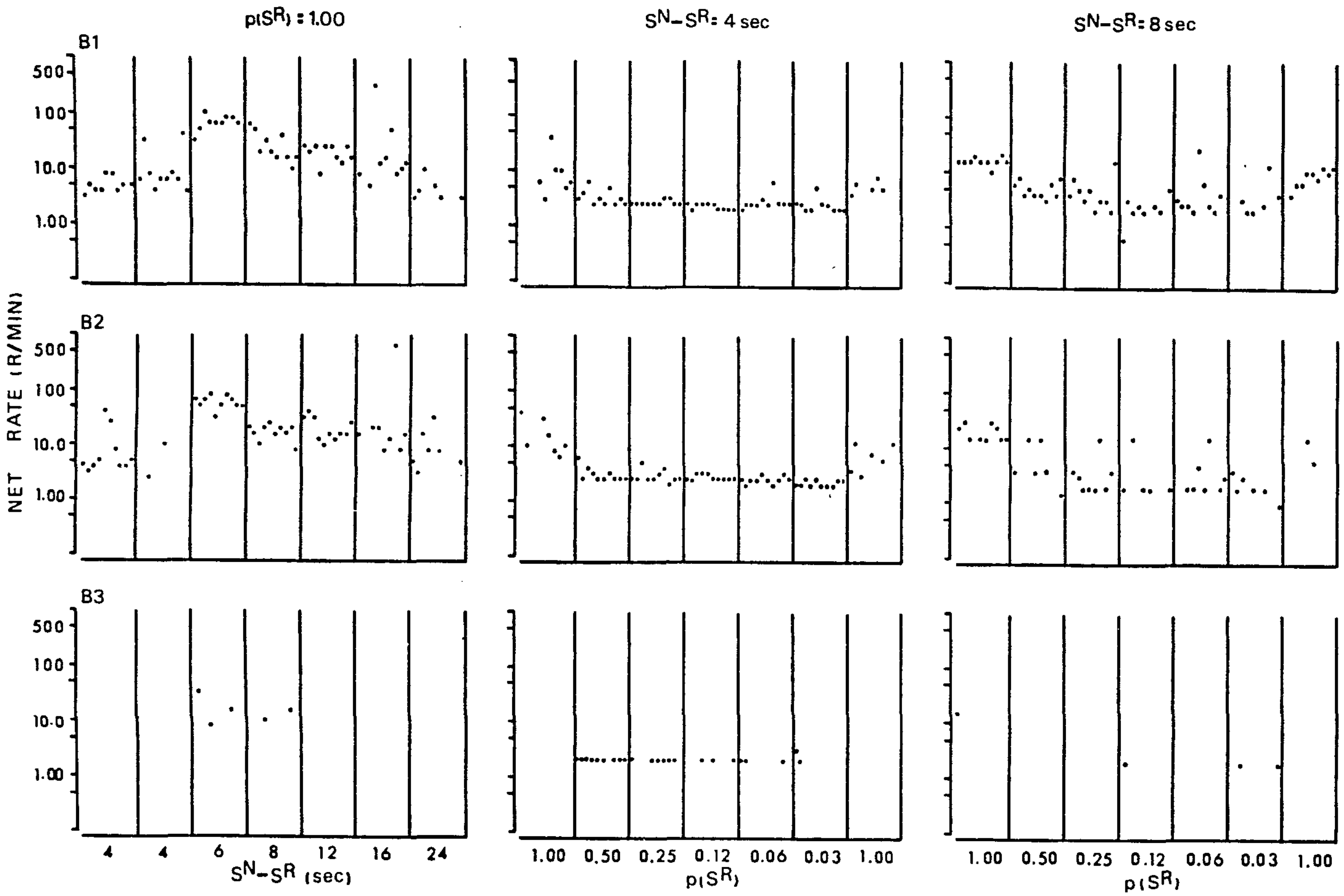

NET RATE R/MIN
50
40
30
20
10
0
64 64
64 32
T
64 16
T=64 sec
GROUP A
4
8
16
24
32
48
T=32 sec
GROUP B
4
8
16
24
S^N-S^R (sec)
T=16 sec
GROUP C
1.00
0.50
p (S^R)
0.25
0.12
0.03
4
8

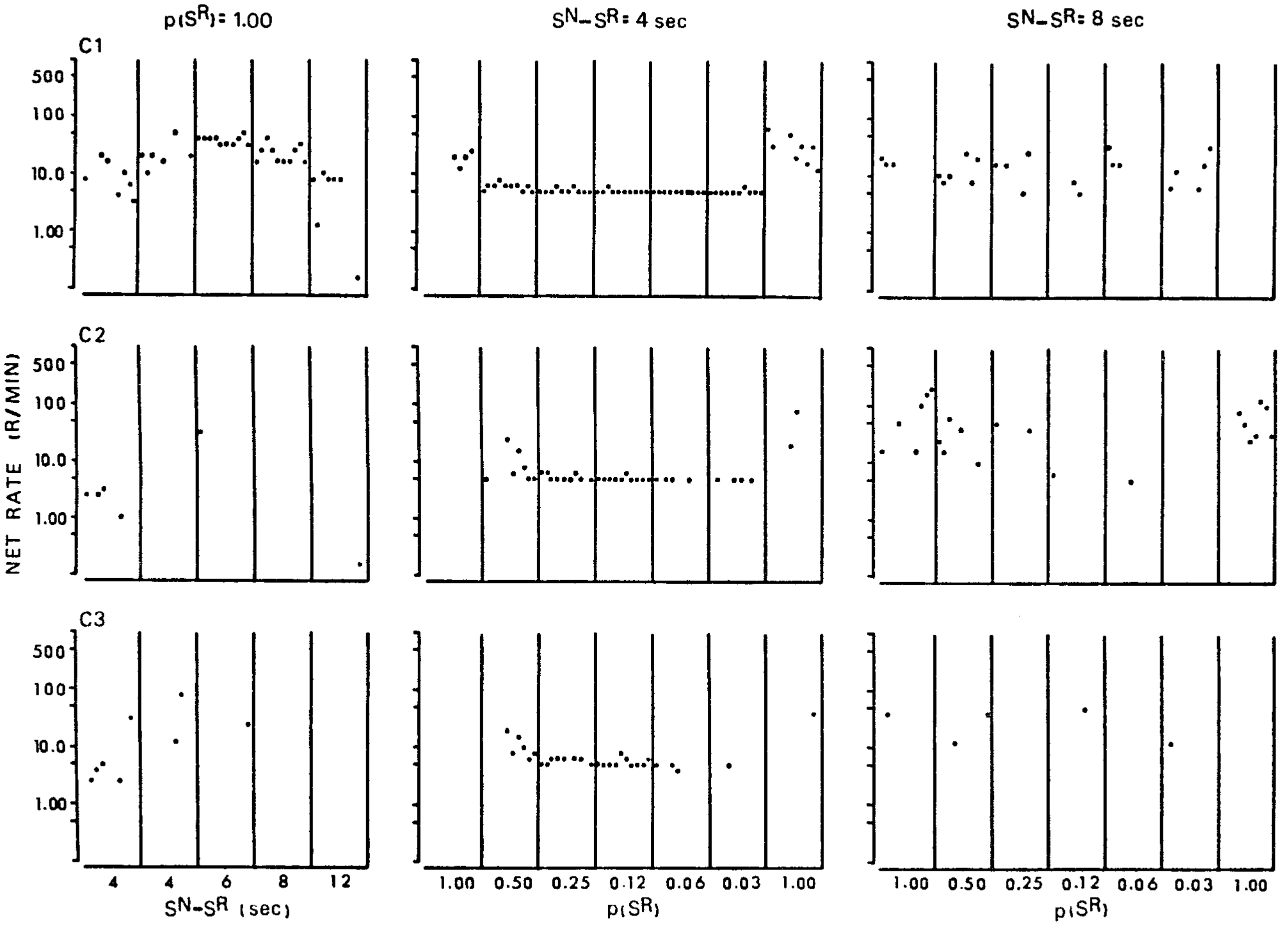

$p(S^R) = 1.00$
$S^N - S^R = 4$ sec
$S^N - S^R = 8$ sec
NET RATE R/MIN
0
10
20
30
40
50
60
70
85
4
6
8
12
16
24
32
48
$S^N - S^R$ (sec)
0.03
0.12
0.25
0.50
1.00
$p(S^R)$
0
0.03
0.12
0.25
0.50
1.00
$p(S^R)$

Figures 47 to 49.- <u>Daily net rates</u>

Daily net rates (see text for details on the calculation of this dependent variable) are shown on a logarithmic ordinate. Sessions without responding have not been plotted in these figures. As in the preceding figures, the first panel shows the effect of the matching procedure while the successive panels separate blocks of ten consecutive sessions, when the value of a given variable was in effect.


p(S^R):1.00
S^N–S^R: 4 sec
S^N–S^R: 8 sec
A1
A2
A3
NET RATE (R/MIN)
500
100
10.0
1.00
4
6
8
12
16
24
32
48
S^N–S^R (sec)
1.00
0.50
0.25
0.12
0.06
0.03
1.00
p(S^R)


p(S^R) = 1.00
S^N–S^R: 4 sec
S^N–S^R: 8 sec
B1
B2
B3
NET RATE (R/MIN)
500
100
10.0
1.00
4
4
6
8
12
16
24
S^N–S^R (sec)
1.00 0.50 0.25 0.12 0.06 0.03 1.00
p(S^R)


p(S^R)= 1.00
S^N–S^R= 4 sec
S^N–S^R= 8 sec
C1
C2
C3
NET RATE (R/MIN)
500
100
10.0
1.00
4
4
6
8
12
S^N–S^R (sec)
1.00
0.50
0.25
0.12
0.06
0.03
1.00
p(S^R)

increments in the value of the S^N-S^R interval caused monotonic decrements in net rate. In group C, net rate was a monotonically decreasing function of lengthening the S^N-S^R interval. The absolute value of net rate was a direct function of the group parameter, T. Group A gave the highest net rates and group C, the lowest. Group B was intermediate between groups A and C.

Decreasing $p(S^R)$ with S^N-S^R fixed at 4 and 8 sec caused monotonic decrements in net rate in all groups. The net rates were higher, in all groups, when $p(S^R)$ was decreased under S^N-S^R=8 sec than when S^N-S^R was 4 sec. When $p(S^R)$ was manipulated, the group parameter was inversely related to the absolute value of this dependent variable. Contrary to its effect when S^N-S^R was lengthened, net rates under both $p(S^R)$ series were higher in group C than in group A, group B being intermediate between A and C.

II. Dependent variables relevant to "A/A" studies.

9. The number of S^N's containing at least one response (R>0).

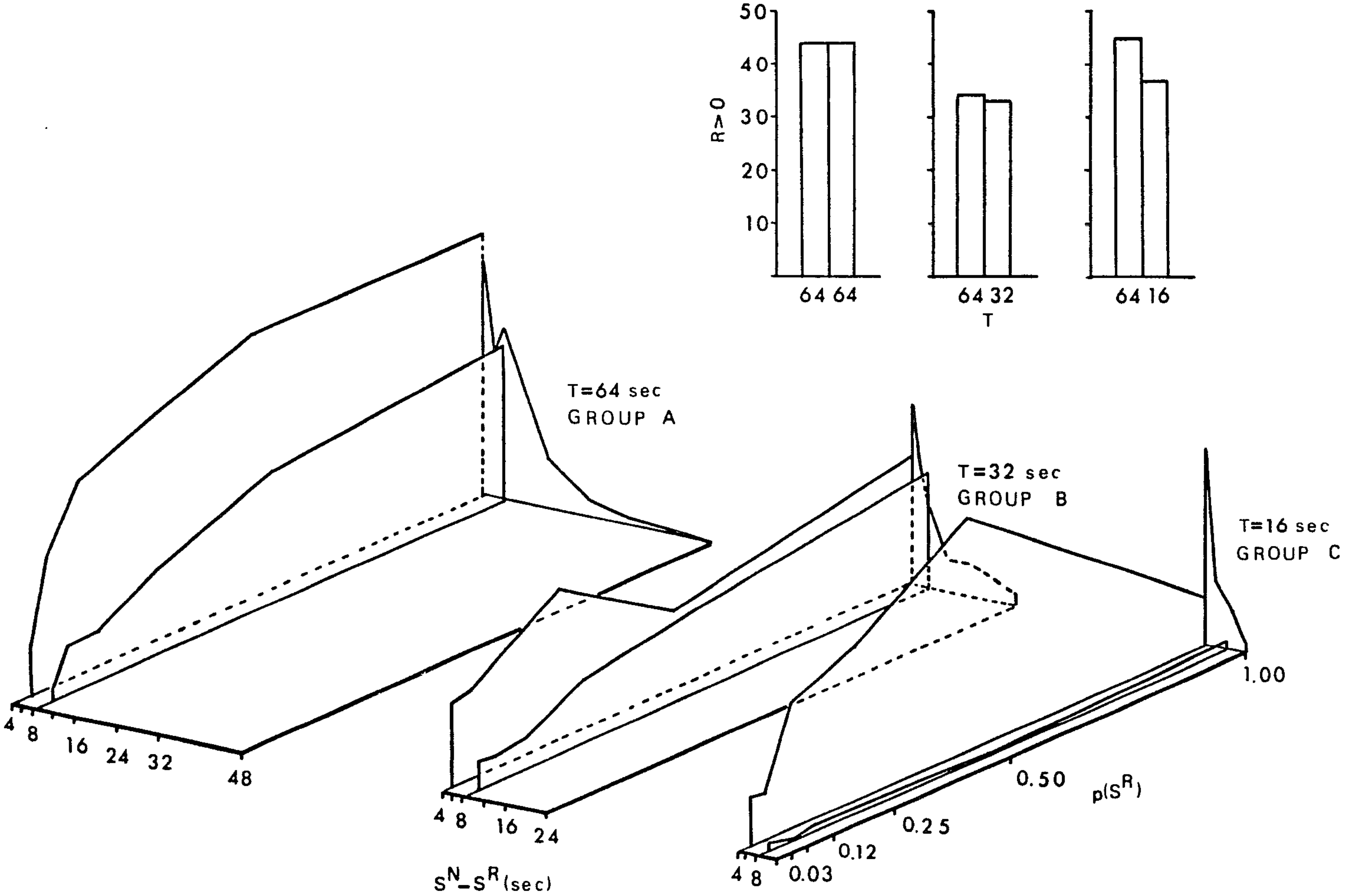
Figures 50 to 54 show the number of S^N's, per session, that contained at least one response. Figures 50 and 51 show group functions while figures 52 to 54 show individual data. Given that responding during S^N has not been analyzed in previous "intruded stimulus" research in terms of R>0, latency and running rate, the

