SOME DISCRIMINATIVE FUNCTIONS OF AN INCIDENTAL STIMULUS ADVENTITIOUSLY ASSOCIATED WITH REINFORCEMENT

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The present study was a systematic replication of a study by Morse and Skinner (1957). An attempt was also made to study some of the parameters involved in the sensory control of operant behavior. Morse and Skinner found that a stimulus present when a response is being reinforced may acquire discriminative control over the response even though its presence at reinforcement is adventitious. Morse and Skinner trained a pigeon to peck on an illuminated orange disc, obtaining reinforcement on a 30-minute variable-interval schedule of reinforcement. Once an hour, a blue light was projected behind the pecking disc for 4 minutes. The schedule of presentation of the blue stimulus was independent of the reinforcement schedule. Although the blue light was not programmed as part of any reinforcement contingency, the response rate did come under the control of the stimulus. In some cases, the response rate dropped to a low level during the blue stimulus periods and was called a

"negative" superstition. In other instances, a "positive" superstition occurred when the response rate, during the presentation of blue stimulus, was consistently higher than the baserate.

In the present study, a 1-minute variable-interval schedule of reinforcement was used as the baseline for two White King female pigeons. The incidental stimulus consisted of a red light projected behind a pecking disc for a duration of either 30 seconds or 1 minute. At all other times, the pecking disc was illuminated from behind by a white light. The incidental stimulus (red light) was projected behind the translucent pecking disc at irregular intervals between 9 and 15 minutes apart. The appearance of the incidental stimulus was independent of the reinforcement schedule. Even though there was no explicit temporal relationship between the appearance of the stimulus and the program of reinforcement, a response was occasionally reinforced either in the presence of the stimulus or immediately upon its termination. It was the slight difference in the rate of reinforcement in its presence or immediate termination that was believed responsible for any of the subsequent discriminations formed.

The Kamin inflection ratio was used as a measure of the effectiveness of the incidental stimulus in bringing about any marked discriminations. Both birds at some time during the 45 sessions formed both a positive superstition (rate enhancement) and a negative superstition (rate suppression). The direction of the superstition formed in the presence of the incidental stimulus was quite stable for one pigeon, but was found to oscillate for the other bird.

The effect of lengthening the stimulus duration from 30 seconds to 1 minute resulted in increased responding during stimulus presentations for one pigeon only. Decreasing the stimulus duration from 1 minute to 30 seconds had no noticeable effect on either bird.

The relationship between reinforcement frequency during incidental stimulus periods and subsequent discriminations formed was discussed. While occasional high frequency of reinforcement during incidental stimulus periods was believed responsible for the positive superstitions, the negative superstitions were attributed mostly to adventitious reinforcement which maintained the initial suppressed reaction to the incidental stimulus.

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Some Discriminative Functions of an Incidental Stimulus Adventitiously Associated with Reinforcement

"A positive reinforcer is any stimulus the presentation of which strengthens the behavior upon which it is made contingent" (Skinner, 1953, p. 185). Food is a well known positive reinforcer for a hungry organism, but when food is given to a hungry organism regardless of what the animal is doing, one might not readily think that any behavior is being strengthened. But since the organism must have been doing something at the time food was presented, it is assumed that any behavior in progress at the time of presentation is reinforced.

> The operation of a reinforcing event is automatic. Whenever such an event occurs in proper relation to behavior it will exert its reinforcing effects, regardless of whether or not the investigator has included such an effect in his experimental design and regardless of whether or not he records the behavior so affected (Sidman, 1960, p. 348).

A demonstration of the automatic action of a reinforcing event was provided by Skinner (1948). Skinner found that the operation of a food magazine every 15 seconds, i.e., a reinforcing event not contingent upon any response, was found to induce hungry pigeons to engage in such ritualistic behavior as bowing, head bobbing, turning, and dancing. In some cases the behavior was stable, while in others the topography slowly changed; but in all cases, the behavior survived indefinitely. Skinner referred to this behavior as "superstitious." The explanation of the superstitious behavior was given in terms of positive reinforcement. The delivery of the food increased the rate of the behavior that was in progress at the moment of delivery. Before the effects of the previous reinforcement had dissipated, reinforcement again occurred, further strengthening the accidental contingency. The increase in rate resulted in the responses being more likely to be reinforced again, and so on.

It is important to note that various forms of behavior may have been reinforced before any one form became dominant within each pigeon. Also, the topography will more than likely drift over an appreciable amount of time, as noted by Skinner, since the reinforcer is not made contingent upon the superstitious response. When reinforcement was withdrawn, however, the superstitious behavior was found to undergo extinction.

"Perhaps because of its intriguing title 'Superstition in the Pigeon,' the mundane implications of Skinner's paper for experimental control techniques were not immediately appreciated by most investigators" (Sidman, 1960, p. 348). In fact, the data was merely regarded as an interesting and curious phenomenon before the variables described in Skinner's article proved of central importance in a wide variety of experimental and clinical situations. "Some theorists now assert that most human behavior is under the control of 'spurious' contingencies similar to those described by Skinner" (Sidman, 1960, p. 39).

Recently, observations similar to those described by Skinner (1948) have become increasingly more frequent. The name given to reinforcement which strengthens behavior without there being any causal relationship between the two, has been termed adventitious reinforcement. Behavioral phenomena traceable to adventitious reinforcement have been observed in experimental studies ranging from magazine training to investigation of multiple-response schedules. Most of the studies reporting adventitious contingencies, however, have been studies in which other phenomena have been the major concern, and adventitious contingencies were merely used to explain the outcome of the data. However, such contingencies are beginning to play an important role in the systematization of a wide range of data. Adventitious contingencies have even been useful in explaining such seemingly diverse forms of behavior as neurotic or psychotic reactions, and in the construction of scientific theories.

The present study was a systematic replication of a study by Morse and Skinner (1957). An attempt was also made to study some of the parameters involved in the sensory control of operant behavior. Skinner and Morse found that a stimulus present when a response is being reinforced may acquire discriminative control over the response even though its presence at reinforcement is adventitious. Morse and Skinner trained a pigeon to peck on an illuminated, orange disc, obtaining reinforcement on a variable-interval thirty-minute schedule of reinforcement. Once an hour, a blue light was projected behind the pecking disc for 4 minutes. The schedule of presentation of the blue stimulus was independent of the reinforcement schedule. Although the blue light was not programmed as part of any reinforcement contingency, the response rate did come under the control of the stimulus. In some cases, the response rate dropped to a low level during the blue stimulus periods, and was called a "negative" superstition. In other instances, the rate was consistently higher during the blue stimulus periods than the baseline, and this was called a "positive" superstition.

A one-minute variable-interval schedule of reinforcement was used as the baseline in the present study, from which to study the effects of an incidental stimulus presented independently of the reinforcement schedule. The color, frequency of presentation, and duration of the stimulus were among other conditions that differed from those prevailing in the original study.

Because adventitious contingencies are seldom studied in their own right, the following review of the literature is mainly concerned with those areas in which adventitious contingencies have been shown to play a role which, if not controlled, can greatly distort the evaluation of the resulting data. In the apparatus used with pigeons (Pigeon test chamber), the specified contingency between behavior and reinforcement only involves some of the properties of a response. It has been noted (Herrnstein, 1966) that pecks must occur in a given location and with a given amount of force. But, other aspects of a response such as its duration, rate, and manner of execution are not specified. These other aspects of a response are potentially conditionable and will be influenced as much by their temporal proximity to the reinforcement as by the location and force. Therefore, pigeons might locate their responses similarly and with equal forces, but will differ due to adventitious contingencies with respect to such things as duration, rate, and topography of the response. If there were no interaction between those aspects of a response which are under adventitious contingencies and those which are specified by the equipment, there would be little need for concern. Unfortunately, this is not the case.

An example of unrecorded behavior in which adventitious reinforcement plays an important role is in magazine training. It has been noticed (Ferester & Skinner, 1957) that during magazine training, a pigeon often comes to stand near the magazine because of adventitious contingencies favorable to such behavior. This superstitious conditioning is avoided by operating the food magazine only when the pigeon has moved about the experimental box. If this procedure is not carried out, there is always the possibility that the superstitious behavior might interfere with the subsequent behavior to be investigated.

Ferester and Skinner (1957) also note that in establishing the peck desired, the experimenter must be quite skilled in anticipating and reinforcing the correct movement. Sometimes, if not done properly, the pigeon will be reinforced when it moves its head past the key during the initial conditioning of the peck response. A pendulum-like oscillation near the key often results, which persists as superstitious behavior for a long time and may require so much time for execution that high rates of responding become impossible. Ferester and Skinner (1957) show an example of a bird which developed a sequence of responses in which it pecked the panel at the side of the key before pecking the key itself. The result was a lower overall rate with small S-shaped curves on the cumulative record that persisted for a considerable amount of time.

Sidman (1960) mentions the fact that any excessive magazine behavior such as licking, grasping, or nosing whatever portion of the food delivery mechanism available to the subject may be perpetuated through adventitious reinforcement. It is therefore necessary for the experimenter to ensure that magazine behavior does not precede reinforcement; otherwise, this inappropriate behavior will become conditioned and interfere with the behavior which is of main concern.

