INFORMATION TO USERS

BEHAVIORS OBSERVED DURING S- IN A SIMPLE

DISCRIMINATION LEARNING TASK

By

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The behavioral criterion of "discrimination" is met
when some type of differential responding is observed. Dif-
ferential performance may be conceptualized as different
strengths of a given response where strength is reflected in
some quantitative dimension, e.g., rate of occurrence. In
the present experiment, keypecking of pigeons was reinforced
with food in the presence of a horizontal line (S+). Key-
pecking was never reinforced in the presence of a vertical
line (S-). Discrimination training resulted in high overall
rates of keypecking in the presence of the S+ and low overall
rates in the presence of the S-. Generalization tests re-
sulted in systematically decreasing overall keypecking rates
as the value of the test stimuli were varied away from the S+
value.

An alternative conceptualization is to consider dif-
ferent rates of keypecking as indicating different probabili-
ties that the behavior of keypecking will be selected from
among all other behaviors in the repertoire of pigeons. There-
fore, this experiment sought to categorize and record specific
activities of the pigeon when it was not engaging in keypeck-
ing. To facilitate direct comparisons of topographically
distinct behaviors, times spent engaging in keypecking and
highly stereotyped behaviors were recorded for each bird. Re-
sults showed that high proportions of the S+ periods were oc-
cupied by keypecking, low proportions of S+ periods were

occupied by stereotyped behavior and, conversely, high proportions of the S- were occupied by stereotyped behavior and low proportions of S- periods were occupied by keypecking. Presentations of values intermediate to the training stimuli resulted in intermediate proportions of each class of behavior.

Durations of keypecking bursts permitted a more molecular analysis of keypecking rates, i.e., running rates were derived by dividing the number of keypecks which occurred in the presence of each stimulus by the total amount of time in which the pigeons were observed to engage in keypecking in the presence of that stimulus. Relatively constant running rates in the presence of the two training stimuli and the test stimuli revealed that the different overall rates were primarily a function of the amount of time in which the pigeon engaged in keypecking rather than a shift in the tempo of keypecking.

Finally, the nature of the stereotyped behaviors was explored. Correlational evidence was obtained indicating that these behaviors and a timeout keypeck may be members of a single class of behaviors. It was suggested that this class can be defined by the behavioral outcome of escape from stimuli associated with low probabilities of reinforcement.

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CHAPTER I

INTRODUCTION

In a simple discrimination learning paradigm, an organism is presented with two stimuli: one is positively correlated with reinforcement (S+) and the other is negatively correlated with reinforcement (S-). As a result of such training, the behavior of the organism in the presence of the S+ is, in some way, different from the behavior occurring in the presence of the S-. Some type of _differential_ _responding_ must be observed before the behavioral criterion of "discrimination" is met.

Traditionally, the behavior of interest in experiments on discrimination learning has been the response which is established in the presence of the S+ and which is an explicit part of the reinforcement contingency. For example, Jenkins and Harrison (1960) obtained a stable, high rate of pigeons' keypecking responses in the presence of the S+ by means of a variable interval (VI) schedule of reinforcement. Keypecks in the presence of the S- were never reinforced and, as a result, they occurred at a lower rate. The criterion for a discrimination was met when the rate of response to the S+ was "at least four times greater" than the rate of response to the S-. Differential responding is, in this case, conceptualized as the existence of different strengths of responses

where strength is reflected in some quantitative dimension, e.g., rate of occurrence, speed of the running response, amount of salivation, etc.

An alternative to conceptualizing differential responding as different rates of a single measured response is to consider those different rates as indicating different probabilities that a single class of responses will be selected from all the other behaviors in the repertoire of an organism. Schoenfeld and Farmer (1970, p. 222) have stated that:

> Behavior is a continuous stream . . . and that the continuousness of behavior means that the organism can be thought of as "always doing something," so that at any instant the probability of occurrence of the R under observation, or $P(R)$, is 1.00 minus the probability of occurrence of any response-other-than R, or $P(\bar{R})$ . . . a derivative aspect of continuousness is that behavior cannot be speeded up [or slowed down], but is of constant "velocity." It is only the relative density in time, or frequency of occurrence of one response relative to all others, which can be made to vary by our reinforcement operations.

Within this theoretical framework, "not responding" in the presence of the S-, is the result of the intrusion of other behaviors which are antagonistic to or incompatible with the response conditioned to the S+. This approach is essentially that which was referred to as the "interference theory of extinction" by Hilgard and Marquis (1940, p. 116). In fact, Pavlov (1927, p. 44) recognized the possibility that some forms of response reduction could be the result of interfering behaviors; "external inhibition" was defined as a "reduction in the measured response due to excitation of an investigatory reflex." Both Guthrie (1935) and Wendt (1936)

considered all forms of response reduction as a consequence

of the increase in the probability of incompatible behaviors.

Guthrie (1935, p. 66) stated that:

> A stimulus may . . . be conditioned by the very simple
> means of becoming a conditioner for an incompatible
> movement. Unlearning becomes merely a case of learning
> something else. And the rule which states whether con-
> ditioning or unconditioning will occur becomes simply
> the familiar principle of conditioning: stimuli which
> are acting at the time of a response become conditioners
> of that response. In this case, the response referred
> to in the rule is a response incompatible with the
> former response.

This approach suggests that, in addition to the re-

sponse conditioned to the S+ (R), other responses (R̸) are con-

ditioned to the S-. Results of several recent experiments

have encouraged such speculation. Migler (1964) trained rats

to press two keys (A-B) consecutively with a 6-second time

delay in the presence of a slow clicker frequency and with no

time delay in the presence of a fast click frequency. During

generalization testing with intermediate click frequencies,

superficial analysis showed a gradually decreasing median

A-to-B time as a function of increases in click frequencies.

Closer examination, however, revealed no intermediate switching

times but a _bimodal_ frequency distribution of A-to-B times at

the intermediate frequency values. When these times were aver-

aged together they yielded intermediate times which, in this

situation, failed to reflect the underlying bimodality of re-

sponse categories. The intermediate click frequencies con-

trolled the relative proportions of slow _or_ fast A-to-B times

rather than affecting the A-to-B times per se.

In a similar study, Migler and Millenson (1969)
trained rats to make two different responses in the presence
of two click frequencies. When the click frequency was 2.5
Hz, responses on one of the two levers were reinforced ac-
cording to a VI 30-second schedule of reinforcement which
generated high rates of responding. In the presence of a 25
Hz click frequency, responses on the other lever were rein-
forced on a VI 226-second schedule which controlled low rates
of response. Subsequent generalization testing demonstrated
that the intermediate click frequencies controlled the
probability of initiating a given response (i.e., which of the
two levers the animal would select was a function of the click
frequency), but that the frequencies had no effect on the lo-
cal rates of response, which remained the same as those estab-
lished during training. The generality of these findings
has been established with other organisms and other types of
responding: Cumming and Eckerman (1965) and Wildemann and
Holland (1972) with the pigeon and spatial location of the
pecking response, and Cross and Lane (1962) with human subjects
and the response of humming different pitches of tones.

In all of these studies, the two behaviors under in-
vestigation were established and maintained by programmed re-
inforcement, i.e., the alternate behaviors were made explicit
and identifiable. The problem with extending these findings
to the simple discrimination learning experiment is, of course,
the fact that in that situation, only one response is explicitly

conditioned. With respect to this single-response situation, Migler and Millenson stated that "any other competing behaviors that might be contributing to a composite response rate must be inferred from the absence of the measured response."

Staddon and Simmelhag (1971) systematically observed the behavior of pigeons in an enclosed experimental chamber and have demonstrated that specific behaviors other than those automatically recorded may indeed be categorized and recorded. Using an observation and recording technique similar to that of Staddon and Simmelhag, a pilot study was performed in an attempt to demonstrate that stereotyped behaviors in the presence of the S- do not have to remain at the level of inference. The behavior of two pigeons were carefully observed during the S- periods of a series of discrimination tasks. One of the subjects (R1) exhibited a great variety of behaviors although no one class of regularly occurring behavior could be observed. This difficulty may have been due to a lack of correspondence between the experimenter-defined response classes and the actual response classes defined by the organism. That is, before the experiment began, various classes of behaviors, such as orientations toward the four walls of the chamber, turning around in the chamber, preening behaviors, pecking behaviors, etc., were established. The possibility exists that these behavior classes were inappropriate; for example, R1 was often observed

to make rapid head movements from left to right directly over the key, but all of these behaviors were subsumed under the class of behavior labeled: facing the magazine wall. This difficulty emphasizes the problems inherent in attempts to isolate certain classes of behaviors from the entire behavioral repertoire of an animal.

The other subject (R4) did, however, consistently engage in an S- behavior which was compatible with the pre-defined response category--turning around and facing the rear wall of the experimental chamber. In the first discrimination task, it was found that as discrimination training progressed, the proportion of the S- periods in which the bird faced the rear wall of the chamber increased up to 40 percent. Roughly 20 percent of the S- period was filled with movements which were considered en route to the rear of the box. The remaining 40 percent of the time was filled with a variety of behaviors such as pecking the floor of the chamber, preening, looking in the magazine opening, etc. Results of a second discrimination task also showed a systematic increase in turning behaviors as the keypeck response decreased in the presence of the S-.

The main objective of the present experiment is to categorize and record specific activities of the pigeon when it is not engaging in the explicitly conditioned response of keypecking. Observations of keypecking and other behaviors will be made throughout the course of a simple discrimination

training procedure. The experiment will also explore three
specific areas of investigation. The first hypothesis is
that, as the probability of the conditioned response declines
in the presence of the S-, other stereotyped behaviors in-
crease in probability of occurrence. In order to facilitate
a direct comparison of topographically different behaviors,
it will be necessary to record the times spent engaging in
keypecking and in the other behaviors. Such a measure will
yield information regarding the proportion of the S+ and
the S- intervals occupied by the various classes of behavior.
As a result of discrimination training, it may be that high
proportions of the S+ interval are occupied by keypecking,
low proportions of the S+ interval are occupied by specific
non-keypecking behaviors and conversely, high proportions of
the S- interval are occupied by the stereotyped behaviors
whereas only a small portion of that interval is occupied by
keypecking.

The second specific area of concern relates to an
analysis of keypeck response rates in the presence of the two
training stimuli (S+ and S-) and in the presence of test
stimuli which are intermediate to the two training stimuli
along a line-tilt dimension. Obtaining a measure of the pro-
portion of S+ and S- intervals occupied by keypecking will
permit an analysis of rates of keypecking at a more molecular
level than is typically possible in the single manipulandum
procedure. As mentioned above, the overall rates of S+ and

S- keypecking usually separate over the course of discrimina-
tion training, resulting in high overall rates to S+ and low
overall rates to S-. These rates are derived by dividing
the total number of keypecks which occur in the presence of
each stimulus by the total amount of time each stimulus is
presented. Results of the pilot study suggest, however,
that considerable portions of the S- interval may be occu-
pied by specific non-keypecking behaviors located away from
the response manipulandum. The possibility exists that the
different overall rates are a function of different amounts
of time spent engaging in keypecking relative to time spent
engaging in other behaviors rather than any underlying shift
in the tempo with which the pigeon strikes the key. In other
words, perhaps the pigeon strikes the key at relatively con-
stant tempo but what changes as a result of discrimination
training is the amount of time allocated to keypecking.

In order to explore this possibility, a running rate
measure will be computed by dividing the total number of key-
pecks to each stimulus by the total times in which the pigeon
is observed to engage in this response. The running rate
measure will also permit investigation of the effects of a
generalization test procedure where stimulus values inter-
mediate to the S+ and S- will be presented. If there obtains
a sloping gradient of overall response rates, can this gradi-
ent be accounted for in terms of changes in the running rates
or, as Migler and Millenson (1969) have suggested, are the
running rates relatively constant while the test stimuli

simply control the relative proportions of behaviors found during S+ (keypecking at some characteristic tempo) and behaviors found during S- (other specific non-keypecking behaviors)?

The third line of investigation concerns the nature of these incompatible behaviors. Some anecdotal evidence suggesting that the turning-around behaviors such as that exhibited by R4 may not be an arbitrarily selected response was provided by Wendt (1936), who performed an observational experiment on the inhibition of food-taking behavior in monkeys. During a delay period (in which reinforcement was not available and was negated if the response of opening a drawer occurred before the onset of an auditory signal), a monkey was observed to utilize an available curtain in order to remove the response manipulation from view. Wendt stated:

> The animal grasped its edge, unrolled about 18 inches of the curtain so as to hide the food drawer from her sight. Sometimes the animal would hold the curtain with one hand, and when it dropped below her eyes, she reached over it with the other hand to open the drawer [thereby negating reinforcement]. Sometimes the animal unrolled a part of the curtain and used it to cover the drawer by pushing it forwards so as to cover the drawer handle.

In describing the behavior of pigeons during the S-periods, Terrace (1966) noted that "it has been regularly observed that following discrimination learning with errors, S- evokes various emotional responses such as wing flapping and turning away from the key." The three photographs provided to illustrate such "emotional responses" (Terrace, 1966,

p. 317) show that the head of the animal was facing in some direction away from the key, whether or not he turned completely around in the chamber. Such observations suggest that the animal may be engaging in behaviors which served to remove the S-.

Terrace (1971), and Rilling, Kramer and Richards (1973) have, in fact, demonstrated that following discrimination training with errors, a pigeon will learn to peck another key, the only consequence of which is to turn off the S- for a brief period of time. Responses on the timeout key did not alter the programmed sequence of stimulus presentation, thus the frequency of positive reinforcement from food remained constant. Pigeons who had learned the discrimination without errors, however, made few if any responses to the timeout key. In addition, Terrace (1972) noted that following errorless discrimination training the birds were observed to sit passively in front of the key and "to await quietly the next presentation of the S+."

The parallel between the responses labeled by Terrace as "emotional responses" and the timeout responses is further illustrated by a decrease in each type of behavior with extended discrimination training in those situations where the discriminations were learned with errors. Terrace (1972) has noted that the gross behaviors of birds changed dramatically with continued training in which the "active" responses such as wing flapping and turning behaviors are

replaced with "passive" behaviors such as grooming, roosting, and exploration of the experimental chamber. The behavior of R4 in our preliminary study also showed a similar transition from turning behaviors to remaining in front of the key in the latter stages of the experiment. In addition, Rilling, Askew, Ahlskog, and Kramer (1969), and Terrace (1971) have demonstrated that, for the majority of birds, the timeout responses show a similar decrease with prolonged discrimination training. Thus the similarity between the "active" gross behaviors and the timeout response suggest the possibility that in conventional discrimination procedures, in which localized visual stimuli are employed, the animal learns some behavior which removes the stimulus from view, whether or not a response manipulandum (e.g., timeout key) is provided by the experimenter.

With respect to the issue of the motivating variables underlying the timeout responses, Terrace (1971, 1972) and Rilling et al. (1969, 1973) have contended that S- timeout responses are negatively reinforced by escape from the S- which is considered to be an "aversive" stimulus. The aversiveness is presumably the result of a "frustration effect" produced by non-reward in the presence of the S- (Amsel, 1962). In addition, it may be that those behaviors labeled by Terrace (1966) as "emotional responses" (e.g., turning away from the key) could be similarly maintained by escape from the aversive S-. The third specific hypothesis

is that as the conditioned response declines in the presence of the S-, other behaviors develop during the S-period and that these behaviors may be considered members of a functionally equivalent class of behaviors, a class defined by the consequences of these behaviors: timeout from S-.

To summarize, this experiment will explore the possibility that as a result of discrimination training, the conditioned response of keypecking (at a constant running rate) may come to occur throughout most of the S+ intervals while another class of behavior (including perhaps turning away from the key or pecking an available timeout key) may occur throughout most of the S- interval. Presentations of stimulus values intermediate to the training stimuli may be accompanied by different proportions of these characteristic S+ and S- behaviors, rather than affecting specific properties of these behaviors. More generally, the present investigation is an attempt to categorize and record various activities of an organism when it is _not_ engaging in the conditioned response. As Schoenfeld and Farmer (1970, p. 223) have stated: "The really interesting question centers upon what _is_ happening (not not happening)."

CHAPTER II

METHOD

Description of the experimental procedure is separated into two major sections: I. Apparatus and Methodology with respect to subjects and II. Apparatus and Methodology with respect to the observer.

I. Apparatus and Methodology (Subject)

Subjects

Eight experimentally naive male White Carneaux pigeons, 5 to 6 years of age, were maintained at approximately 80 percent of their free-feeding weights throughout the experiment. Water was available at all times in their home cages.

Apparatus

Experimental chamber.--The experimental chamber was a 16 (40.64 cm) x 16 x 16 inch box made of 0.5 in. (1.27 cm) plywood painted uniformly flat black. For viewing purposes the top of the chamber was a plate of 0.25 in. (0.63 cm) thick glass. Two circular response keys, 1.5 in. (3.81 cm) in diameter, were located on the discriminanda wall 8 in. (20.32 cm) from the floor of the chamber. The main key was positioned in the center of this wall and a timeout key was located 3 in. (7.62 cm) to the left of the main key. This

timeout key was covered with black electrical tape for one experimental group. Both keys required approximately 0.22 N of force to be operated. All keypecks were recorded automatically by standard electromechanical equipment. Reinforcement consisted of grain made available automatically by a Lehigh Valley Electronics Grain dispenser for 3 seconds, through a 0.75 in. (1.90 cm) x 0.75 in. opening located in the floor of the chamber directly below the main response key. Extraneous sounds were masked by a speaker delivering white noise within the chamber.