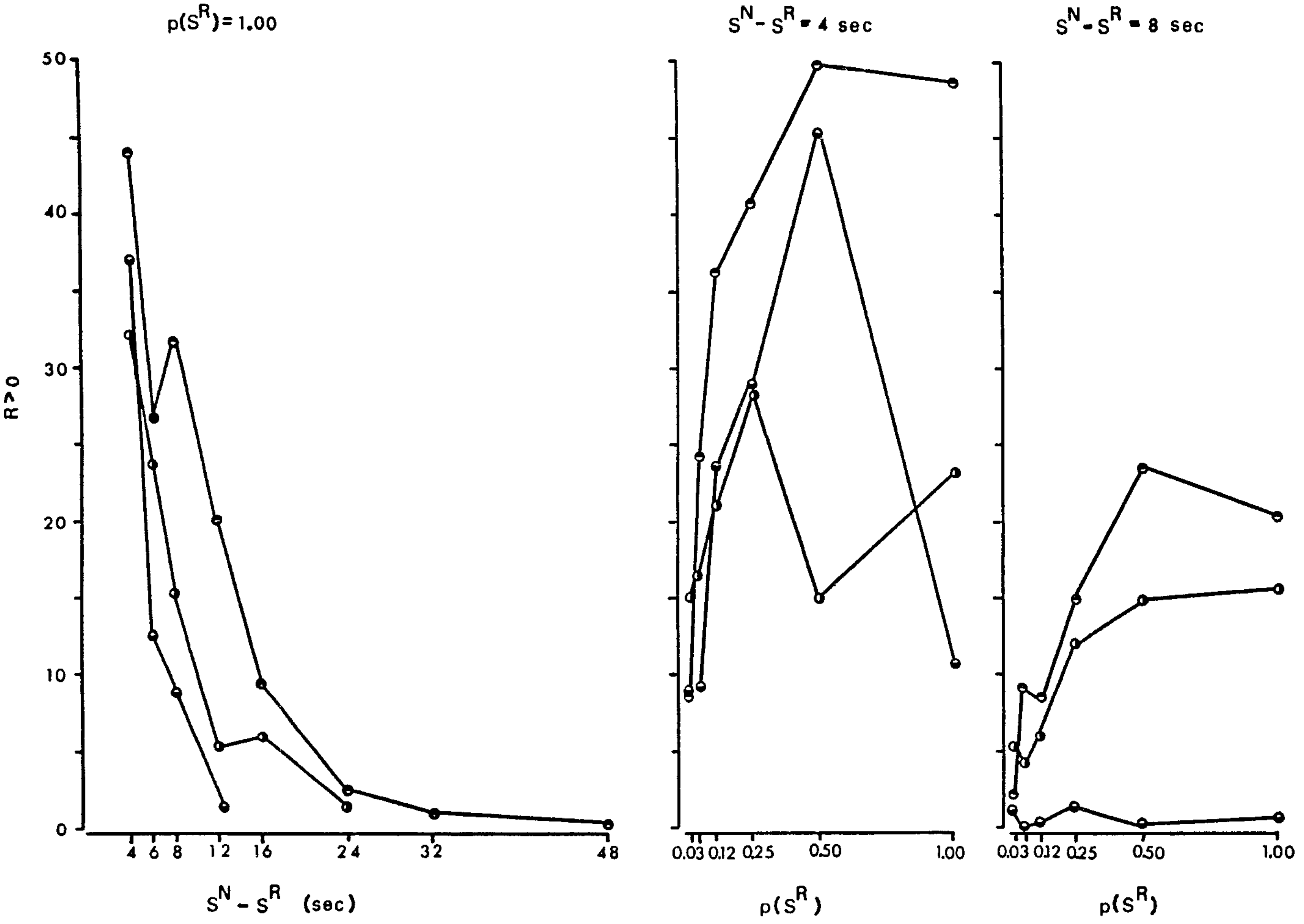
Figures 50 and 51.- Averaged $R>0$ during S^N (group data)

Figures 50 and 51 show $R>0$ during S^N for all experimental conditions. The data are the averages of the three subjects in each group over the last five sessions of each procedure. Figure 50 shows $R>0$ as a function of S^N-S^R and $p(S^R)$. The bargraph on the right corner of the figure shows this dependent variable as T was held constant at 64 sec and the effect of changing the values of T from 64 sec to 32 and 16 sec. The ordinate scale of the three dimensional plot is the same as in the bargraph. Each surface of the figure shows the performance of a different group of subjects for which the group parameter T was held constant. The points of intersection between $p(S^R)$ and S^N-S^R functions are the averages of two redeterminations at $p(S^R)=1.00$.

Figure 51 shows the same data plotted on two dimensional coordinates. The meaning of the symbols is as follows:

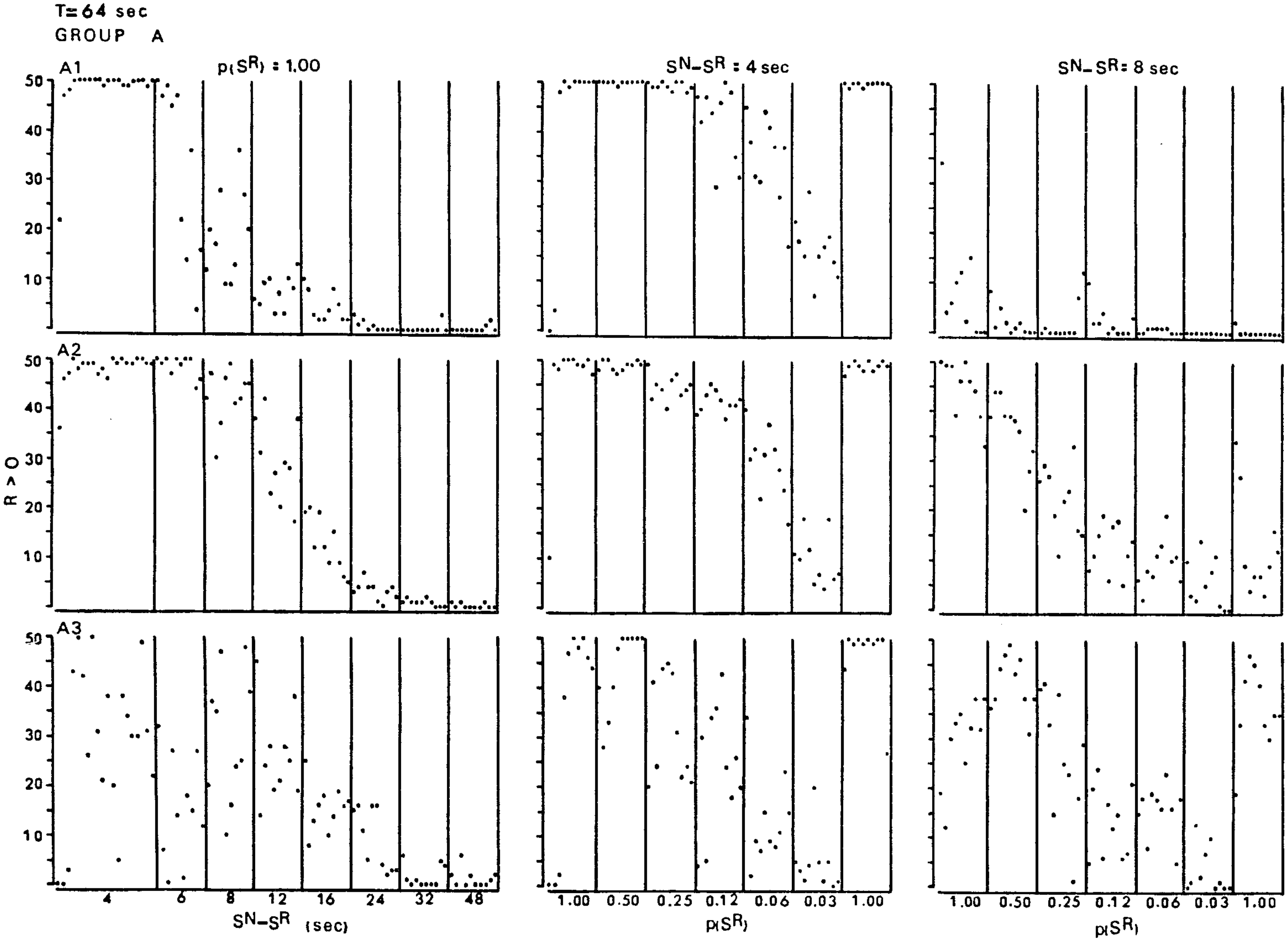
◓ indicates group A (T=64 sec)
◑ indicates group B (T=32 sec)
◒ indicates group C (T=16 sec)

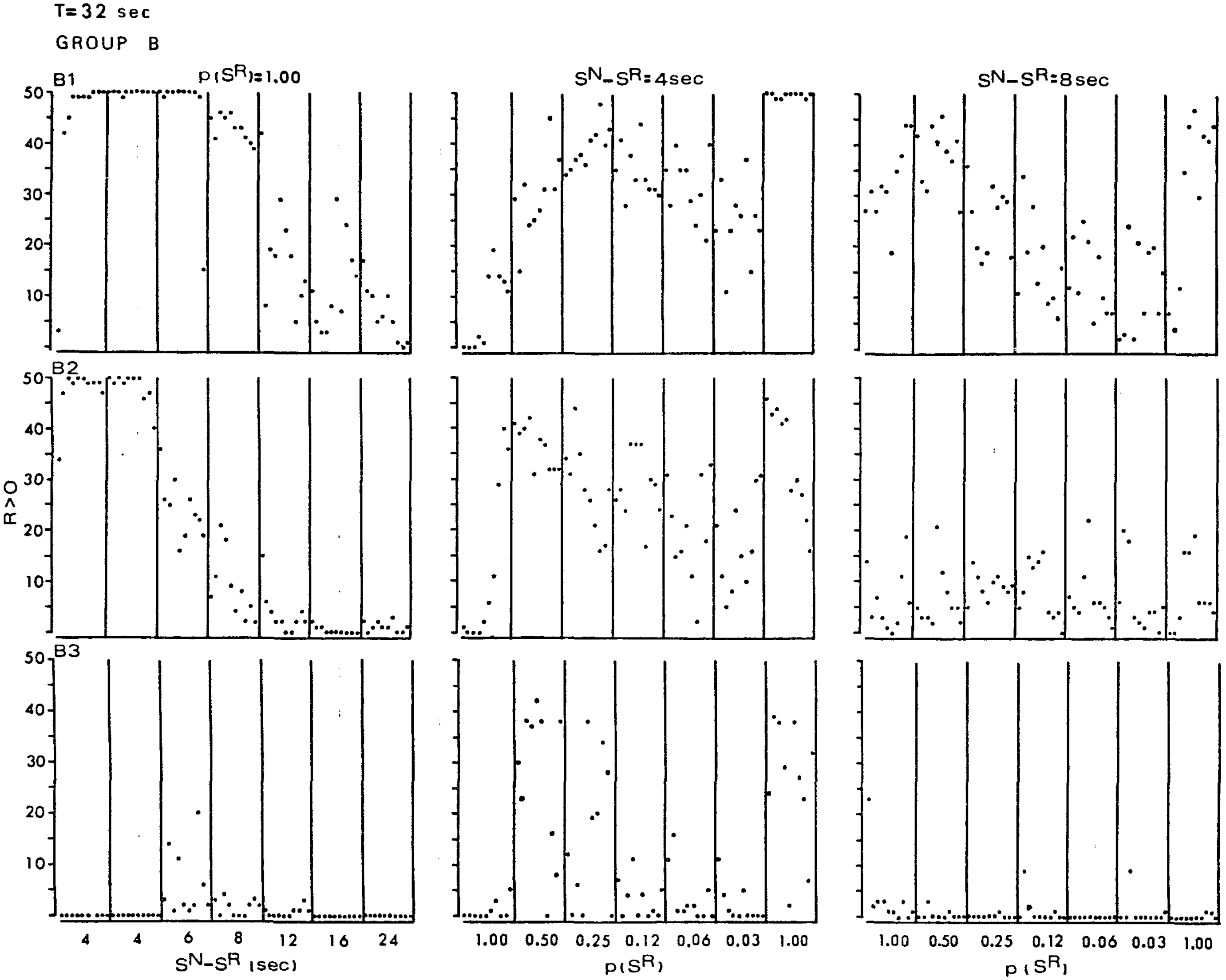

50
40
30
20
10
R>0
64 64
64 32
T
64 16
T=64 sec
GROUP A
T=32 sec
GROUP B
T=16 sec
GROUP C
4
8
16
24
32
48
4
8
16
24
S^N-S^R (sec)
4
8
0.03
0.12
0.25
0.50
1.00
$p(S^R)$