Another area in which unrecorded behavior can be adventitiously correlated with reinforcement is in delayed reinforcement experiments. Delayed reinforcement experiments involve some sort of delay imposed between recorded behavior and its programmed consequences. The general results of delayed reinforcement experiments have shown that the effectiveness of a reinforcer decreases with longer delays (Chung, 1965; Grice, 1948; Perin, 1943; Skinner, 1938).

One way of explaining the general results of delayed reinforcement experiments according to Sidman (1960) is through the inevitable adventitious contingencies during the delay period. The major effect of the reinforcer will be on the behavior manifested during the delay and not on the response required for its production. In fact, the longer the delay, the greater the chance that adventitious contingencies are being reinforced and not the required behavior.

Several investigators (Blough, 1959; Ferester, 1953; Hearst, 1962) have, in fact, observed superstitious behavior during the delay between recorded behavior and reinforcement. It is even possible to actually make use of the adventitious contingencies to support behavior whose primary reinforcement is extremely long delayed. One method used to accomplish this was demonstrated by Ferester (1953) in which a short delay between behavior and reinforcement was applied to an ongoing operant and gradually increased to 60 seconds. The result was no observable change in the rate of the ongoing operant. This was explained as follows:

> Because of the extinction taking place during the 60 sec. delay the opening of the magazine is preceded by a wide variety of behaviors and no single response is likely to be reinforced frequently enough to acquire any strength. If the delays are the order of 1 to 5 sec., however, the likelihood of the same response occurring prior to the opening of the magazine is high, and the members of a single response class will be reinforced frequently enough to be conditioned. When the delay interval is lengthened after a number of reinforcements of the same response, the delay defines a fixed-interval schedule of reinforcement of the superstitious response. The schedule is different from those ordinarily employed only in that the magazine will open whether or not the response is maintained (Ferester, 1953, p. 223).

Thus, Ferester gives a good example of how adventitious contingencies can be put to good use when properly understood. Sidman (1960) points out one limitation to Ferester's technique of gradually increasing the delay, which is that the response which does come to be adventitiously conditioned cannot be specified in advance. It is, therefore, difficult to observe more than one animal under comparable conditions.

In order to study more than one animal under comparable conditions, the question arises as to how can one specify in advance which response will come to be adventitiously conditioned. In viewing the superstitious behavior reported by Skinner (1948), it was noticed that the acts reported, such as head bobbing and pecking, were distinctly pigeon-like. Herrnstein (1956) suggests that the adventitious contingencies merely accentuated the very forms of responses which were initially dominant among the pigeons. Herrnstein and Morse (reported in Herrnstein, 1966) demonstrate a technique of making a response dominant by training an animal to engage explicitly in the behavior that one wishes to make dominant. A pigeon was trained to peck on an illuminated disk, obtaining reinforcement on a FI 11 second schedule. Sessions were terminated every fortieth reinforcement. After 9 sessions, the pigeon was no longer reinforced for pecking, but received reinforcement (access to food) every 11 seconds, irrespective of its behavior. The results over twenty-one daily sessions showed the rate to decline slightly when the response contingency was withdrawn, but pecking still remained at a substantial level for a considerable amount of time. This study is of special interest because the behavior was conditioned with a deliberate reinforcement contingency and then was maintained superstitiously.

Recent studies (Edwards, West, & Jackson, 1968; Rescorla & Skucy, 1969; Zeiler, 1968) have also reported superstitious key pecking either after an unknown number or a large number of response correlated reinforcements for key pecking. However, a recent study (Neuringer, 1970) suggests that superstition can be established by three response correlated reinforcements. In yet another study (Fenner, 1969), only a single reinforcement was needed to establish a superstitious response. Although Herrnstein's response-dominance hypothesis could account for the subsequent superstitious behavior following response correlated reinforcement, Neuringer's analysis (1970) is more in agreement with Skinner's analysis (1948) which implies that a single accidental correlation between act and response-independent reinforcement begins the process leading to the establishment of superstition.

"There are several types of delayed-response experiments, and all of them are ideal spawning grounds for adventitious contingencies" (Sidman, 1960, p. 375). An example of a classical delayed-response procedure would be illustrated by an experiment where an organism like a monkey is permitted to view a piece of fruit being placed in one of several containers. A barrier is then interposed between the monkey and the containers. After a specified delay, the experimenter removes the barrier and notes whether or not the monkey selects the correct container.

During the delay period before the organism is permitted to make a response, it has been noticed by various investigators (Harrison & Nissen, 1941; Nissen, Risen, & Nowles, 1938) that there are some regularities in their subject's behavior. These regularities have been described as orienting responses in that the subject adopts a posture in which his whole body or a part of it maintains a consistent position relative to the correct choice after the lapse of a considerable amount of time.

Sidman (1960) suggests that because no specified response is required by the experimenter before he makes the reinforcement available to the subject, the orienting response is controlled by adventitious contingencies. Sidman (1960) also points out that this is actually a special case of adventious reinforcement because not just any orienting behavior is reinforced, but only that which does lead to the correct choice. Therefore, this is a case of differential adventitious reinforcement.

Spaced-responding comes about through the differential reinforcement of low rates (DRL). For example, the timer may make reinforcement available every 20 seconds, but only if the subject has not responded for 20 seconds. Each response of the subject resets the timer and starts the 20 second period all over again. Every time the subject waits for 20 seconds without responding, the next response will produce reinforcement. The schedule has the effect of extinguishing responses that occur at high rates and results in spaced-responding.

Wilson and Keller (1953) originally observed that a sequence of stereotyped behavior which they called "collateral behavior" may develop during the delay period. It was found that this behavior was different for each animal, as expected, since no specification was made in the reinforcement contingency. It was also found that with an increase in the delay intervals, more links were conditioned to the chain of collateral behavior.

Analogous superstitious behaviors during DRL schedules have been observed in various settings and with several species. Hodos, Ross, and Brady (1962) observed excessive licking and head jerking in monkeys restrained in primate chairs. Laties, Weiss, Clark, and Reynolds (1965) studied a rat that nibbled its tail in a stereotyped way between spaced responses. Bruner and Revusky (1961) and Randolph (1965) found that humans would operate extra pushbuttons before the response reinforced by the DRL schedule. The various collateral behaviors in all of these studies formed no part of the actual reinforcement contingency.

Experimental studies of punishment and avoidance behavior have also demonstrated the need for control of adventitious contingencies. Sidman (1960) suggests that if avoidance behavior is being studied whereby an organism presses a lever to postpone the appearance of an electrical shock, the components of the lever pressing behavior all share in the reinforcing effect of the shock avoidance; but they may also be punished by shock when the contingency is not met. For example, shock may occur just as the subject is in the process of making the avoidance response. The avoidance response being made up of various components other than just the recorded behavior, becomes itself adventitiously correlated with punishment.

Azrin (1956) found that immediate punishment was far more effective than non-immediate punishment in reducing the number of responses during the warning periods. In the previous discussion of delayed reinforcement studies, it was noted that the effectiveness of reinforcement decreased with an increase in the delay period. It would appear that Azrin's findings could likewise be explained in terms of adventitious contingencies.

Azrin (1956) also investigated the effects of shock on a response where shock was not correlated with responses. His procedure was very similar to that of Skinner's (1948) in which food was delivered to pigeons at fixed intervals of time without explicitly correlating the delivery of food with any response. The difference was that shock was delivered instead of food. The effect of shock in his procedure appears to be opposite that of food in Skinner's procedure. Whereas the food produced positively accelerated responding due to adventitious reinforcements, the shock produced negatively accelerated responding.

A negative reinforcer has been defined by Skinner (1953) as any stimulus the withdrawal of which strengthens behavior. Electrical shock is a well known negative reinforcer and because its withdrawal is reinforcing, it would be expected that if terminated independently of an animal's action, superstitious behavior would result. Migler (1963) and Keehn and Chaudrey (1964) presented a shock that was automatically turned off after a fixed duration. The rate in these experiments continued to press a lever (previously used to escape shock) during the shock as if the lever press terminated the shock. Migler also observed one rat to press a spare second lever during the shock, even though that lever had never had any effect. The superstitious escape behavior in these experiments was maintained by the accidental correlation of response and shock termination. Skinner (1953) suggests that certain illness such as lameness and allergic reactions in human beings are of such duration that any measure to cure them is likely to be reinforced when the condition clears up.

Up to this point, adventitious contingencies have been discussed only with respect to unrecorded behavior or non-instrumental aspects of instrumental responses. However, adventitious contingencies are by no means limited to unrecorded behavior or solely to primary reinforcement. Reinforcement in the preceding cases has been of the primary type, but it is also possible for conditioned reinforcers to function in the same way in bringing about superstitious behavior.

A common procedure for studying the process of stimulus discrimination is to alternate a stimulus in whose presence some form of response is reinforced (S^D) with a stimulus in whose presence no reinforcement is forthcoming (S^{Δ}). Morse (1955) has shown that these two stimuli may take on properties in addition to their discriminability, since the procedure itself may make them either reinforcing or punishing. For example, an originally neutral stimulus in whose presence behavior is positively reinforced is known to become a stimulus which can itself reinforce other behavior, i.e., a conditioned reinforcer. Morse (1955) found that when the positive conditioned stimulus (S^D) was presented to the animal independently of its behavior, it produced superstitious behavior. Usually the syperstitious behavior resulted in being the same form as that required for reinforcement during S^D presentation; however, the superstitious behavior took place during the S^{Δ} presentation. The superstitious responding occurred during the S^{Δ} presentation because it is only during this period that a response could be continguous in time with the onset of the positive stimulus (S^D).