Stimuli.--The stimuli employed in this study were various orientations of a 1.1 x 3.4 cm black Tactype line superimposed on a white background. A horizontal line (0 degrees) served as the S+ while a vertical line (90 degrees) served as the S-. Test orientations included 0, 15, 30, 45, 60, 75, and 90 degrees rotation around the center of the stimulus exposure. All discriminative stimuli and test stimuli were changed manually.

The stimuli were located at a distance of 1.5 in. (3.8 cm) directly behind the main response key and were mounted in Kodak Gelatin Filter Frames. The exposed surface of the entire display was 6.02 cm in diameter. A 15-watt light located 0.5 in. (1.27 cm) behind the stimulus transilluminated the stimulus display.

The back of the timeout key was covered with green acetate film and white vellum, producing an unsaturated green

light with a dominant wavelength of approximately 535 nan-
ometers. The timeout key was transilluminated by a 7-watt
light located directly behind the key. This key remained
on throughout the entire session.

Experimental design and procedure

Experimental groups.-- The eight subjects were assigned
to one of two groups. Group 1 (n = 4) had access to the main
key but not the timeout key which was covered with black
electrical tape. Group II had access to both keys.

Preliminary training.--On the first day, all subjects
were shaped to peck the main key in the presence of the S+.
Each peck was reinforced on a continuous reinforcement
schedule (CRF). After the keypeck had been established, a
12-second blackout period was introduced which served to
separate the 60-second stimulus-on periods and to permit the
experimenter to change the stimuli during subsequent discrimina-
tion training and generalization testing. When this blackout
was in effect, the main key light went dark, no responses
were recorded and reinforcement was unavailable.

During this first session the timeout key was illumi-
nated for Group II. A single peck on this key produced a 10-
second timeout in which the main key was dark and pecks on
either key had no effect. It should be noted that the stimulus
change produced by the timeout keypeck was identical to that
produced by programmed blackout periods with the exception of

the length of that stimulus change. For purposes of clarification, however, the term "timeout" will refer to the stimulus changes produced by the timeout keypeck and term "blackout" will refer to the experimenter-programmed separation of stimulus-on periods. The timer controlling the stimulus-on periods was unaffected by the timeout responses, in order to insure the independence of the timeout responses and the scheduled presentations of the discriminative stimuli.

Sessions two through ten involved a reduction in the frequency of reinforcement. On days 2-4, main keypecks were reinforced according to a variable interval 15-second schedule (VI 15-sec); on days 5-7, the schedule was VI 30-sec; and on days 8-10, the schedule was VI 45-sec. In this preliminary training phase, the session length was 30 stimulus-on periods.

Non-differential training.--After the 10 days of preliminary training, the schedule of reinforcement was further reduced to VI 60-sec. Non-differential training was continued for 25 days at which time it appeared that the behaviors of most birds had become relatively stable. Session length during this baseline was 24 stimulus-on periods.

Discrimination training.--Discrimination training consisted of equal presentations of S+ (0 degree line) correlated with VI 60-sec. and S- (90 degree line) correlated with extinction. The stimuli were randomly alternated with

the stipulation that neither the S+ nor the S- appear for more than three consecutive periods. Each stimulus was presented for 12 of the 24 periods per session. Discrimination training continued for 10 days.

Generalization testing.--Following a warm-up phase during which each training stimulus was presented for three periods and each was correlated with the appropriate training condition, generalization testing was introduced. Seven test stimuli were employed: 90-, 75-, 60-, 45-, 30-, 15-, and 0-degree angular orientations of the line superimposed on the white background. All stimuli were correlated with extinction and were presented once within each of four blocks. To minimize the effects of testing under extinction, a retraining phase was administered between each successive block; this phase consisted of presentations of both S+ and S- with their appropriate training conditions. The length of the test session was 38 stimulus-on periods. Nine such tests were administered, tests being separated by five sessions of discrimination training. The order of stimulus presentation was counterbalanced across all test sessions.

II. Apparatus and Methodology (Observer)

Observational apparatus

Figure 1 presents a schematic diagram of the characteristics and location of the observational equipment in relation to the experimental chamber. All observed behaviors

were recorded via levers and push buttons operated by the
same observer (JFR) throughout the entire experiment. The
observed behaviors as well as the automatically recorded
keypeck responses were recorded on an Esterline Angus 20
channel Multiple Event Recorder. In addition, three ob-
served response classes (to be described below) were recorded
by timing devices and counters.
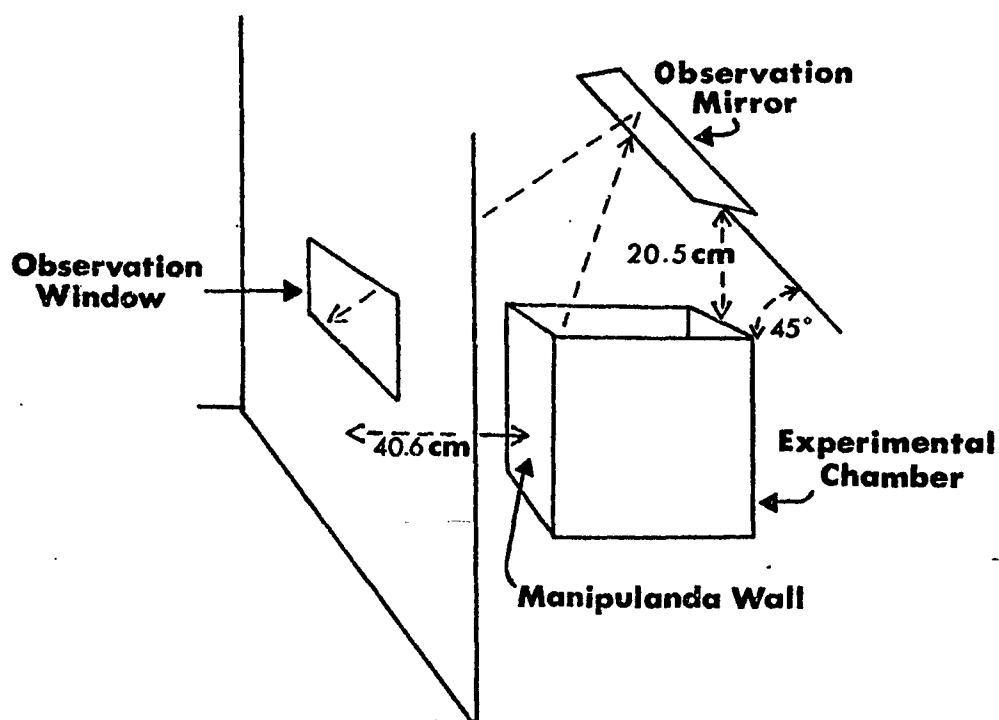
Fig. 1.--Schematic diagram of experimental apparatus
illustrating spatial relationship between animal chamber and
observational equipment.

Observed response description

On the basis of observations made during the pre-
liminary training phase, the following response classes were
identified for each bird:

1. Keypecking behaviors.--Continuous head movements directed at the main key was the defining characteristic of this class of behaviors. Due to the difficulty of tracking each discrete keypeck, this class of behaviors was recorded continuously, i.e., the appropriate lever was depressed throughout an entire burst of discrete keypecks. In addition, behaviors of the bird could qualify for this category of response even if actual contact between the bird's beak and the glass key was not of sufficient force to operate the key microswitch.

2. Systematic patterns of behavior.--The defining characteristic of this response class was any regularly occurring behavior pattern other than keypecking behavior. Due to equipment limitations, durations of only one systematic pattern of behavior could be recorded within any one experimental session. Staddon and Simmelhag (1971) have presented a classification of observed activities of pigeons in a similar experimental environment, and for the sake of continuity their terminology will be maintained in this paper. Table 1 presents some of these activities and their response numbers. This response class will be discussed in greater detail in Chapter III.

3. General timeout behaviors.--The major source of illumination in the chamber was the stimulus lamp located behind the discriminative stimuli. This fact, coupled with the

TABLE 1

DESCRIPTION OF OBSERVED ACTIVITIES[1]

Response Number	Name	Description
R_1	Magazine wall	Any response in which the bird's head and body are oriented towards the magazine wall.
R_3	Pecking floor	Any pecking movements directed towards floor.
R_4	Turning around in chamber	Responses in which the body of the bird is oriented more than 90 degrees away from the magazine wall.
R_5	Flapping wings	Vigorous movements of bird's wings.
R_8	Pacing movements along walls of chamber	Side-stepping movements from left to right with breastbone close to the walls of the experimental chamber. Often accompanied by (a) beak pointed towards top of chamber, (b) wing flapping, (c) hopping.
R_9	Preening	Movements in which the beak makes contact with the feathers on the bird's body.
R_{11}	Head in magazine	Head movements in the immediate vicinity of magazine opening.
R_{17}	Roosting	Bird "squats down." Absence of mobility.
R_{18}	Facing right	Movements in which head and/or body of bird orient towards right side of chamber, i.e., from right side of main key to 90 degrees away from key.
R_{19}	Facing left	Movements in which head and/or body of bird orient towards left side of chamber, i.e., from left side of main key to 90 degrees away from key.

[1] Adapted from Staddon and Simmelhag (1971).

flat black surface of the experimental chamber, produced clearly defined shadows both within the chamber and on the surface of the bird itself.[1] This sharp shadow gradient (illustrated in Figure 2) provided an unambiguous measure of this general timeout response class which was defined as any behavior which resulted in both eyes of the bird being located in the areas of low illumination. This criterion was conservative in that it excluded head positions in which the eye was illuminated by only an extreme portion of the background which did not include the discriminative stimulus per se. It will be recalled that the discriminative stimulus was a 1.1 x 3.4 cm line superimposed on a circular field 6.02 cm in diameter; it was this background which actually illuminated the chamber.

The fact that the systematic patterns of behaviors and the general timeout behaviors are not necessarily incompatible response classes deserves further elaboration at this time. The following situations illustrate different degrees of relatedness which could conceivably exist between the two categories of behaviors. The bird could engage in a systematic behavior in which (1) all portions of that behavior also qualify for the general timeout category, e.g., head in magazine opening, head movements in either the left or right front corners of the chamber; (2) no portion

_____

[1]The timeout key did not substantially alter these lighting conditions.
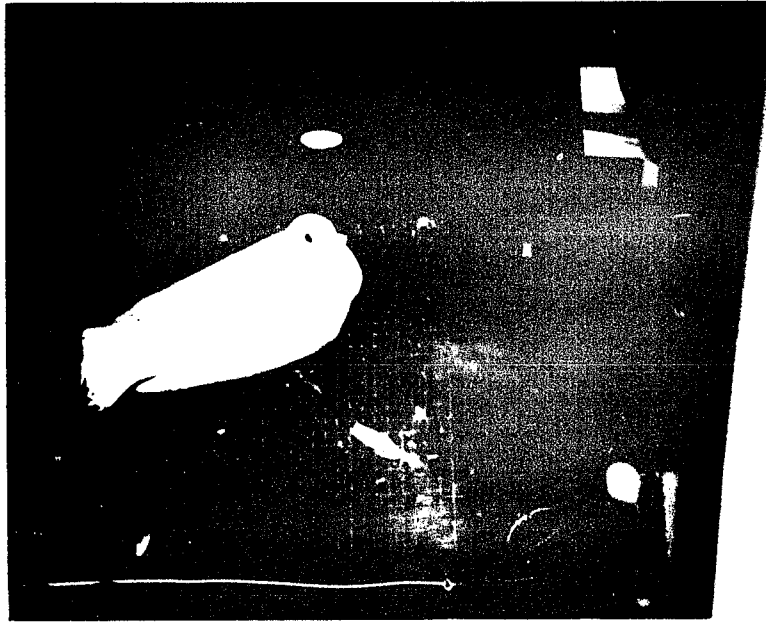
Fig. 2a.--Photograph of the observational mirror (see Fig. 1) reflecting the interior of the experimental chamber. The camera angle was the same as the angle of observation used in the experiment. Overhead lighting has been added for purposes of illustration. The timeout key, located 7.62 cm to the left of the main key, has been covered.

Fig. 2b.--Photograph taken from the same angle as Fig. 2a with the overhead lighting omitted. It illustrates the sharply contrasted levels of illumination on the surface of the bird. The stimulus lamp which illuminates the main key was increased to 100 watts for photographic purposes but the resultant picture approximates very closely the actual experimental conditions in regard to sharpness of the shadow gradient. It should be noted that the head position of this bird does not qualify for the general timeout behavior class since both eyes are not within the areas of low illumination.

of which could qualify for the general timeout class, e.g., backing away from, but still facing the main key; and (3) only some portions of which could qualify for the general timeout response class, e.g., when turning a full circle, only when the bird faced the rear wall would both eyes be out of the area directly illuminated by the stimulus lamp.

Recording techniques

The three major observed response classes (keypecking, systematic patterns of behavior, and general timeout behaviors) were recorded continuously, i.e., the appropriate lever was depressed throughout the duration of the response. The three levers operated timing devices so that at the end of the session the total amount of time during which each behavior occurred was available. Other behaviors which did not qualify for any of the three major categories were also recorded via push buttons. In addition, to all observed behaviors, main keypecks, timeout keypecks, reinforcement and programmed stimulus changes were recorded on the Esterline Angus Multiple Record. Figure 3 presents an actual sample of this permanent record.
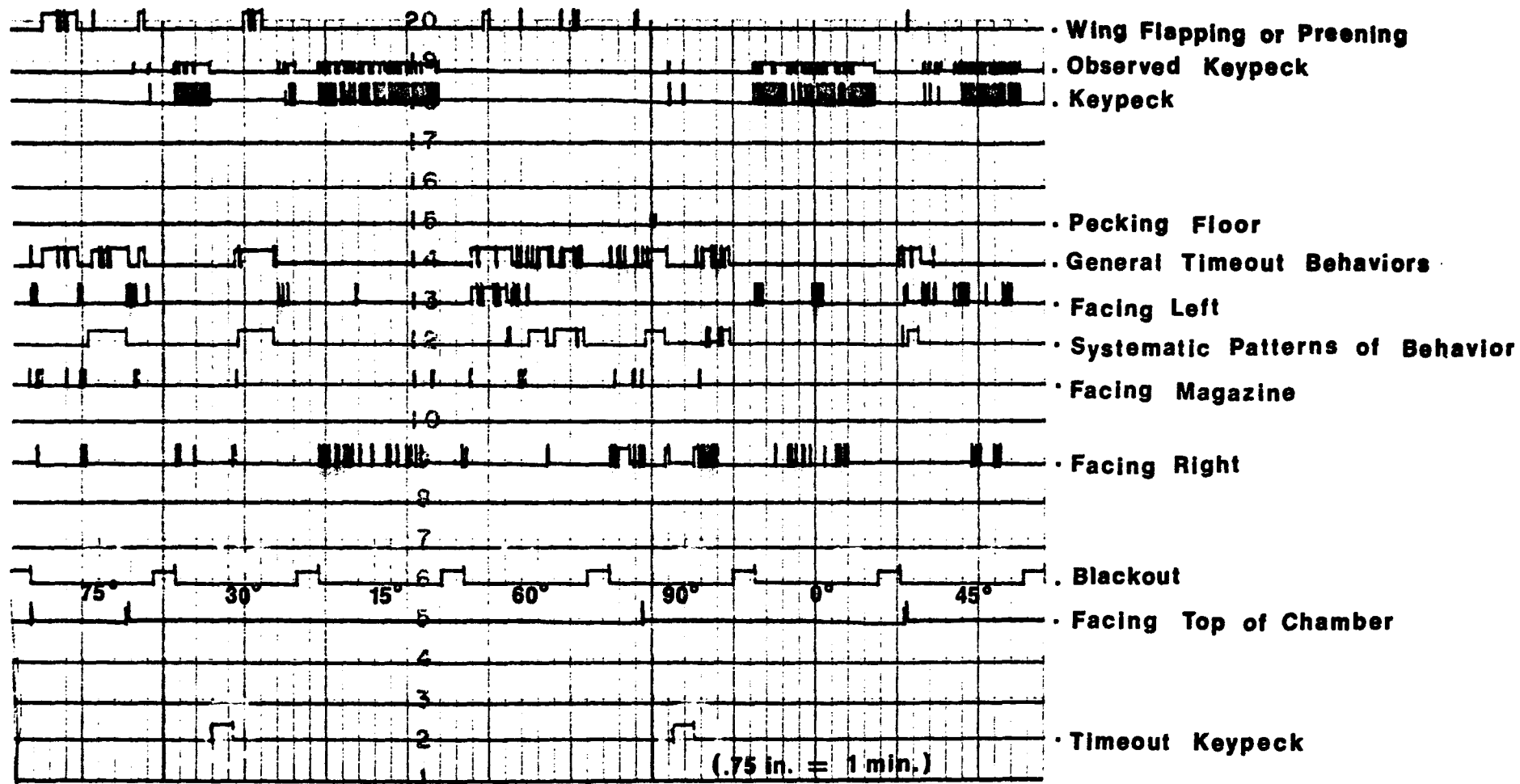
Fig. 3.--Sample of Esterline-Angus Multiple Record. Response classes and experimenter-programmed events are noted at right. This sample was taken from the second generalization test of bird 101. The particular test stimuli are noted immediately below line 6.

CHAPTER III

RESULTS

Preliminary training

As the frequency of reinforcement was decreased from CRF to VI 15-sec during preliminary training, systematic patterns of behaviors and general timeout behaviors began to appear immediately after the presentation of food. With further reductions in the schedule, these behaviors were also observed between bursts of keypecking. No timeout key-pecks occurred for any subject in Group II during this phase of the experiment. The nature of these behaviors and their temporal relationship with food presentation were similar to those behaviors labeled by Staddon and Simmelhag (1971) as "interim" behaviors, suggesting the possibility that they were controlled by stimuli associated with low probabilities of reinforcement and would, therefore, be likely candidates for the behaviors which would be observed during S- in sub-sequent discrimination training. Thus a decision was made to select the most regularly occurring behavior which followed reinforcement as the systematic pattern of behavior. For the most part, this decision was not difficult as there was usually one predominant mode of behavior for each bird. Table 2 presents for each bird, behaviors selected as the systematic pattern of behavior and behaviors most frequently

observed which also qualified for the general timeout response class.