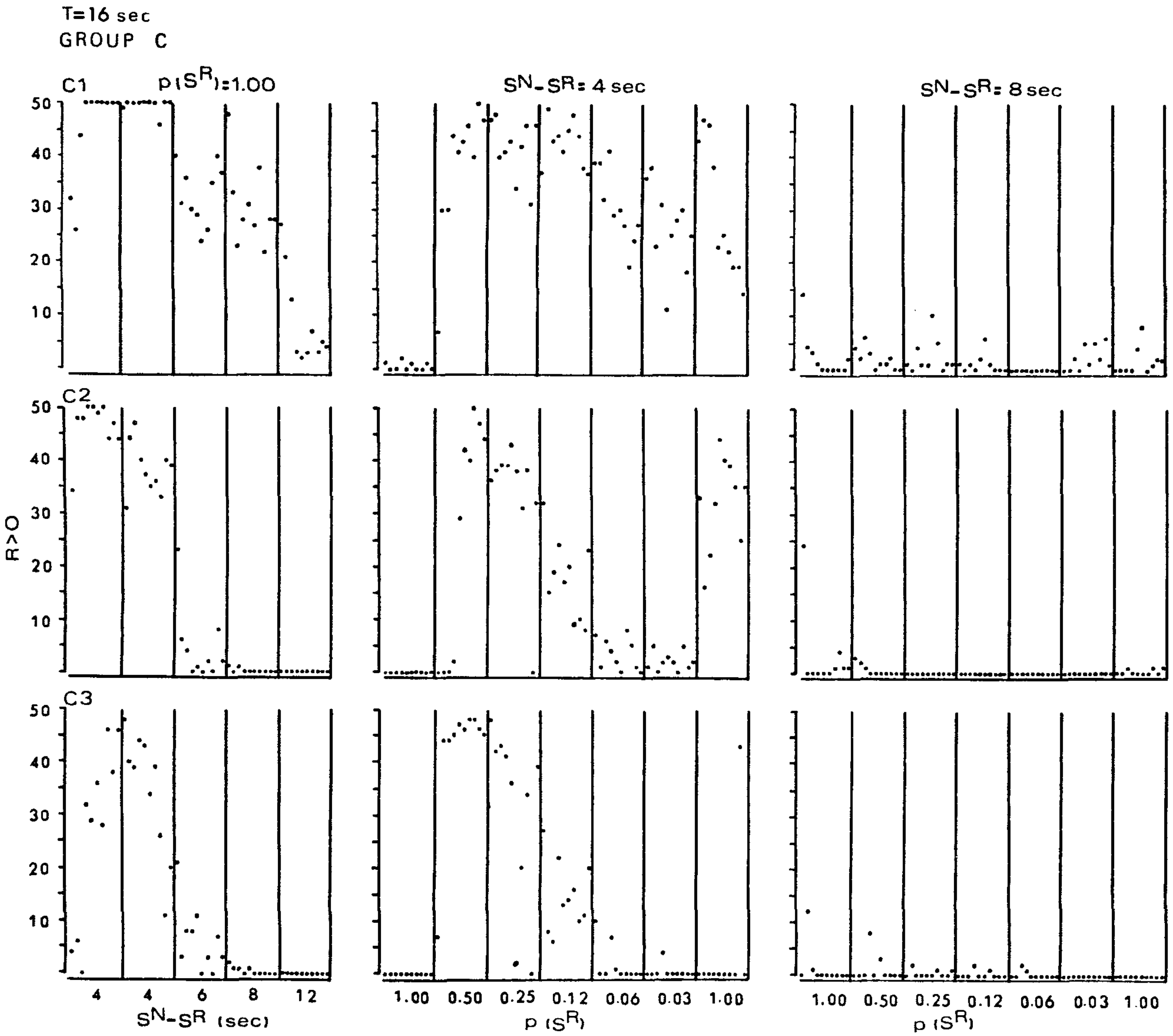

p(S^R)= 1.00
S^N - S^R = 4 sec
S^N - S^R = 8 sec
R>0
50
40
30
20
10
0
4
6
8
12
16
24
32
48
S^N - S^R (sec)
0.03
0.12
0.25
0.50
1.00
p(S^R)
0.03
0.12
0.25
0.50
1.00
p(S^R)

Figures 52 to 54.- <u>Daily R>0 during S^N (individual data)</u>

These figures show the total number of S^N periods, per sessions, that contained at least one key peck (R>0). The performance of the three individual subjects within each group is shown on a daily basis throughout the entire study. The first panel in each figure shows the effect of the matching procedure while the successive panels separate blocks of ten consecutive sessions, when the value of a given variable was in effect.


T=64 sec
GROUP A
A1
A2
A3
p(SR) : 1.00
SN-SR : 4 sec
SN-SR: 8 sec
50
40
30
20
10
R > O
4
6
8
12
16
24
32
48
SN-SR (sec)
1.00
0.50
0.25
0.12
0.06
0.03
1.00
p(SR)


T=32 sec
GROUP B
B1
p(S^R)=1.00
S^N-S^R=4sec
S^N-S^R=8sec
B2
B3
R>O
50
40
30
20
10
4
4
6
8
12
16
24
S^N-S^R (sec)
1.00
0.50
0.25
0.12
0.06
0.03
1.00
p(S^R)
1.00
0.50
0.25
0.12
0.06
0.03
1.00
p(S^R)


T=16 sec
GROUP C
C1
p(S^R)=1.00
S^N-S^R= 4 sec
S^N-S^R= 8 sec
C2
C3
R>O
50
40
30
20
10
4
4
6
8
12
S^N-S^R (sec)
1.00
0.50
0.25
0.12
0.06
0.03
1.00
p (S^R)
1.00
0.50
0.25
0.12
0.06
0.03
1.00
p (S^R)

description of these dependent variables will be based on the individual daily data.

As can be seen, there is very good agreement between the individual and group functions. For all subjects, $R>0$ was a monotonically decreasing function of lengthening the S^N-S^R interval.

When $p(S^R)$ was decreased at $S^N-S^R=4$ sec, $R>0$ decreased monotonically for all subjects in group A. For the subjects in groups B and C, $R\ 0$ increased rapidly when $p(S^R)$ was decreased from 1.00 to .50 and then .25. It decreased steadily with further decrements of that variable.

When $p(S^R)$ was decreased at $S^N-S^R=8$ sec, responding became infrequent in group C. However, it still remained substantial in groups A and B. For those subjects where responding remained frequent, $R>0$ was a monotonically decreasing function of $p(S^R)$.

The effect of cycle length was very prominent on this dependent variable. Longer values of T were associated with more responding during S^N. One clear difference among the groups was that animals with shorter values of T stopped responding earlier, i.e., at the same values where animals with longer T's continued responding. Longer values of T were also associated with greater intra- and inter-subject consistency and with the ease with which the initial values of $R>0$ were recovered after a given phase of the research.

10. The latency of the first response in S^N.

Figures 55 and 56 show the latency of the first response in S^N in terms of the median for each group. Figures 57 to 59 show the average daily latency of the first response after S^N onset. Sessions with no responding have not bee plotted in these figures. As indicated before, the following description will be based on the individual data.

During the manipulation of the S^N-S^R interval, two subjects in each groups A and B and one subject in group C showed monotonically increasing functions with that variable. In the remaining subjects, no trend appeared.

For S^N-S^R=4 sec, latency was a monotonically increasing function of the $p(S^R)$ varialbe in all subjects.

When $p(S^R)$ was manipulated at S^N-S^R=8 sec, latency was again an increasing function of $p(S^R)$ but only in three of the responding subjects. In other cases it appeared as a flat (e.g., A3) or even a decreasing function of the variable (e.g., B2).

Group C seemed to have shorter latencies than groups A and B during the manipulation of the S^N-S^R interval; but, if any, this difference was small. No such difference was observed during either $p(S^R)$ series.

11. The running rate during S^N.

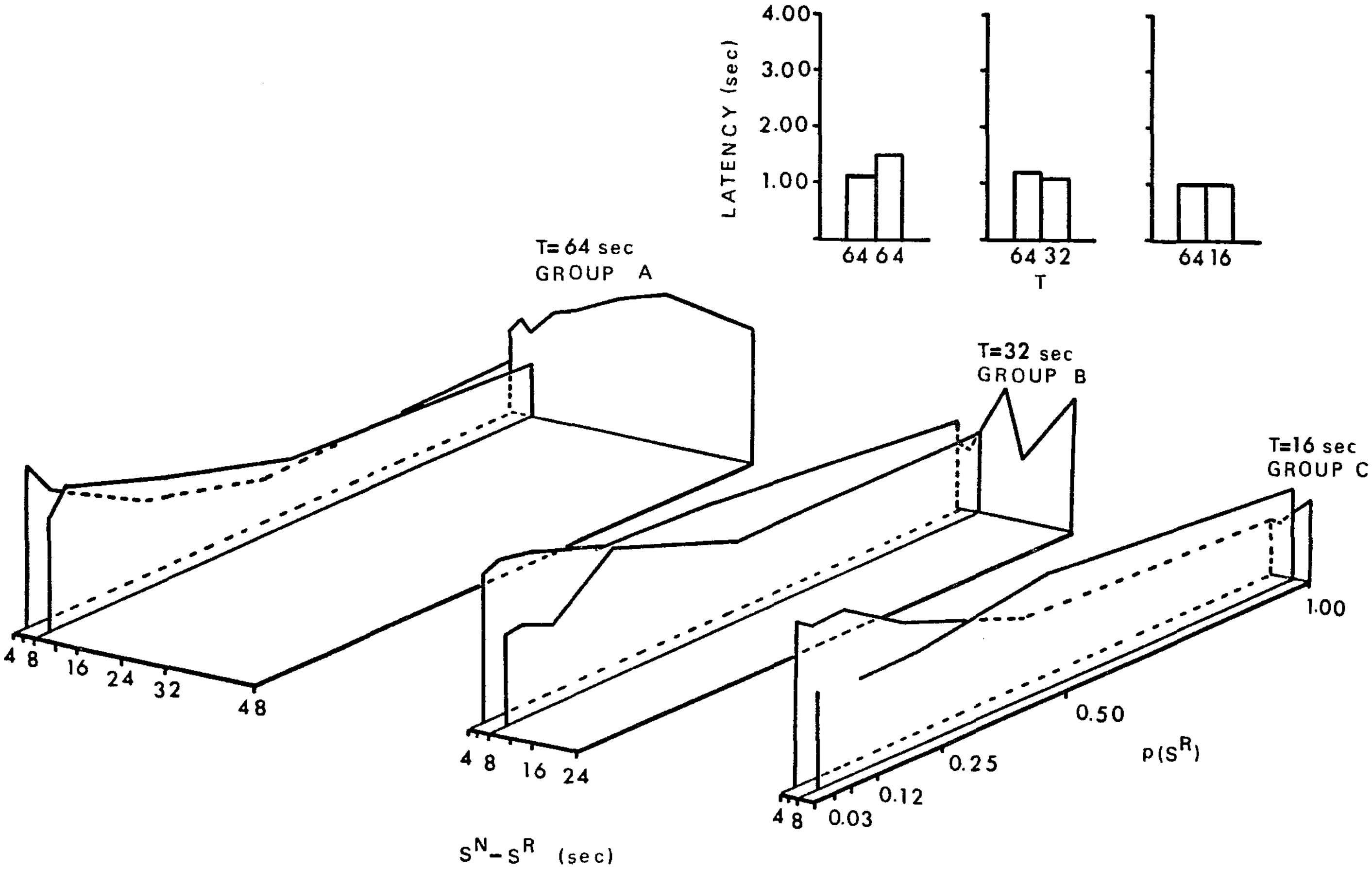
Figures 60 and 61 show the median running rate