The stimulus discrimination procedure is therefore much like a multiple schedule (Ferester & Skinner, 1957). The organism responds basically to two stimuli: in the presence of S^D a specified form of behavior is maintained by a primary reinforcer, and in the presence of the S^{Δ} some unspecified form of behavior is maintained by the onset of the S^D. It is when the unspecified form of behavior in the presence of S^{Δ} takes on the same form of behavior as that maintained by the primary reinforcer that stimulus control is not established.

This problem imposed by adventitious reinforcement is generally solved, as suggested by Sidman (1960), either by interposing an adequate delay between S^{Δ} and S^{D} or by arranging the primary reinforcement schedule and the stimulus presentation schedule in such a way that if adventitious contingencies occur there will be at least a difference in behavior patterns during each stimulus period.

"The principle exemplified by the stimulus discrimination procedure is that in any procedure in which stimuli occur independently of behavior, there is the possibility that some unknown response is being adventitiously influenced" (Herrnstein, 1966, p. 39). Herrnstein suggests that it is possible for such stimuli as the opening of a start-box of a maze to have some influence on the behavior of the animal as it waits in the start-box. Although the effect of the adventitious reinforcement may be small, it could still be a source of either intersubject or interexperimenter variability.

As more and more complex phenomena are experimentally manipulated and investigated, it becomes more evident that adventitious contingencies become increasingly more frequent and complex. Sidman (1960) points out that adventitious contingencies are an inevitable feature of multiple response situations and that control techniques must permit one to evaluate rather than to eliminate such contingencies.

Whenever two or more forms of behavior are investigated simultaneously, i.e., a separate reinforcement contingency is arranged for each response and programmed concurrently, there is always the possibility of uncontrolled interaction mediated by adventitious contingencies. Skinner (1950) gives an example in which a pigeon was occasionally reinforced for pecking on either of two keys. The reinforcements on each key were programmed by equal and independent VI schedules. A reinforcement on one key did not alter the probability of reinforcement on the other key. The results of occasionally reinforcing a response on one key or the other without favoring either key show that equal rates of responding on both keys result. This was explained as follows:

> Given a system in which one key or the other is occasionally connected with the magazine by an external clock, then if the right key has just been struck, the probability of reinforcement via the left key is higher than that via the right key since a greater interval of time has elapsed during which the clock may have closed the circuit to the left key (Skinner, 1950, p. 211).

The result is that the contingency actually generates a chain of behavior: key pecking, followed by switching to the other key, followed by key pecking. The middle member of the chain, the switching or changeover is an adventitious yet important member of the reinforcement contingency.

In an experiment reported by Sidman (1958) a monkey pulled on a chain for reinforcement on a VI schedule. An avoidance contingency was programmed concurrently for a lever-pressing response. The lever press postponed the electric shock for 20 seconds. However, because of adventitious contingencies, the food response became involved in the avoidance contingency. The sequence (chain pull, followed by the switching behavior, followed by lever pressing) became established as an adventitious reinforced avoidance response.

In fact, the accidental strengthening or maintenance of one operant by reinforcement programmed for another has been called "concurrent superstition" (Catania & Cutts, 1963). It has been found in studies where the two operants are compatible, i.e., they can occur simultaneously, (Ferester, 1957; Lane, 1961; Sidman, 1958) as well as in studies where the two operants are incompatible if the two operants occur in rapid succession (Ferester & Skinner, 1957; Hearst, 1961; Skinner, 1950).

There are a number of miscellaneous types of adventitious contingencies which do not confine themselves to any particular experimental studies. A good example is demonstrated when a "limited hold" contingency is applied to an ongoing baseline such as a VI reinforcement schedule. On a VI schedule, when normally applied, a reinforcement becomes available and remains available after a variable-interval of time. When a "limited hold" contingency is applied, i. e., a response has to occur within a set amount of time after reinforcement becomes available or else the subject loses the opportunity to secure a reinforcement, the initial effect is a marked reduction in reinforcement frequency (Ferester & Skinner, 1957). Afterwards, the subject adjusts by increasing its rate as the new contingency takes hold, but the initial effect can be self-perpetuating due to adventitious contingencies (Sidman, 1960).

> . . . the stimuli coincident with the beginning of the session have become correlated with a low reinforcement frequency. The low frequency, in turn, generates a low rate, and low response rates may then characterize the start of each succeeding session (Sidman, 1960, p. 381).

Another example is demonstrated by a "locked rate." When a pigeon has been responding for a considerable amount of time on a VI reinforcement schedule in which a constant high rate has been observed day after day, there is always the possibility that the rate will become conditioned or locked (Sidman, 1960). That is, key-pecking alone is not correlated with reinforcement, but key-pecking characterized by a particular rate of responding. However, the rate of responding is conditioned through adventitious contingencies alone. Sidman mentions the fact that when a "locked rate" occurs, the schedule becomes useless as a baseline from which to measure the effects of some other variable due to its insensitivity.

Method

Subjects

Three White King female pigeons between the ages of one and five were used. All of the pigeons were experimentally naive and were obtained from the Palmetto Pigeon Plant, Sumter, South Carolina. One pigeon was dropped from the study when he failed to meet the six-session stability criterion established by Schoenfeld, Cumming, and Hearst (1956). The birds were housed in separate compartments approximately one cubic foot in size.

Apparatus

The pigeon test chamber was built of plywood and pegboard approximately 30 x 12 x 15 inches. The floor of the box consisted of a heavy wire mesh under which paper towels were spread. Fresh water was supplied in a cup at the rear of the cage at all times. The compartment was illuminated by a 6-watt light located at the top of the intelligence panel.

The intelligence panel consisted of three translucent keys with tri-stimulus lights behind each key. However, for the present study, only the center key and two color lights were used. The height of the aperture which exposed the surface of the key to the pigeon was 8½ inches from the floor. The food magazine presented the food for a fixed amount of time (4 seconds). A solenoid would draw the tray into horizontal position, and the bird would reach the grain through a 3/8 inch square aperture. A 6-watt bulb was wired in parallel with the solenoid so that the grain was well lighted during the operation of the magazine. The grain used was Purina brand pigeon mix obtained from an animal supply house.

A cumulative recorder was used to record rates of key pecking on a sheet of pressure-sensitive paper that continuously moved under a metal stylus. During the operation of the food magazine, the paper feed of the recorder was stopped so that pauses were not confused with eating time. Reinforcement frequency was recorded on a counter and marked by hand at the appropriate place on the cumulative record. The occurrence of the incidental stimulus was also recorded by hand on the cumulative record. All other aspects of the programming were automatic and carried out by various types of relays and electric timing and counting devices.

Procedure

Control of body weight. The *ad-lib* weight of each bird was obtained by giving each bird continuous access to food for 3 days or until his weight showed no appreciable increase. All food was then removed for 2 days, and beginning with the third day, 5 grams was given daily until the weight of the bird fell to 80 per cent of its *ad-lib* weight.

Daily entries of the body weight were made for each bird immediately before and after each experimental session. If a bird was heavier than its designated weight, it was not used or fed that day. However, if its weight was on or below its designated weight, it was used. After an experimental session, each bird was given only the required amount of food to bring its weight up to its 80 per cent _ad-lib_ level for the next session.

Adaption to the apparatus. The pigeons were adapted to the experimental chamber concurrently with adjustment to the body weight. Each pigeon was placed in the experimental chamber for about one hour per day until it reached its designated 80 per cent _ad-lib_ weight. It was then allowed to eat from the food magazine held in place so that the bird had continuous access to the grain for about one to two minutes. If the bird did not eat in 10 minutes, it was returned to the living cage without food until the following day. This procedure was repeated until each bird ate readily from the open magazine. The next step was to operate the magazine by hand until the bird showed no emotional reaction to the noise element. It was also necessary to avoid accidental contingencies between any behavior on the part of the bird and the opening of the food magazine. This was accomplished by operating the magazine only after the bird moved about the experimental box. This procedure was continued until each bird would turn and move quickly the food magazine from any position in the chamber upon the operation of the magazine.

Conditioning the peck response. A small grain of corn was attached with Scotch tape to the pecking disc, which was illuminated from behind by a white light. Each pigeon was then placed in the chamber and "shaped-up" by hand to peck at the grain of corn, i.e., the experimenter operated the magazine and reinforced any response in the direction of the key or grain of corn. The pigeons quickly learned to peck the corn which had the effect of opening the food magazine. After conditioning to the key had taken place, the grain of corn was removed by a progressive reduction in size until it disappeared altogether. Immediately after conditioning of the peck response, each response was continuously reinforced for 3 sessions containing 60 reinforcements each.

Establishing baseline behavior. After the 3 sessions of continuous reinforcement, each of the three pigeons were placed on a variable-interval schedule of reinforcement with the mean interval being 1 minute. A punched tape driven by a constant speed motor was used to time the intervals. As each hole in the tape passed beneath a sensing device, a switch closed and allowed the next response to produce a reinforcement. The actual distribution of intervals consisted of a randomized, arithmetic progression (40, 90, 10, 100, 50, 80, 1, 60, 20, 30, 110, 70, 120 seconds).