TABLE 2

OBSERVED BEHAVIORS FOR EACH SUBJECT[1]

Subject Number	Systematic Patterns of Behavior	General Time-out[2] Behaviors	Other
110	R_4	R_4, R_{18}, R_{11}	
111	R_4	R_4, R_8	R_5
112	R_8/R_4	R_8, R_4, R_{18}	R_5, R_1
113	R_4	R_4, R_8, R_9	R_3, R_{17}
101	R_4	R_4, R_9, R_3	
102	R_4	R_4	R_{18}, R_{19}
103	R_{19}/R_4	R_{19}, R_4	R_{17}, R_1
104	R_{18}	R_{18}, R_4	

[1]Based on classification system presented in Table 1.

[2]Behaviors under General Timeout category are listed in order from most frequently to less frequently observed modes of behavior qualifying for this response class.

Non-differential training

The proportions of the total stimulus-on periods occupied by each of the three classes of behavior during the non-differential training sessions are plotted in Figure 4. It can be seen that most of the birds had stabilized by the last ten sessions of this training phase. Towards the end
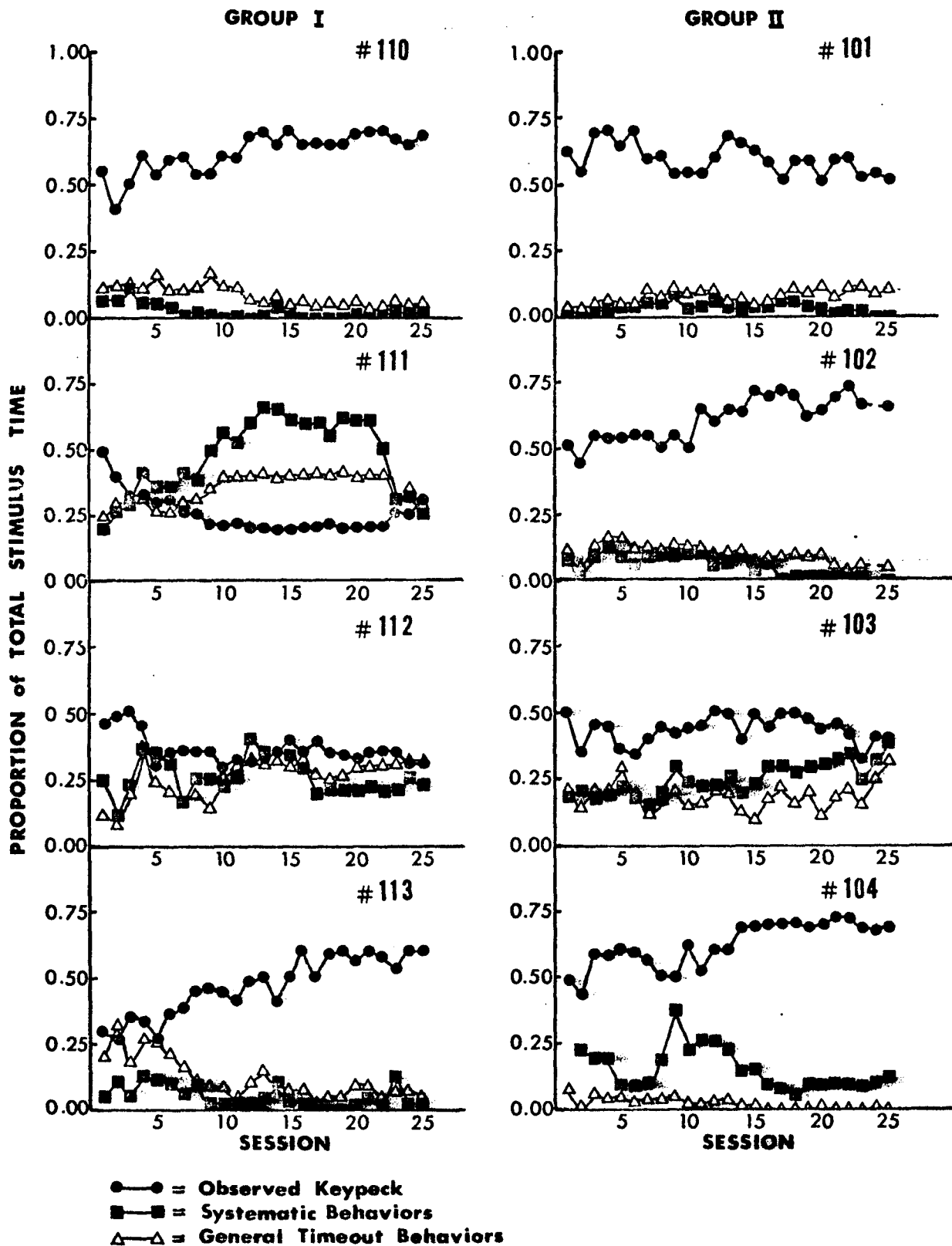
Fig. 4.--Proportions of total stimulus on periods occupied
by three observed behavior classes throughout nondifferential train-
ing. Subject 102's data from session 24 were inadvertently destroyed.

of the non-differential training phase, the systematic

patterns of behavior and the general timeout behaviors for

the majority of birds occupied only a small portion of the

total period relative to the keypecking response. For

birds 111, 112, and 103, however, these behaviors occupied

a considerable portion of the stimulus-on periods, reaching

durations equal to or greater than those for the keypecking

behaviors. Of particular interest was the case of 111,

whose behavior can be described as a highly stereotyped

sequence of one or two discrete keypecks separated by a full-

circle turn. This turning behavior occurred up to 65 percent

of the periods as compared with only 20 percent occupied

by the keypecking behavior. The last three days of non-

differential training were featured by an abrupt decrease

in this turning behavior although the factors contributing

to the change were not apparent.

As mentioned in Chapter II, the possibility existed

that the bird could engage in a systematic pattern of be-

havior in which all portions, no portions, or only some

portions of that behavior could also qualify for the general

timeout class of behavior. It was found that the observed

systematic behaviors for all birds had at least some com-

ponents which also met the criterion for the general time-

out response class. Since the two response categories were

not independent, the duration of the general timeout be-

haviors was partially a function of the duration of the

systematic patterns of behavior. It should be stressed,
however, that other behaviors (e.g., preening, pecking the
floor of the chamber, head in magazine, head in extreme
corners of the chamber, etc.) could also meet the criterion
of general timeout. Therefore, the obtained durations of
this class of behavior were the sum of (1) portions of the
systematic patterns of behavior and (2) other behaviors.
Of the four birds in Group II, only 102 and 103 pecked the
timeout key during non-differential training, 3 and 17
times, respectively.

Discrimination training

Overall keypeck response rates, obtained during dis-
crimination training, and a running rate measure (computed
by dividing the total number of keypecks by the observed
duration of keypecking) are presented in Figure 5. The pro-
portions of the S+ and S- stimulus-on periods occupied by
the three observed response classes and the timeout keypeck
responses are plotted in Figure 6.

Five of the eight birds exhibited considerable diffi-
culty in acquisition of the line-tilt discrimination, a re-
sult unexpected on the basis of previous studies employing
similar stimuli (e.g., Terrace, 1971). After 15 days of
discrimination training (and two generalization test sessions,
to be described below), a decision was made to increase the
schedule of reinforcement from VI 60-sec to VI 20-sec in an

Fig. 5a.--Overall and running rates of keypecking across all discrimination training sessions. Data points representing those discrimination training sessions separated by generalization tests are not connected (e.g., 10 and 11, 15 and 16, etc.). A VI 60 sec schedule of reinforcement was in effect except for sessions 16 through 20 when the schedule was VI 20 sec. Running rates were not computed for those sessions in which the overall rates were less than 0.10 keypecks per second. See text for further details. Subjects 110, 111.