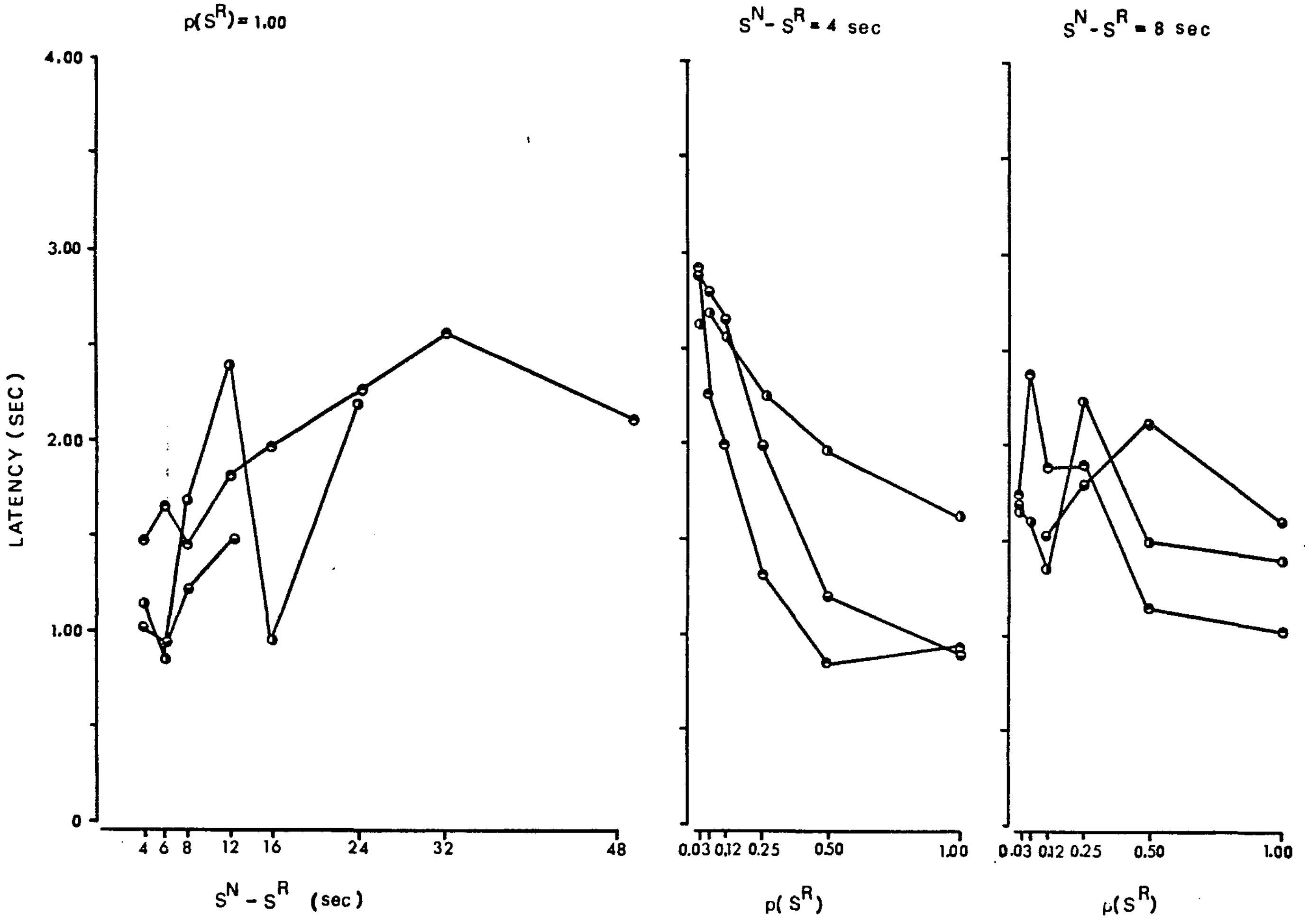
Figures 55 and 56.- Median latency in S^N (group data)

Figures 55 and 56 show the latency of the first response in S^N in terms of the medians for each group. The data are based on the last five sessions at any given value of a variable. Figure 55 shows median latency as a function of S^N-S^R and $p(S^R)$. The bargraph on the right corner of the figure shows this dependent variable as T was held constant at 64 sec and the effect of changing the values of T from 64 sec to 32 and 16 sec. The ordinate scale of the three dimensional plot is the same as in the bargraph. Each surface of the figure shows the performance of a different group of subjects for which the group parameter T was held constant. The points of intersection between $p(S^R)$ and S^N-S^R functions are the averages of two redeterminations at $p(S^R)$=1.00.

Figure 56 shows the same data plotted on two dimensional coordinates. The meaning of the symbols is as follows:

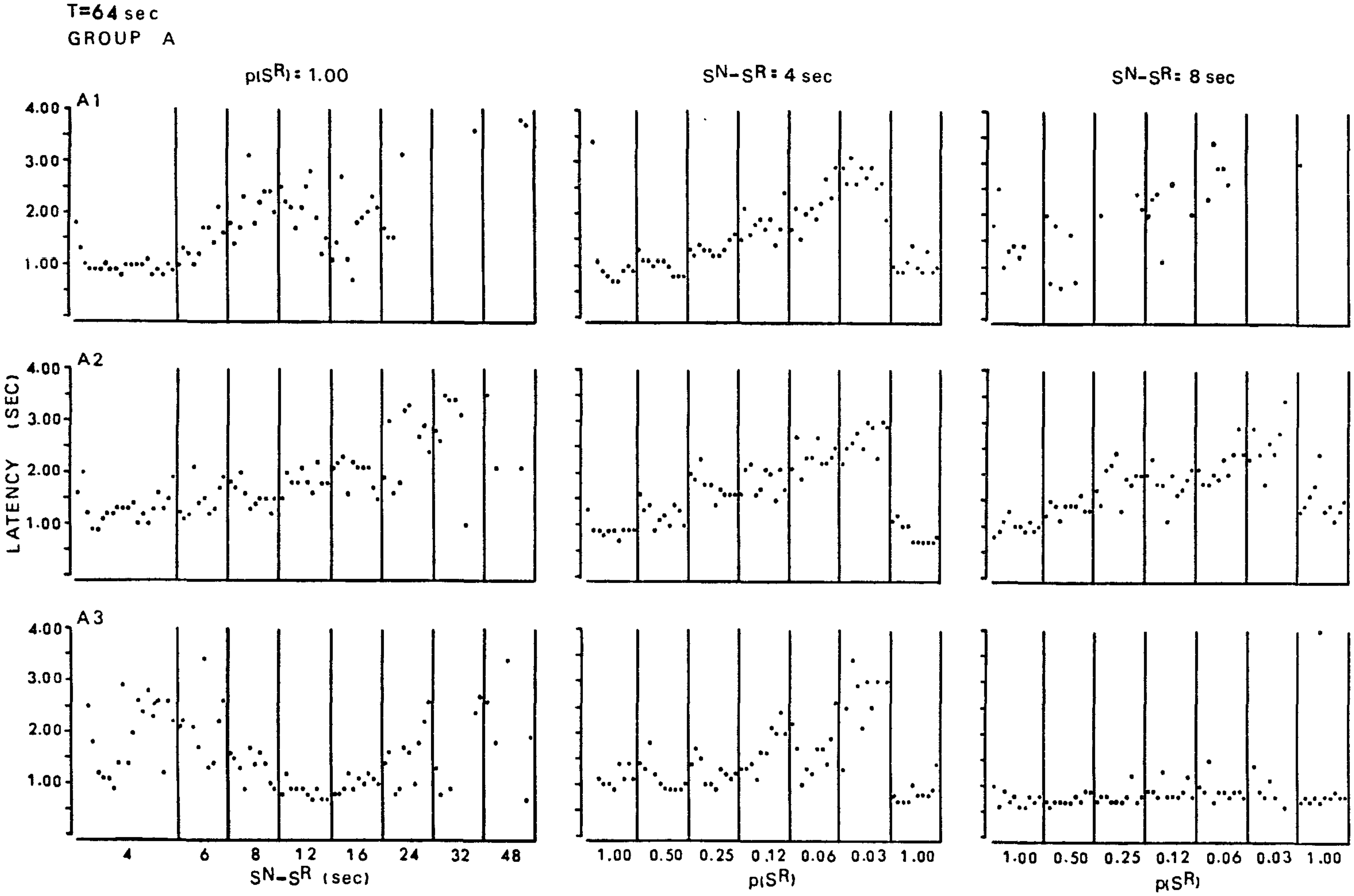
◓ indicates group A (T=64 sec)
◑ indicates group B (T=32 sec)
◒ indicates group C (T=16 sec)

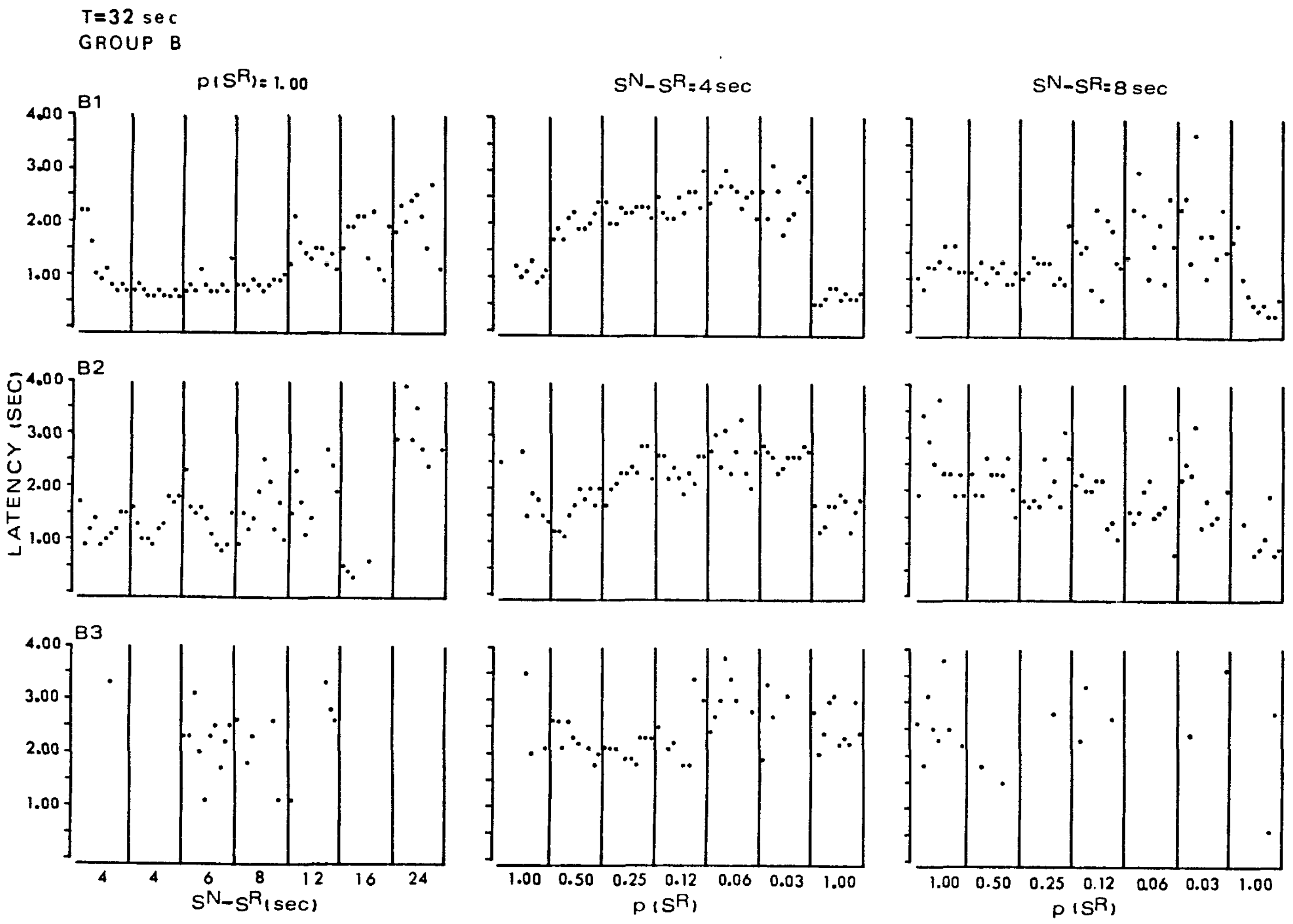

4.00
3.00
2.00
1.00
LATENCY (sec)
64 64
64 32
T
64 16
T= 64 sec
GROUP A
T=32 sec
GROUP B
T=16 sec
GROUP C
4 8 16 24 32 48
4 8 16 24
4 8 0.03 0.12 0.25 0.50 1.00
p(S^R)
S^N–S^R (sec)