Each of the pigeons was placed on the VI 1 minute schedule of reinforcement with the pecking disc normally illuminated from behind by a white light for approximately 60 reinforcements per day. Thus, a session consisted of approximately 60 reinforcements or for about 1 hour per day. Each bird was kept on the VI 1 minute schedule until its response rate had reached a steady state as defined by the stability criterion established by Schoenfeld, Cumming, and Hearst (1959). The first 6 days on the schedule were not considered in computing stability. For the next 6 days, the mean of the first 3 days of the 6 was compared with that of the last 3 days; if the difference between these means was less than 5 per cent of the 6 days' mean, the bird was considered to have a stable baseline. If the difference between submeans was greater than 5 per cent of the grand mean, another experimental day was added and similar calculations were made for that day and the five immediately preceding it. Only the last 15 minutes of the session were used in calculating stability criteria. Pigeon #1 required 13 sessions to meet the stability criteria, Pigeon #2 required 12 sessions, while the third pigeon never met the established criteria after more than 20 sessions.

Application of incidental stimuli. Once a baseline was well established, a red stimulus was projected behind the pecking key, replacing the white light which normally illuminated it. The white stimulus would reappear immediately upon the termination of the red stimulus. The red stimulus appeared for 30 seconds, four times per session at irregular intervals between 9 and 15 minutes apart. Thus, the red stimulus schedule was completely independent of the reinforcement schedule, i. e., sometimes the pigeon would get reinforced in the presence of the red stimulus and sometimes it would not. This procedure was continued for 15 sessions or 60 presentations of the red stimulus. During sessions 16 through 30, the duration of the incidental stimulus was increased to 1 minute in length with the frequency and schedule of presentation remaining unchanged. Sessions 31 through 45 consisted of a return to the original duration of 30 seconds with the same frequency and schedule of presentation.

Results

The general results are shown in Figure 1 and Figure 2 for Pigeon #1 and Pigeon #2, respectively. The Kamin inflection ratio (Annau & Kamin, 1961) was used as a measure of the effectiveness of the incidental stimulus in bringing about any adventitious discriminative control. The Kamin inflection ratio equaled B/A+B, where B represents the number of responses during the incidental stimulus and A represents the number of responses during a period immediately preceding the stimulus of the same length as the stimulus. A ratio of 0.50 represents no change in responding, and a ratio of 0.00 indicates complete suppression. Any ratio above 0.50 reflects rate enhancement with the theoretical limit of 1.00.

The means plotted in Figures 1 and 2 were derived by calculating a single inflection ratio (pooling four trials) for each pigeon each day. The greatest suppression for both birds occurred during the initial presentation of the incidental stimulus ("a"). Even though there was no explicit temporal relationship between the appearance of "a" and the program of reinforcement, a response was occasionally reinforced either in the presence of "a" or immediately upon its termination. Reinforcements were indicated on the cumulative record by the small downward pen strokes (see Figures 3-8). The slight differences in the rate of reinforcement in the presence of "a" or upon its immediate termination were believed responsible for any of the subsequent discriminations formed in its presence. It was found that when the rate had fallen in the presence of "a," a second effect, also noted by Morse and Skinner (1957), followed. Reinforcements which were made available during "a" were not obtained because responses were not made. The first response following the withdrawal of "a" was then reinforced. Similarly, when the rate was increased during "a" because of favorable accidental reinforcement, all reinforcements set up during "a" were likely to be obtained and, thus, strengthen the discrimination.

The effect of increasing the incidental stimulus from 30 seconds to 1 minute in length can be seen in Figures 1 and 2. The effect appears to result in increased responding during the presence of "a" for Pigeon #2, but one can not be certain that the change in duration ofthe stimulus alone was responsible for this change. Decreasing the stimulus duration from 1 minute to 30 seconds appeared to have no noticeable effect for either bird. The difference between the discriminative control observed during the first 15 sessions with the 30-second stimulus and the last 15 sessions with the 30-second stimulus (see Figures 1 & 2) is easily explained in terms of adventitious reinforcement correlated with the ongoing rate during stimulus presentation.

Both pigeons at sometime during the 45 sessions formed a positive superstition (rate enhancement) and a negative superstition (rate suppression). The direction of the superstition formed in the presence of "a" was quite stable for Pigeon #2 with large changes occurring only after several sessions. For Pigeon #1, however, there was considerable oscillation from one presentation to the next. Sometimes, during the presentation of the stimulus itself, a disruption of the response pattern would occur, suggesting a complete loss of stimulus control. Over several sessions, the process remained open-ended with no final state established for either bird. The adventitious contingencies provided no consistent relationship between the incidental stimulus and reinforcement; therefore, no stable response form was ever selected.

It should be pointed out that the overall magnitude for the positive superstitions observed were not quite as substantial as those found for the negative superstitions (see Figures 4 & 5). This was most likely due to the VI 1 minute schedule of reinforcement used as the baseline, which was already characterized by high rates of responding and, therefore, not very sensitive to further increases in rate.

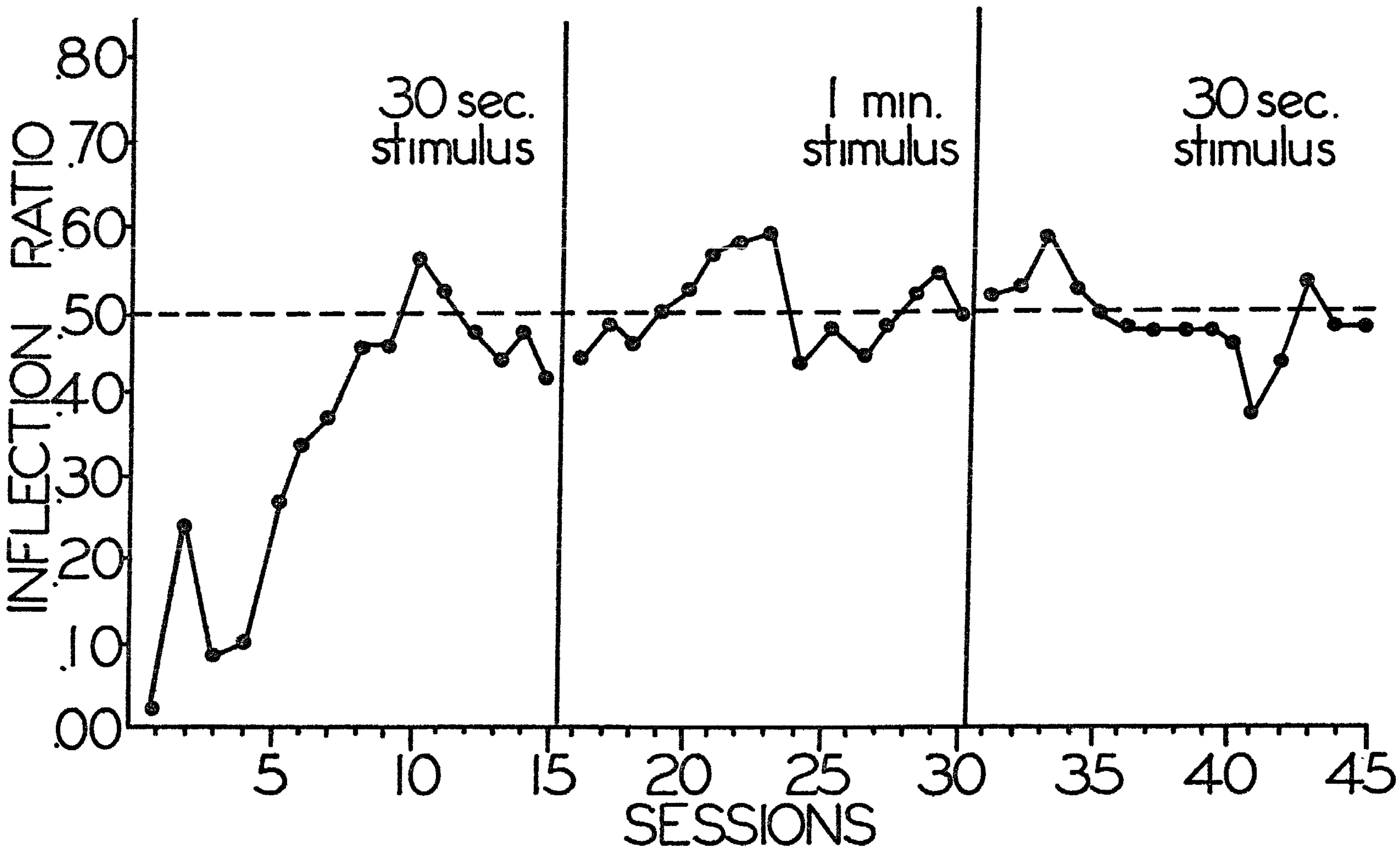

Fig. 1. Mean inflection ratios for Pigeon #1. A ratio of .50 represents no change in rate during the stimulus period relative to the baseline. Ratios less than .50 reflect rate suppression and ratios above .50 reflect rate enhancement.