SUBJECT: 112

SUBJECT: 113

Fig. 5b.--Overall and running rates of keypecking across all discrimination training sessions. Data points representing those discrimination training sessions separated by generalization tests are not connected (e.g., 10 and 11, 15 and 16, etc.). A VI 60 sec schedule of reinforcement was in effect except for sessions 16 through 20 when the schedule was VI 20 sec. Running rates were not computed for those sessions in which the overall rates were less than 0.10 keypecks per second. See text for further details. Subjects 112, 113.
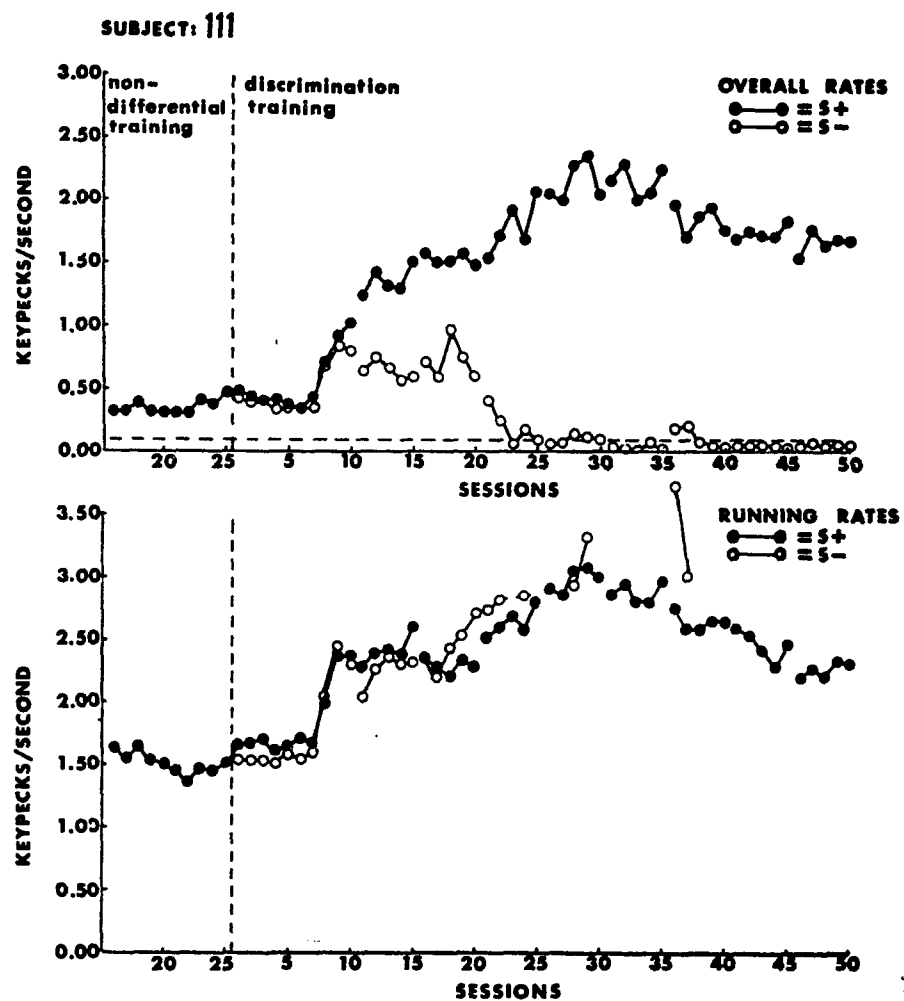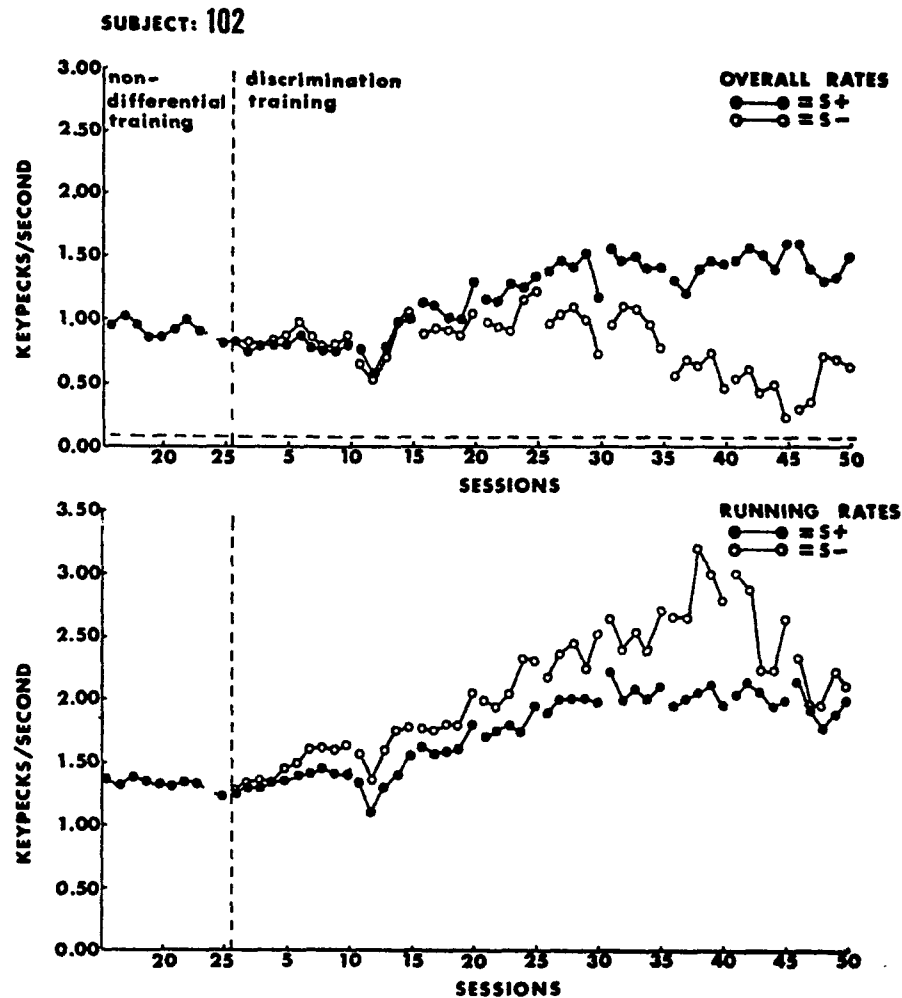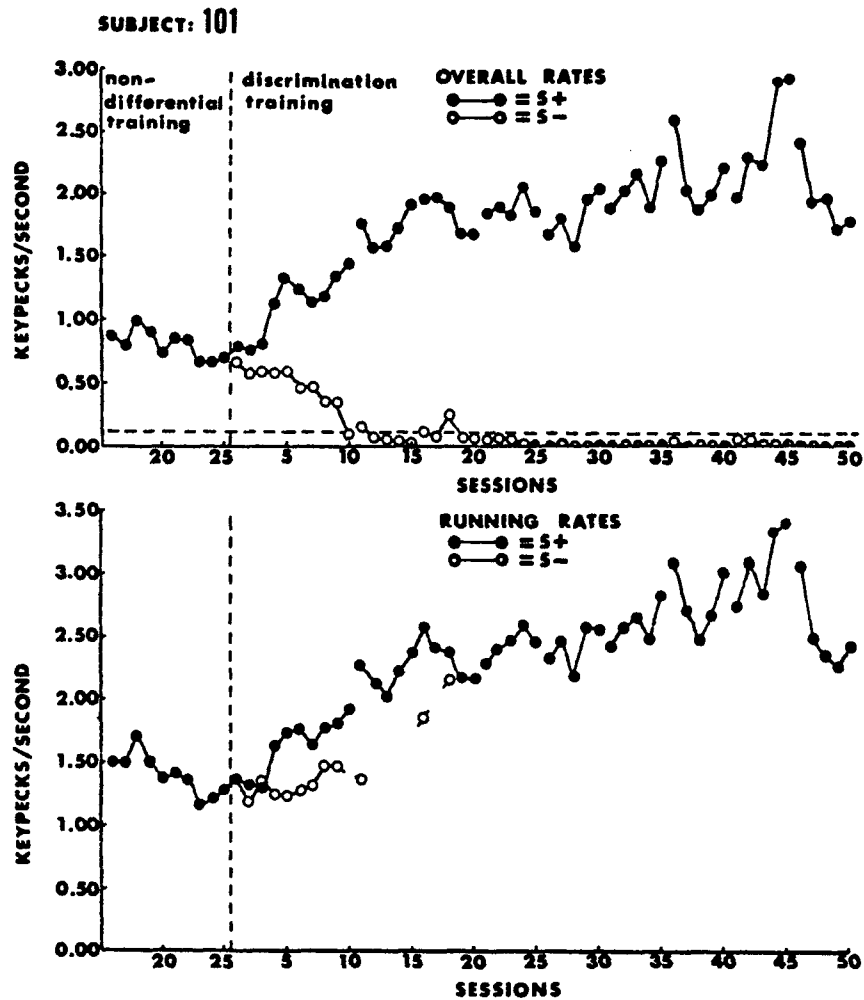
Fig. 5c.--Overall and running rates of keypecking across all discrimination training sessions. Data points representing those discrimination training sessions separated by generalization tests are not connected (e.g., 10 and 11, 15 and 16, etc.). A VI 60 sec schedule of reinforcement was in effect except for sessions 16 through 20 when the schedule was VI 20 sec. Running rates were not computed for those sessions in which the overall rates were less than 0.10 keypecks per second. See text for further details. Subjects 101, 102.
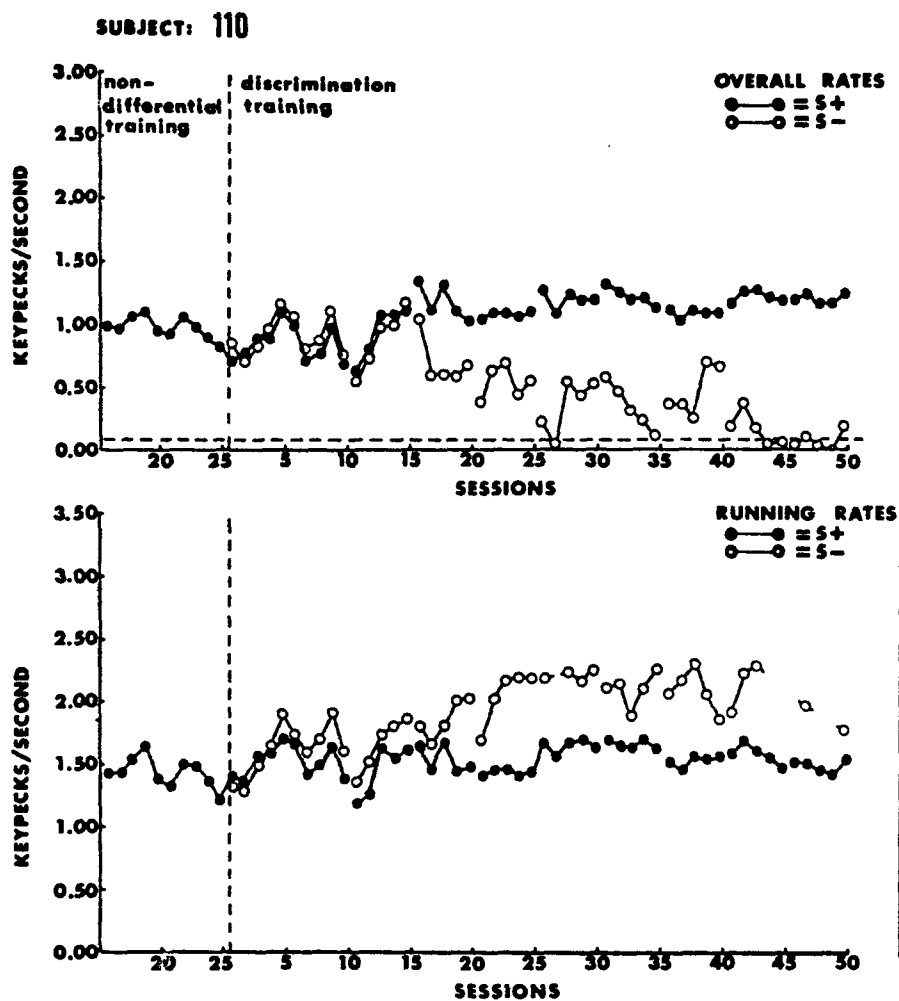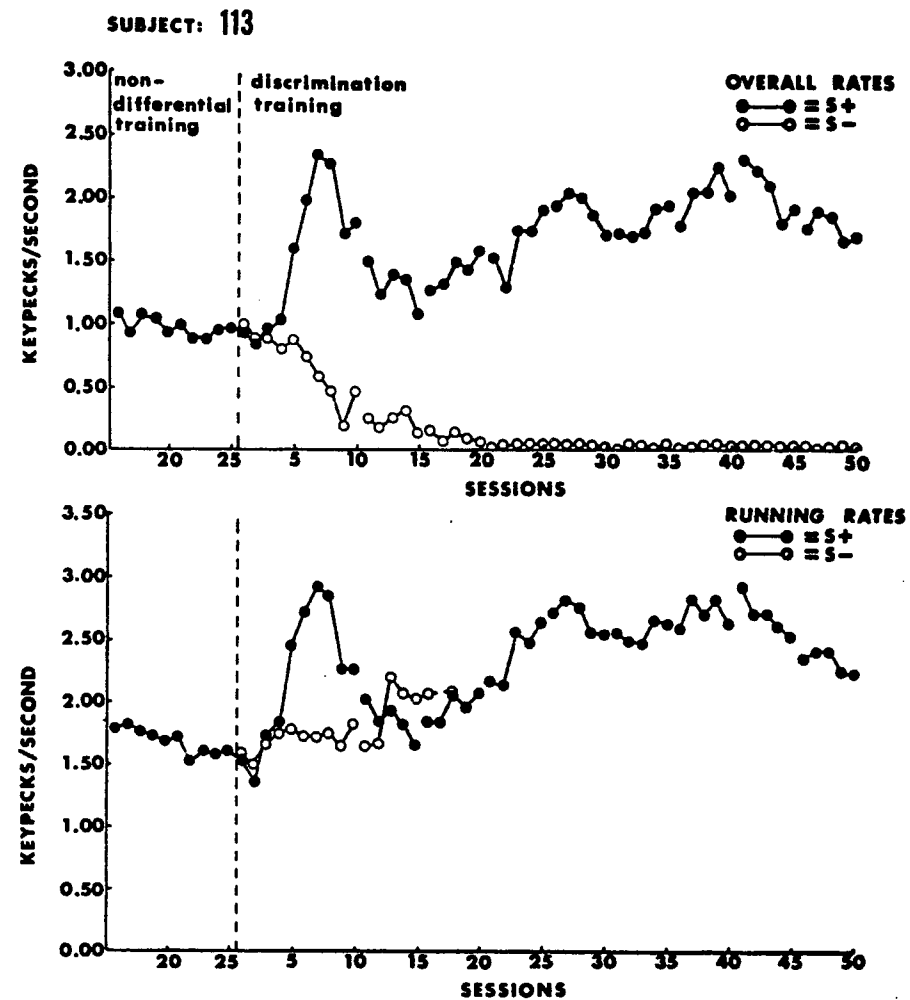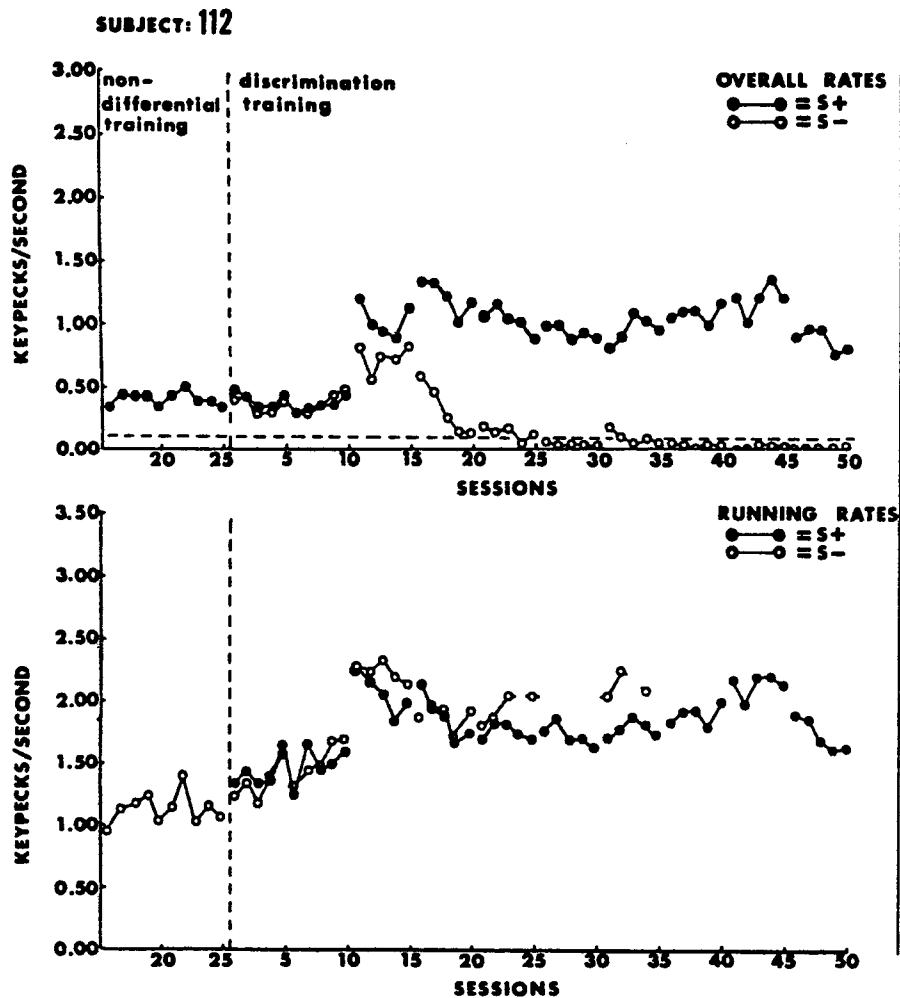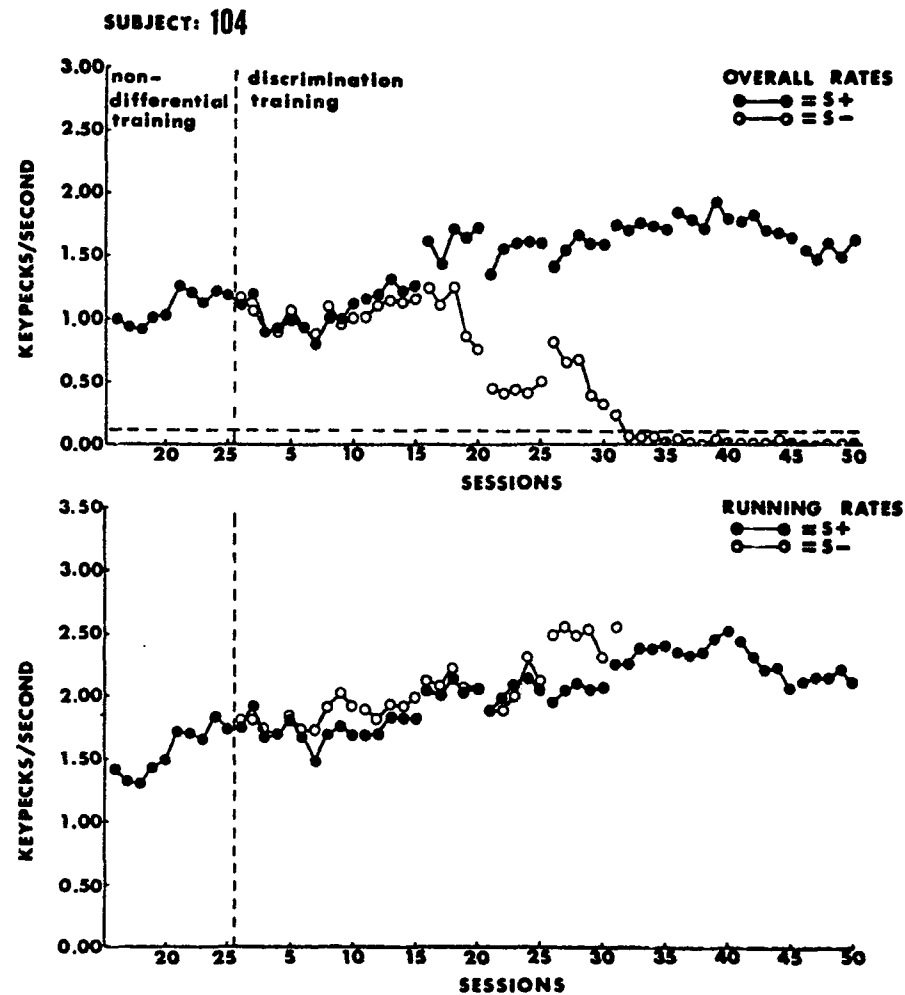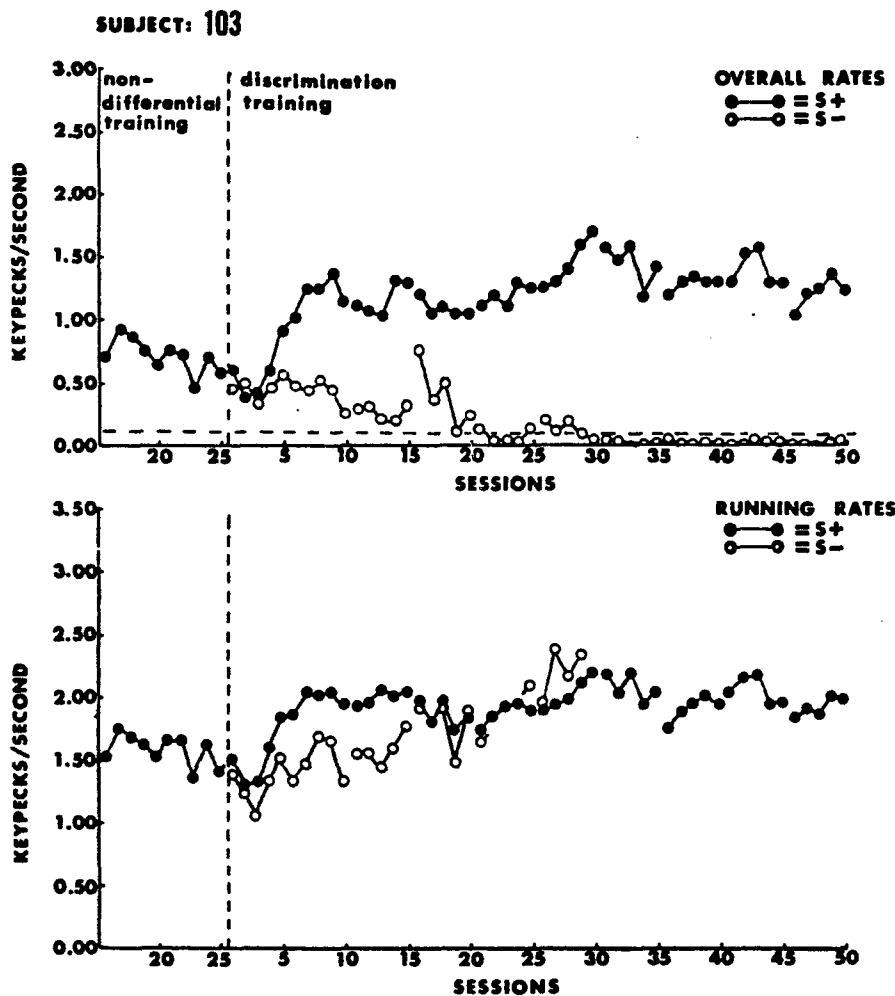
Fig. 5d.--Overall and running rates of keypecking across all discrimination training sessions, Data points representing those discrimination training sessions separated by generalization tests are not connected (e.g., 10 and 11, 15 and 16, etc.). A VI 60 sec schedule of reinforcement was in effect except for sessions 16 through 20 when the schedule was VI 20 sec. Running rates were not computed for those sessions in which the overall rates were less than 0.10 keypecks per second. See text for further details. Subjects 103, 104.

