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THE EFFECTS OF REINFORCEMENT UPON THE PREPECKING BEHAVIORS OF PIGEONS IN THE AUTOSHAPING EXPERIMENT

A Thesis Presented

by

Michael Gibbs Wessells

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February, 1974

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ABSTRACT

The effects of repeated light-food pairings upon key peck acquisition in the pigeon autoshaping experiment are confounded with the effects of reinforcement upon behaviors which occur antecedent to the pecking response both inside and outside of the experimental setting. In Experiment I, acquisition of the key orient, the key approach, and the key peck was systematically monitored. The key orient and key approach behaviors frequently occurred in contiguity with food presentation prior to peck acquisition. In Experiment II, a negative contingency procedure was used to assess the sensitivity of the key approach to its consequences. When the key approach resulted in nonreinforcement, the probability of occurrence of the key approach decreased to zero despite repeated light-food pairings. Since the key approach is sensitive to its consequences, and since the key approach and the key peck are likely to be nonindependent under certain conditions, it is possible that key peck acquisition is determined by prior reinforcement of the key approach. In Experiment III, peck probability was shown to be related to the effects of prior reinforcement and nonreinforcement of the key approach. Response-reinforcer variables as well as stimulus-reinforcer variables must be included in an analysis of the autoshaping phenomenon.

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Brown and Jenkins (1968) first reported that response-independent, forward pairings of a briefly lighted key with food presentation reliably resulted in acquisition of the key peck in the pigeon. The operations of pairing a briefly lighted key with food presentation independently of the subject's behavior will hereafter be referred to as the response-independent procedure. The behavioral effects observed following exposure to the response-independent procedure show that the operations characteristic of Pavlovian conditioning procedures can be used to determine the probability of occurrence of directed skeletal behaviors. Brown and Jenkins (1968) and others (e.g., Gamzu and Williams, 1971) have shown that the stimulus variables known to determine the probability of occurrence of a conditioned response in more conventional Pavlovian conditioning preparations also exert strong control over the probability of key pecking in the response-independent procedure. Furthermore, the key pecking that results from pairing a briefly lighted key with food presentation has been shown to be nonoperant in that it is relatively insensitive to its consequences (Williams and Williams, 1969; Schwartz and Williams, 1972). Specifically, it was shown that even when pecks directed towards the lighted key cancelled food presentation, the probability of occurrence of the key peck remained quite high.

Although the pecking observed in the response-independent procedure shares important common properties with traditional Pavlovian conditioned responses, a potentially nontrivial difference lies in the antecedents of the pecking response both inside and outside of the experimental setting. Within the experimental setting, Brown and Jenkins (1968) noted (p. 3) that after ten or twenty pairings of the lighted key with food presentation, movement patterns controlled by the presence of the light had been conditioned. In contrast, acquisition of the key peck occurred following forty-five pairings on the average. Since the movement patterns were occurring in temporal proximity to food presentation, the operations definitive of operant conditioning (i.e., that a class of behaviors be followed by a reinforcer) were met with respect to these movement patterns prior to peck acquisition. Therefore, the effects of differential stimulus-reinforcer ($S\text{-}S^R$) pairings upon the acquisition of the key peck were confounded with the effects of reinforcement upon antecedent behaviors.

The likelihood that the confounding of $S\text{-}S^R$ variables with response-reinforcer ($R\text{-}S^R$) variables presents serious problems for an experimental analysis is increased by the consideration that the antecedent behaviors which occurred may be related to pecking, possibly as a function of

phylogenetic as well as ontogenetic antecedents. For example, in the ontogeny of the White Carneaux pigeon, certain behaviors such as visual orienting and approaching may be assumed to frequently precede the occurrence of a peck that has the consequence of food ingestion. Under species-typical feeding conditions, the orient and approach behaviors which are directed towards some localized stimulus are reinforced only when pecks directed to that same stimulus are emitted. Therefore, if any of these behaviors were directed to some stimulus and were followed by food ingestion, then one would predict that there would subsequently be an increased probability of occurrence of all three directed behaviors in the presence of that stimulus. In other words, the behavioral components of the sequence of feeding behaviors are likely to be nonindependent under conditions such that any of the components are followed by food ingestion. One common situation in which such conditions are clearly present is that where the peck is shaped through successive approximations. There, increases in the probability that a key peck will occur are easily brought about by reinforcing approaches to the key.

Such considerations suggest that the behavioral effects observed following exposure to the response-independent procedure may result from complex interactions of the effects of both $S\text{-}S^R$ variables and $R\text{-}S^R$ variables. The

purpose of the experiments described below was to describe rigorously the occurrence of key-directed behaviors which reliably precede acquisition of the key peck in the response-independent procedure, and to analyze experimentally the effects of reinforcement upon one of the antecedent directed behaviors.

Experiment I

In previous pilot experiments in which a response-independent procedure was used, the author made casual yet extensive observations of the behaviors of pigeons other than those who served in this experiment. No clear effects of reinforcement of antecedent behaviors upon the probability of occurrence of the key peck were discernible. However, for each subject, certain key-directed behaviors reliably occurred prior to the acquisition of the key peck. All key-directed behaviors seemed to fall into one of three descriptive categories. These categories were not formulated on the basis of a priori considerations; the categories most completely described all of the key-directed behaviors which had been observed.

The purpose of this experiment was to systematically monitor the acquisition in the response-independent procedure of the three most obvious directed behaviors that had been reliably observed by the author in previous experiments. Although data obtained from systematic

observation may sometimes be subject to the criticism that they are too much a product of the peculiar reinforcement histories of the observers, failure to systematically observe behavior may result in the confusion of the inconspicuousness of the effects of certain variables with the lack of effects of those variables.

METHOD

Subjects. The subjects used were three experimentally naive White Carneaux pigeons, three to nine months old, who were bred from stock originally obtained from the Palmetto Pigeon Plant. Each subject was maintained at 80% of his ad lib weight for the duration of the experiment.

Apparatus. A standard Lehigh Valley experimental chamber for pigeons was used. Standard programming and recording equipment were located in an adjacent room. White noise was constantly delivered through a speaker mounted on the front wall, and the sound of the ventilating fan of the chamber provided additional masking noise. Diffuse illumination was constantly provided by a houselight located centrally on the front wall, one inch from the ceiling. The houselight was a G-E 44 bulb operated at 6 v dc. The bulb was unhoused so as to allow for sufficient illumination for recording purposes. The hole for the observation window of the chamber was covered on the inside by a sheet of transparent plexiglass and on the outer surface by a one-way window.

Of the two keys mounted on the front panel, only the left was used in the experiment. The stimulus projected on the key was a white line on a black background. The stimulus was selected from one of eight, six volt lamps housed in an in-line display cell (Industrial Electronics Engineers). The following angular orientations of the white line were used: 8.2°, 24.6°, 32.8°, 41.0°, 49.2°, 57.4°, 73.8°, and 90.0°.

The behaviors of the subjects were recorded by using the following Sony video taping equipment: AVC-3200 camera, AV 3650 recorder with slow motion capabilities, and CVM-9204 monitor. During each session, the camera was located at a constant point outside of the observation window of the chamber.

Procedure. Each subject was placed in the chamber for fifteen minutes on successive days. The chamber was illuminated only by the light housed inside the feeder aperture, and mixed grains were continuously available. This procedure continued until the subject ate from the hopper. During the next session, the houselight was turned on and the subject was trained to approach and eat from the hopper readily. Food was presented independently of the subject's behavior according to a VI 30" schedule (Fleshler and Hoffman, 1962). Duration of food access was progressively decreased to four seconds, at which point it was held

constant throughout the experiment. During these magazine training sessions, the key remained darkened.

Following magazine training, each subject was exposed to a response-independent procedure. Occurring at the same 30-second variable intervals used in hopper training were twenty trials consisting of a six second illumination of the key followed immediately by four seconds of access to grain. During these trials, hereafter referred to as S^+ trials, the 41.0° white line was projected on the key. Randomly interspersed among the twenty S^+ trials were seven presentations of the lighted key alone. During these unpaired key light presentations, a white line of orientation other than 41.0° was presented. Each of the seven other stimuli was presented once in each session and the order of presentation was random. These seven stimuli were presented so that the stimulus control of key-directed behaviors could be assessed. The stimulus control data are not directly relevant to this report and so they will be described in a forthcoming manuscript (in preparation).

During either type of trial, no behaviors had any programmed consequences. During the intertrial interval, the key remained darkened and those pecks which resulted in microswitch closures delayed the onset of the next trial by five seconds.

Procedure for Describing Behaviors. Following the experimental session, the video taped record of intratrial

behaviors was displayed in slow motion (one-tenth of normal playback speed). On a table directly in front of the seated observer was a panel upon which were mounted sixteen push buttons, each of which corresponded to a particular category of behavior. The video monitor was located at the other end of the table and faced directly towards the observer at all times. Each response of the observer was fed directly into an eight-channel, binary coded, tape punch unit which automatically recorded the time between successive events to the nearest tenth of a second. This taped record provided information concerning both the frequency and duration of each behavior, and provided a record which was easily analyzable by computer.

Behaviors were described as belonging to one of sixteen categories which were quite similar to those used by Staddon and Simmelhag (1971). The major difference was that here, three categories of key-directed behaviors were used. Only the key-directed behaviors will be described fully since they are of major concern in this experiment.[1] Those behaviors were: (1) the key orient, (2) the key approach, and (3) the key peck.

The key orient should not be confused with the orienting reflex discussed by Sokolov (163). The key orient included two clearly discriminable types of response, both of which could be described as "looking towards the key." The first type consisted of a brief cessation of movement

[1]See Appendix A for a discussion of all behaviors.

following a turning of the beak towards the key. During this binocular orientation, the subject's beak pointed directly towards the key. The second type consisted of a turning of the head such that one of the subject's eyes directly faced the key. For the latter response, all head and trunk movements ceased momentarily, and the one eye was held at the same height as the key. The topography of the key orient provided to be quite discernible during the slow-motion playback, and so no mentalistic guessing as to whether or not the subject actually "saw" the key was required of the observers or implied in the description. The key approach consisted of any movement of the head or trunk which brought the subject relatively closer to the key. The key peck consisted of any pecking movement which was directed towards the key.