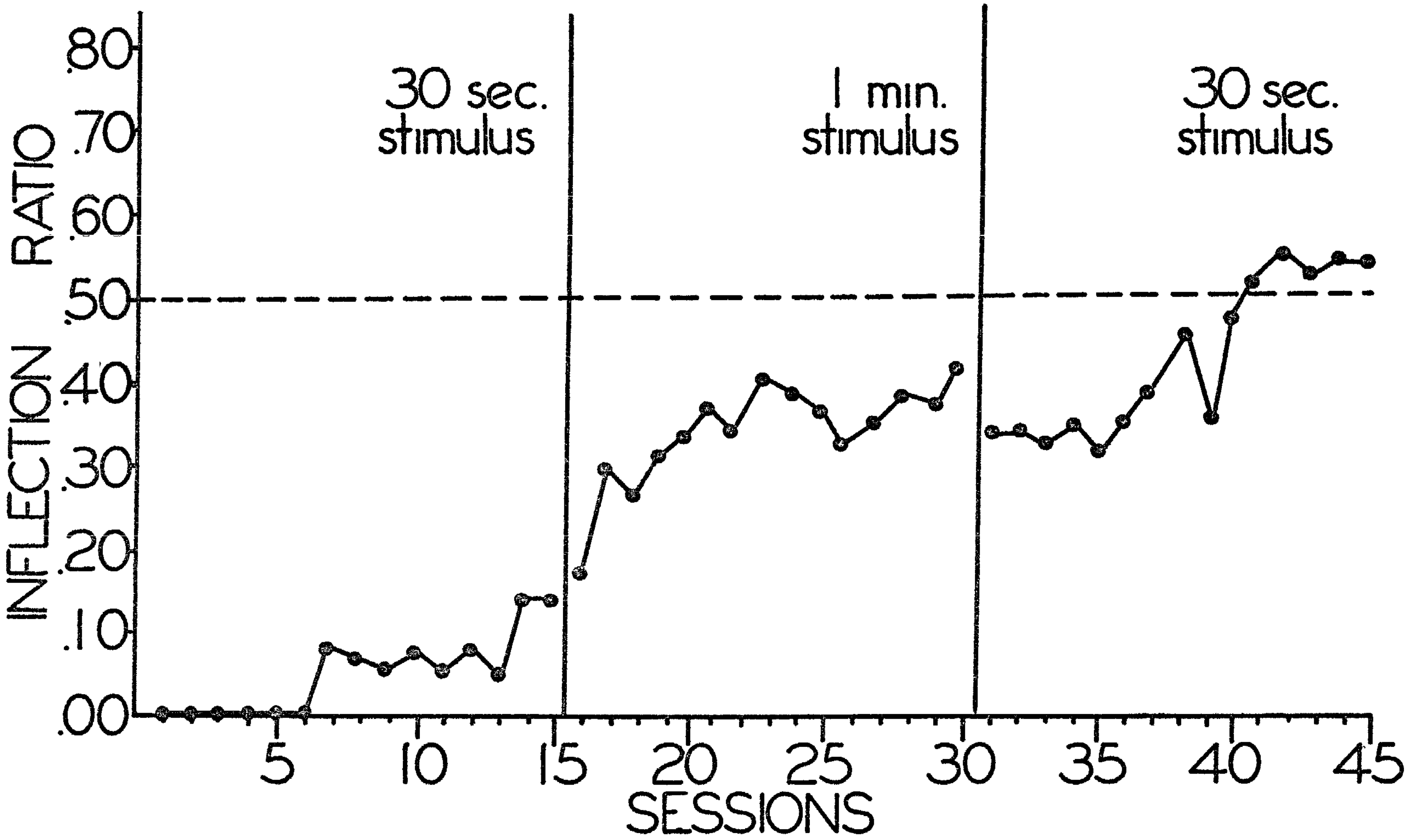

Fig. 2. Mean inflection ratios for Pigeon #2. A ratio of .50 represents no change in rate during the stimulus period relative to the baseline. Ratios less than .50 reflect rate suppression and ratios above .50 reflect rate enhancement.

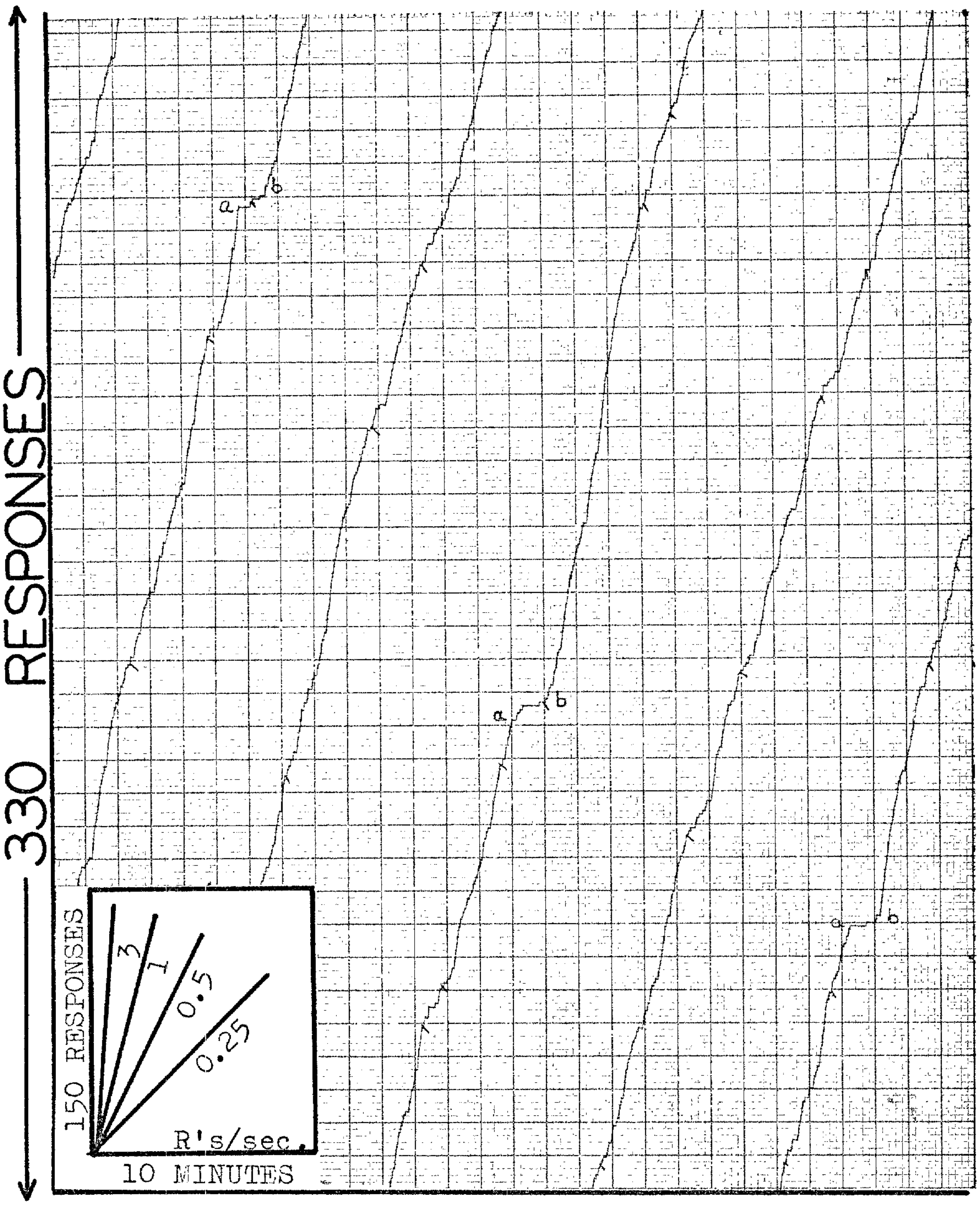

Fig. 3. Selected performances for Pigeon #1 showing rate suppression in the presence of a 30 second incidental stimulus. The onset and termination of the stimulus is indicated on the cumulative record by the points "a" and "b," respectively.