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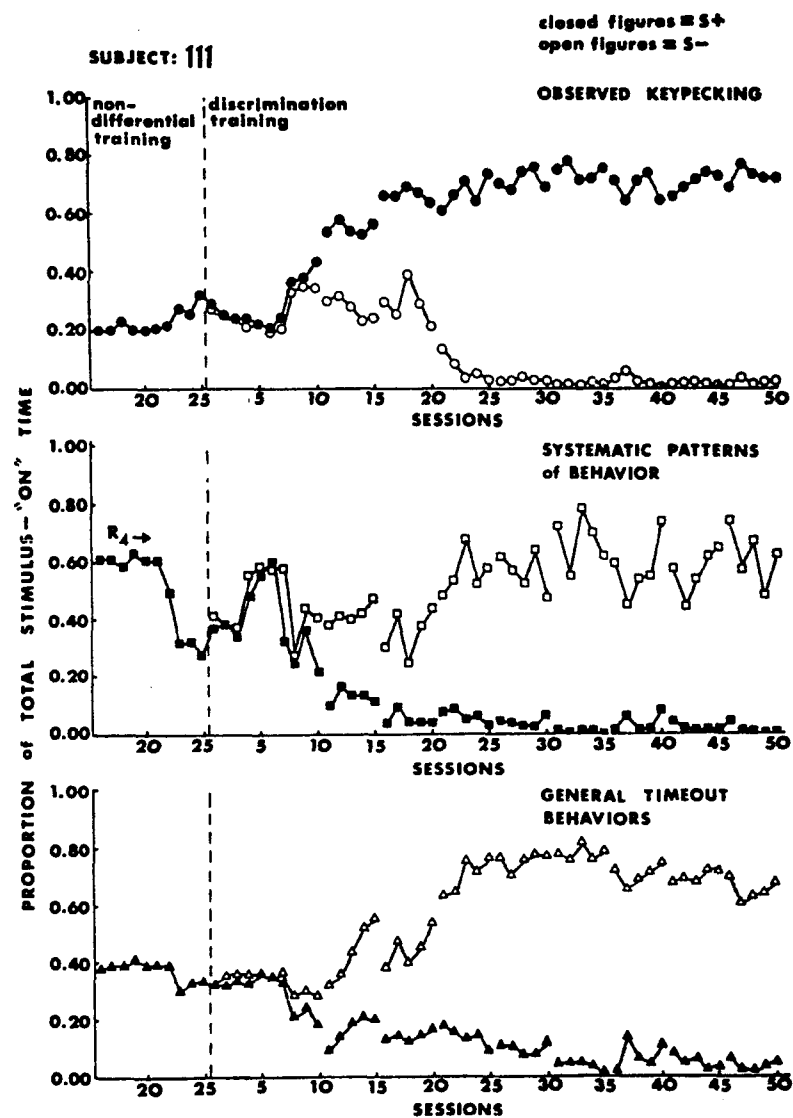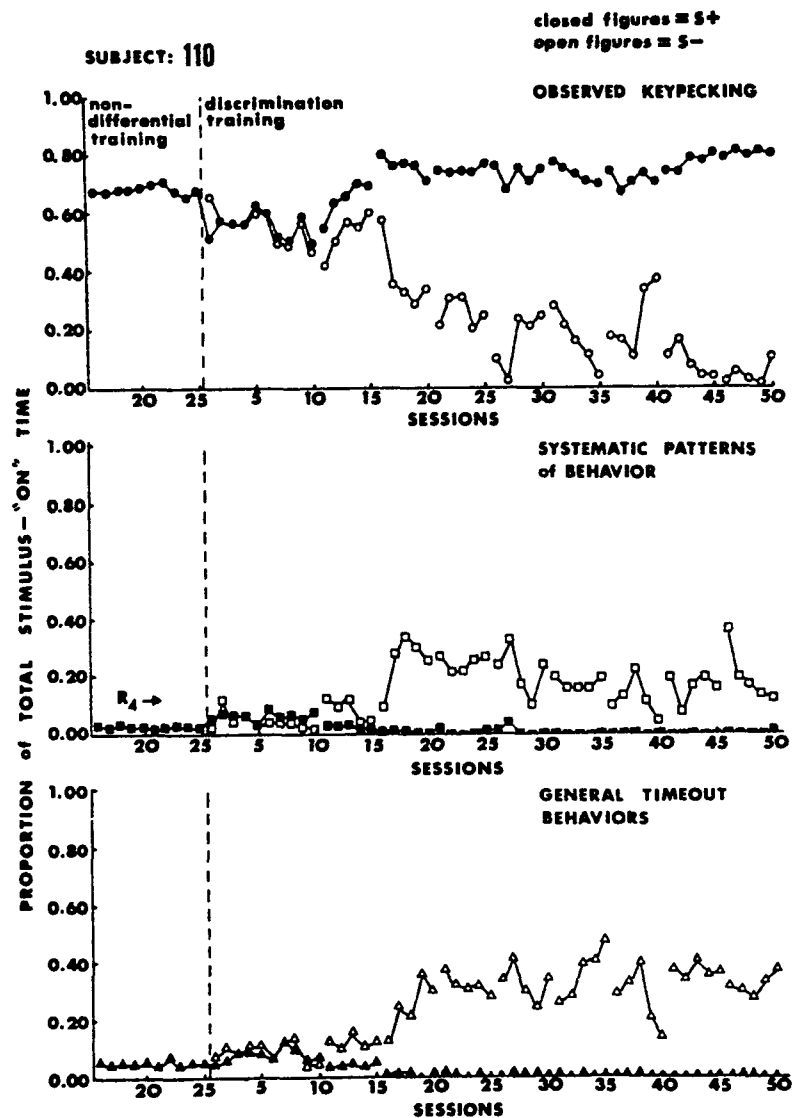
Fig. 6a.--Proportions of total stimulus time occupied by three observed response classes. Data points representing those discrimination training sessions separated by generalization tests are not connected (e.g., 10 and 11, 15 and 16, etc.). A VI 60 sec schedule of reinforcement was in effect except for sessions 16 through 20 when the schedule was VI 20 sec. See text for further details. Subject 110, 111.
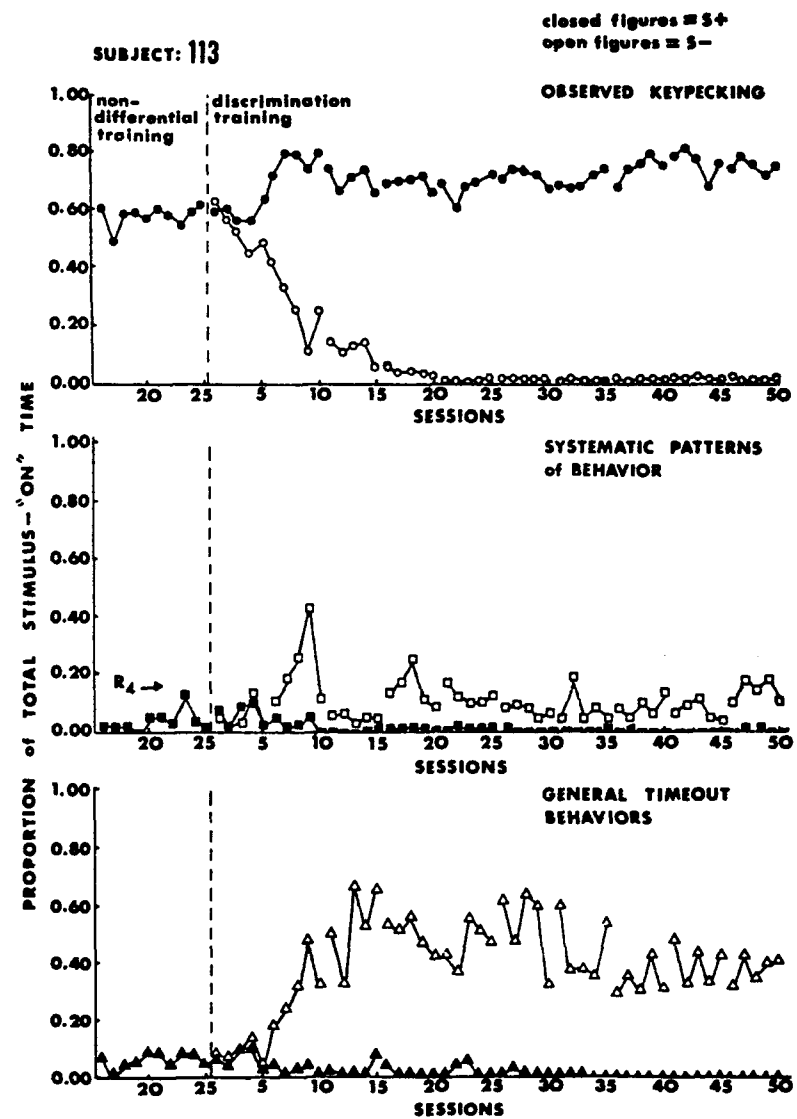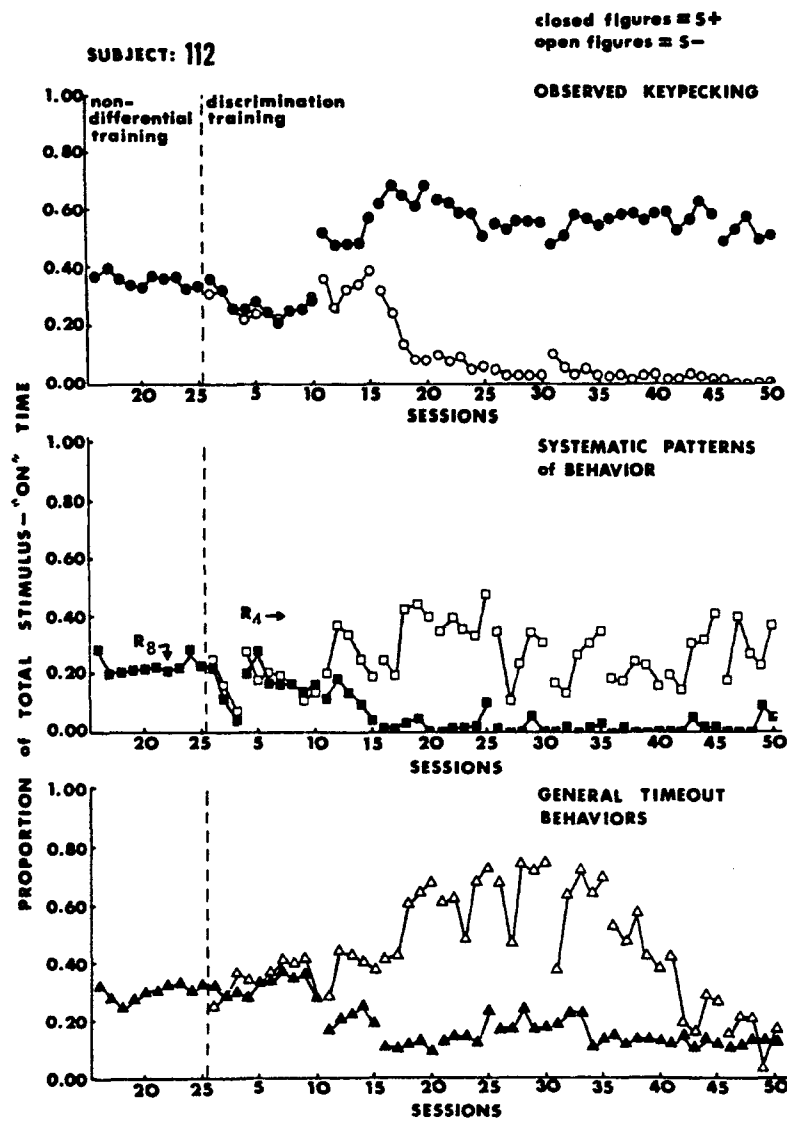
Fig. 6b.--Proportions of total stimulus time occupied by three observed response classes. Data points representing those discrimination training sessions separated by generalization tests are not connected (e.g., 10 and 11, 15 and 16, etc.). A VI 60 sec schedule of reinforcement was in effect except for sessions 16 through 20 when the schedule was VI 20 sec. See text for further details. Subjects 112, 113.
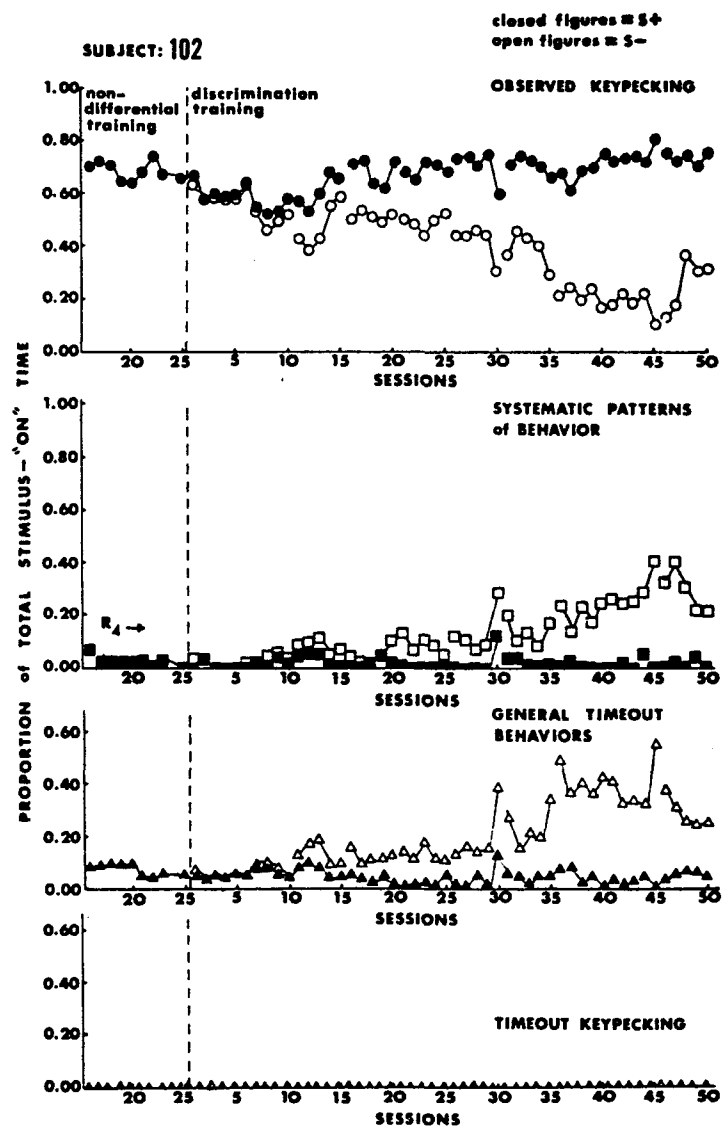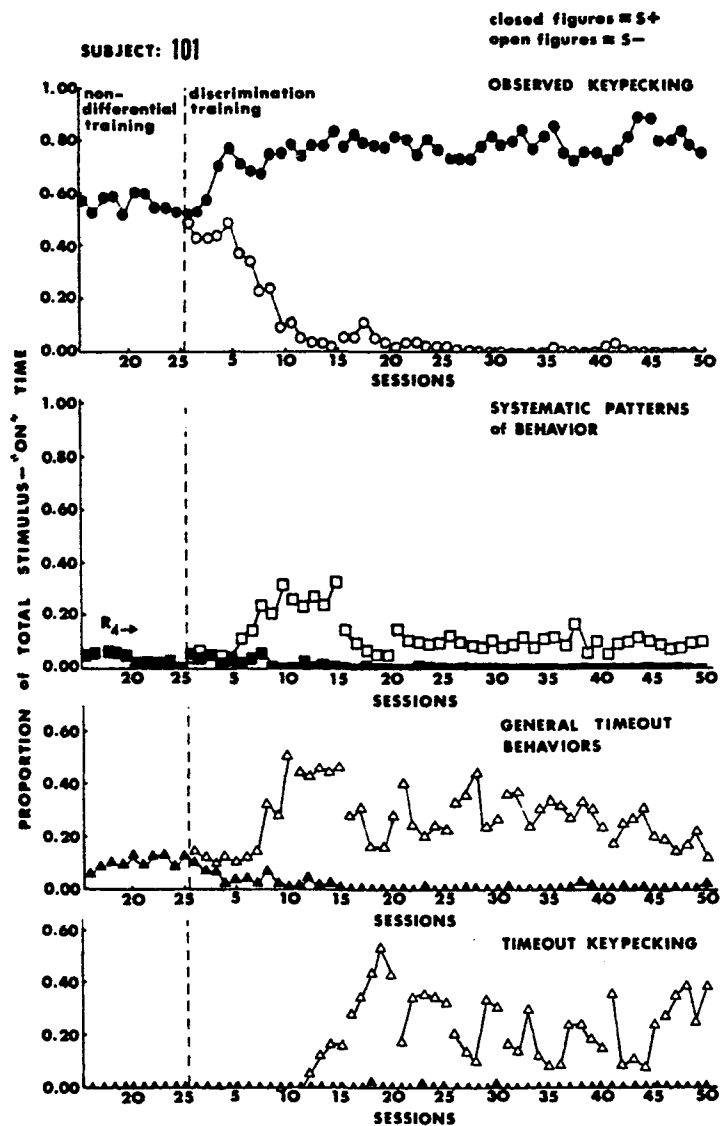
Fig. 6c.--Proportions of total stimulus time occupied by three observed response classes and by timeout keypecks. Data points representing those discrimination training sessions separated by generalization tests are not connected (e.g., 10 and 11, 15 and 16, etc.). A VI 60 sec schedule of reinforcement was in effect except for sessions 16 through 20 when the schedule was VI 20 sec. See text for further details. Subjects 101, 102.
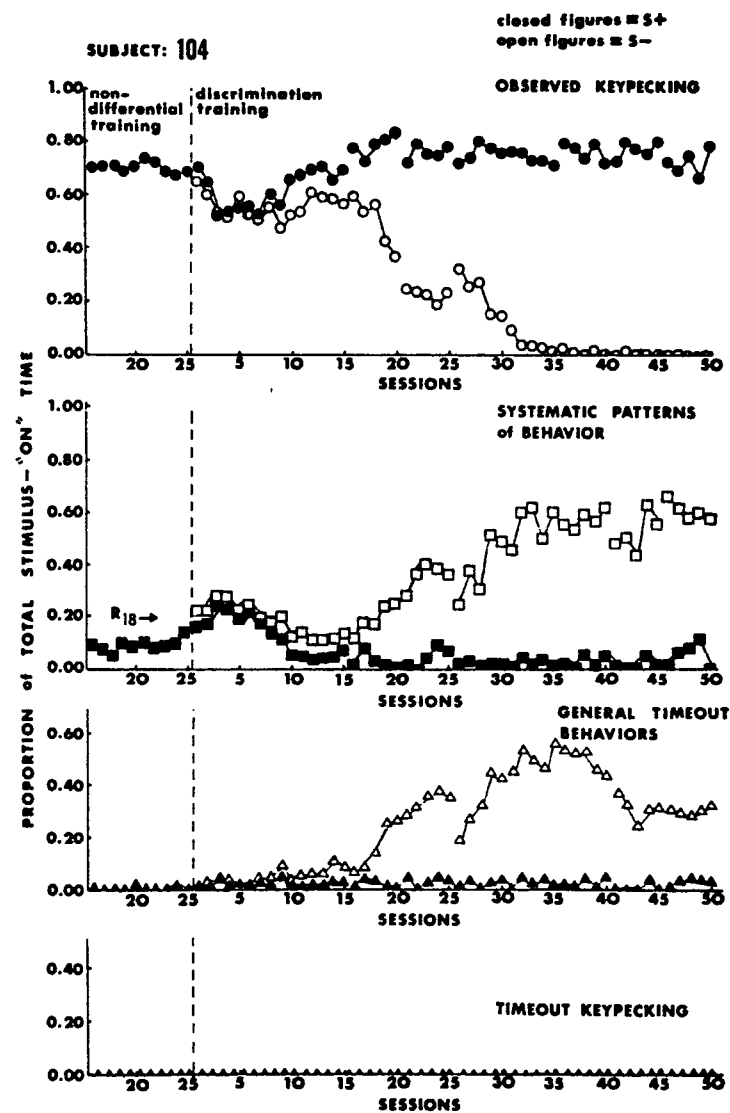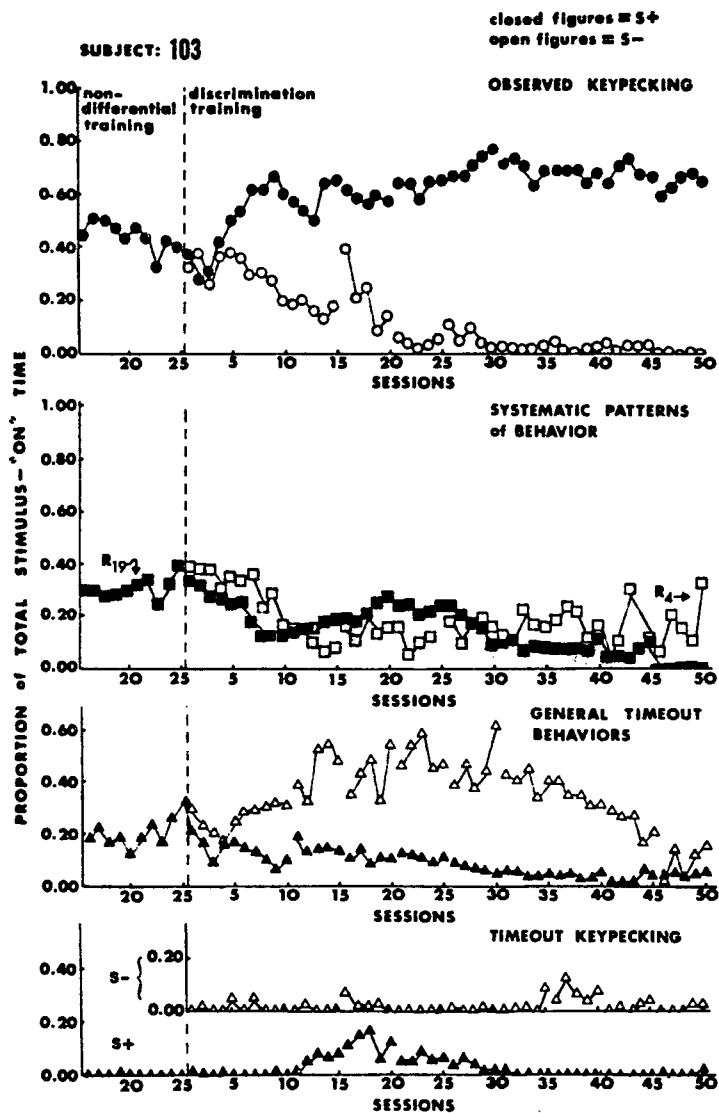
Fig. 6d.-Proportions of total stimulus time occupied by three observed response classes and by timeout keypecks. Data points representing those discrimination training sessions separated by generalization tests were not connected (e.g., 10 and 11, 15 and 16, etc.). A VI 60 sec schedule of reinforcement was in effect except for sessions 16 through 20 when the schedule was VI 20 sec. See text for further details. Subjects 103, 104.