Although there is a large degree of overlap between these categories, they were treated as if they were mutually exclusive so as to allow finer discriminations between behaviors to be made. For example, all key pecks are also key approaches, but to describe pecks as approaches would result in inability to discriminate approaches occurring antecedent to key peck acquisition from the later key pecks.

RESULTS

Table I shows for each subject the frequency with which directed behaviors occurred within successive two-second segments of S^+ trials over successive blocks of

five S^+ trials. Table I shows that over S^+ trials, there was an increased frequency of occurrence of the key orient, the key approach, the orient-approach sequence, and the key peck within each segment of S^+ trials. Although key peck acquisition occurred after different numbers of S^+ trials for different subjects, in each case there were clear increases in the frequency of occurrence of all non-pecking directed behaviors prior to peck acquisition. It is important to note that these nonpecking directed behaviors were occurring with increased frequency in the third segment of the S^+ trials.

Insert Table One About Here

Since these directed behaviors occurred in temporal contiguity with food presentation and increased in frequency of occurrence, the conditions which define operant conditioning were met with respect to those behaviors. Examination of the records revealed that even though these directed behaviors occurred frequently in the final two-second segment, there was little increase in the frequency with which key-directed behaviors occurred as the last intratrial behaviors. This finding is consistent with the observations of Rachlin (1969). He photographed his subjects at the moment of food presentation in a response-

independent procedure, and he found that key-directed behaviors did not reliably occur just prior to the reinforcer before the acquisition of the key peck.

Figure 1 shows that the increased frequency of occurrence of the orient-approach sequence found in the third trial segment appeared before the acquisition of the key peck. To emphasize this fact, the cumulative frequency of key pecking across all S^+ trials is shown. For P5 and P2, key peck acquisition occurred soon after the orient-approach sequence increased in frequency while for P11, the course of key peck acquisition did not follow so closely the change in frequency of that sequence. The occurrence of

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Insert Figure One About Here

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key peck acquisition in each subject following the frequent occurrence of the orient-approach sequence contiguously with food presentation may be the result of a reinforcement history such that the conditions under which orienting to and approaching towards food-related stimuli were reinforced were also those under which successful pecks directed at the food-related stimuli occurred. Once key peck acquisition occurred for each subject, the orient-approach-peck sequence which is emitted in response to food-related stimuli under typical feeding conditions occurred soon

after the start of virtually every trial.

Comparison of the data presented in Figure 1 with those of Table I shows that for each subject, the increase in the frequency of occurrence of the orient-approach sequence took place at the same point and followed the same trend as the increase in frequency of the individual components. The decreased frequency of occurrence of the orient-approach sequence which occurred following key peck acquisition resulted from the treatment of the directed behaviors as mutually exclusive. That is, once key peck acquisition occurred, the subjects were most often positioned directly in front of the key and were pecking so that by definition, the key approach occurred with decreased frequency.

P11 pecked the key upon the very first S^+ trial, although reliable acquisition did not occur until later. Prior to key peck acquisition, all subjects oriented to and pecked at different environmental stimuli such as the houselight and the speaker. Such observations are consistent with those made by Skinner (1948) and by Staddon and Simmelhag(1971) in showing that directed behaviors occur with high probability in intermittent, free-feeding situations even apart from explicit $S\text{-}S^R$ pairings.

For the determination of interobserver reliability, forty trials during which behaviors were scored by two observers were selected randomly from all trials scored by

both. Trials scored by both observers were treated as a pair of observations in the computation of the correlation between the frequencies of occurrence of each behavior as scored by the two observers. The correlation coefficient (r) for the key orient was .87. For the key approach, the value of r was .93, and for the key peck, the value of r was .99. All correlations were highly significant ($p < .01$). Thus, interobserver reliability was very high for all directed behaviors.

Experiment II

The effects of the occurrence of the key orient and key approach behaviors in temporal proximity to food presentation are unclear since these events are confounded with the increased number of stimulus-reinforcer pairings. Perhaps the entire orient-approach-peck sequence of feeding behaviors typically observed in the pigeon is directly generated by repeated light-food pairings. If that view were valid, then the orient and approach behaviors should be relatively insensitive to their consequences, as the key peck appears to be (Williams and Williams, 1969; Schwartz and Williams, 1972) under conditions of light-food pairings. If the orient and approach behaviors were insensitive to their consequences, then the confounding of $S\text{-}S^R$ variables with $R\text{-}S^R$ variables inherent in the response-independent procedure would have trivial consequences.

The purpose of Experiment II was to determine the extent to which the key approach is sensitive to its consequences. Accordingly, a negative contingency procedure similar to that used by Sheffield (1965) and by Williams and Williams (1969) was employed.

METHOD

Subjects. Two White Carneaux pigeons at 80% of their ad lib weight served. One of them was P5 from Experiment I.

Procedure. The apparatus and magazine training procedures were the same as in Experiment I. Following magazine training, each subject was exposed to daily experimental sessions identical to those of the first experiment. Following three successive sessions during which at least one key peck occurred on 90% of the S^+ trials, the response-independent procedure was terminated and the negative contingency procedure for the key approach was begun. Under the negative contingency procedure, the S^+ was presented intermittently as before, but the number of trials per session was increased to forty. The S^+ remained on for six seconds and was followed immediately by four seconds of access to grain if and only if no key approach occurred during that particular trial. Whenever an intratrial key approach occurred, the key light was immediately turned off and food was not presented. The time at which trials were presented was independent of intratrial behaviors, but trial onset was delayed for five seconds by an intertrial

key peck.

The environmental manipulations were determined by the operations of a handswitch by the author, who viewed the behavior through the observation window of the chamber. A key approach was defined as any movement which brought any part of the subject's body within the predefined front, left quarter of the chamber. The chamber was divided into quarters by the intersection of two imaginary planes lying at right angles to each other and both lying perpendicular to the floor. One plane was perpendicular to the front panel and intersected the front panel one-quarter inch to the left of the leftmost edge of the feeder aperture. The other plane ran perpendicular to the observation window and bisected that window. The front left quarter was that which included the area closest to the key on the left side of the chamber. If the subject were in the left quarter of the chamber at the onset of a trial, the key approach was then defined as the slightest detectable movement towards the key. On all trials, the occurrence of the key orient was observed and recorded, but this behavior had no programmed consequences. The key orient was defined as in Experiment I.

RESULTS

Figure 2 shows the percentage of trials on which the key orient and key approach behaviors occurred within each session. For both subjects, the key approach was totally

eliminated by the negative contingency. This apparent sensitivity of the key approach to its consequences was not confounded with a decrease in the functional pairings

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Insert Figure Two About Here

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of the key light with food since the key orient did not drop out simultaneously. The fluctuations in the percentage of trials on which at least one key orient occurred for P17 were transient. Also, the number of pairings of the key light with food presentation was inversely related to the number of trials on which a key approach occurred. As the key approach dropped out, the number and frequency of light-food pairings increased correspondingly. Since this increased number and frequency of light-food pairings did not result in a corresponding increased frequency of the key approach, it may be concluded that the approach was in fact strongly controlled by its consequences.

During the last sessions of this experiment, the intratrial behaviors of both subjects were very similar. Between trials, each subject was most frequently pacing back and forth in front of the observation window. These pacing movements were interrupted by frequent key orients. At trial onset, a key orient was followed immediately by locomotion to the right front quarter of the chamber.

There, the subject paced along the front wall with his head held high. Pacing was interrupted only by the occurrence of the key orient. When the key orient occurred, the subject most often left his feet motionless and pulled his head out from the front wall. Pacing was resumed following such a key orient. These behaviors were highly stereotyped, and so acquisition of behaviors incompatible with the key approach may be an essential condition for the effectiveness of this negative contingency procedure.

The important point is that the approach component of the orient-approach-peck sequence was strongly affected by its consequences. Therefore, the confounding of S-S^R pairings with approach-reinforcer pairings inherent in the response-independent procedure does indeed introduce a serious impediment to an analysis of the variables controlling the probability of occurrence of the key peck.

EXPERIMENT III

In the response-independent procedure, the effects of S-S^R and R-S^R variables are not only seriously confounded, but additionally, the locus of the effects of those variables is indeterminate since several behaviors are conditioned. Since the approach component of the orient-approach-peck sequence is sensitive to its consequences, and since the approach is likely to be nonindependent of the peck for reasons described earlier, then perhaps the probability of occurrence of the key peck in the response-

independent procedure is determined by the antecedent effects of reinforcement contingencies upon the key approach.

According to this view of peck acquisition, when a pigeon has oriented towards the key light and has approached that light, the probability of occurrence of a key peck is dependent upon the prior reinforcement or extinction of the approach response in the presence of that stimulus. The purpose of the third experiment was to test this view by using a procedure in which the key approach was followed immediately by the presentation of either stimulus S^+ or stimulus S-. In the presence of S^+, the key approach had been previously reinforced while in the presence of S-, the key approach had never been reinforced. If the probability of occurrence of the keypeck is determined at the time of the key approach by the presence of stimuli correlated with the prior reinforcement or nonreinforcement of the approach response, then key peck probability should be high in the presence of S^+ but low in the presence of S-.

METHOD

Subjects. The subjects were three experimentally naive White Carneaux pigeons maintained at 80% of their ad lib weight for the duration of the experiment.