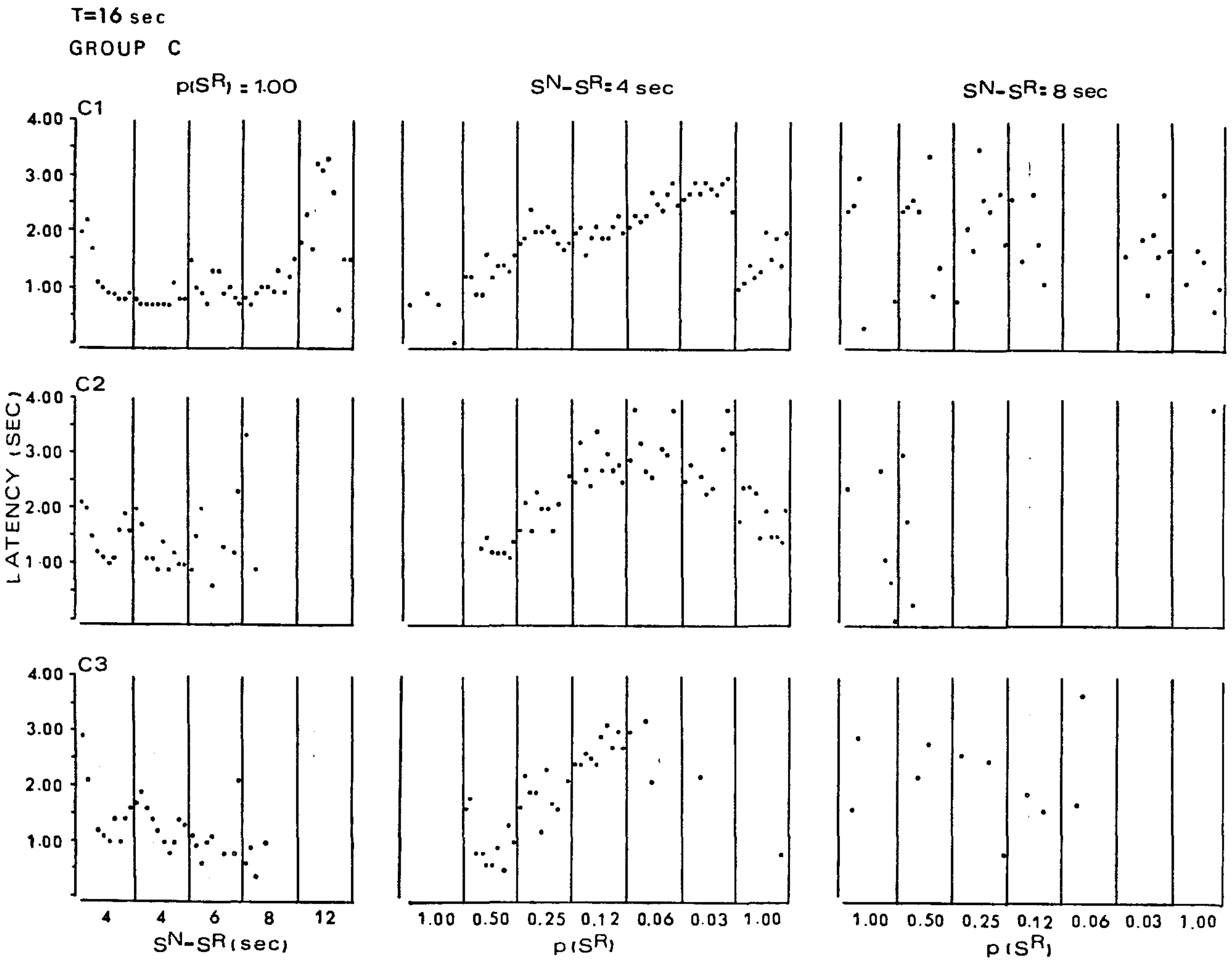

$p(S^R) = 1.00$
$S^N - S^R = 4$ sec
$S^N - S^R = 8$ sec
LATENCY (SEC)
0
1.00
2.00
3.00
4.00
4
6
8
12
16
24
32
48
$S^N - S^R$ (sec)
0.03
0.12
0.25
0.50
1.00
$p(S^R)$
0.03
0.12
0.25
0.50
1.00
$p(S^R)$

Figures 57 to 59.- Daily latency in S^N (individual data)

The latency of the first response after S^N onset is shown as a daily average. The first panel in these figures shows the effect of the matching procedure while the successive panels separate blocks of ten consecutive sessions. Sessions without responding have been left blank in the figures.


T=64 sec
GROUP A
p(S^R): 1.00
S^N-S^R: 4 sec
S^N-S^R: 8 sec
A1
A2
A3
LATENCY (SEC)
4.00
3.00
2.00
1.00
4
6
8
12
16
24
32
48
S^N-S^R (sec)
1.00 0.50 0.25 0.12 0.06 0.03 1.00
p(S^R)
1.00 0.50 0.25 0.12 0.06 0.03 1.00
p(S^R)


T=32 sec
GROUP B
p(S^R)=1.00
S^N-S^R=4 sec
S^N-S^R=8 sec
B1
B2
B3
LATENCY (SEC)
4.00
3.00
2.00
1.00
4
4
6
8
12
16
24
S^N-S^R(sec)
1.00
0.50
0.25
0.12
0.06
0.03
1.00
p(S^R)

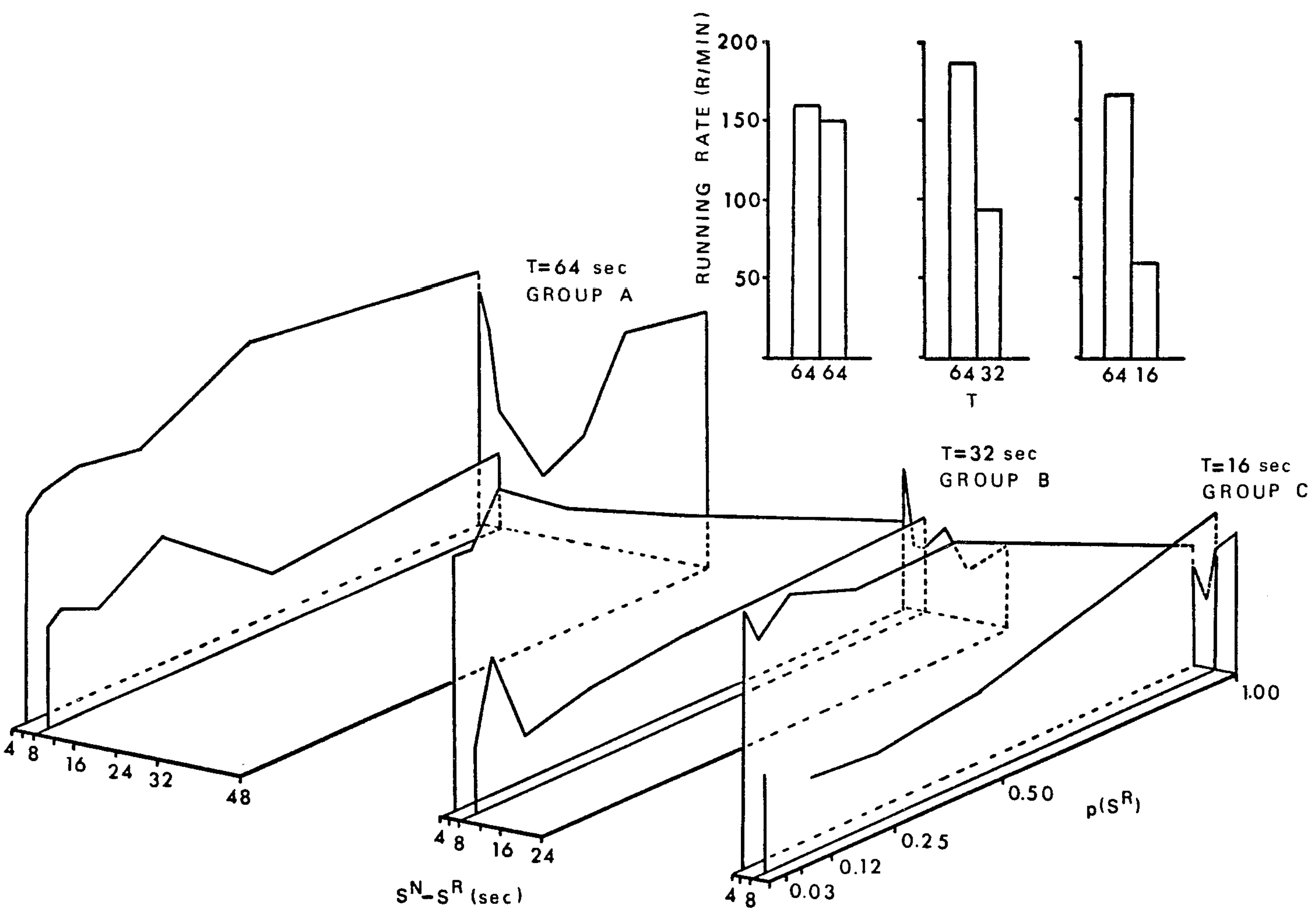

T=16 sec
GROUP C
p(S^R) = 1.00
S^N-S^R: 4 sec
S^N-S^R: 8 sec
C1
C2
C3
LATENCY (SEC)
4.00
3.00
2.00
1.00
4
4
6
8
12
S^N-S^R (sec)
1.00 0.50 0.25 0.12 0.06 0.03 1.00
p(S^R)
1.00 0.50 0.25 0.12 0.06 0.03 1.00
p(S^R)

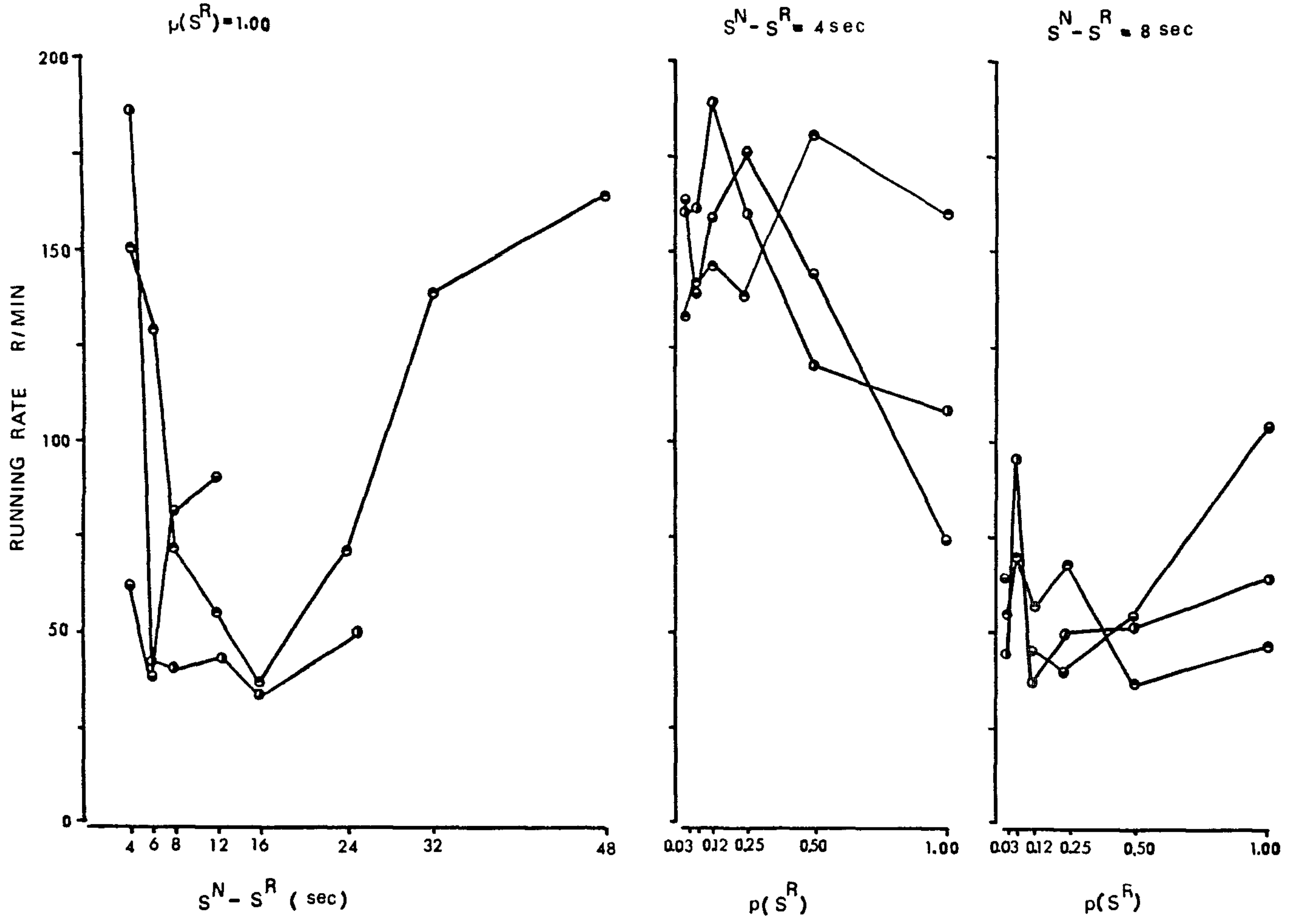
Figures 60 and 61.- Median running rates during S^N (group data)

Figures 60 and 61 show the group running rates during S^N for all experimental conditions. The data are the medians of each group of subjects calculated over the last five sessions of each procedure. Figure 60 shows median running rates in S^N as a function of S^N-S^R and $p(S^R)$. The bargraph on the right corner of the figure shows this dependent variable as T was held constant at 64 sec and the effect of changing the values of T from 64 sec to 32 and 16 sec. The ordinate scale of the three dimensional plot is the same as in the bargraph. Each surface of the figure shows the performance of a different group of subjects for which the group parameter T was held constant. The points of intersection between $p(S^R)$ and S^N-S^R functions are the averages of two redeterminations at $p(S^R)=1.00$.