attempt to facilitate the development of the discrimination. This schedule change was implemented for all subjects during sessions 16 through 20, whether or not they had demonstrated differential performance in any of the three response classes. The VI 60-sec was reinstated on discrimination training session 21 and was in effect for the remainder of the experiment. Figures 5 and 6 show that the higher frequency of reinforcement was accompanied by an improved discriminative performance for the majority of subjects. It appeared to have a disruptive effect for birds 111, 101, and 102 although such effects were temporary.

Keypecking behavior.--Figure 5 shows that with continued differential training the overall rate of main keypecking decreased in the presence of the S-. This decrease in rate was accompanied by a corresponding decrease in the duration of observed main keypecking (Figure 6). Figure 5 also presents the running rates of the S- keypecking response where it can be seen that the S- running rates remained approximately the same as the S+ running rates. The decrease in the overall rates of S- keypecking appears, therefore, to be primarily a function of the decrease in the amount of time engaged in this behavior.

The running rates were not computed for those sessions in which the overall rate of keypecking was less than 0.10 responses per second. Such low overall rates often

reflected isolated pecking responses resulting in the observer "tracking" each keypeck in a discrete fashion, i.e., each peck was recorded as 1/3 second since the timing device was set at three pulses per second. Thus when each peck was recorded discretely, the running rates would spuriously approach 3.00 pecks per second. For those overall rates greater than 0.10 per second, the keypecks usually occurred in bursts of several responses.

The running rates in the presence of the S- were consistently higher than those in the presence of the S+ in the cases of subjects 102 and 110. It is possible, of course, that the running rates to S- reflected a real decrease in the length of the inter-response interval. Another possibility is that they reflected a topographical change such as increases in the average force with which the key was pecked during the S-. The observed keypeck measure was not sensitive to such changes since the switch-closure was not a part of the criteria for the observed key-pecking response. The increase in running rates may, therefore, have reflected a decrease in the number of keypecks which were below the minimum force required to close the response key micro-switch. It is not readily apparent why such changes would occur in the presence of the S-, as opposed to the S+. There were, however, instances in the case of subject 110 where it appeared that bursts of S-keypecks were more vigorous. Such an explanation is, at

best, tenuous, and clearly requires experimental verification.

An alternative explanation is that this discrepancy may have been due to an anticipatory response "set" on the part of the observer. As the discriminative performance of both birds (102 and 110) was very slow and erratic in its development, it is conceivable that more attenion was placed on behaviors other than keypecking and that the keypeck lever may have been released somewhat sooner than was the case for the other birds. Thus the higher running rates may have been produced by spuriously low durations resulting from this "expectancy" on the part of the observer. This difficulty was not encountered for any of the other subjects.

The overall keypeck rates to the S+ also increased over the baseline rates when the S- keypecking behaviors were decreasing. This phenomenon, known as behavioral contrast, was obtained for birds 101, 103, 111, 112, and 113. In each of these five cases, the overall S+ rates rose rather sharply in the early stages of discrimination. It should be noted that the introduction of the VI-20 sec schedule did not appear to disrupt the contrast effects. The duration of the S+ keypecking behavior also increased, but the running rates indicate that this increase in overall rates was not solely a function of increases in amount of time occupied by this behavior class. The most outstanding

case is that of bird 113, who exhibited dramatic changes in

S+ keypecking. It appeared that the tempo of the keypeck

increased. It was clear that the overall time spent in

the general category of keypecking was not sufficient to

account for the dramatic rise in the total frequency of

this behavior. It is interesting to note also that while

the S- running rates were similar to the S+ running rates

toward the latter stages of discrimination training, they

did not show the sharp rise in rates or any major changes

in topographical aspects during this early portion of the

discrimination.

Systematic patterns of behavior.--Figure 6 illus-

trates the changes in durations of the systematic patterns

of behavior which resulted from differential training. As

the S- keypecking was being extinguished the S- systematic

behaviors were increasing for the majority of subjects.

This finding supports the hypothesis that those behaviors

which occurred following reinforcement in the non-

differential training phase would be observed during S- in

discrimination training. In addition to increasing during

the S-, these behaviors generally decreased or remained at

low baseline level in the presence of the S+.

Two exceptions to this finding are in the cases of

subjects 103 and 112. The systematic pattern of behavior

observed during baseline training for bird 103 was R_{19}--

rapid head movements towards the general vicinity of the

timeout key. Discrimination training did not, however, result in differential performance with respect to this behavior class, as it occupied approximately equal portions of both S+ and S- stimulus-on periods. Because of the relationship of this behavior class to the behavior of pecking the timeout key which occurred in the presence of both S- and S+, a decision was made to continue recording this behavior as the systematic pattern. Unfortunately, this choice sacrificed other behaviors which appeared to occur with some regularity in the presence of the S-, such as turning away from the key and facing the rear wall. The behavior of turning was recorded as the systematic pattern during the last training block (sessions 46 - 50) where it can be seen that it occurred almost exclusively in the presence of the S-.

The systematic pattern of behavior for subject 112 (R_8 - pacing movements at the key wall, accompanied by vigorous wing flaps) was observed during the non-differential training phase but dropped off sharply in the early stages of discrimination training and was replaced by another behavior, R_4, or turning around in the chamber. This new behavior was then selected as the systematic pattern of behavior which occupied a considerable portion of the S- periods throughout the remainder of the experiment.

General timeout behaviors.--Figure 6 shows that as

the S- keypecking decreased, the amount of time occupied by

the general timeout behaviors increased. In the presence

of the S+, this behavior class either remained at a low

baseline level or decreased to low levels. The general

timeout behaviors occupied a considerable portion of the

S- periods throughout the experiment, except for birds 104,

112, and 103. Towards the end of the experiment, the S-

general timeout behaviors of these birds decreased sub-

stantially. Birds 103 and 112 were observed to be spending

an increasing amount of time directly in front of the key

engaging in what are described as roosting behaviors.

Bird 104 continued to engage in the systematic pattern of

behavior of turning to the right side of the chamber, al-

though less of this behavior also qualified for the general

timeout classification, i.e., he would turn to the right

but well within the area of direct illumination from the

stimulus lamp.

Timeout keypecking.--Figure 6 shows that only two

birds (103 and 101) of the four birds in Group II pecked

the timeout key with any regularity. On the eleventh dis-

crimination training session, 101 pecked the timeout key

during S- for the first time. The frequency of this response

rose sharply and although highly variable, the response was

maintained through the remainder of the experiment.

In the early stages of discrimination training, the timeout keypeck for 103 occurred in the presence of the S+, an unexpected result since the frequency of the obtained reinforcement was diminished (the tape programmer stopped during the S+ timeouts). Toward the end of discrimination training the timeout keypecks occurred more often during the S- periods. Based on observations of these keypecks, there were noticeable topographical differences between the S+ timeout response and the S- timeout response. As noted above, the systematic pattern of behavior for this bird included rapid pecking-type head movements toward the general vicinity of the timeout key and also toward the area between the timeout key and the main key. It appeared that the S+ timeout keypeck was embedded in this systematic pattern of behavior. As the source of control over the timeout key response was shifting to the S-, the bird appeared to be developing S+ behaviors incompatible with the timeout keypeck such as lowering the head below the timeout key and then moving to the right of the main key. The S- timeout response, on the other hand, was very similar to the main keypeck which can be characterized as single, directed movements toward the key.

The frequency distributions of the timeout key responses as a function of the portion of the S- intervals are plotted in Figure 7 where it can be seen that the timeout keypecks were more frequent in the last two-thirds of the
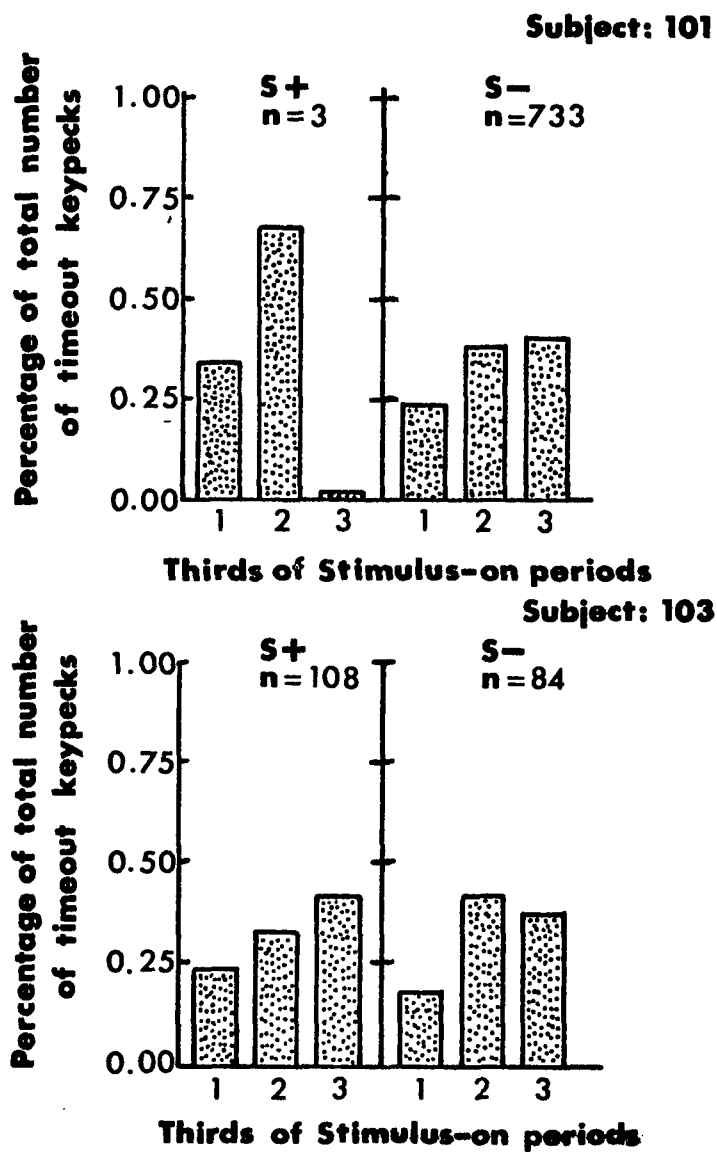
Fig. 7.--Percentage of total number of timeout keypecks as a function of thirds of both S+ and S- intervals throughout all discrimination training sessions.

interval. Analysis of the Esterline-Angus record revealed that in 63 percent and 44 percent of the intervals in which a timeout keypeck occurred, birds 101 and 103, respectively, engaged in turning away from the manipulanda wall prior to pecking the timeout key.

Generalization testing

In addition to the traditional gradients of overall rates of keypecking, results of generalization testing include gradients of running rates of keypecking, gradients of timeout keypecks and gradients of the observed systematic patterns of behavior and general timeout behaviors. Figures 8 through 15 present the results of the generalization testing procedure which was administered after the first 10 discrimination training sessions and subsequently after each block of five training sessions. Nine such tests were given and provided the means of tracking the development of the discrimination and of detecting changes in the degree of stimulus control over the course of the experiment.

Keypeck gradients (overall and running rates).--Careful comparison of the discrimination training data (Figures 5 and 6) and the generalization data (Figures 8 through 15) reveals that once the discrimination was acquired, as evidenced by differential performance with respect to the keypecking behavior, the overall rates of keypecking systematically decreased when the test stimuli were varied away