Procedure. The apparatus used was the same as in the preceding experiments. Magazine training was conducted

as previously except that training included two additional sessions during which the average interval between successive food presentations was increased to sixty seconds. The duration of food presentation was held constant at four seconds for the entire experiment. Entrance into the left front quarter (as defined earlier) of the chamber was prohibited by the presence of a transparent barrier made of one-quarter inch plexiglass. The placement of the plexiglass wall required only minor modifications of the typical bodily position of a pigeon eating from the grain hopper. The wall prohibited the occurrence of complete approaches to the area directly in front of the key. Use of the wall in pilot work by the author facilitated the discrimination of effects upon approaching from those upon pecking and vice versa. The results of the pilot study showed that key-directed pecks do occur in a response-independent procedure even when the wall is blocking the full key approach. However, peck acquisition occurred only after extended exposure to the response-independent procedure, and it did not occur in all subjects used. Since for all subjects there was a period of several sessions during which the key light controlled approach behavior but not pecking, no variables could directly affect the key peck during that period.

The first five sessions (Phase I) following magazine training consisted of eighty, six-second presentations of

a lighted key with an average intertrial interval of thirty seconds. On half of these trials, a green light (S^+) appeared on the left key and was followed immediately by food presentation. On the other half of the trials, a white light (S_-) appeared on the key and was not followed by food presentation. The order of presentation of the stimuli was random except that no more than three successive occurrences of either stimulus could occur. No behaviors of the subject had programmed consequences.

In the sessions following the first five, the plexiglass wall was removed from the chamber so that the subject could approach to that area closest to the key. The first session (Phase II) following the removal of the plexiglass wall consisted of thirty presentations on the left key of a 41.0° white line on a black background. The white line stayed on for six seconds and was followed immediately by food presentation. The average intertrial interval was thirty seconds in duration. All events in this phase were response-independent. The purpose of this phase was to ensure that each subject reliably approached and pecked a stimulus other than those used in the preceding phase.

Following Phase II were three, forty trial sessions (Phase III) during which three types of trials could occur. These three types are illustrated in Figure 3. Which of the three trial types occurred was partially dependent upon

the occurrence of an intratrial key approach. Following an average intertrial interval of thirty seconds, a trial was begun by the presentation of the white line on the key. If and only if no key approach occurred in the presence of the white line, the white line was left on the key for six seconds and was followed immediately by the reinforcer. But if the subject approached the key in the presence of the white line, the white line was immediately replaced on the key by either the S^+ or the S- from Phase I. The probability of presentation of either S^+ or S- was .50 on any trial during which an approach occurred. Their order of presentation was random except that neither could occur more than three times successively. Both S^+ and S- were of five second duration. The green light was immediately followed by the response-independent occurrence of the reinforcer while the white light was never followed by the reinforcer.

Insert Figure Three About Here

The key approach was defined as before. The stimulus changes which occurred contingent upon the key approach were controlled by the handswitch operations of the author. The dependent variable of primary interest in Phase III was the probability with which key pecks occurred in the presence of the green and white stimuli. All

intratrial pecks were recorded by the author.

RESULTS

Figure 4 shows the number of S^+ and S- trials from Phase III on which at least one key peck occurred within each successive block of five S^+ and S- trials, respectively, for each subject. Each subject pecked at the green stimulus upon the very first presentation of that stimulus as well as on each later presentation. Conversely, each subject halted and abruptly turned away from the key upon the very first presentation of S- as well as on almost all subsequent S- presentations. The immediacy of the effects observed in Phase III is crucial for the interpretation of the data presented below. As Figure 4 shows, pecking occurred very infrequently in the presence of the S-, and P8 never pecked in the presence of S-.

Insert Figure Four About Here

Observation of each subject during Phase I revealed that intratrial key approaches occurred with increasing frequency in the presence of both S^+ and S- during the first few sessions. Those key approaches almost invariably consisted of locomotion to the area where the plexiglass wall intersected the front panel of the chamber. Such locomotion brought the subject as close to the key as

possible under the conditions of Phase I. While in that area, the subject's beak was often pointing directly towards the lighted key and head-bobbing frequently occurred. During the first sessions of Phase I, the approaches were paired with food presentation in the presence of S^+ but not in the presence of S-. Therefore, the conditions definitive of operant discrimination training were met with respect to the key approach. During the final sessions of Phase I, differentiation of the key approach occurred. In the presence of S^+, each subject approached the key on every trial. The number of S- trials on which a key approach occurred decreased across successive blocks of S- trials. In Phase I, no subject emitted pecks directed to an area of the chamber other than the floor. This result is consistent with data from the pilot study earlier referred to.

A more rigorous description of the behaviors which occur under Phase I conditions is presented in Figure 5. The data shown in Figure 5 were collected from two subjects who did not serve in Experiment III but who had the same experimental history and treatment as the subjects in Phase I of Experiment III. The only programmed difference was that the white light was now S^+ and the green light was S-. The sequences of behaviors found across sessions for both P18 and P19 were similar to those of the subjects in the experiment proper. So the differential occurrence

and nonoccurrence of the key approach in the presence of S^+ and S- was not peculiar to some unconditioned effect of either the green or the white stimulus.

Insert Figure Five About Here

In the single session of Phase II, each subject pecked the key in the presence of the white line within the first fifteen trials. Also, each subject emitted a key peck on each of the last ten trials of the session. The facilitation of key peck acquisition which thus occurred following Phase I was probably due to the fact that the subjects were already highly controlled by stimuli presented on the key.

In Phase III, each subject approached the key in the presence of the white line on almost every trial. P6 and P7 approached during every trial, while P8 did not approach on the first two trials of the second session of Phase III. Since the probability of occurrence of the key approach was so high in the presence of the white line, the subjects did not come into contact with the contingency whereby nonemission of an intratrial key approach was always followed by food presentation.

Even though each subject approached in the presence of the white line, the probability of occurrence of a key peck was clearly a function of the stimulus conditions which

prevailed following the initiation of the key approach instead of the stimulus conditions which prevailed at the time of initiation of the key approach. If peck probability were determined by the stimulus conditions which prevailed at the time of initiation of the key approach, then peck probability would have been the same in the presence of both S^+ and S-. Since pecking did not occur in Phase I, the differential effects of the S^+ and S- in Phase III cannot be attributed to the direct effects of variables in Phase I upon the keypeck. Since the effects found in the last phase were immediate, they were not the result of effects associated with presenting stimuli from Phases II and I in a successively compound manner. The results of Experiment III therefore support the view that the probability of occurrence of the keypeck is affected during the occurrence of the approach response by the presence of stimuli correlated with prior reinforcement and extinction of the key approach.

In Phase III, each subject very rarely pecked in the presence of S- while pecks in the presence of S^+ occurred reliably. With respect to the key peck, the acquisition of the green-white discrimination might therefore be described as errorless. However, the errorless pecking performance may be considered to have resulted from the transfer of the effects of reinforcement and nonreinforcement

of the key approach to the key peck. The implication is that in some situations, an apparently errorless discrimination may actually be the result of prior reinforcement and nonreinforcement of a nonindependent, antecedent behavior.

GENERAL DISCUSSION

The results of the above experiments suggest that in the response-independent procedure, highly complex stimulus-response-reinforcer interactions occur even before key peck acquisition takes place. The interactions which occur are likely to seem especially complex since the responses which are conditioned are probably nonindependent as a result of the prior developmental and reinforcement histories of the pigeon. Since several directed behaviors are conditioned as a result of repeated light-food pairings, a variable which appears to affect a particular behavior directly may instead affect that behavior indirectly by exerting a direct effect upon a related, antecedent behavior. That is, different key-directed behaviors may be differentially affected by the same variable. The complexity arises when the effects of that variable provide the conditions under which other variables may then exert effects upon behavior. In the response-independent procedure, unprogrammed but reliably occurring $R\text{-}S^R$ pairings may continuously interact with $S\text{-}S^R$ variables. Therefore, an

analysis of the effects of S-S^R variables upon the key peck without consideration of the interaction of the effects of both S-S^R and R-S^R variables upon the antecedent orient and approach behaviors is likely to be incomplete.

Before one can present an interpretation of key peck acquisition in the response-independent procedure based upon consideration of both S-S^R and R-S^R pairings, a consideration of the reinforcement history of the pigeon's feeding behavior is absolutely necessary. Under the species-typical feeding conditions of the pigeon, food-related stimuli which are both localized and visual are provided directly by the food source. Necessarily, the pigeon must orient to, approach towards, and peck at the food-related stimuli in order for food ingestion to occur. In other words, the stimulus in whose presence the orient is reinforced is also the stimulus in whose presence the approach is reinforced. Also, the stimulus in whose presence the approach is reinforced is that in the presence of which the peck is reinforced.

In the response-independent procedure, the locus of the food-related stimulus has been shifted from the food source itself to the key. As a result of this shift, the responses of orienting and approaching towards the food-related stimulus (the key light) can be and are followed by food ingestion in the absence of pecks at the food-related, key light stimulus. Since the subjects have an

extensive history of reinforcement for approaching a localized, food-paired stimulus in whose presence they have been previously reinforced for orienting to, the probability of an approach to that stimulus is increased. Then the subject is orienting to and approaching towards the food-related stimulus, and both behaviors are followed by food ingestion even though no pecks to the stimulus have occurred. Since the subjects have extensive histories such that a food-related stimulus in whose presence the approach is reinforced is also that in the presence of which the peck is reinforced, the probability of pecking at the food-related stimulus is increased. The peck and the approach responses should be highly interrelated not only because of similar reinforcement histories but also because the peck is a subset of the general class of approach behaviors. Once the peck occurs, it is paired with the reinforcer, and so the future probability of occurrence of a peck is increased. Under the latter conditions, the orient, approach and peck components of the typical feeding sequence should occur with increased probability in the presence of the food-related stimulus.