Figure 61 shows the same data plotted on two dimensional coordinates. The meaning of the symbols is as follows:

◓ indicates group A (T=64 sec)
◑ indicates group B (T=32 sec)
◒ indicates group C (T=16 sec)

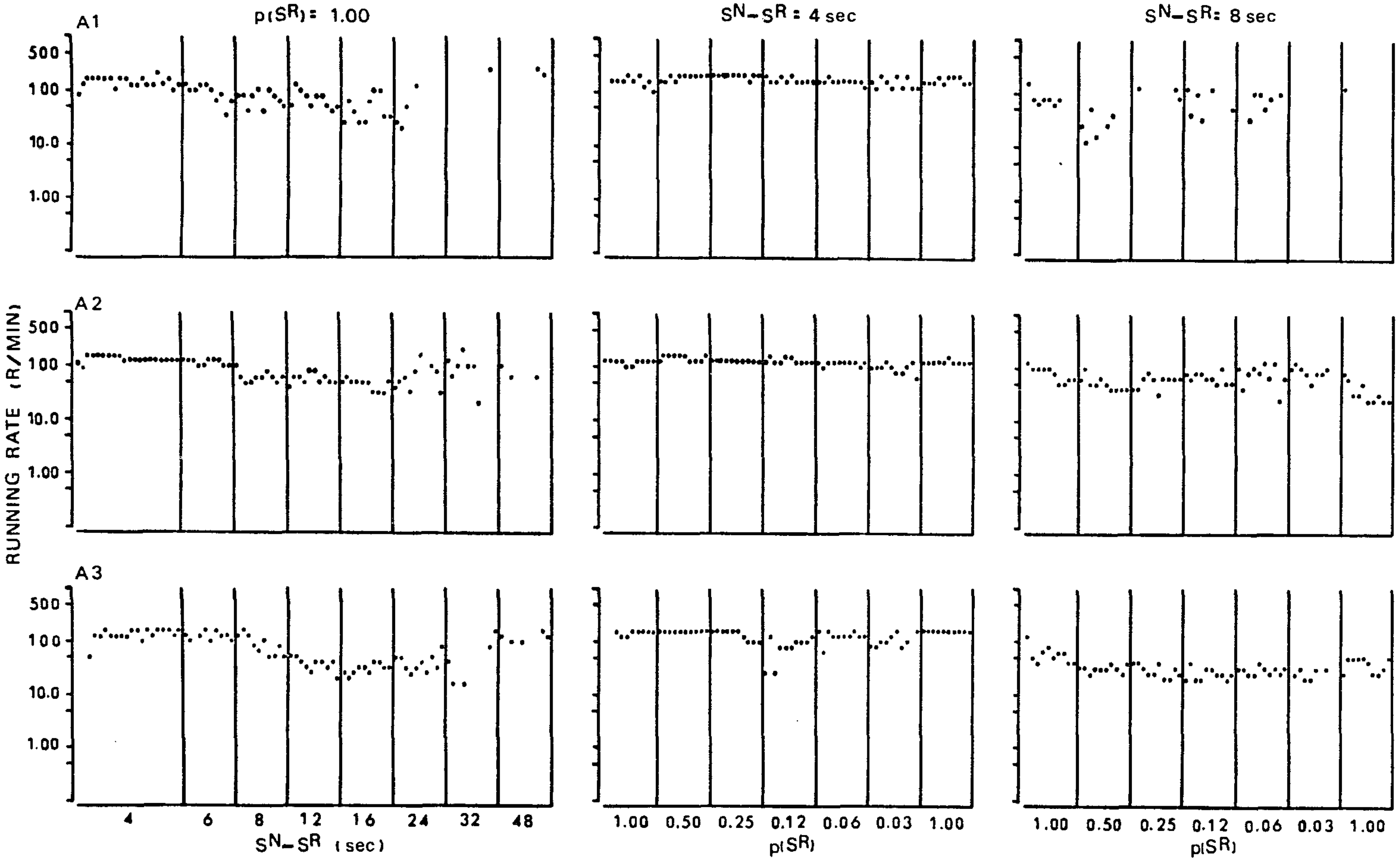

RUNNING RATE (R/MIN)
200
150
100
50
64 64
64 32
64 16
T
T=64 sec
GROUP A
T=32 sec
GROUP B
T=16 sec
GROUP C
4
8
16
24
32
48
4
8
16
24
$S^N - S^R$ (sec)
4
8
0.03
0.12
0.25
0.50
1.00
$p(S^R)$

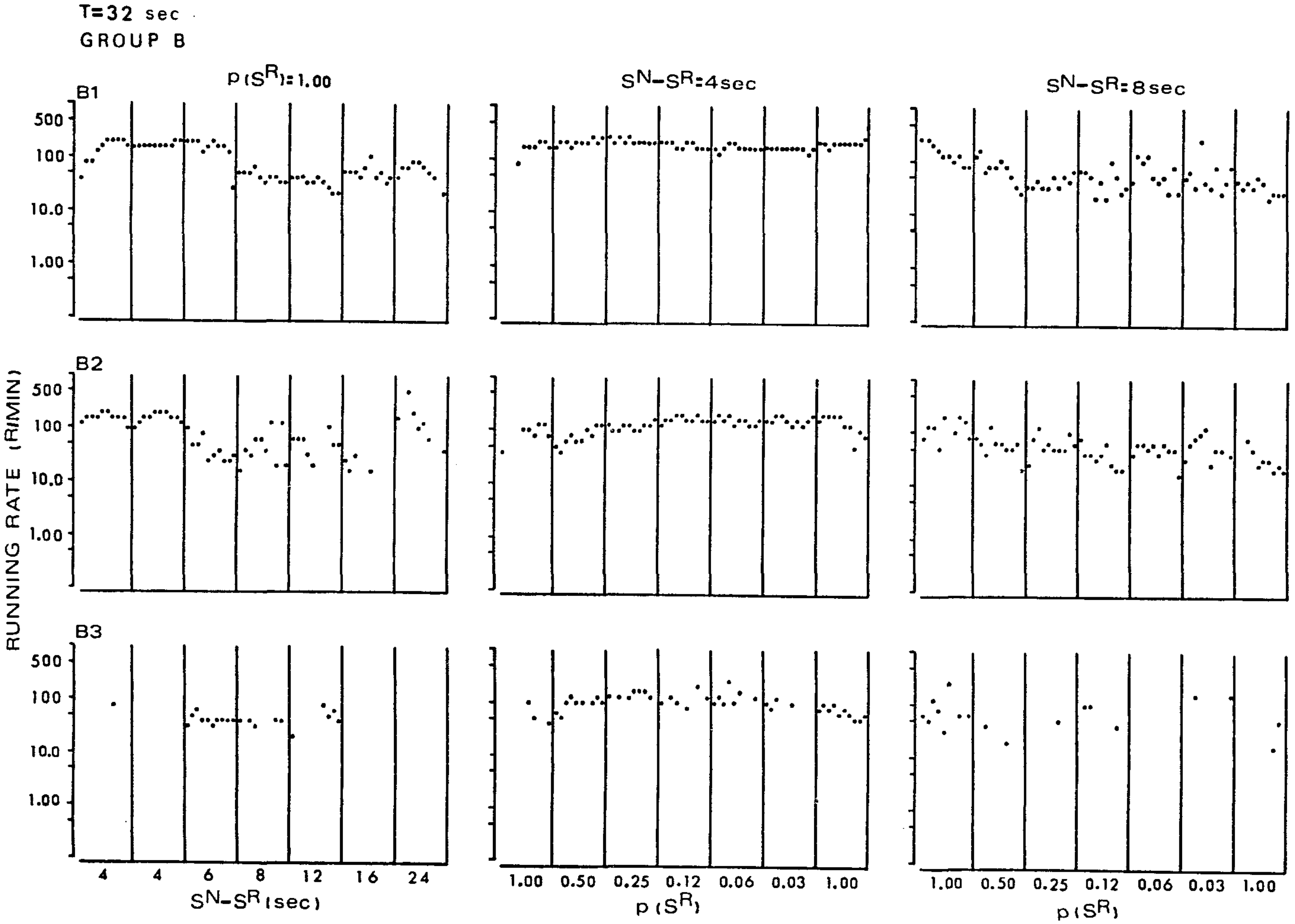

$\mu(S^R)=1.00$
$S^N-S^R=4$ sec
$S^N-S^R=8$ sec
RUNNING RATE R/MIN
0
50
100
150
200
4
6
8
12
16
24
32
48
S^N-S^R (sec)
0.03
0.12
0.25
0.50
1.00
$p(S^R)$
0.03
0.12
0.25
0.50
1.00
$p(S^R)$

Figures 62 to 64.- <u>Daily running rates during S^N</u>

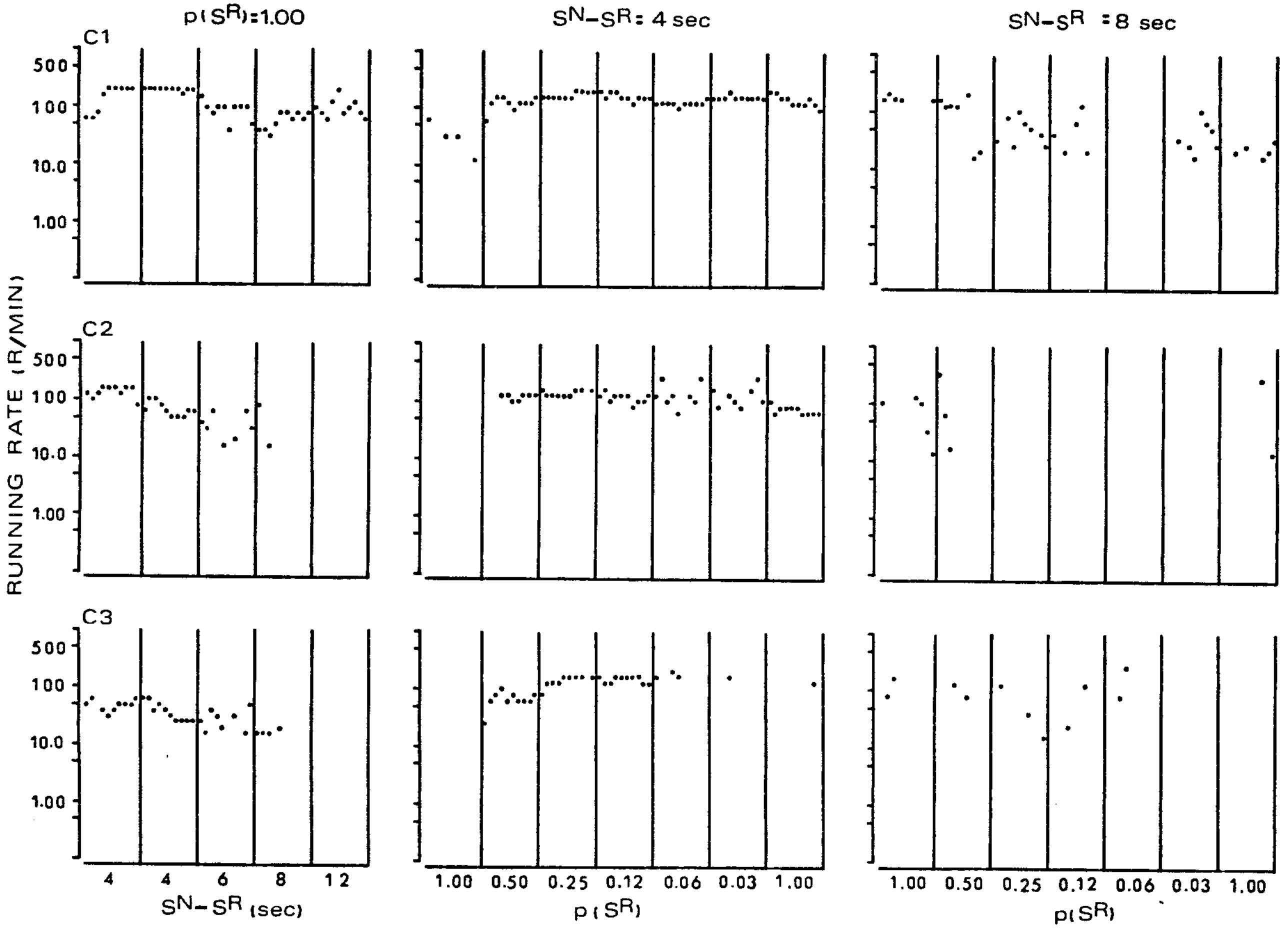
Daily running rates during S^N are shown on a logarithmic ordinate. Sessions without responding have not been plotted in these figures. As in the preceding figures, the first panel shows the effect of the matching procedure while the successive panels separate blocks of ten consecutive sessions, when the value of a given variable was in effect.

T=64 sec
GROUP A




T=32 sec
GROUP B
p(S^R)=1.00
S^N-S^R:4sec
S^N-S^R:8sec
B1
B2
B3
RUNNING RATE (R/MIN)
500
100
10.0
1.00
4
4
6
8
12
16
24
S^N-S^R (sec)
1.00 0.50 0.25 0.12 0.06 0.03 1.00
p(S^R)
1.00 0.50 0.25 0.12 0.06 0.03 1.00
p(S^R)

T=16 sec
GROUP C



in S^N for each group of subjects. Figures 62 to 64 show daily running rates. Running rate in S^N was the least consistent of the four dependent variables recorded during S^N. As far as the group data are concerned, this dependent variable showed no uniform trend as a function of increasing the S^N-S^R interval or decreasing $p(S^R)$. The absolute value of running rate, however, seemed to be directly related to T during the matching procedure and during the manipulation of S^N-S^R. When $p(S^R)$ was decreased, the absolute value of running rate was about the same in the three groups.

Plotting the individual daily data against a logarithmic ordinate revealed some consistent trends in running rate as a function of S^N-S^R and $p(S^R)$.

In most cases, running rate during S^N was a decreasing function of lengthening S^N-S^R . One interesting observation was that this dependent variable tended to increase when responding became infrequent as a consequence of long S^N-S^R values. If these infrequent but high data points are included in the functions, running rate appears to be U functions of lengthening S^N-S^R.

Running rate was a flat function of $p(S^R)$ at S^N-S^R=4 sec. When $p(S^R)$ was decreased with S^N-S^R fixed at 8 sec, this measure was a monotonically decreasing function of $p(S^R)$ (i.e., in those animals where responding still persisted during this phase).

12. Rate, R>0, latency, and running rate during S^N as a function of S^N-S^R values representing fractions of T ($p(S^R)=1.00$).