Fig. 8.--Generalization gradients (Tests 1-9) of the three observed classes of behavior (upper portion of each test panel) and overall and running rates of keypecking (lower portion of each test panel). Subject 110.
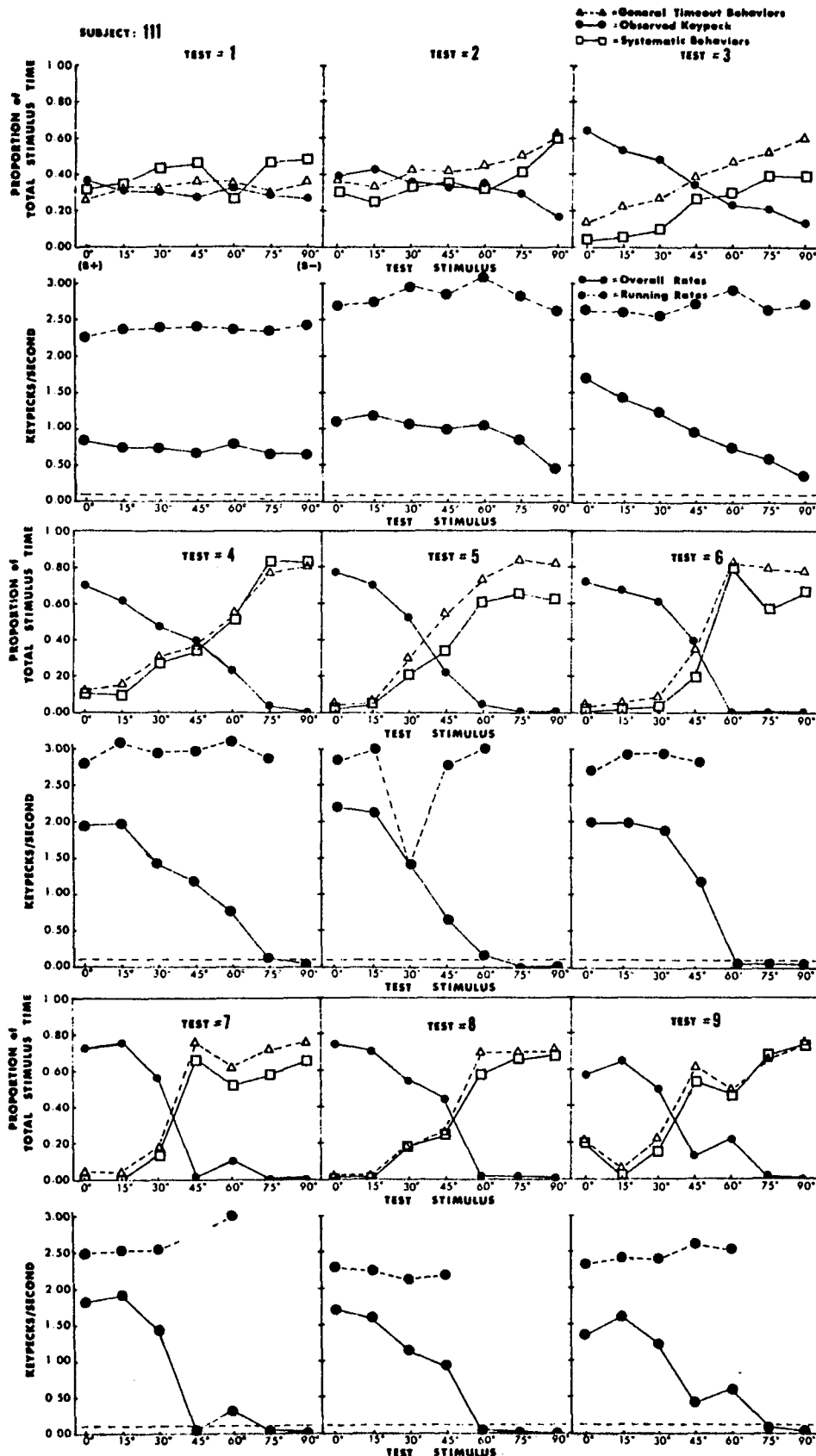
Fig. 9.--Generalization gradients (Tests 1-9) of the three observed classes of behavior (upper portion of each test panel) and overall and running rates of keypecking (lower portion of each test panel). Subject 111.
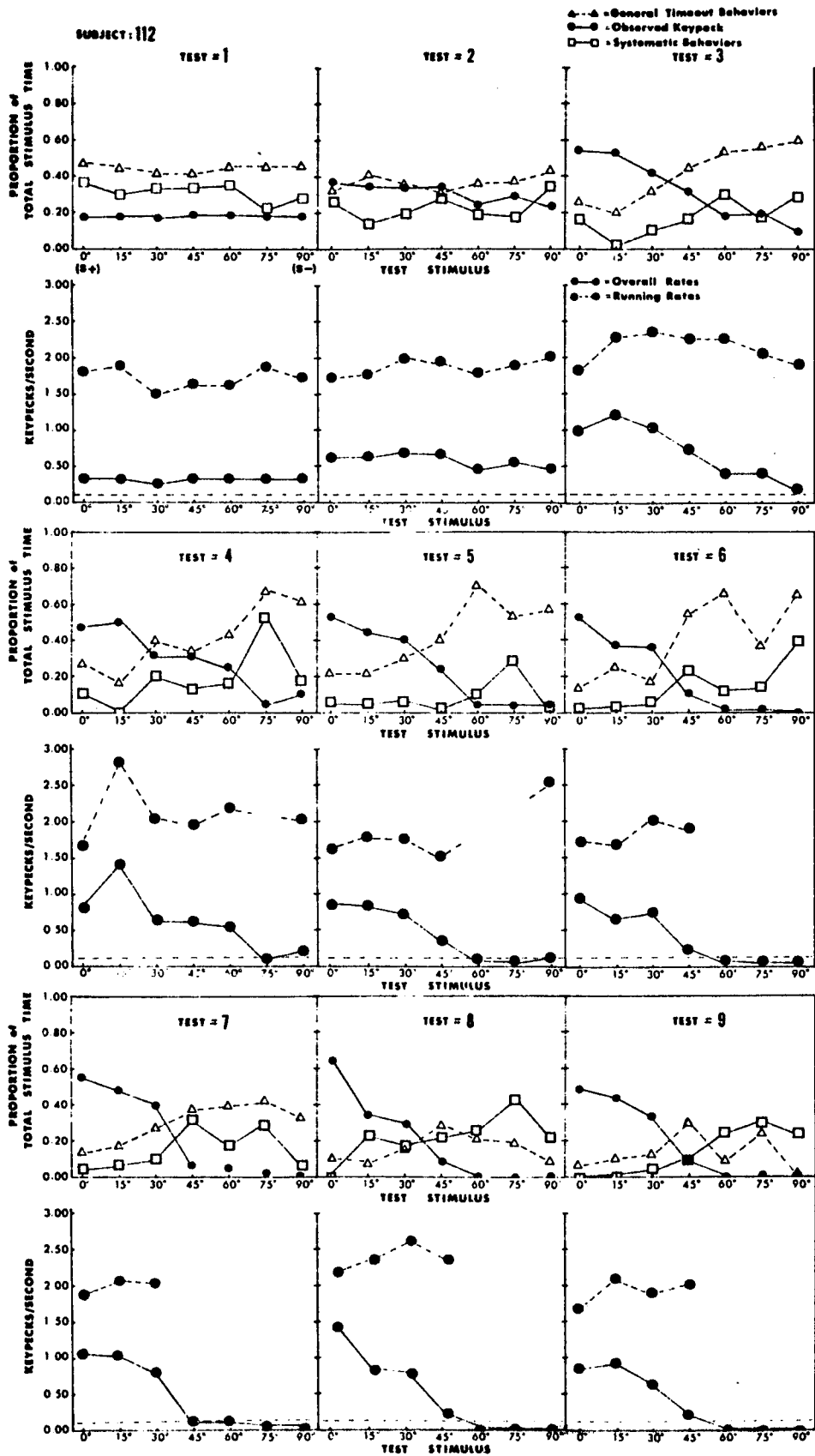
Fig. 10.--Generalization gradients (Tests 1-9) of the three observed classes of behavior (upper portion of each test panel) and overall and running rates of keypecking (lower portion of each test panel). Subject 112.
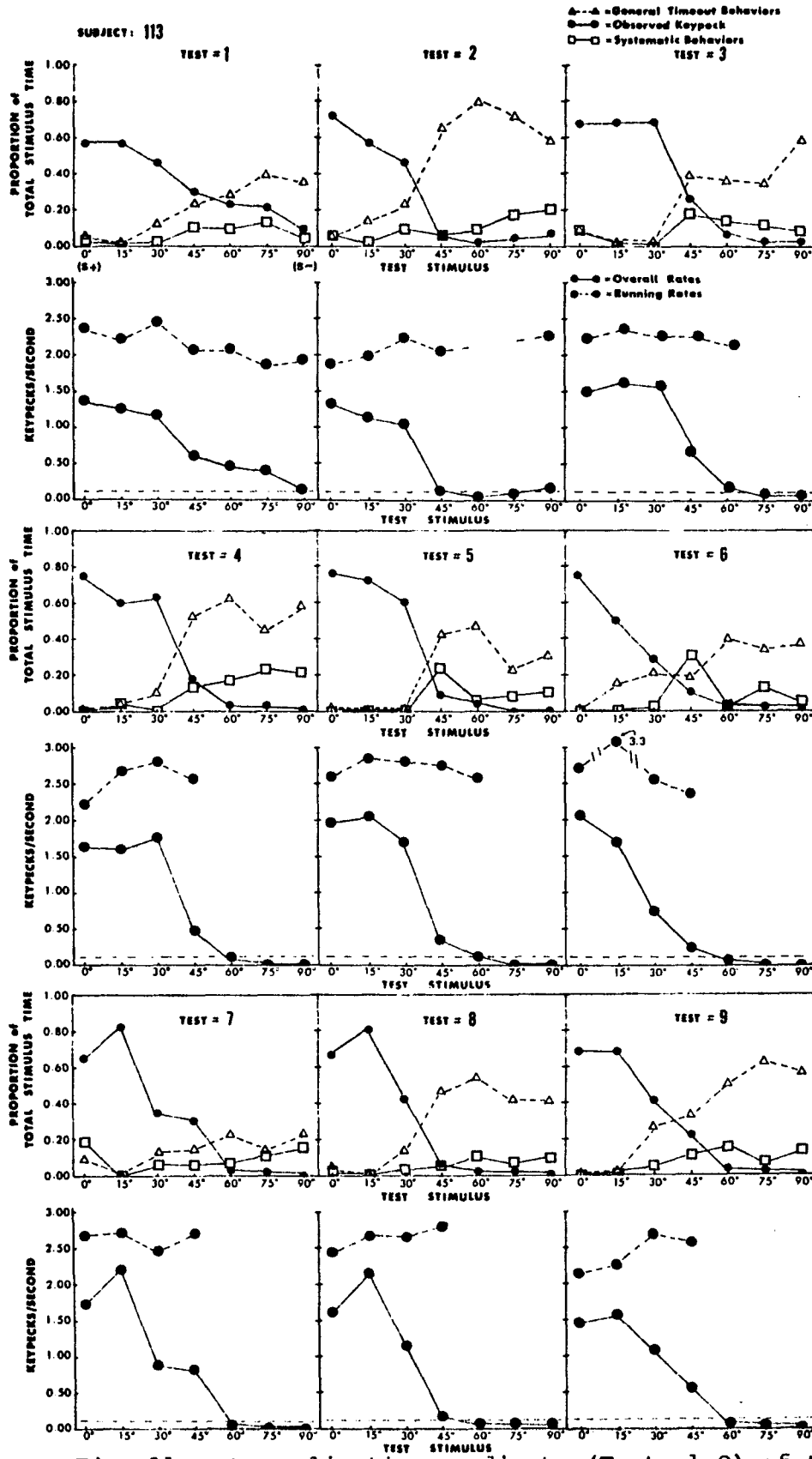
Fig. 11.--Generalization gradients (Tests 1-9) of the three observed classes of behavior (upper portion of each test panel) and overall and running rates of keypecking (lower portion of each test panel). Subject 113.