Stimulus-reinforcer variables probably exert differential effects upon the various directed behaviors which occur in the response-independent procedure. For example, the results of Experiment II showed that light-food pairings

do not exert strong control over the key approach. In Experiment II, when an intratrial key approach resulted in nonreinforcement, the probability of occurrence of the key approach decreased to zero even though repeated light-food pairings were occurring. Also, the results of Experiment III suggest that the contingencies of reinforcement for the key approach affect the probability of occurrence of the keypeck. $S\text{-}S^R$ variables probably exert their greatest effects upon the key orient. The key orient is probably crucial because it is the interaction of the effects of $S\text{-}S^R$ and $R\text{-}S^R$ variables upon that behavior which leads ultimately to the conditions under which peck acquisition occurs.

According to this view, the probability of occurrence of the key peck in the response-independent procedure is affected by prior effects of reinforcement upon the non-independent key approach. If variables affecting the key approach simultaneously affect the key peck (and this effect is exactly that which is commonly made use of in hand-shaping the key peck through successive approximations), then the key peck will appear to be sensitive to its consequences only under conditions where the consequences of both the approach and the peck are either positive or negative. This consideration suggests that the insensitivity of the key peck to its consequences described by Williams

and Williams (1969) may only be apparent. For example, even when pecking is nonreinforced, its probability of occurrence may remain high despite the negative consequences, if, under those same conditions, the key approach is sometimes reinforced. Observations made by the author of several pigeons behaving in a negative contingency for key pecking situation as similar as possible to that used by Williams and Williams (1969) showed that the subjects approached the key on virtually every trial. Since pecks did not occur on all trials, the key approach intermittently occurred in temporal contiguity with the reinforcer. The latter conditions are precisely those which preceded key peck acquisition in the first and third experiments described above. The nonreinforcement of the key approach that results from the occurrence of the key peck has the effect of decreasing the probability of occurrence of the key peck (since the peck has been shown in many cases to be sensitive to its consequences). Then the stimulus is again paired with the reinforcer, the key approach occurs contiguously with the reinforcer with increased frequency, and soon the probability of occurrence of the key peck is again increased. The cycle is self-perpetuating under conditions in which the stimulus on the key is constant for all behaviors. However, the results of Experiment III showed that if the subject were presented

with stimuli which signalled whether or not his approach would be reinforced, then peck probability would vary accordingly.

A complete account of autoshaping in the pigeon cannot yet be given. The effects of reinforcement upon antecedent behaviors should be investigated if a complete behavioral analysis is to be forthcoming. Clearly, any account of the phenomenon based solely upon stimulus-reinforcer variables or solely upon response-reinforcer variables is premature. If the account of autoshaping in the pigeon presented above is valid, then generalizations based on data obtained from pigeons may have limited applicability to species having vastly different feeding behaviors. Such a consideration also applies to situations other than those in which food presentation is the reinforcer.

REFERENCES

Brown, P. and Jenkins, H. Autoshaping of the pigeon's key peck. Journal of the Experimental Analysis of Behavior, 1968, 11, 1-8.

Fleshler, M. and Hoffman, H. S. A progression for generating variable-interval schedules. Journal of the Experimental Analysis of Behavior, 1962, 5, 529-530.

Gamzu, E. and Williams, D. Classical conditioning of a complex skeletal response. Science, 1971, 171, 923-925.

Rachlin, H. Autoshaping of key pecking in pigeons with negative reinforcement. Journal of the Experimental Analysis of Behavior, 1969, 12, 521-531.

Schwartz, B. and Williams, D. The role of the response-reinforcer contingency in negative automaintenance. Journal of the Experimental Analysis of Behavior, 1972, 17, 351-357.

Sheffield, F. D. Relation between classical conditioning and instrumental learning. In W. F. Prokasy (Ed.), Classical Conditioning. New York: Appleton-Century-Crofts, 1965. pp. 302-322.

Skinner, B. F. "Superstition" in the pigeon. Journal of Experimental Psychology, 1948, 38, 168-172.

Sokolov, E. N. Higher nervous functions: The orienting reflex. Annual Review of Physiology, 1963, 25, 545-580.

Staddon, J. E. R. and Simmelhag, V. The superstition experiment: A reexamination of its implications for the principles of adaptive behavior. Psychological Review, 1971, 78, 3-43.

Williams, D. R. and Williams, H. Automaintenance in the pigeon: Sustained pecking despite contingent nonreinforcement. Journal of the Experimental Analysis of Behavior, 1969, 12, 511-520.

FIGURE LEGENDS

Fig. 1. The frequency of occurrence of the orient-approach sequence (circles) and the key peck (squares) over S^+ trials. The circles show the frequency with which the orient-approach sequence occurred within the final 2.0 sec. segment of blocks of five S^+ trials. The squares show the cumulative frequency of occurrence of the key peck over all S^+ trials. Each graph shows data collected from a single subject.

Fig. 2. The percentage of trials on which the key orient (squares) and key approach (circles) behaviors occurred during the negative contingency for approach procedure. The first point on the graph shows the data from the last session of the response-independent procedure. Each graph is for a single subject.

Fig. 3. The three types of trial which could occur during Phase III.

Fig. 4. The number of trials on which a key peck occurred within successive blocks of five S^+ and S- trials during Phase III. Circles show the number of S^+ trials on which at least one key peck occurred while the squares show the number of S- trials on which a peck occurred. Each graph shows data for a single subject.

Fig. 5. The number of trials on which a key approach occurred during a procedure identical to Phase I. Each session consisted of 40 S^+ trials and 40 S- trials. The

circles show the number of S^+ trials on which a key approach occurred; the squares show the number of S- trials on which a key approach occurred. Each graph shows data for a single subject.

Table I. The frequency of occurrence of key-directed behaviors within successive 2.0 sec. segments of S^+ trials over successive blocks of five S^+ trials. Different numbers of S^+ trials are shown for each subject since the acquisition of the key peck occurred at different rates between subjects. O = Key orient. A = Key approach. O-A = Orient-approach sequence. P = Key peck.

TABLE I

P5

S^+ Trial Block	Trial Segment											
	0 sec.-2 sec.				2 sec.-4 sec.				4 sec.-6 sec.			
	O	A	O-A	P	O	A	O-A	P	O	A	O-A	P
1	1	0	0	0	1	1	0	0	3	2	1	0
2	0	0	0	0	2	4	0	0	5	2	2	0
3	4	0	0	0	2	0	0	0	0	1	0	0
4	2	0	0	0	0	0	0	0	2	1	0	0
5	4	1	0	0	3	2	1	0	0	2	0	0
6	3	1	1	0	2	2	0	0	0	1	0	0
7	2	0	0	0	7	2	2	0	4	3	2	0
8	3	1	1	0	6	3	2	0	3	2	1	0
9	3	2	0	0	6	4	3	0	6	3	2	0
10	8	3	2	0	6	2	1	0	6	4	4	0
11	7	3	2	0	5	3	1	0	13	7	7	1
12	6	3	3	0	6	4	4	2	13	4	4	3
13	16	7	7	1	10	1	1	7	16	7	5	8
14	9	3	3	2	9	2	2	6	12	6	5	12
15	11	5	5	2	10	3	3	7	15	2	2	13
16	14	5	5	7	7	0	0	16	8	0	0	16
17												
18												
19												
20												
21												
22												
23												
24												

TABLE I

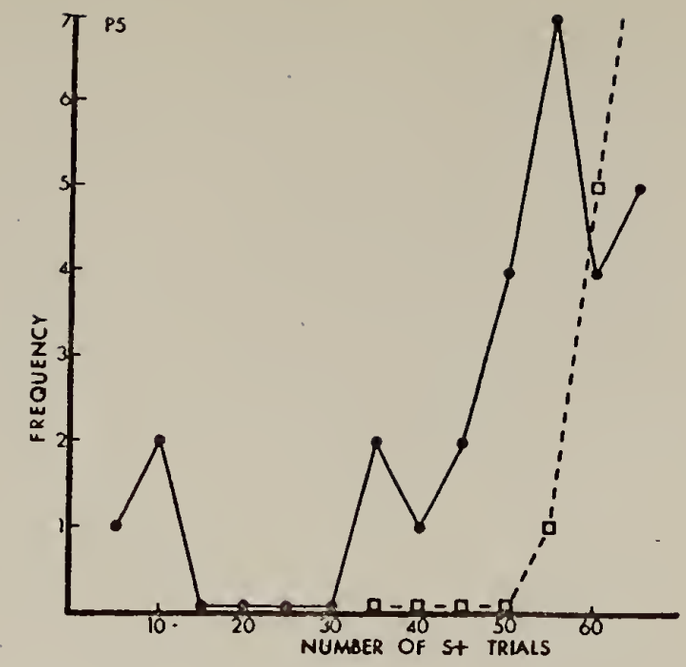
P11

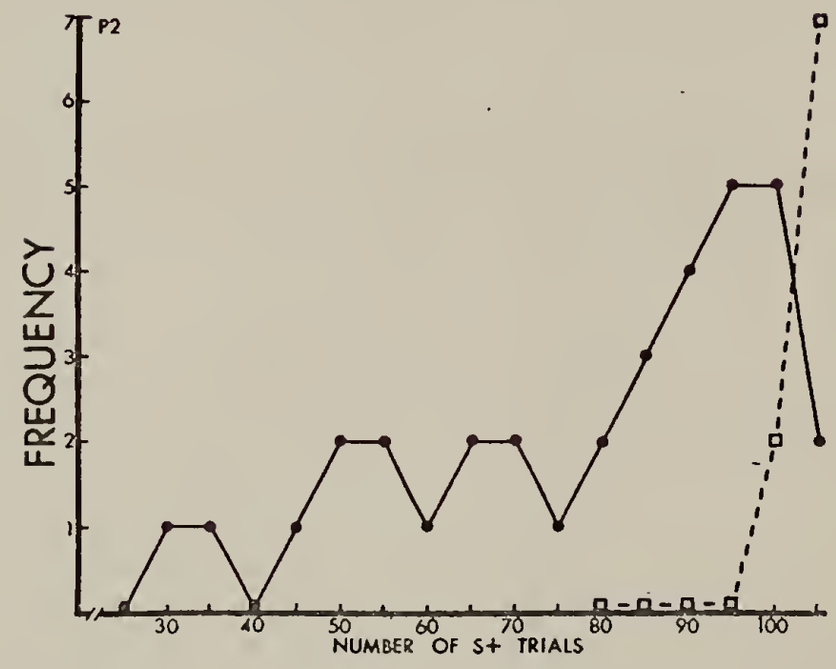
S^+ Trial Block	Trial Segment											
	0 sec.-2 sec.				2 sec.-4 sec.				4 sec.-6 sec.			
	O	A	O-A	P	O	A	O-A	P	O	A	O-A	P
1	13	5	2	1	4	2	2	0	6	5	2	0
2	2	4	1	0	10	6	4	0	6	4	4	0
3	9	5	4	0	9	4	4	0	10	8	7	0
4	13	7	7	0	10	5	4	0	11	6	6	0
5	12	4	1	0	12	4	4	0	10	7	7	0
6	19	6	6	1	11	5	5	4	12	6	4	2
7	15	5	4	3	10	3	3	5	13	5	5	4
8	12	4	3	4	12	3	3	6	10	1	1	9
9	11	6	5	9	6	0	0	12	6	0	0	18
10	11	5	5	18	7	2	2	20	7	1	1	29
11	12	5	5	13	7	0	0	22	6	0	0	26
12	13	5	5	9	3	0	0	21	7	0	0	31
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												