The series of S^N-S^R intervals studied in the present research included values representing 1/4, 1/2, and 3/4 of the T cycle for each group. The four dependent variables recorded during S^N can therefore be plotted as a function of these fractional S^N-S^R values. Figure 65 shows group rates, R>0, latency, and running rate during S^N as a function of these selected S^N-S^R intervals.

When rate in S^N and R>0 are plotted against these S^N-S^R values, group C had the highest rates and R>0, followed by group B which in turn had higher rates and higher levels of R>0 than group A.

Latency of the first response in S^N was generally longest in group A and shortest in group C, group B being intermediate between groups A and C.

As far as running rate is concerned, group A showed the highest running rates, followed by group C and finally group B, which had the lowest levels of this dependent variable.

When rate and R>0 during S^N are plotted as a function of S^N-S^R values representing 1/4, 1/2, and 3/4 of the value of T for each group, cycle length appears to be inversely related to the absolute level of these dependent variables. This is opposite to its effect when the same dependent variables were plotted as a function of the

Figure 65.- <u>Rate, R>0, latency, and running rate during S^N as a function of S^N-S^R values representing fractions of T ($p(S^R)=1.00$)</u>

Figure 65 shows the four dependent variables observed during S^N as a function of S^N-S^R intervals representing 1/4, 1/2, and 3/4 of the value of T for each group. One additional data point, 1/8, is included in each figure. The data are averages and medians of these measures based on the last five sessions at a given value of a variable.

The S^N-S^R values being compared are the following:

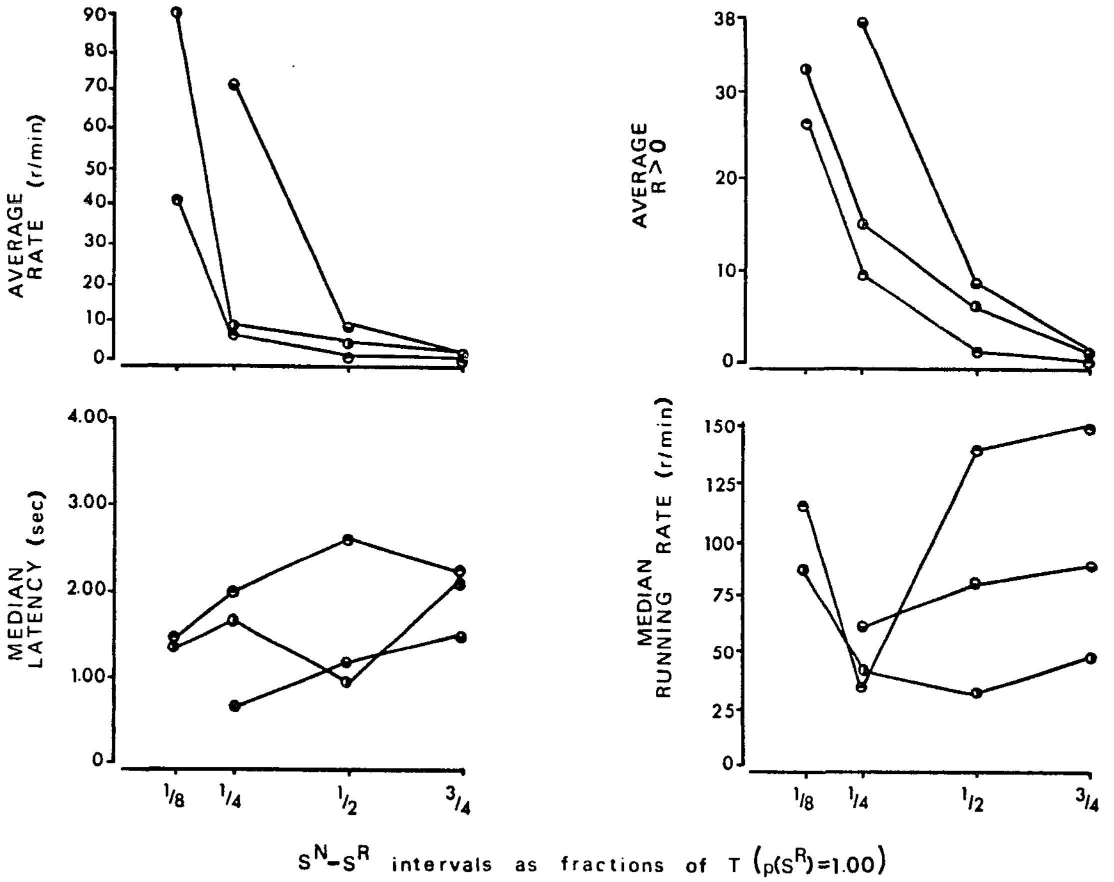
1/8 = S^N-S^R=4 sec; T=32 sec (group B)
S^N-S^R=8 sec; T=64 sec (group A)
1/4 = S^N-S^R=4 sec; T=16 sec (group C)
S^N-S^R=8 sec; T=32 sec (group B)
S^N-S^R=16 sec; T=64 sec (group A)
1/2 = S^N-S^R=8 sec; T=16 sec (group C)
S^N-S^R=16 sec; T=32 sec (group B)
S^N-S^R=32 sec; T=64 sec (group A)
3/4 = S^N-S^R=12 sec; T=16 sec (group C)
S^N-S^R=24 sec; T=32 sec (group B)
S^N-S^R=48 sec; T=64 sec (group A)

The meaning of the symbols is as follows:

◓ indicates group A (T=64 sec)

◑ indicates group B (T=32 sec)

◒ indicates group C (T=16 sec)


AVERAGE RATE (r/min)
0
10
20
30
40
50
60
70
80
90
AVERAGE R>0
0
10
20
30
38
MEDIAN LATENCY (sec)
0
1.00
2.00
3.00
4.00
MEDIAN RUNNING RATE (r/min)
0
25
50
75
100
125
150
1/8
1/4
1/2
3/4
1/8
1/4
1/2
3/4
S^N-S^R intervals as fractions of T ($_p(S^R)$=1.00)

entire range of S^N-S^R intervals.

The effect of T on latency and running rate in S^N was about the same whether plotted against fractional or absolute values of the S^N-S^R interval.

It can be concluded that at least as far as rate and $R>0$ are concerned, the absolute value of the S^N-S^R interval is a powerful determinant of the value of these dependent variables when the T cycle length is held constant. This is not to say that the relative S^N-S^R interval did not have an effect upon S^N responding. As indicated before in this section, the absolute value of rate and $R>0$ during S^N at most S^N-S^R intervals studied was a direct function of the group parameter.

DISCUSSION

The effect of S^N-S^R, $p(S^R)$ and their interactions are well known in operant experiments done in the tradition of the t-system. Alternatively, these variables have not been investigated systematically in "A/A" studies That being the case, the present research attempted to evaluate the generality of S^N-S^R and $p(S^R)$ in the "A/A" situation.

The results of this investigation will be discussed in terms of the experimental variables of the study.

S^N-S^R interval

There are no "A/A" studies where the S^N-S^R interval has been manipulated systematically. There is one report, by Newlin and Lolordo (1976), in which responding was compared in a "trace" and a "delay" procedure. The relevant findings from that study were that responding in the "delay" situation occurred at higher rates than in the "trace" procedure. Newlin and Lolordo also found that rates of responding during the "trace" period were even higher than rates during S^N.

In the present study, as in Newlin and Lolordo's, rate in S^N also decreased when S^N was temporally removed from S^R. Since the range of S^N-S^R intervals studied here was much wider (compared to the two values in the study by Newlin and Lolordo), the present research found that rate in S^N was a monotonically decreasing function of lengthening the S^N-S^R interval. It was also found that the absolute rates of responding during S^N were directly related to the values of the T cycle. In the present study, however, responding between S^N termination and S^R was infrequent in most subjects; when it did occur, however, it seemed to be associated with longer values of T.

The effects of lengthening the S^N-S^R interval have been investigated in a number of "intruded stimulus" experiments (e.g., Farmer and Schoenfeld, 1966 a and b; Evra, 1974). As indicated before, these studies employed a R-S^R contingency and showed that manipulation of the S^N-S^R interval caused complex, although consistent, changes in the pattern of responding within the T cycle. For example, one common finding in "intruded stimulus" research is that of "double scallops," i.e., two positive accelerations in rate before and after the S^N intrusion. The "double scallops" tend to occur when S^N is placed about halfway between the T_R cycle.

The response patterns observed during the manipulation of the S^N-S^R interval in this study differed in some respects from those reported by Farmer and Schoenfeld and Evra. The main difference was that in the present study, rates of responding during S^N were much higher, at most S^N-S^R values, than during the rest of the cycle. "Double scallops," such as those reported by Farmer and Schoenfeld and Evra, were observed only occasionally (e.g., A2, figure 2; C2, figure 10). By comparison, Newlin and Lolordo had shown that in a trace-"A/A" procedure, responding can occur during the "trace" period at rates even higher than those during S^N. This discrepancy is possibly due to the fact that Newlin and Lolordo exposed a different group of subjects to different values of the S^N-S^R interval. In the present study, the S^N-S^R interval was lengthened very gradually, using the same subjects. Newlin and Lolordo used a 30-sec "ITI," similar to one of the T values used here; therefore, cycle length was probably not responsible for the different outcome.

In spite of the fact that "double scallops" were not obtained in this research, there were a number of similarities between the present findings and the *t*-system studies mentioned previously. For example, when S^N was placed just before S^R delivery (i.e., S^N-S^R=4 sec), the rates during S^N were much higher than those following S^R. This was true for all pigeons. This "discriminative" function of S^N was not affected by the differences in cycle length among the three groups nor was it affected by decreasing values of $p(S^R)$. These findings are therefore consistent with those previously reported by Farmer and Schoenfeld and especially with those reported by Evra, who also manipulated T length and $p(S^R)$.

Another study that has systematically manipulated the S^N-S^R interval is that of Martin (1971). In comparison to Martin's data, the results of the present experiment differed in the form of the functions relating overall rate and net rate to S^N-S^R. In Martin's study, the overall rate during the T cycle, PS^RP and the net rate of responding were not systematically related to increments in S^N-S^R. In the present study, however, the overall rate was a monotonically decreasing function of lengthening S^N-S^R. The net rates were inverted U functions, with a maxima occurring at about S^N-S^R=6 sec for two of the groups (A and B). For group C, the same function was a monotonically decreasing one. The course of PS^RP is difficult to evaluate in the present research. This is due to the fact that only S^R's that were followed by a response prior to S^N onset were counted as "true" PS^RP's.

The reason for deliberately ignoring PS^RP's that exceeded the S^R-S^N interval is the following. In Martin's study, S^N-S^R were response-contingent. Because of this feature, a given PS^RP could not be interrupted by S^N since S^N was response-produced. The R-S^R and R-S^N contingencies permitted Martin to separate PS^RP's and PS^NP's and thus to attribute control over their respective lengths to the event (S^N or S^R) that immediately preceded each of these pauses. In the present research, S^N and S^R were both response-independent and could freely intrude into a PS^RP or PS^NP. Accordingly, it was necessary to select as PS^RP's and PS^NP's only those pauses that were not interrupted by S^N or S^R. Otherwise, it would have been impossible to attribute control, over the duration and number of these pauses, to the preceding experimental event. Given that the pigeons responded infrequently between S^R and the following S^N, only a few PS^RP's were recorded. Even so, in those few instances where the course of PS^RP is visible over most of the range of S^N-S^R intervals, PS^RP appears to be a trendless function of the independent variable. This is in agreement with the results of Martin.

Other than the differences mentioned above, most of the data of both studies seem to be quite similar. Using a single T value of 30 sec, Martin found that as the S^N-S^R interval was lengthened the number of responses made during S^N decreased monotonically. This is essentially the same finding of the present study for all values of T. Furthermore, in the present study it was also found that the decremental effect of S^N-S^R on the number of responses per S^N depended on the value of T. In general, the longer the value of T, the less severe was the effect of S^N-S^R.

In Martin's research, as in the present one, the rate during S^N was a monotonically decreasing function of lengthening the S^N-S^R interval. In the present study, it was also found that the absolute rate of responding at any given S^N-S^R interval was a direct function of the value of T.

In the study by Martin, the value of PS^NP tended to increase as the S^N-S^R interval was lengthened. Although this effect was not a strong one in either study, in the present research the PS^NP's also became longer as the S^N-S^R interval was increased. In this investigation, the absolute value of PS^NP did not appear to covary with the group parameter. However, the tendency to respond after S^N termination appeared to be a direct function of the value of T.

<u>$p(S^R)$ at S^N-S^R=4 sec and S^N-S^R=8 sec</u>

Gonzalez (1974) and Perkins *et al.* (1975) studied the effect of decreasing the percentage of S^N's that were followed by the presentation of contiguous food in the "A/A" situation. In these studies, response rate during S^N increased as the S^R percentage was decreased from 100% to 50%-30%. Further reductions in S^R percentage produced orderly decrements in response rate. Gonzalez also found that R>0 and latency of the first response in S^N were decreasing and increasing functions, respectively, of the "percentage of S^R" variable. The running rate during S^N, also studied by Gonzalez, turned out not to vary systematically as a function of that same experimental variable.

The phase of the present study that most closely resembles that of Perkins *et al.* and of Gonzalez as well was the manipulation of $p(S^R)$ at S^N-S^R=4 sec. The results obtained in the present study were essentially the same as those mentioned above. Rate of responding and R>0 during S^N were decreasing functions of decreasing $p(S^R)$ for those subjects where responding in S^N was rapidly reinstated after studying the S^N-S^R interval. In those animals where responding in S^N was low at the beginning of the $p(S^R)$ series, the rates in S^N and $R>0$ were more like inverted U functions with a maxima at about $p(S^R)=.50$. The latency of the first response in S^N was, in all cases, an increasing function of decreasing $p(S^R)$ values. Running rates in the present research were a flat function of $p(S^R)$ for all subjects.