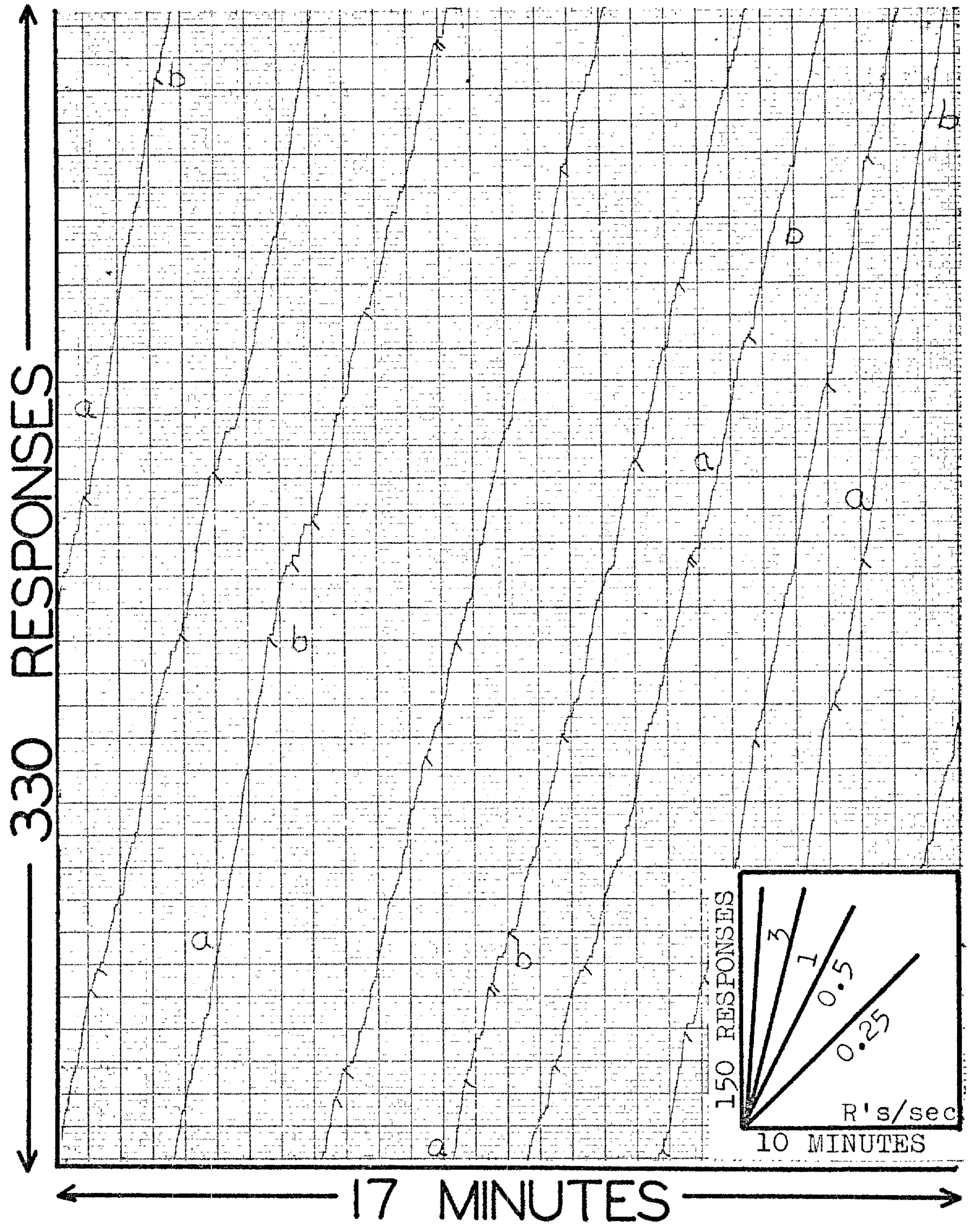

Fig. 4. Selected performances for Pigeon #1 showing five presentations of an incidental 1 minute stimulus. The first two presentations and the last show rate enhancement, while the third and fourth presentations show no change in responding during its presence.

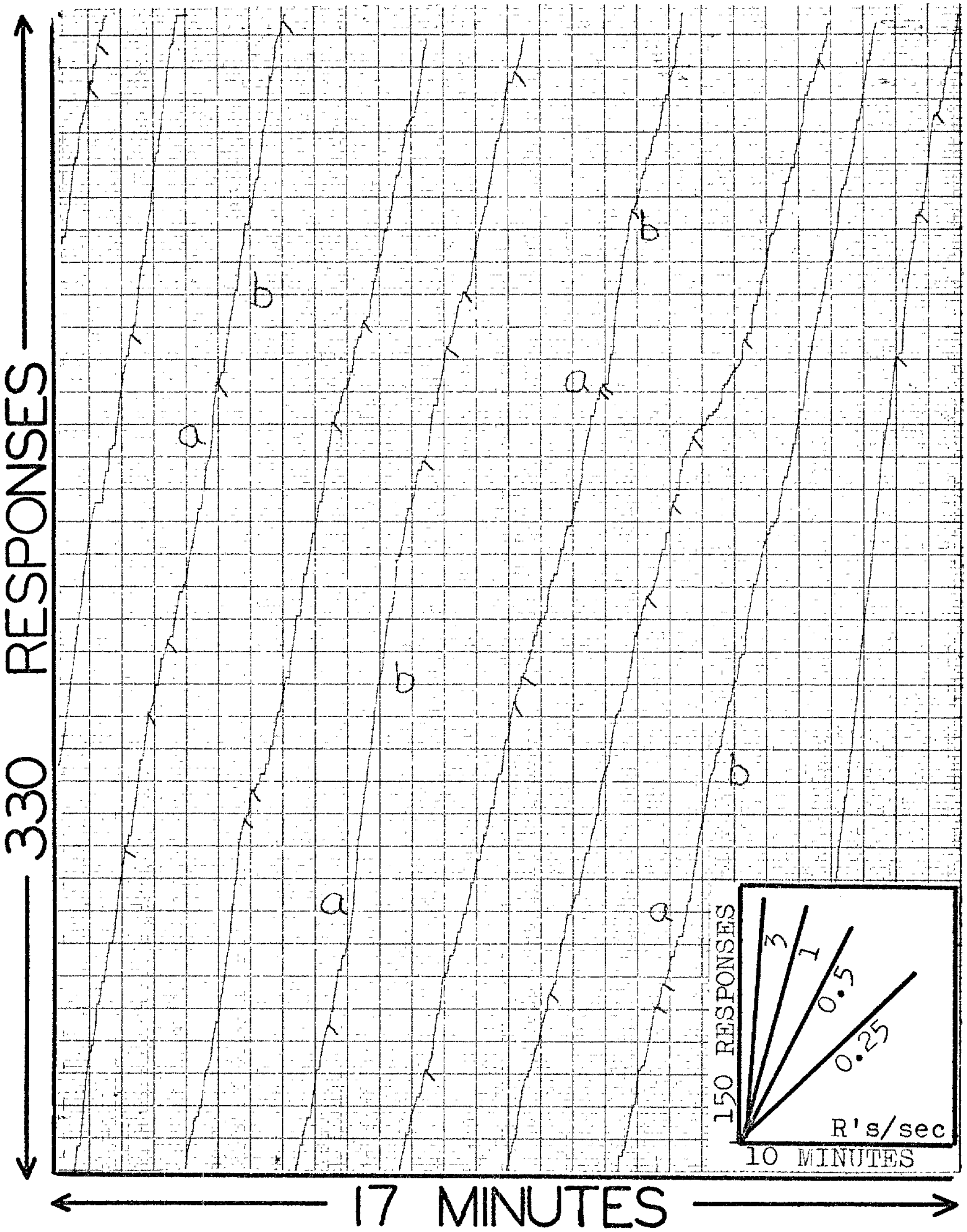

Fig. 5. Selected performances for Pigeon #1 showing four presentations of a 30 second incidental stimulus. The first presentation shows no rate change, and the last three presentations show rate enhancement.

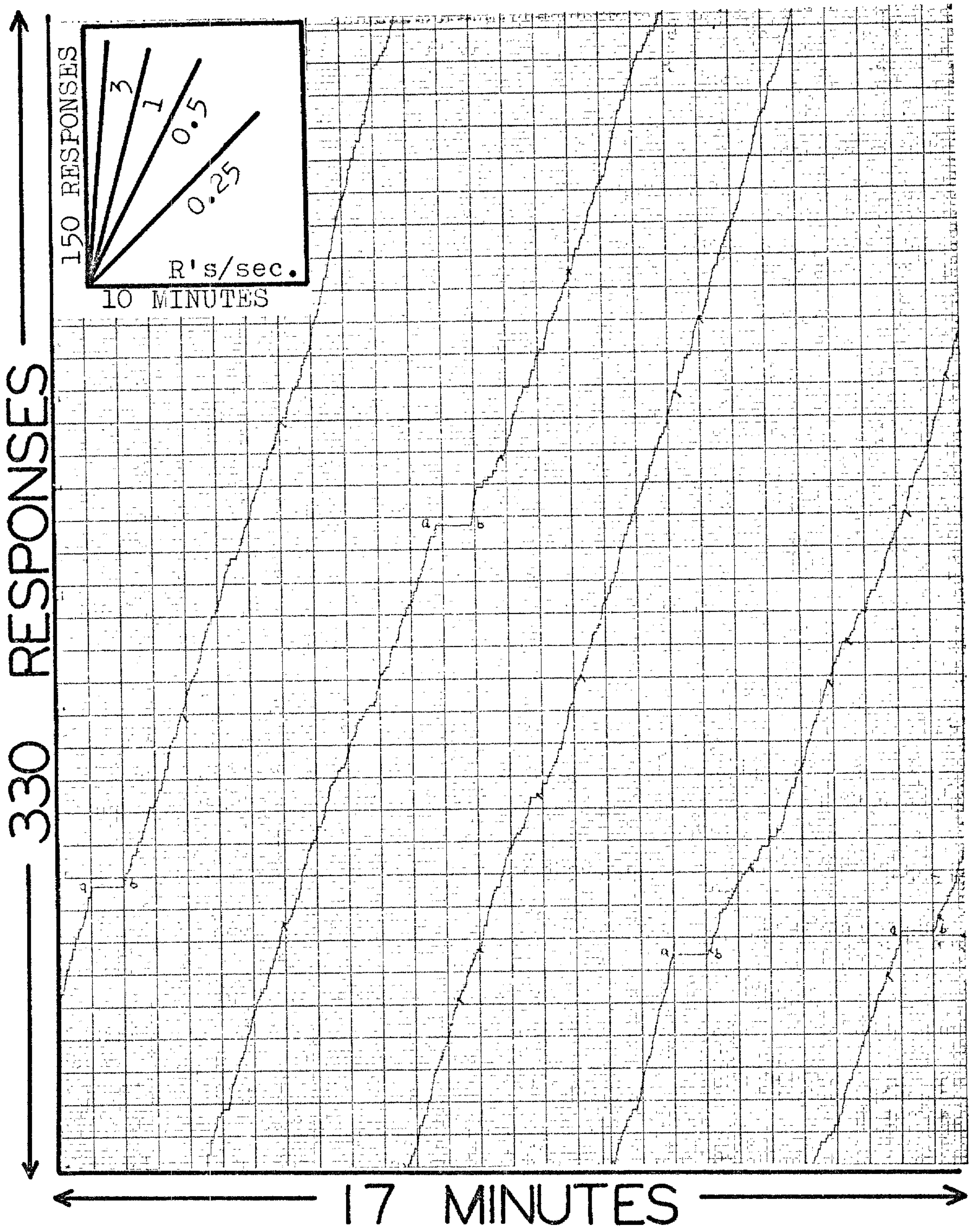

Fig. 6. Selected performances for Pigeon #2 showing complete suppression during four presentations of a 30 second incidental stimulus.