TABLE I

P2

S^+ Trial Block	Trial Segment											
	0 sec.-2 sec.				2 sec.-4 sec.				4 sec.-6 sec.			
	O	A	O-A	P	O	A	O-A	P	O	A	O-A	P
1	1	1	0	0	1	2	0	0	2	0	0	0
2	7	4	3	0	1	0	0	0	3	0	0	0
3	2	0	0	0	5	3	1	0	5	2	0	0
4	1	3	0	0	0	1	0	0	0	0	0	0
5	0	0	0	0	1	1	0	0	0	0	0	0
6	2	0	0	0	1	1	1	0	1	2	1	0
7	1	2	0	0	1	2	0	0	3	0	1	0
8	4	2	2	0	2	2	1	0	1	0	0	0
9	0	2	0	0	0	1	0	0	3	1	1	0
10	1	1	1	0	4	2	0	0	6	3	2	0
11	5	3	2	0	4	2	2	0	3	3	2	0
12	1	1	0	0	2	1	1	0	2	1	1	0
13	4	3	2	0	2	1	0	0	3	1	2	0
14	7	1	0	0	3	2	1	0	4	2	1	0
15	4	2	2	0	3	2	2	0	2	1	2	0
16	3	0	0	0	7	2	2	0	4	2	2	0
17	5	6	2	0	5	2	3	0	6	3	3	0
18	12	4	3	0	4	4	4	0	10	4	4	0
19	8	5	5	0	8	4	4	0	8	6	5	0
20	12	8	7	1	8	5	4	0	8	4	5	1
21	7	4	4	1	10	5	4	2	10	2	2	5
22	10	3	3	2	10	3	3	5	10	3	4	6
23	15	5	5	8	9	5	3	3	12	5	4	3
24	10	6	5	10	11	3	4	5	10	4	4	5


P5
FREQUENCY
1
2
3
4
5
6
7
10
20
30
40
50
60
NUMBER OF S+ TRIALS


P2
FREQUENCY
1
2
3
4
5
6
7
30
40
50
60
70
80
90
100
NUMBER OF S+ TRIALS

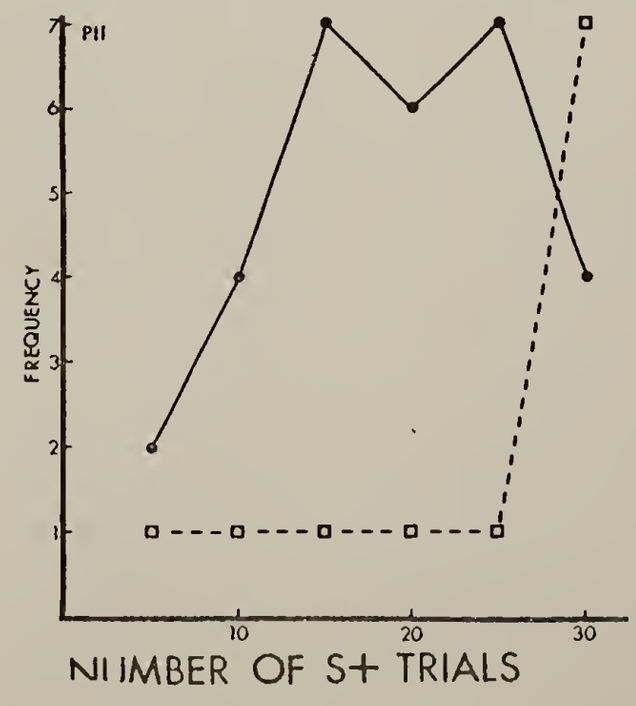
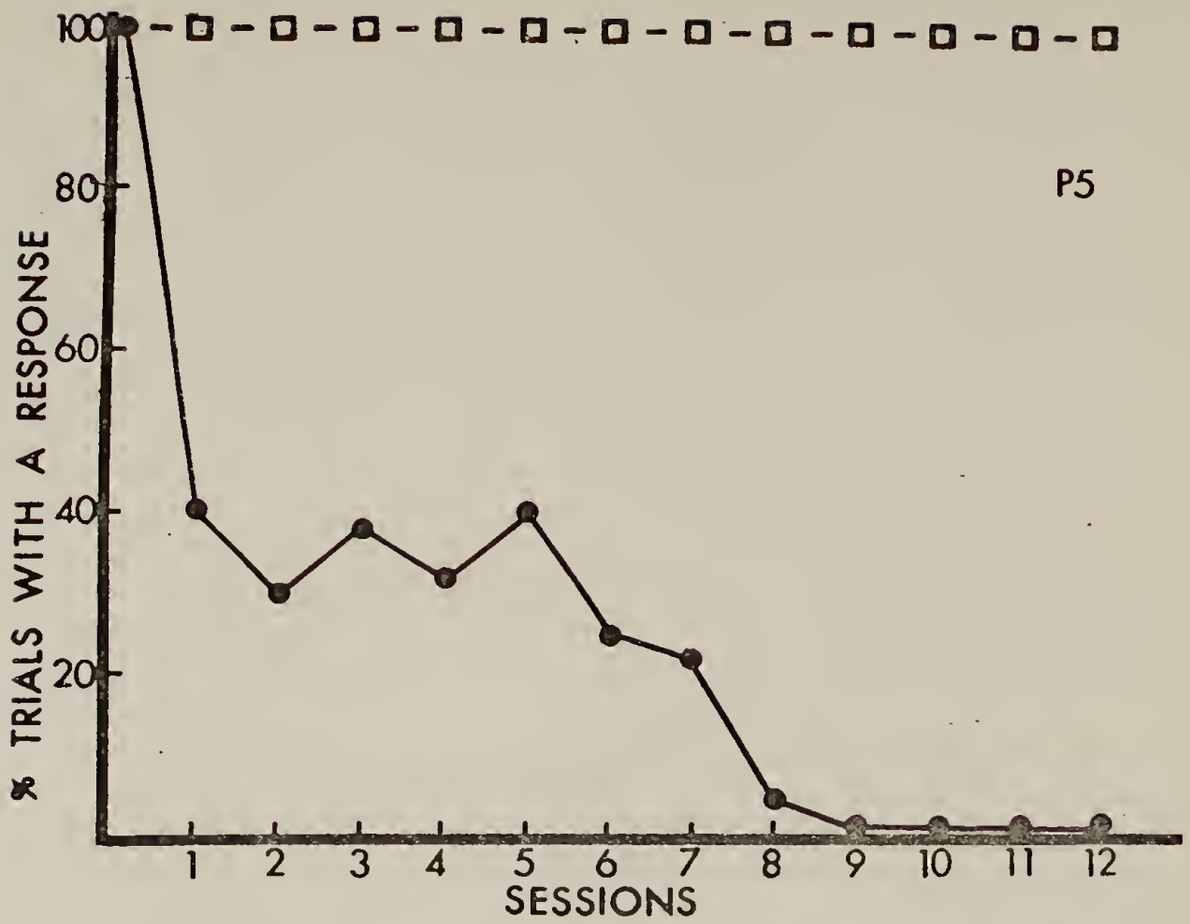