Decreasing $p(S^R)$ while S^N termination was non-contiguous with the probable occurrence of S^N is another variation of the "A/A" procedure for which there are no precedents in the literature. In this phase of the present study, responding persisted at substantial levels only for those groups with the longer values of T. In those cases where the pigeons pecked frequently during S^N, rate and $R>0$ were decreasing functions of $p(S^R)$ Running rate was a slowly decreasing function of the same variable. The course of the latency of the first peck during S^N was more difficult to evaluate due to the increased variability. Where a function is apparent, however, it seems to be an increasing one, as in the preceding $p(S^R)$ series.

The effects of decreasing $p(S^R)$ at different values of the S^N-S^R interval has been studied in "intruded stimulus" experiments by Martin (1971) and Evra (1974). The results of these experiments have shown that relative to the S^N-S^R interval, $p(S^R)$ is a weak variable in this type of experiment.

Evra, for example, showed that the response patterns controlled by the S^N-S^R variable were not different under $p(S^R)=1.00$ and .20. In the present study it also was found that the changes in response pattern produced by lengthening the S^N-S^R interval were not significantly affected by decreasing $p(S^R)$ at either S^N-$S^R=4$ or 8 sec.

In Martin's experiment none of his variables changed in an orderly fashion with decreasing values of $p(S^R)$. He found, however, that when $p(S^R)$ was decreased at different values of the S^N-S^R interval, responding during S^N was controlled almost exclusively by the latter variable. Under such circumstances, responding at all values of the $p(S^R)$ variable decreased as a function of lengthening the S^N-S^R interval.

In the present study, decreasing $p(S^R)$ at S^N-$S^R=4$ and 8 sec did cause steady decrements in the number of responses per S^N and consequently in rate during S^N. The overall rate and the net rates were also found to decrease and thus to be a function of $p(S^R)$. These results are only apparently at odds with those of Martin. It should be noted that the lowest <u>p</u> value studied by Martin was 0.10. Note that at the lowest possible value of $p(S^R)$, i.e., $p(S^R)=0$, there <u>must</u> be an effect. In the present study it was found, as in other "A/A" studies (e.g., Gonzalez, 1974), that the function relating rate in S^N

to $p(S^R)$ becomes noticeably steeper when $p(S^R)$ is reduced beyond .30-.20. This phenomenon was particularly evident in the present study when T=32, which is comparable to the value of T used by Martin. It seems possible that Martin failed to observe the same outcome because his $p(S^R)$ values were longer than those used in the present study. At any rate, the fact that the absolute value of the dependent variables common to both studies decreased in each $p(S^R)$ series as a function of lengthening the S^N-S^R parameter is in close agreement with Martin's findings. Both studies also established that within the range of S^N-S^R and $p(S^R)$ values common to both investigations, the effect of $p(S^R)$ was less dramatic than the effects of S^N-S^R.

T cycle length

In addition to documenting the interaction between S^N-S^R and $p(S^R)$, the present study also observed the interaction between T cycle length and S^N-S^R and $p(S^R)$.

The effect of different values of the "inter-trial interval" ("ITI") on responding during S^N has been studied systematically in at least two "A/A" investigations. The results of these studies are in agreement in that rate of responding (Perkins *et al.*, 1975; Terrace *et al.*, 1975) and R>0 (Terrace *et al.*, 1975) are a direct function of increasing values of "ITI." The results of the present study are consistent with these investigations. During the manipulation of S^N-S^R and $p(S^R)$, longer values of T were associated with higher rates of responding and higher levels of $R>0$ during S^N. This effect of T became quite prominent when $p(S^R)$ was reduced at S^N-S^R=8 sec. This set of values resulted in the virtual disappearance of responding for group C. Longer values of T also seemed to produce shallower slopes in the functions and to favor the recovery of the original rates at the redeterminations. Latency and running rate during S^N, however, were not clearly different across groups (i.e., for those cases where responding was substantial).

Cycle length is a variable that has not been systematically investigated in "intruded stimulus" experiments. Evra (1974), for example, found that for FI and RI schedules (that differed in their T values and $p(S^R)$'s as well) the S^N-S^R interval exerted its effects relative to T rather than as a function of its absolute value. There is also the research by Dews (1970), who has shown that the rate of responding during an S^N, "intruded" in any given segment of an FI schedule, is a direct function of the inter-S^R interval. The results of the present study are in agreement with those of Evra and Dews. In this research, lengthening the S^N-S^R interval produced a rapid diminution of responding throughout the entire T cycle but especially during S^N. Decreasing $p(S^R)$ with S^N-S^R=4 and 8 sec also produced decrements in responding. The decremental effects of these variables were, however, clearly diminished in the groups with the longer T's. While most subjects in group C had stopped responding altogether at a given value of S^N-S^R and $p(S^R)$, most subjects in group A continued responding at the same value of the independent variable. In view of these results, it might be concluded that S^N-S^R does not only appear to interact with T but that the effect of $p(S^R)$ also depends on the T parameter. The fact that the value of T influences the slope of the $p(S^R)$ function is particularly important for the reduction argument. It has been suggested (e.g., Rescorla and Solomon, 1967; Kimble, 1961) that the effect of $p(S^R)$ may be used to distinguish between "classical" and "operant" conditioning. In the first case, $p(S^R)$ seems to have severe decremental effects on responding. In "operant" conditioning experiments, however, $p(S^R)$ not only does not have such a decremental effect but frequently results in an increase in responding (e.g., Kimble, 1961). From the data of the present study, it can be seen that whether $p(S^R)$ will have a severe or a comparatively slight decremental effect depends on the value of the cycle length parameter.

Conclusions

The manipulations of the present study were ostensibly similar to those of "classical" conditioning experiments because throughout the entire study S^N and S^R

occurred independently of the subjects' behavior. If, however, an R-S^R or an R-S^N dependency had been instituted, the same procedures would have become identical to those of "operant" conditioning research. The ability to move from one paradigm to the other by simply instituting or by-passing the contingency requirement is predicated on the fact that the variables of the "intruded stimulus" paradigm are defined in temporal terms only.

In the present study a number of "A/A" procedures and results were replicated. This was done by the experimental adjustment of the variables of the "intruded stimulus" paradigm, to specific values, and by making S^R noncontingent. The data obtained in this research were in general agreement with the outcome of previous "A/A" research (e.g., Brown and Jenkins, 1968; Terrace *et al.*, 1975; Gonzalez, 1974).

The same "intruded stimulus" variables were then systematically manipulated to generate variants of the "A/A" procedure, the effects of which have not been previously reported in the literature. The effects of these same manipulations, however, are well known in "operant" experiments done in the tradition of the *t*-system.

In comparison with the data obtained in "intruded stimulus" experiments, the results of the present study are quite similar. The main difference between this study and the previous investigations was the relatively infrequent responding between successive S^N presentations. This difference, however, may be due to the specific sequence of manipulations employed in this study rather than to any intrinsically different effect of the same experimental variables in the "A/A" situation. The procedure of slowly separating S^N from S^R, for example, may be seen as similar to that of presenting a "discriminative" stimulus for not responding for increasingly longer periods of time. This is known to generate no "errors" in discriminative training (e.g., Terrace, 1966). This interpretation gets some support from the findings of Newlin and Lolordo, mentioned before. In that study it was shown that in a "trace-A/A" procedure the rates after S^N termination are even higher than the rates during S^N. In Newlin and Lolordo's research, however, the pigeons were exposed to the "trace" situation from the outset of the experiment. Finally, there is the study by Evra (1974) which also indicates that the differences observed here were not due to an intrinsically different effect of the same variables. In that study, the value of S^N-S^R, T and $p(S^R)$ were held constant. However, S^R delivery, initially R-dependent, was gradually made R-independent. When S^R was R-dependent, Evra replicated a number of typical behavior patterns described in other "intruded stimulus" experiments (e.g., the "double scallops" originally reported by Farmer and Schoenfeld). When S^R was made R-independent, several of the "A/A" experiments studied here were replicated. Nevertheless, the behavior sequences obtained with contingent

S^R remained largely unaffected.

Given that the "A/A" phenomenon can be considered to be an example of "classical" conditioning, it might then be said that S^N-S^R, $p(S^R)$ and T are variables that have similar effects in "classical" and "operant" conditioning.

It is clear, however, that it will be difficult to predict, based on these results, that the same variables will have similar effects in any "classical" conditioning experiment. Although it would be quite simple to effect the same manipulations of the present study in any Pavlovian situation, there still remains the problem of selecting an appropriate response. The problem, of course, is one of comparability. As indicated before, the use of the "A/A" phenomenon is advantageous because the peck pecking response of pigeons is well known in "operant" experiments. In addition to the fact that it can be measured in both cases in terms of its rate or occurrence, its definition is rather precise. Alternatively, in the typical Pavlovian experiment, responding is not measured by its rate but rather according to its threshold, magnitude, latency, and after-discharge (cf. Skinner, 1938, pp. 12-14).

Thus, one difficulty in comparing the effects of the same variables in "classical" and "operant" conditioning is the selection of a response unit that is common to both types of procedures. The other difficulty is, of course, finding variables that are common to both procedures. As indicated before, the inclusion of a R-S^R dependency in "operant" experiments, as part of the definition of its independent variables, makes it difficult to identify such variables. Furthermore, it may also be noted that the R-S^R contingency in "operant" procedures compromises the status of many of its supposedly independent variables as truly "independent." It may reasonably be asked how "independent" these variables really are, given that the subject contributes significantly to their determination (Schoenfeld *et al.*, 1972; Schoenfeld and Cole, 1975).

In this experiment, the minimal conditions for "operant" stimulus control were met (Morse and Skinner, 1957, 1958; Brown and Jenkins, 1968). Accordingly, it is it is not surprising that the behavioral changes that were observed were those known to occur in "operant" conditioning experiments (e.g., Farmer and Schoenfeld, 1966 a and b; Martin, 1971; Dews, 1970; Evra, 1974). The minimal conditions for Pavlovian control were also met because these are not different from those in the operant case (e.g., Pavlov, 1927, p. 41). In both cases S^N precedes a given R and both are followed by S^R. It is difficult, however, to compare the results of this investigation with other Pavlovian findings because of the lack of equivalence in response measurements and the nature of the response.

As indicated by Terrace (1973), the notion of stimulus control seems to have potential value in achieving the reduction of conditioning paradigms. The fact that many phenomena that are related to the notion of stimulus control are common to "classical" and "operant" conditioning seems to support this hypothesis (e.g., Kimble, 1961).

In view of the outcomes of this research, it is concluded that:

(a) The procedures of the present study can be regarded as forms of "superstitious" conditioning. Nevertheless, results obtained in "operant" conditioning studies were replicated. That is to say, a $R\text{-}S^R$ contingency was not necessary to duplicate most of the effects of T, $S^N\text{-}S^R$ and $p(S^R)$. This finding supports the thesis that such a contingency is not a <u>necessary</u> parameter for "operant" conditioning experiments. If a $R\text{-}S^R$ contingency is not necessary for "operant" conditioning, then there is no procedural basis to distinguish "operant" from "classical" conditioning.

(b) The experimental manipulations also can be properly regarded as examples of "classical" conditioning. Nevertheless, previously reported "operant" data were replicated. There seems to be, therefore, no basis to distinguish the conditioning paradigms in terms of their behavioral effects.

There are at least two alternative ways to interpret any similarity in outcome, as a function of similar variables, in "operant" and in "classical" conditioning procedures. These interpretative possibilities stem from the "mediation argument" (e.g., Rescorla and Solomon, 1967). In the case of the present experiment, these alternative interpretations work out as follows:

> (a) It is possible to argue that the common effects observed here are due to the fact that "A/A" represents a case of "superstitious-operant" conditioning and <u>not</u> a case of Pavlovian conditioning. If so, it might be concluded that the crucial variable in "A/A" is the R-S^R interval, which is also known to be crucial in "operant" conditioning. The Pavlovian variable, S^N-S^R, would be relatively inconsequential according to this point of view (e.g., Hursh, Navarick and Fantino, 1974).
>
> (b) It is also possible to argue that "A/A" represents a case of Pavlovian conditioning, that the effective variable is the S^N-S^R interval and/or contingency and that the R-S^R interval <u>plays no role</u> in the phenomenon (e.g., Williams and Williams, 1969). From this point of view, a demonstration of the generality of a variable between "A/A" and "operant" experiments would be interpreted as showing the influence or mediation of "classical" conditioning in "operant" conditioning. In this vein, some authors claim that the Pavlovian conditioning represented by "A/A" effectively interacts with "operant" responding

and is thus responsible for some of the phenomena previously considered as typically "operant" (e.g., behavioral contrast: Schwartz and Gamzu, 1977; Keller, 1974; Boakes, Halliday and Poli, 1975; conditioned facilitation: Lolordo, 1971; errorless discrimination: Wilkie and Ramer, 1974; discrimination of "negative/positive" features: Wasserman and Anderson, 1974).

It seems clear, however, that to interpret any demonstration of variable generality and effect in terms of either of the above arguments involves the *a priori* assumption that the distinction between "classical" and "operant" conditioning as representing two different processes is correct. This is a point of view opposite to the one held in the present work.

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