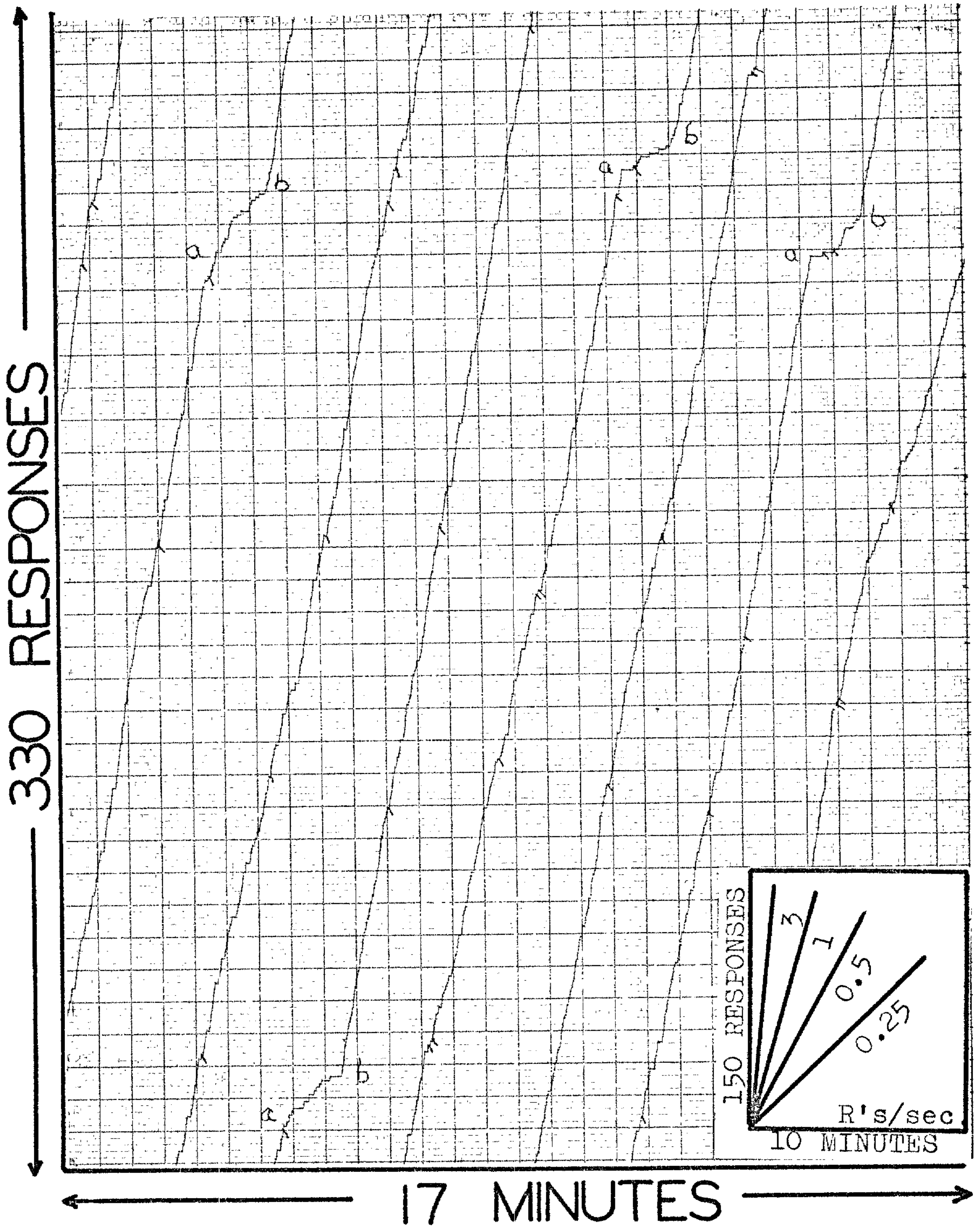

Fig. 7. Selected performances for Pigeon #2 showing rate suppression during four presentations of a 1 minute incidental stimulus.

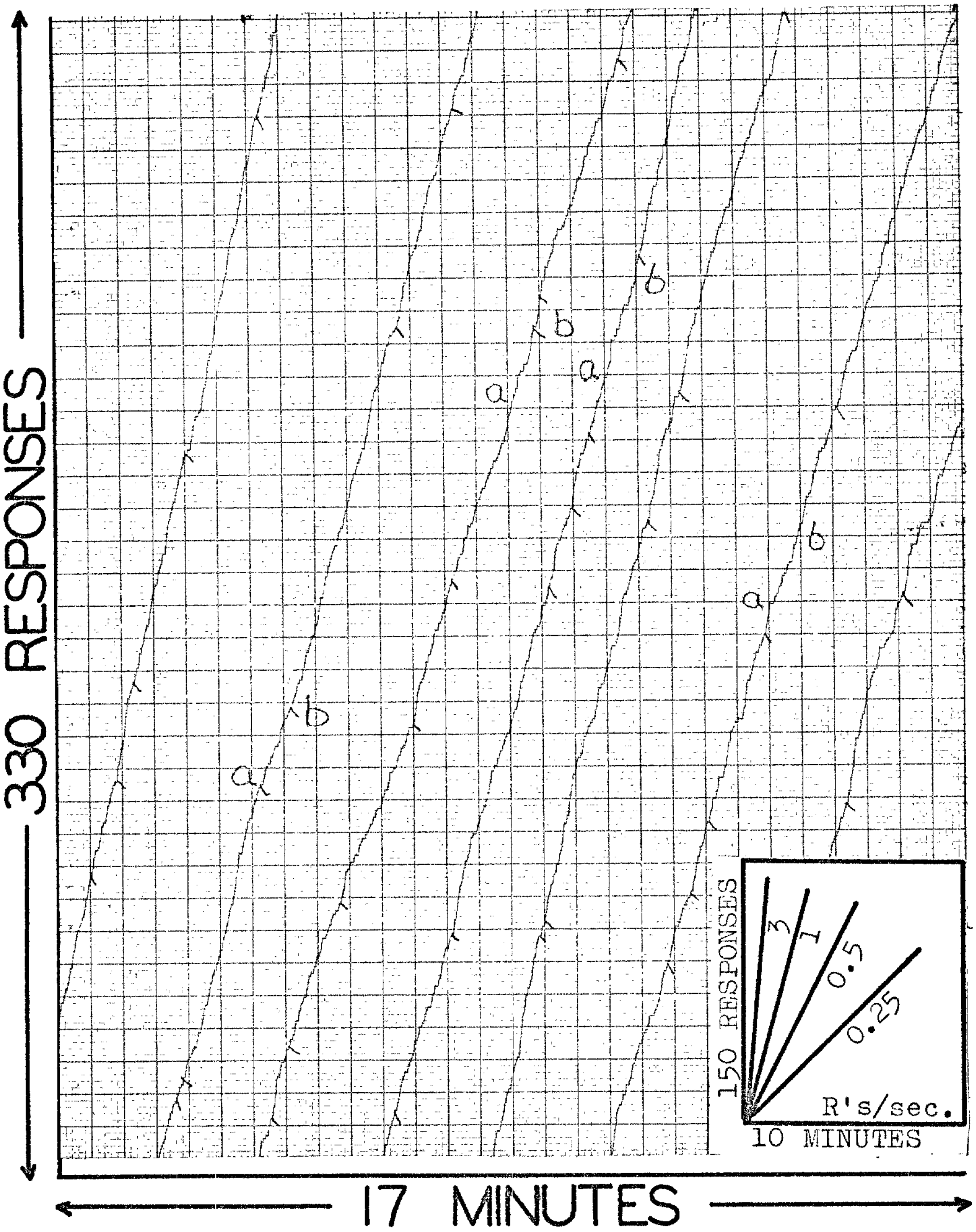

Fig. 8. Selected performances for Pigeon #2 showing no change in the rat^ of responding during four presentations of a 30 second incidental stimulus.

Discussion

Ongoing operant behavior was found to take on discriminative functions in the presence of an incidental stimulus adventitiously associated with reinforcement. This replicates, under different conditions, the findings reported by Morse and Skinner (1957). Morse and Skinner explained the discriminative functions observed as follows:

> . . .a response will occasionally be reinforced in the presence of A (incidental stimulus). For a brief period the frequency of such reinforcement may be appreciably greater than in the absence of A. An organism which is sensitive to the slight differences in rate of reinforcement will form a discrimination; its rate of responding in the presence of A will become greater than in the absence of A. This might be called a positive sensory superstition. If, on the other hand, reinforcement happens to occur relatively infrequently in the presence of A, a discrimination will develop in the opposite direction, as a result of which the rate in the presence of A will be relatively low--a sort of negative sensory superstition (Morse & Skinner, 1957, pp. 308-309).