P11
FREQUENCY
1
2
3
4
5
6
7
10
20
30
NUMBER OF S+ TRIALS

Figure 1


100
80
60
40
20
% TRIALS WITH A RESPONSE
P5
1 2 3 4 5 6 7 8 9 10 11 12
SESSIONS

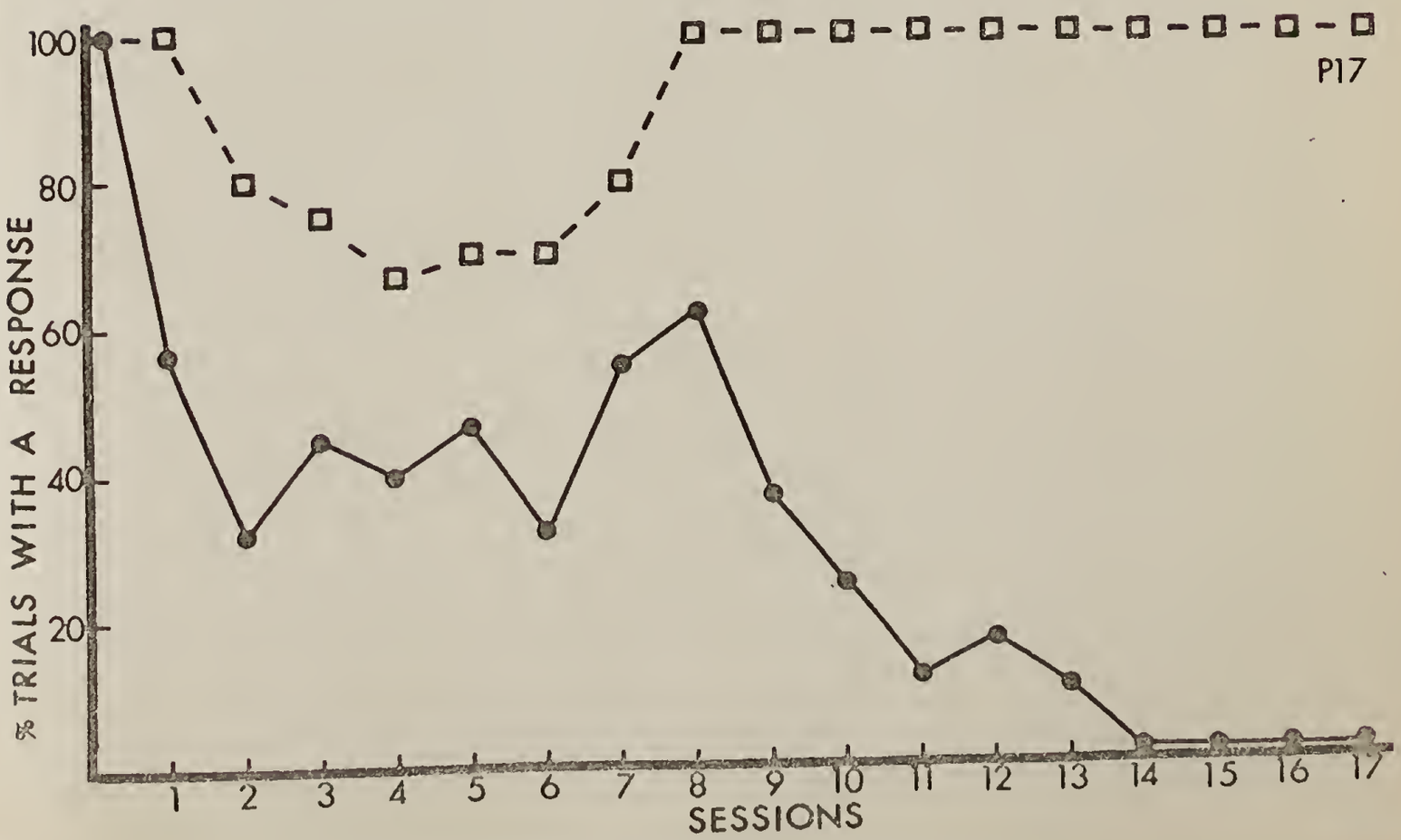

100
80
60
40
20
% TRIALS WITH A RESPONSE
P17
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
SESSIONS