The explanation of the negative sensory superstition resulting from low reinforcement frequency during the incidental stimulus periods does not agree with Morse's analysis (1955) of responding in the presence of a stimulus correlated with periods of non-reinforcement. Morse found that the onset of a conditioned positive stimulus (S^D) could maintain behavior during periods of non-reinforcement. Therefore, there could be generalized responding during the incidental stimulus periods maintained by adventitious reinforcement (onset of S^D or white light in the present study). The generalized responding in the presence of the incidental stimulus does not necessarily have to be of a lower response rate than the baseline.

In the present study, the greatest suppression occurred during the initial presentations of the incidental stimulus for both birds. This suggests that the novelty of the incidental stimulus results in temporary suppression which is then maintained adventitiously. Morse and Skinner (1957) give a concise analysis of how the suppression is maintained once it develops.

> If the rate has fallen in the presence of A (incidental stimulus). . . responses will be less likely to be reinforced in the presence of A. In the limiting case no response will be made in the presence of A, and no responses, of course, reinforced. Moreover, reinforcements which are made available during A are not obtained because responses are not made. The first response following the withdrawal of A is further strengthened (Morse & Skinner, 1957, p. 309).

Miczel and Grossman (1971) found that a conditioned stimulus (CS), which consisted of a 30 second tone, followed immediately by a response-independent reinforcement resulted in conditioned suppression during stimulus presentation. Although there are parametric differences, Miczel and Grossman's findings would certainly support Morse and Skinner's analysis of how the suppression was maintained.

Miczel and Grossman also noted that the lengthening of the duration of the tone (CS) from 30 seconds to 1, 2, and 3 minutes resulted in a loss of stimulus control. Other investigators (Stein, Sidman & Brady, 1958; Kamin, 1965; Metlzer & Brahleh, 1970) suggest that only a short CS suppresses ongoing operant behavior when a positive unconditioned stimulus (US) is used in the conditioned suppression paradigm. Increasing the duration of the incidental stimulus in the present study did appear to result in less suppression for Pigeon #2, but one can not be certain if the change in the duration of the stimulus alone was responsible for the change. Morse and Skinner had suggested that a short incidental stimulus would be less likely to receive reinforcement on a given schedule, and might be expected to produce negative superstition more frequently than a long incidental stimulus. Lessening the stimulus duration from 1 minute to 30 seconds did not appear to have any effect whatsoever for either bird in the present study. This would tend to support the hypothesis that the suppression in the present study was maintained after its initial onset and did not result from a low reinforcement frequency.

References

Azrin, N. Some effects of two intermittent schedules of immediate and non-immediate punishment. Journal of Psychology, 1965, 42, 3-21.

Azrin, N. & Hake, D. F. Positive conditioned suppression: conditioned suppression using positive reinforcers as the unconditioned stimuli. Journal of the Experimental Analysis of Behavior, 1969, 12, 167-173.

Annau, Z. & Kamin, J. L. The conditioned emotional response as a function of the intensity of the US. Journal of the Experimental Analysis of Behavior, 1961, 54, 428-432.

Blough, D. S. Delayed matching in the pigeon. Journal of the Experimental Analysis of Behavior, 1959, 2, 151-160.

Brunner, A. & Revuskey, S. H. Collateral behavior in humans. Journal of the Experimental Analysis of Behavior, 1961, 4, 349-350.

Catania, A. C. & Cutts, D. Experimental control of superstitious responding in humans. Journal of the Experimental Analysis of Behavior, 1963, 6, 203-208.

Chung, S. H. Effects of delayed reinforcement in a concurrent situation. _Journal of the Experimental Analysis of Behavior_, 1965, 8, 439-444.

Edwards, D. D., West, J. R., & Jackson, V. The role of contingencies is the control of behavior. _Psychonomic Science_, 1968, 10, 39-40.

Fenner, D. H. Key pecking in pigeons maintained by short-interval adventitious schedules of reinforcement. _Proceedings, 77th Annual Convention APA_, 1969, 831-832.

Ferester, C. B. Sustained behavior under delayed reinforcement. _Journal of Experimental Psychology_, 1953, 45, 218-224.

Ferester, C. B. Concurrent schedules of reinforcement in the chimpanzee. _Science_, 1957, 1090-1091.

Ferester, C. B. & Skinner, B. F. _Schedules of reinforcement_, New York: Appleton-Century-Crofts, 1957.

Grice, G. R. The relation of secondary reinforcement to delayed reward in visual discrimination learning. _Journal of Experimental Psychology_, 1948, 38, 1-16.

Harrison, R. & Nissen, H. W. Visual and positional cues in the delayed response of chimpanzee. _Journal of Comparative Psychology_, 1941, 31, 437-445.

Hearst, E. Effects of d-amphetamine on behavior reinforced by food and water. Psychological Review, 1961, 8, 301-309.

Hearst, E. Delayed alternation in the pigeon. Journal of the Experimental Analysis of Behavior, 1962, 5, 145-161.

Herrnstein, R. B. Superstition: A corollary of the principles of operant conditioning. In W. K. Honig (Ed.), Operant Behavior: Areas of Research and Application, New York: Appleton-Century-Crofts, 1966, 33-51.

Hodos, W., Ross, G. S. & Brady, J. V. Complex response patterns during temporally spaced responding. Journal of the Experimental Analysis of Behavior, 1962, 5, 473-479.

Kamin, L. J. Temporal and intensity characteristics of the conditioned stimulus. In W. F. Prokasy (Ed.), Classical Conditioning: A Symposium. New York: Appleton-Century-Crofts, 1965.

Keehn, J. D. & Chaudrey, S. Superstitious escape behavior during sidman avoidance training. Journal of the Experimental Analysis of Behavior, 1964.

Lane, H. Operant control of vocalization in the chicken. Journal of the Experimental Analysis of Behavior, 1961, 4, 171-177.

Laties, V. G., Weiss, B., Clark, R. L. & Reynolds, M. D. Overt "mediating" behavior during temporally spaced responding. Journal of the Experimental Analysis of Behavior, 1965, 8, 107-116.

Meltzer, D. & Brahlek, J. A. Conditioned suppression and conditioned enhancement with the same positive UCS: an effect of CS duration. Journal of the Experimental Analysis of Behavior, 1970, 13, 67-73.

Miczel, A. K. & Grossman, P. S. Positive conditioned suppression: effects of CS duration. Journal of the Experimental Analysis of Behavior, 1971, 15, 243-247.

Migler, B. Experimental self punishment and superstitious behavior. Journal of the Experimental Analysis of Behavior, 1963, 6, 371-385.

Morse, W. H. An analysis of responding in the presence of a stimulus correlated with periods of nonreinforcement. Unpublished doctoral dissertation, Harvard University, 1955.

Morse, W. H. & Skinner, B. F. A second type of superstition in the pigeon. American Journal of Psychology, 1957, 70, 308-311.

Neuringer, A. J. Superstitious key pecking after three peck-produced reinforcements. <u>Journal of the Experimental Analysis of Behavior</u>, 1970, 13, 127-133.

Nissen, H. W., Risen, A. H. & Nowles, V. Delayed responses and discrimination learning by chimpanzees. <u>Journal of Comparative Psychology</u>, 1938, 26, 361-386.

Perin, C. T. The effect of delayed reinforcement upon the differentiation of bar responses in white rats. <u>Journal of Experimental Psychology</u>, 1947, 37, 377-392.

Randolph, J. J. A further study of collateral behavior in humans. <u>Psychonomic Science</u>, 1965, 3, 227-228.

Rescorla, R. A. & Skuey, J. C. Effects of response independent reinforcers during extinction. <u>Journal of Comparative and Physiological Psychology</u>, 1969, 67, 381-389.

Schoenfeld, W. N., Cumming, W. W. & Hearst, E. On the classification of reinforcement schedules. <u>Proceedings of the National Academy of Science</u>, 1956, 42, 563-570.

Sidman, M. By-products of aversive control. <u>Journal of the Experimental Analysis of Behavior</u>, 1958, 1, 265-280.

Sidman, M. *Tactics of Scientific Research: Evaluating Experimental Data in Psychology*. New York: Basic Books, 1960.

Skinner, B. F. *The Behavior of Organisms*. New York: Appleton-Century-Crofts, 1938.

Skinner, B. F. Superstition in the pigeon. *American Journal of Psychology*, 1948, 70, 308-311.

Skinner, B. F. Are theories of learning necessary? *Psychological Review*, 1950, 57, 193-216.

Skinner, B. F. *Science and Human Behavior*. New York: Macmillan Company, 1953.

Stein, L., Sidman, M. & Brady, J. V. Some effects of two temporal variables on conditioned suppression. *Journal of the Experimental Analysis of Behavior*, 1958, 2, 153-162.

Wilson, M. P. & Keller, F. S. On the selective reinforcement of spaced-responding. *Journal of Comparative and Physiological Psychology*, 1953, 46, 190-193.

Zeiler, M. D. Fixed and variable schedules of response independent reinforcement. *Journal of the Experimental Analysis of Behavior*, 1968, 11, 405-414.