Figure 2

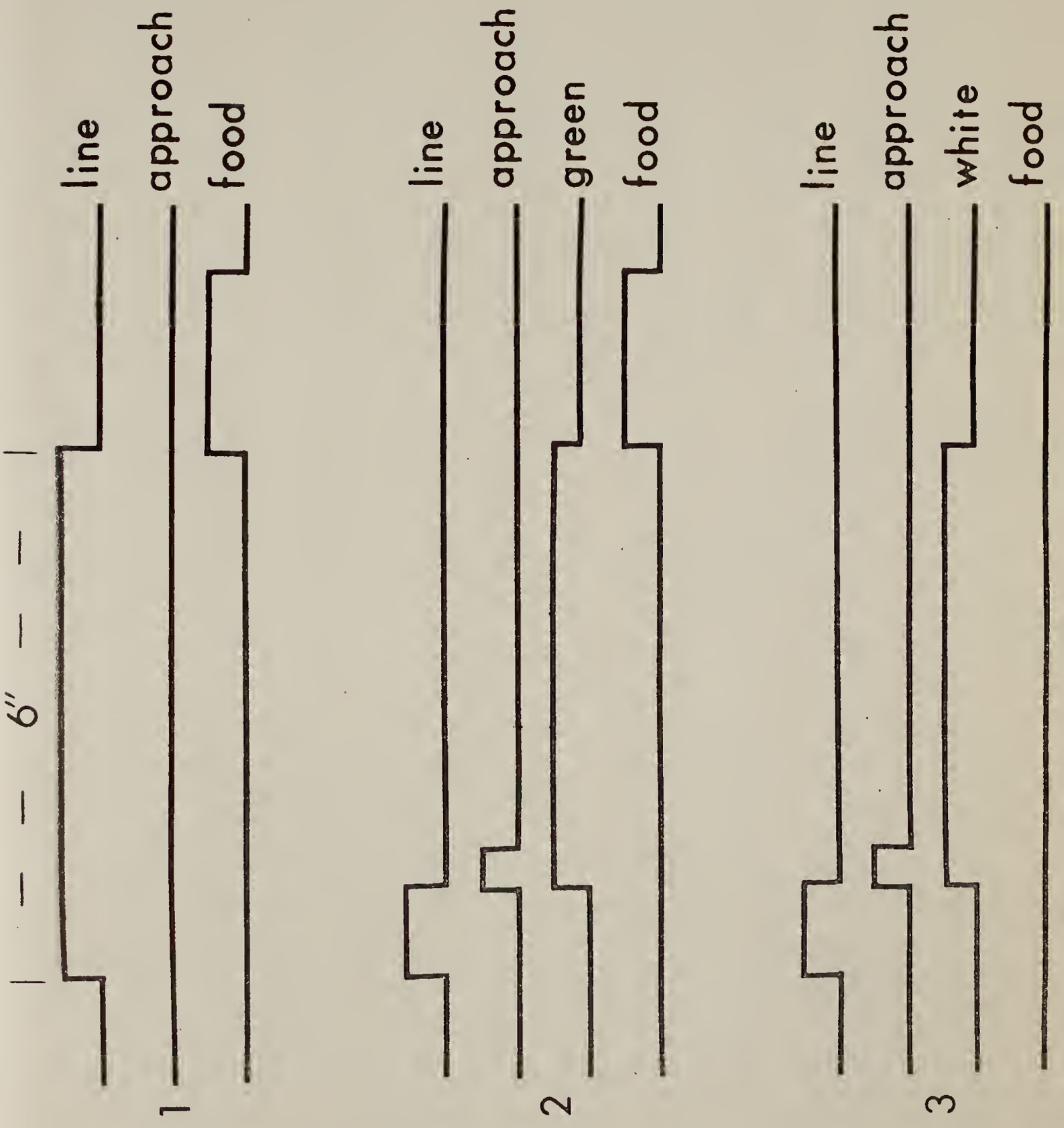

6"
line
approach
food
1
line
approach
green
food
2
line
approach
white
food
3

Figure 3

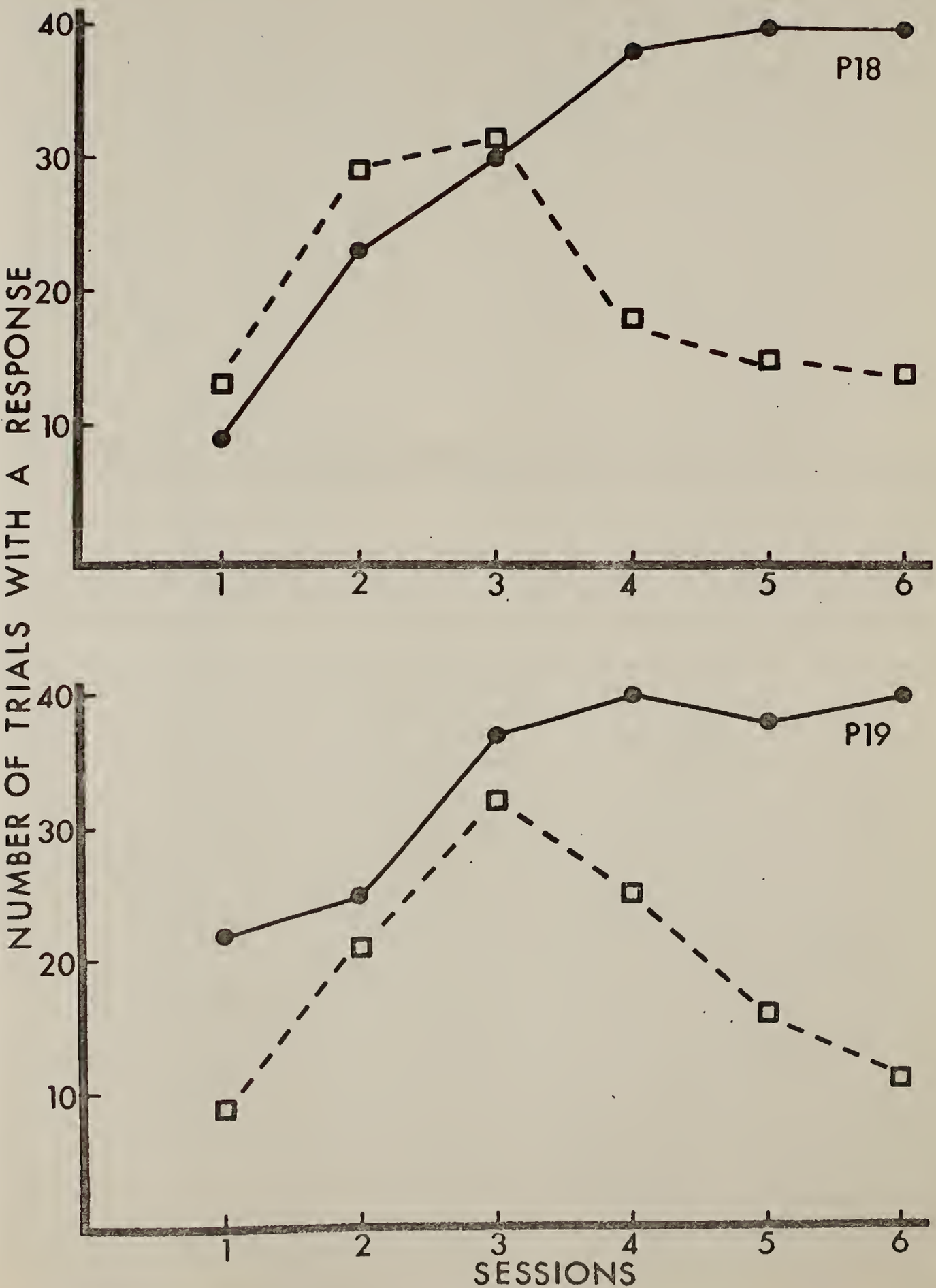

P18
P19
NUMBER OF TRIALS WITH A RESPONSE
SESSIONS
40
30
20
10
1
2
3
4
5
6

Figure 4

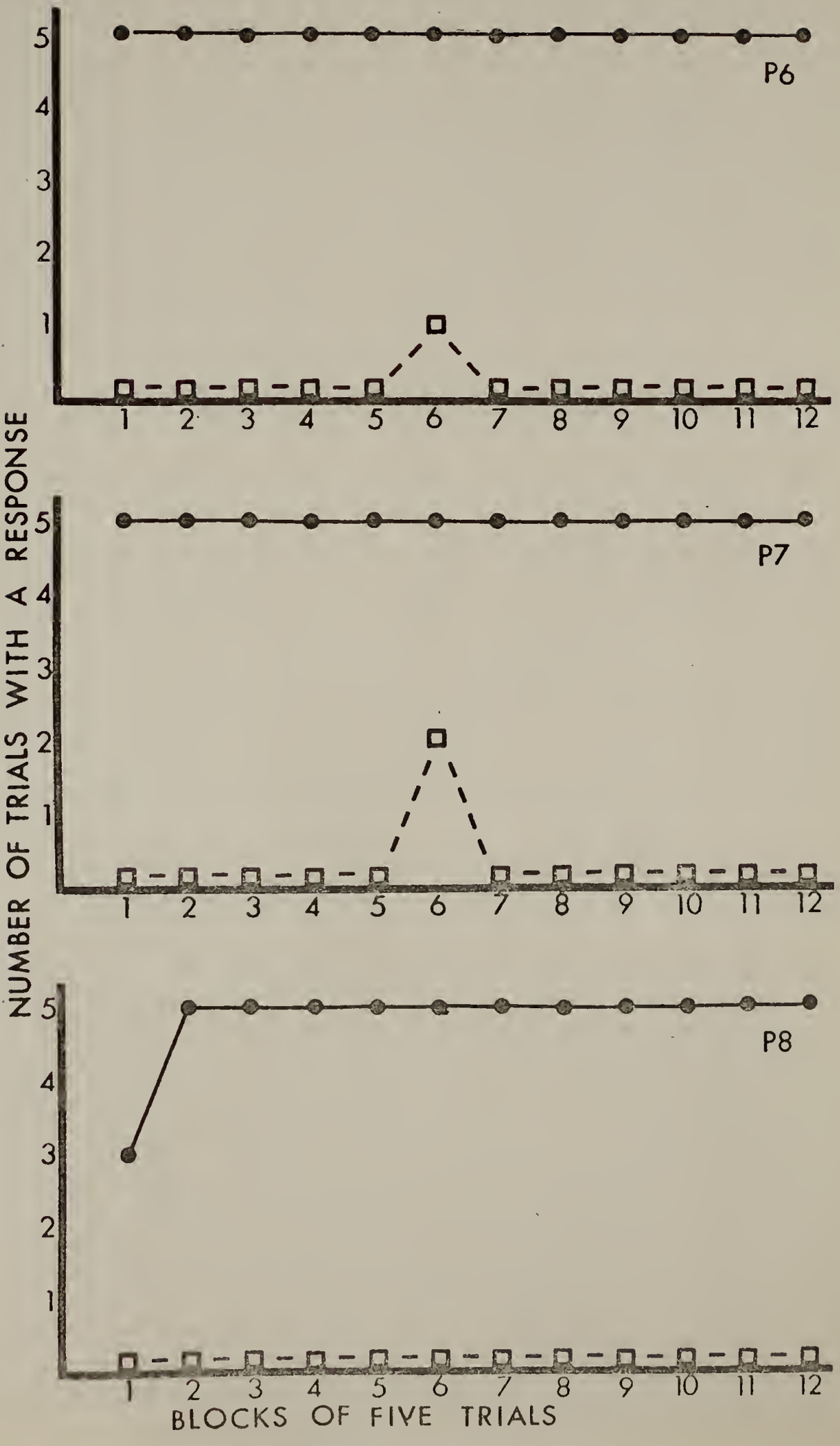

P6
P7
P8
NUMBER OF TRIALS WITH A RESPONSE
BLOCKS OF FIVE TRIALS
1 2 3 4 5 6 7 8 9 10 11 12
1 2 3 4 5

Figure 5

APPENDIX A

The purpose of this section is to provide a more detailed description of the behaviors observed in Experiment I. A complete list of the behavioral categories used in Experiment I is given in Table IA. The behaviors of only one subject, P5, will be considered. Generally, the behavioral trends for P5 were also observed in P2 and P11, and so the following may be considered to be a representative description of behaviors occurring in the acquisition stages of the response-independent procedure.

In the text, only the acquisition of key-directed behaviors was described. The possibility exists that behaviors other than the key-directed ones were also conditioned. Table IIA shows that such other behaviors did not clearly increase in frequency over successive S^+ trial blocks. Table IIA shows the frequency of occurrence of each of the sixteen behaviors within successive two-second trial segments over successive blocks of five S^+ trials. Only blocks 1-12 are included in the table since key-directed behaviors occupied virtually all intratrial time after block 12 (see Table I of text). No nondirected behavior showed the unequivocal increase in frequency over S^+ trials which was observed for the key orient, the key approach, and the key peck. One cannot conclude on the basis of these data that there was not some qualitative shift in some behavior over S^+ trials. The latter

possibility is, however, highly unlikely in the opinion of the author. Qualitative behavioral variations other than those noted in Table IA were very rare, and variation within a behavioral category was unsystematic. For example, the frequency of occurrence of either of the two stated topographical variants of the key orient was a function of the bird's position in the chamber rather than the number of S^+ trials or the time of occurrence within a single S^+ trial.

Of the behaviors studied in the autoshaping experiments of others, only a small subset of all key-directed behaviors have been examined. Additionally, behaviors directed to environmental stimuli other than the CS have not even been mentioned in any published report known by the author. Table IIA shows that behaviors directed to both the houselight and the speaker do occur, albeit infrequently, prior to acquisition of the key peck. These behaviors have reliably occurred for all pigeons in the response-independent procedure used by the author. Such directed behaviors (those involving orienting, approaching, or pecking) have also been observed by the author to reliably occur during magazine training sessions in which food is presented intermittently and independently of the behaviors of the subject. Apparently, intermittent access to food sets the occasion for the occurrence of a variety of behaviors directed to particular types of environmental

stimuli for a food-deprived pigeon. It is possible that in the feeding history of the birds used in these experiments, the probability of reinforcement of directed behaviors is higher given the recent occurrence of successful feeding in a particular setting. Regardless of the antecedents of these directed behaviors, unconditioned occurrences of these behaviors may interact with experimentally programmed events. Future research in the area of autoshaping should be concerned with the problem of what variables determine the occurrence of what kinds of directed behaviors.

Consideration of averaged frequencies of occurrence of individual behaviors and behavioral sequences is insufficient for the reconstruction of the exact intratrial event sequence. Information concerning the latter is fundamental for the analysis of autoshaping since the effects of potentially relevant variables are not obscured by averaging. Table IIIA shows the entire sequence of events within 15 individual S^+ trials. Three blocks of five successive trials are shown. The first block of trials occurred prior to the conditioning of the key-directed behaviors (see Figure 1); the second block occurred during the conditioning of key-directed behaviors; the third block occurred after the acquisition of the key peck had occurred. Successive trials within each block are shown so that one can see the effects of variables which were

possibly operative in trial n upon the sequence of events in trial n+1.

Table IIIA shows that behavioral variability decreased considerably across trial blocks. Generally, key-directed behaviors occurred more frequently and occupied a greater percentage of intratrial time as training proceeded. Non-directed behaviors such as standing at the window wall (16), circling (6), and standing at the magazine well (12) occurred with decreased frequency and shorter duration across blocks.

More interestingly, reliable shifts in sequential dependencies for certain pairs of behaviors occurred over blocks. For example, in blocks 1 and 2, behavior 9 (head movement along the magazine wall) occurred on 20 occasions. Whereas in block 1 the (move head along magazine wall-magazine wall) sequence occurred 10 times, that sequence occurred in block 2 only 6 times. Also, the (move head along magazine wall-key orient) sequence occurred only once in block 1 but occurred 5 times in block 2. In block 3, the key orient occurred following each occurrence of a head movement along the magazine wall. Generally, sequential dependencies between pairs of behaviors other than the key-directed ones decreased across blocks while there was of course a concommitant increase in the probability of occurrence of a key-directed behavior given the prior occurrence of a behavior not directed towards the key.

Across blocks, there was a decrease in the probability of occurrence of a behavior not directed towards the key given the prior occurrence of a key-directed behavior. That is, there was an increased probability that a particular key-directed behavior would be immediately followed by another key-directed behavior. For example, in block 1, the key orient occurred 7 times but was followed by a key approach only twice, and neither of these orient-approach sequences occurred in the third portion of the trial (4.0-6.0 sec.). In block 1, the key approach occurred 6 times but only one approach-orient sequence occurred. In contrast, in block 2, the frequency of occurrence of the orient-approach sequence relative to the frequency of occurrence of the key orient was 12/25. Five orient-approach sequences occurred in the last trial segment. In block 2, the key approach occurred 13 times and was followed by the key orient on 11 occasions. Seven of these approach-orient sequences occurred in the last portion of the trial. Generally, the increased frequency of occurrence of the key orient and the key approach over blocks 1 and 2 was accompanied by an increased probability that the key orient would be followed by the key approach and vice versa. Acquisition of the key peck occurred shortly following not only an increased frequency of occurrence of the key orient and the key approach behaviors in the last trial segment but also following an increased

sequential dependency between these behaviors. Perhaps the presentation of food following these antecedent behaviors affects the subsequent probability of occurrence of the key peck only if the antecedent behaviors occurred in a particular sequence. Whether or not reinforcement acts specifically upon certain sequences of antecedent behaviors remains an empirical question. The fact that the orient-approach, the approach-orient, and the orient-approach-orient behavioral sequences occurred more frequently and more contiguously with food presentation in the trials just prior to that on which the first key peck occurred (54) strongly suggests that the effects of reinforcement upon such sequences should be more thoroughly investigated.

Table IA. Each behavioral category used to exhaustively describe the behaviors observed in Experiment I is shown along with its numerical representation and a brief description.

Table IIA. The frequency of occurrence of each of the 16 behaviors observed within successive 2.0-sec. segments of S^+ trials over blocks of 5 S^+ trials. Each numbered response corresponds to a particular type of behavior as listed in Table IA.

Table IIIA. The entire sequence of events in 15 individual S^+ trials. The number of the S^+ trial is shown on the extreme left and the corresponding sequence of events is shown in the same row. The duration of each behavior is shown as the distance between successive dashed lines. Each of the three columns represents a single, 2.0-sec. trial segment.

TABLE IA

1. Pecking the magazine wall

   Pecking movements directed toward some point on the magazine wall. This point may vary both between and within birds.

2. Behavior directed towards the speaker of the chamber

   Pecking movements directed towards the speaker or orientation of the head towards the speaker.

3. Behavior directed towards the houselight

   Pecking movements directed towards the houselight or orientation of the head towards the houselight.

4. Pacing

   The bird side-steps along the chamber walls other than the magazine wall with his breastbone close to the wall. These movements may be accompanied by beak to ceiling, wing-flapping, etc.

5. Circling

   The bird emits a rapid turning movement of at least 180^{o}.

6. Wing-flapping

   Movement of the wings up and down in a vigorous manner.

7. Floor-pecking

   Pecking movements directed to the floor of the chamber.

8. Head movements along the magazine wall

   The bird faces the magazine wall and moves its head

in either the horizontal or vertical plane. These movements do not bring the bird towards the key.

9. Body movements along the magazine wall

A side-stepping motion with the breast held close to the magazine wall. These movements do not bring the bird closer to the key.

10. Head to magazine

The bird orients to or approaches towards the food magazine.

11. Standing at the magazine wall

The bird stands in one place facing the magazine wall, but makes no specific response such as orienting his head towards the key or magazine. This category includes relatively stationary responses.

12. Pecking the key

Pecking movements directed towards the key.

13. Orienting towards the key

The bird orients his head towards the key from anywhere in the chamber. The orient may be either monocular or binocular. The monocular orient consists of a brief pause and turning of the head while the binocular orient consists of facing the key directly while remaining relatively stationary.

14. Approaching the key

The bird makes any movements which brings him closer

to the key.

15. Standing at the window wall

The bird's head and body are directed towards the door of the experimental chamber containing the observation window.

TABLE IIA

Response	Blocks of five S^+ trials											
	1	2	3	4	5	6	7	8	9	10	11	12
1 0"-2"	0	0	0	0	0	0	0	0	0	0	0	0
1 2"-4"	0	0	0	0	0	0	0	0	0	0	0	0
1 4"-6"	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	1	0	1	1	0	0	0	0	0	0
2	0	1	0	0	1	1	0	1	1	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0
	0	0	1	0	0	1	0	0	3	3	1	1
3	0	2	0	0	0	2	0	2	0	0	2	1
	0	0	1	1	1	2	2	0	0	0	2	1
	0	1	0	0	0	1	0	0	0	0	1	0
4	0	0	0	0	0	0	0	0	0	0	0	0
	2	1	0	1	0	0	0	0	0	0	0	0
	0	0	1	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	1	1	0	0	0	0	0	0	0
	2	0	0	0	2	0	0	0	0	0	1	0
6	0	0	0	0	0	0	0	0	0	0	0	0
	1	0	0	0	1	0	0	1	1	1	0	0
	0	0	0	0	1	0	0	0	3	0	0	0
7	0	2	0	0	0	2	0	2	0	0	2	1
	0	0	0	0	1	0	0	0	0	0	0	0
	0	1	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
	0	1	2	0	0	0	0	0	1	0	0	0
	4	3	12	13	6	4	4	6	7	13	5	9
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	5	7	5	3	8	3	7	5	2	4	8	8
	2	0	1	0	1	0	0	2	0	0	0	3
10	0	0	1	0	1	3	0	1	1	2	2	1
	0	1	1	1	0	1	3	2	2	2	0	4
	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	2	0	0	1	0	0	0	0

		1	2	3	4	5	6	7	8	9	10	11	12
		10	7	6	5	7	6	9	11	6	4	4	5
12		5	9	3	4	4	4	7	3	3	5	5	3
		3	6	6	2	9	3	7	7	5	6	3	7
		0	0	0	0	0	0	0	0	0	0	0	0
13		0	0	0	0	0	0	0	0	0	0	0	2
		0	0	0	0	0	0	0	0	0	0	1	3
	0"-2"	1	0	4	2	4	3	2	3	3	8	7	6
14	2"-4"	1	2	2	0	3	2	7	6	6	6	5	6
	4"-6"	3	5	0	2	0	0	4	3	6	6	13	13
		0	0	0	0	1	1	0	1	2	3	3	3
15		1	4	0	0	2	2	2	3	4	2	4	4
		2	2	1	1	2	1	3	2	3	4	7	4
		9	7	5	7	5	3	6	3	0	1	2	4
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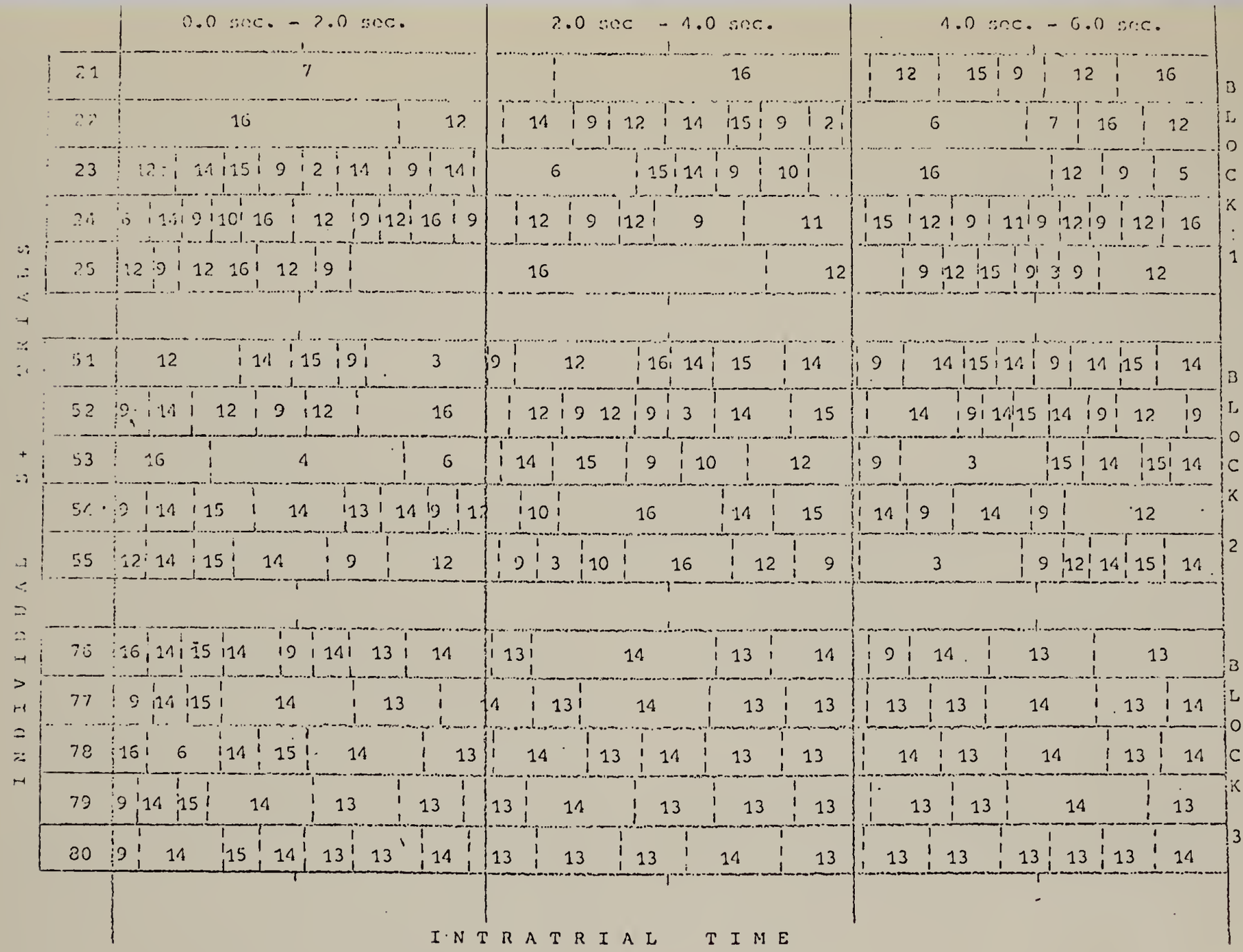
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INDIVIDUAL SERIALS
INTRATRIAL TIME
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BLOCK 2
BLOCK 3
21 7 16 12 16
22 16 12 14 9 12 14 15 9 2 6 7 16 12
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