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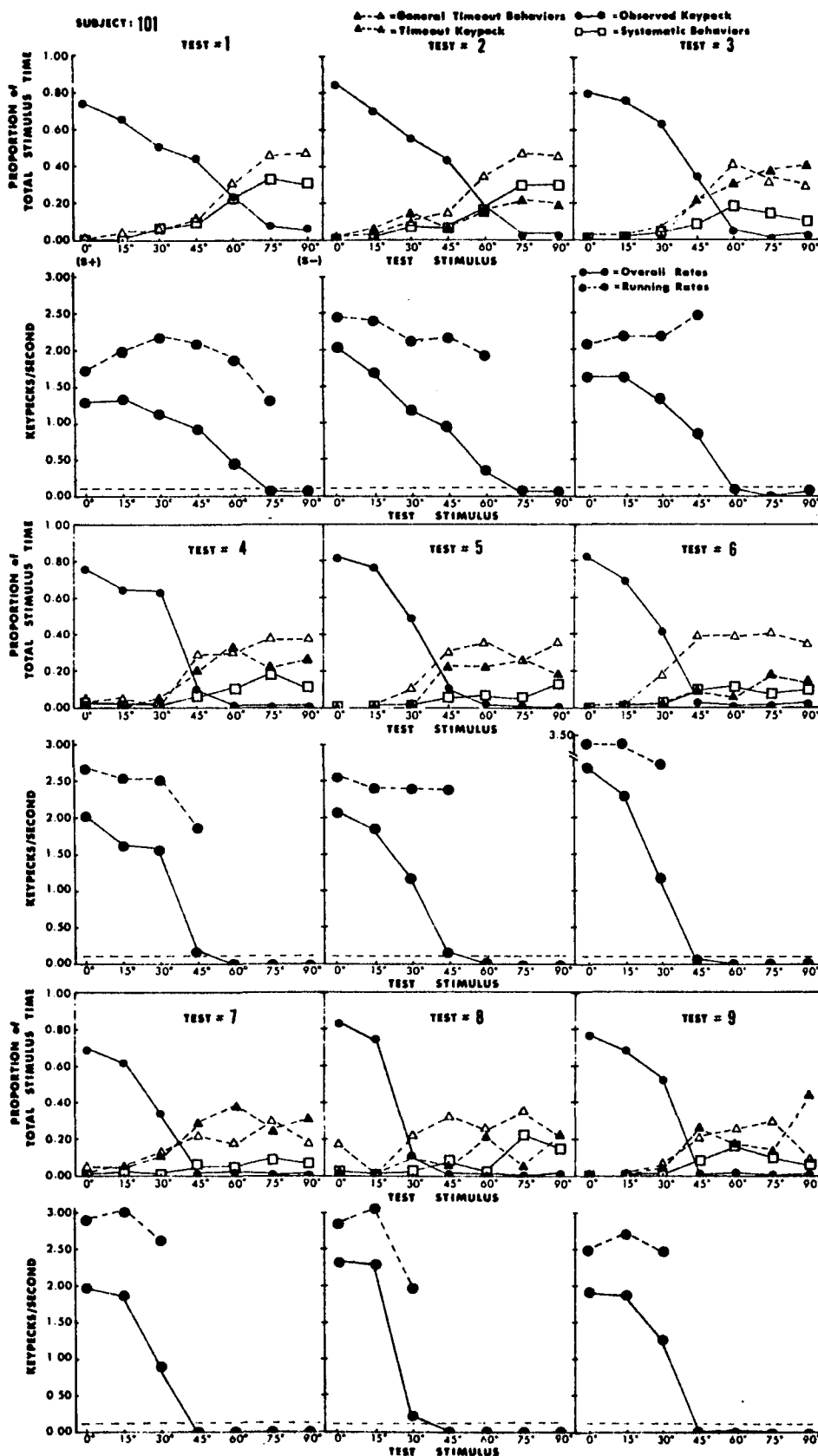
Fig. 12.—Generalization gradients (Tests 1-9) of the three
observed classes of behavior and timeout keypecks (upper portion of
each test panel) and overall and running rates of keypecking (lower
portion of each test panel). Subject 101.
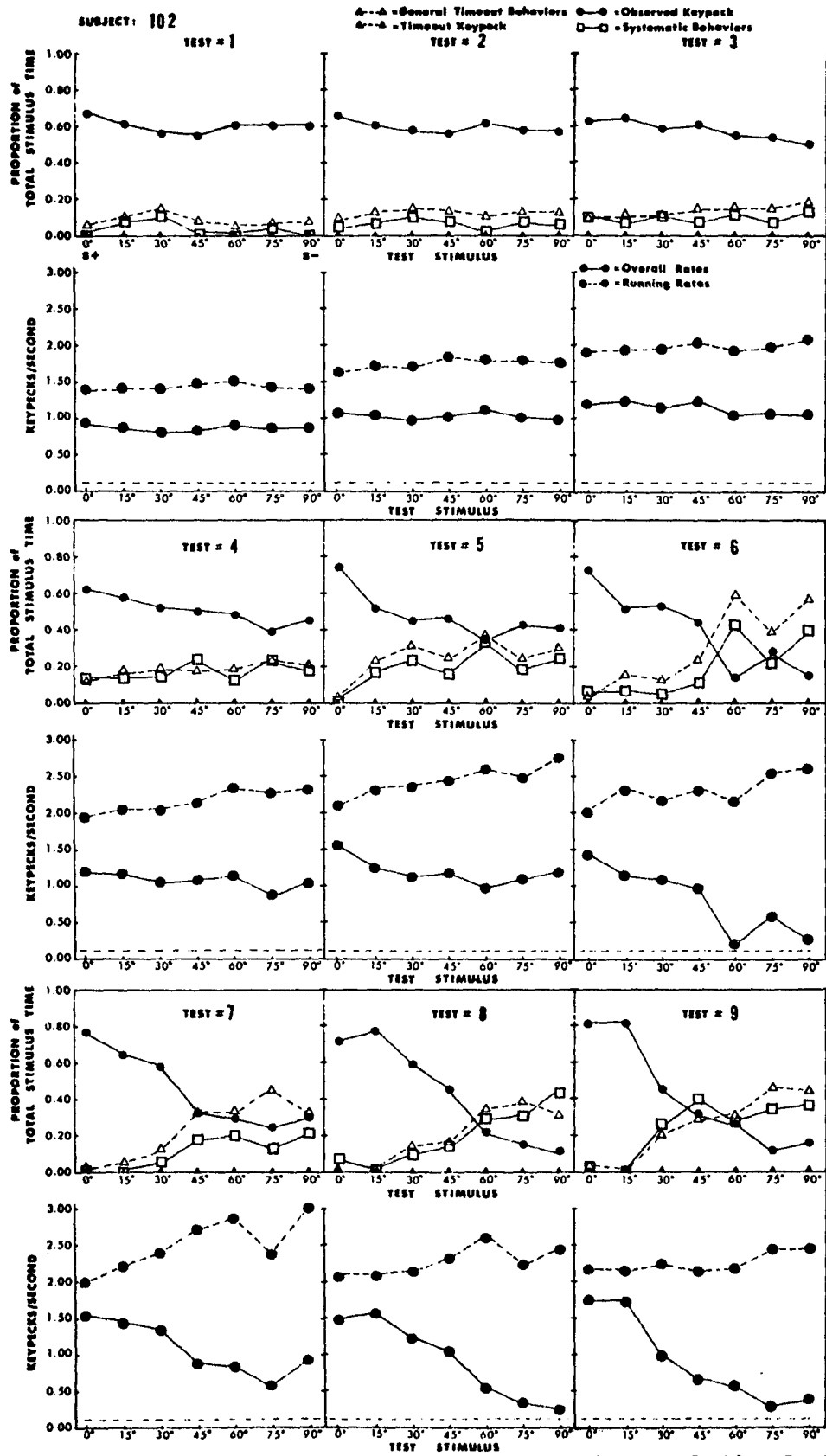
Fig. 13.--Generalization gradients (Tests 1-9) of the three observed classes of behavior and timeout keypecks (upper portion of each test panel) and overall and running rates of keypecking (lower portion of each test panel). Subject 102.
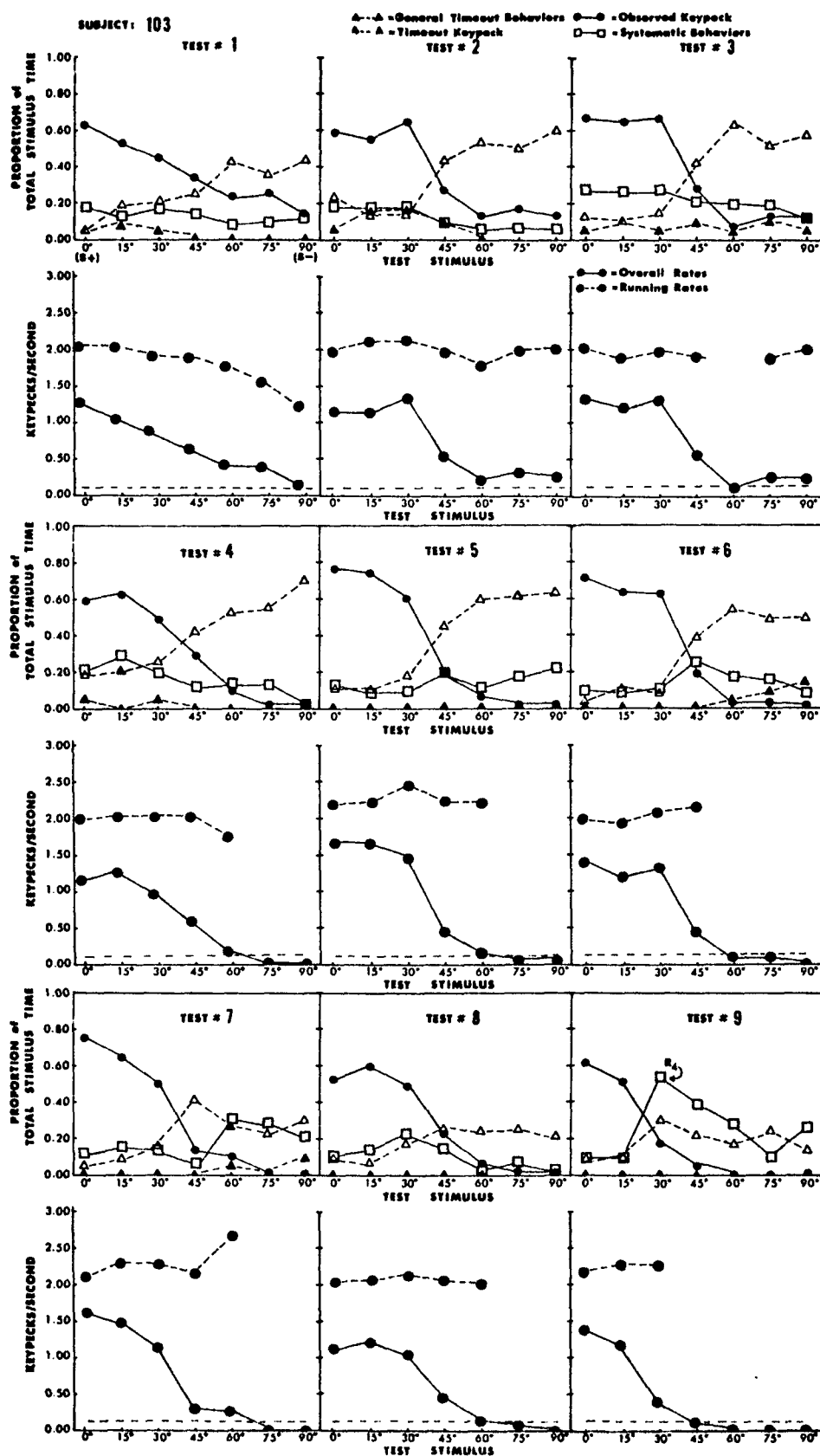
Fig. 14.--Generalization gradients (Tests 1-9) of the three observed classes of behavior and timeout keypecks (upper portion of each test panel) and overall and running rates of keypecking (lower portion of each test panel). Subject 103.
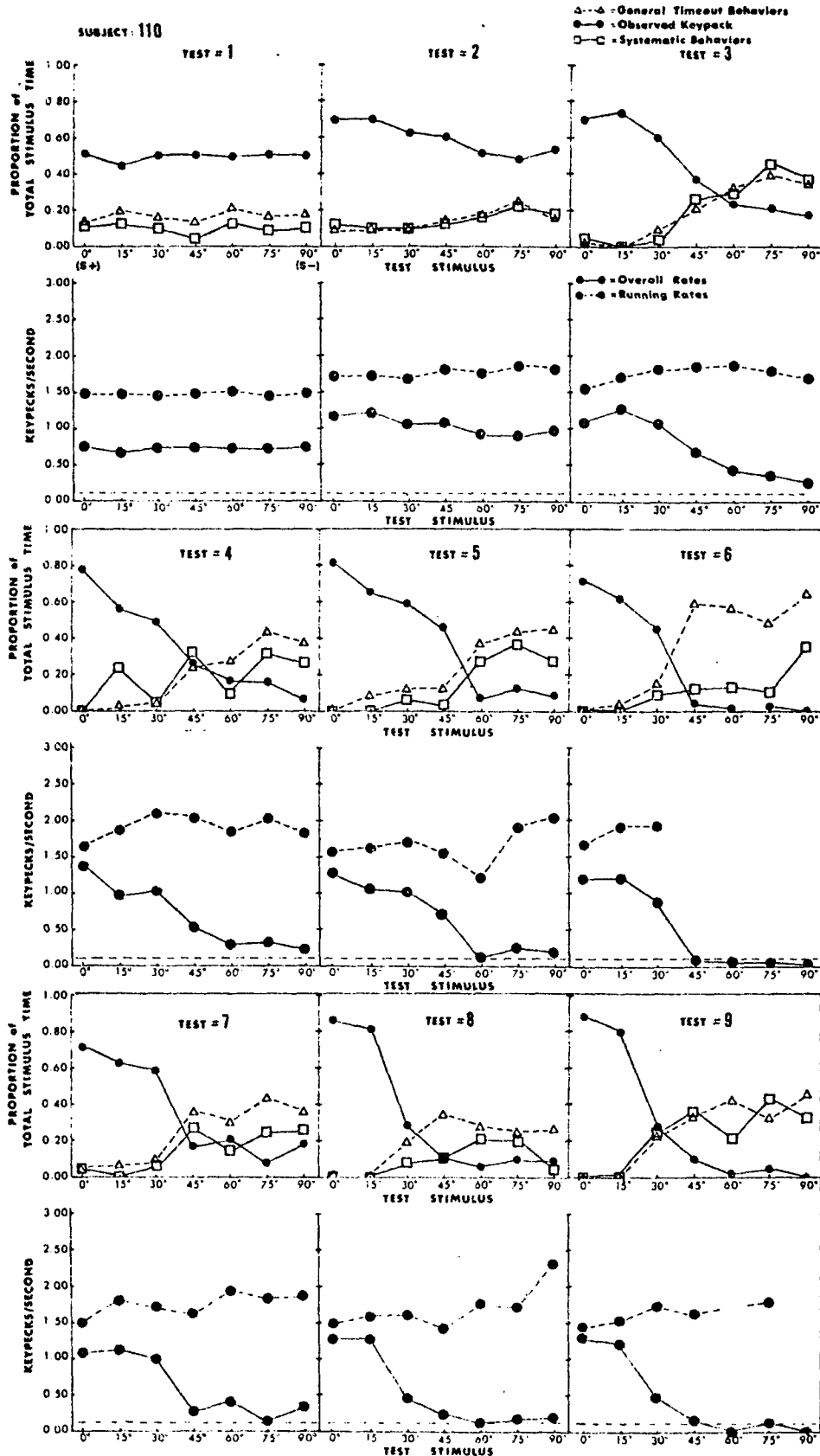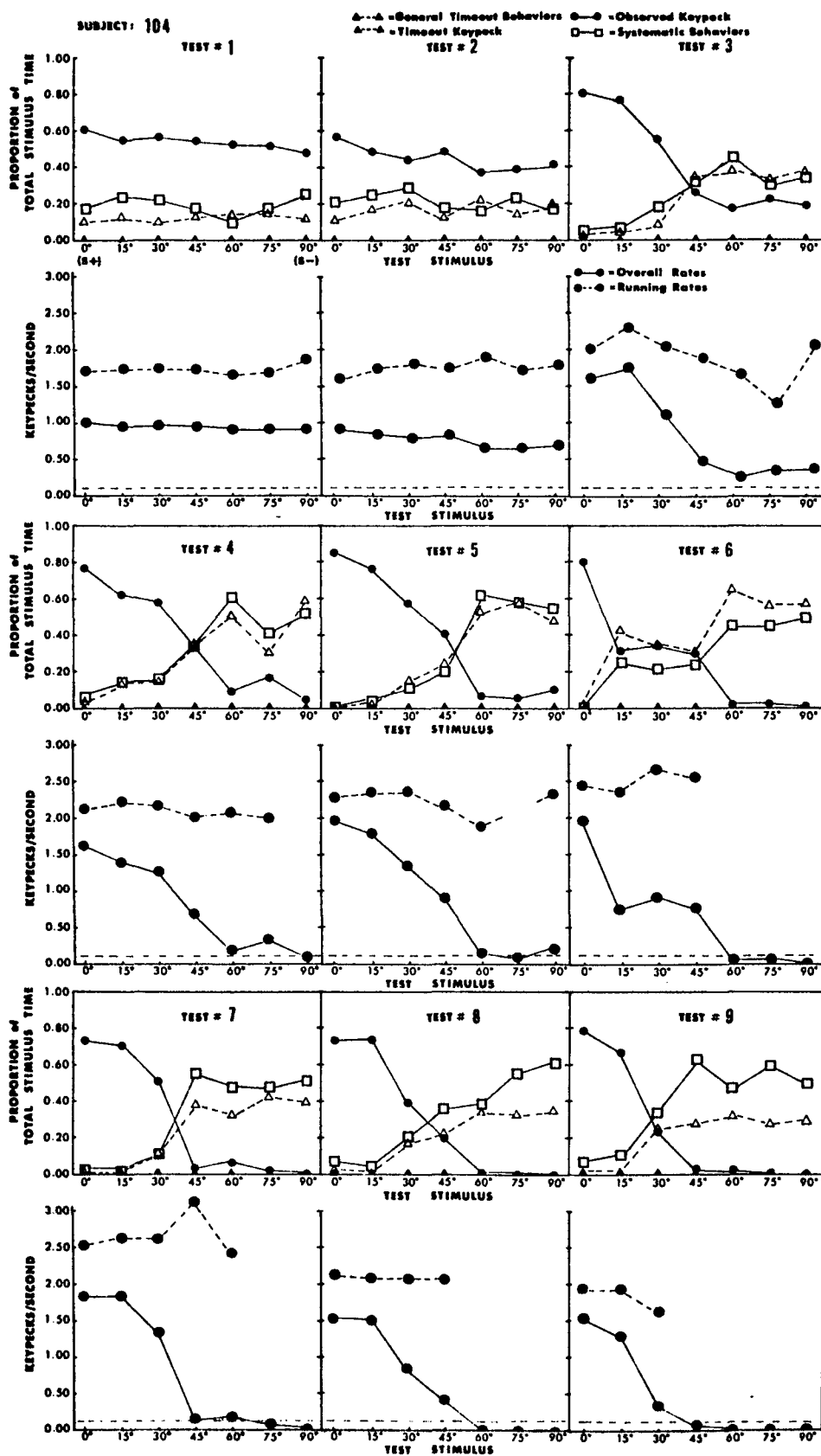
Fig. 15.--Generalization gradients (Tests 1-9) of the three observed classes of behavior and timeout keypecks (upper portion of each test panel) and overall and running rates of keypecking (lower portion of each test panel). Subject 104.

from the S+ training value. The running rates, however, suggest that these different overall rates are best accounted for in terms of differences in duration of this behavior class, i.e., when the birds were pecking the main key, they did so at a relatively constant running rate. The consistent density of keypecks within bursts shown in Figure 3 provides a visual illustration of the fact that the intermediate test values controlled not intermediate rates but rather controlled intermediate proportions of the keypecking behaviors.

Systematic patterns of behavior, general timeout behaviors, and timeout keypeck gradients.--For the majority of subjects, the amount of time occupied by the systematic patterns of behavior and the general timeout behaviors decreased as the test orientations were varied from the S- training value. The timeout keypeck behaviors of 101 were under control of the S- as evidenced by the fact that they decrease in frequency as the test stimuli were varied away from the S- training value. The timeout keypecks of 103 appeared to be under the control of the S+ in the early stages of training, equally controlled by both training stimuli in the middle of the experiment, and under control of the S- towards the latter stages of the experiment. The generalization test data provide additional evidence for the transition in the source of control. As was the case for the

training sessions, the timeout keypecks occurred in all portions of the stimulus-on intervals. Figure 16 presents these data.

As discrimination training progressed, the degree of stimulus control over main keypecking behaviors was sharpened, i.e., the slopes of these gradients increased during the course of the experiment. This sharpening effect was attributed to the fact that the generalization test was a modified discrimination training procedure in that each test block was separated by retraining conditions in order to maintain responding throughout the test sessions. Such a procedure established some of the test values as functionally equivalent S-'s, as evidenced by the fact that the proportions of the stimulus intervals occupied by the four classes of behaviors (keypeck, systematic patterns of behavior, the general timeout behaviors, and the timeout keypeck) were similar for the 45, 60, 75, and the 90 (S-) degree test stimuli.
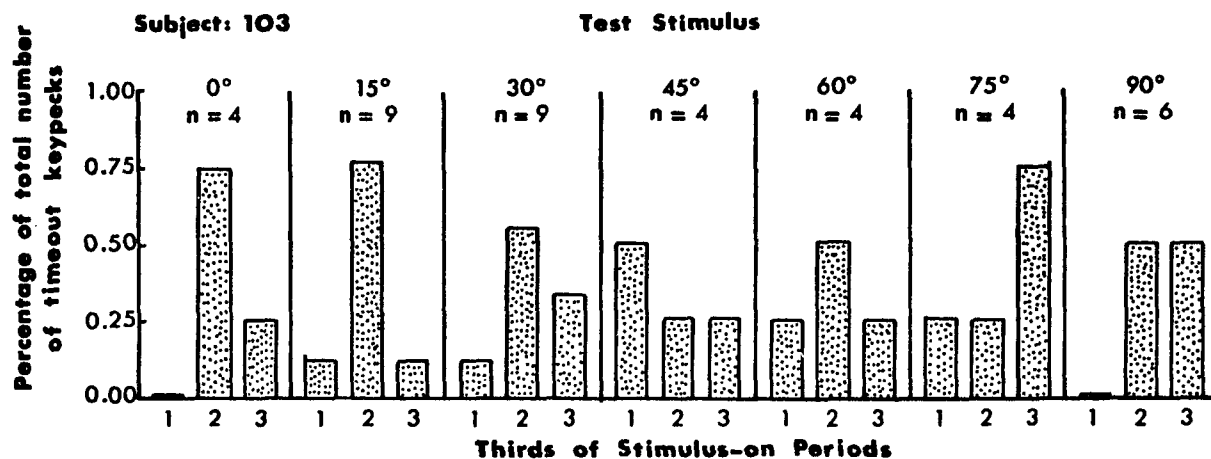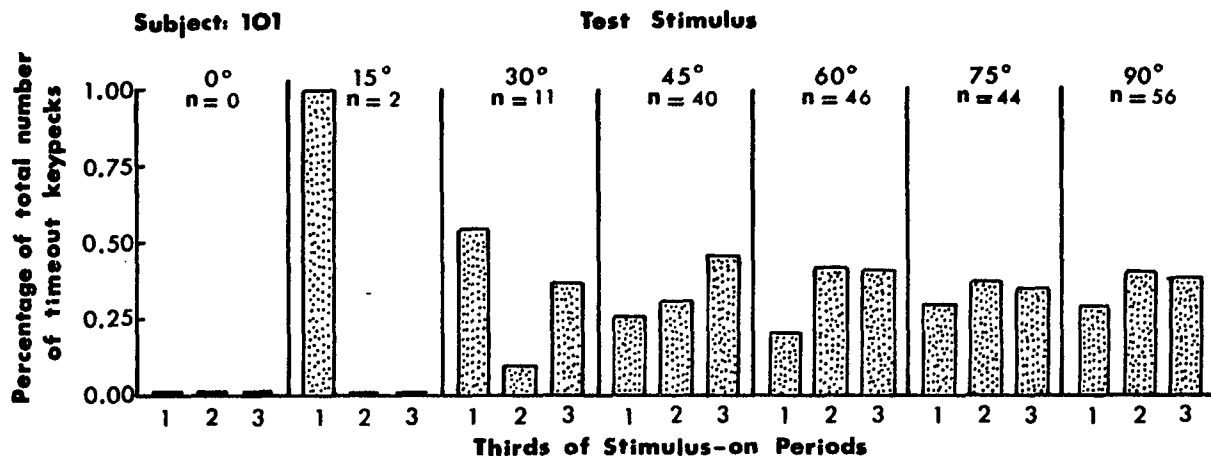
Fig. 16.--Percentage of total number of timeout keypecks as a function of thirds of test stimulus intervals throughout all nine generalization testing sessions.

CHAPTER IV

DISCUSSION

As in previous studies of this kind (e.g., Jenkins
and Harrison, 1960), it was found that the frequency of
responding was a useful index of differential performance.
Discrimination training resulted in high overall rates of
the keypeck response to the S+, low overall rates to the
S-, and intermediate rates to the intermediate stimulus
values. In addition, observations of the keypeck response
revealed similar changes in the duration of this class of
behavior; high keypeck durations were found in the presence
of the S+, low keypeck durations in the presence of the S-,
and intermediate durations in the presence of the inter-
mediate test stimulus values. Considering only the class
of keypecking, differential performance can, therefore, be
adequately represented by absolute changes in the number of
keypecks or the amount of time the organism actually spends
engaging in the keypecking activity.

On the basis of these results, it would appear that
the two measures have equal utility in describing performance
of an organism in a simple discrimination learning task.
Where interest is focused on behaviors other than those
which are readily digitized, however, describing performance
in terms of duration may be more advantageous, especially

since it affords direct comparison with other topographically different behaviors which are more readily measured in units of time.

An additional advantage is that the measure of overall rate is susceptible to the notion that it is an index of the velocity of discrete occurrences of the conditioned response. Thus it may be assumed that as the rate to the S- decreases, the speed with which the organism strikes the key is similarly decreasing. The running rates obtained by dividing the total number of keypecks by the observed duration of this behavior are a more appropriate measure of the velocity of such responding since the time base excludes portions of the interval in which the organism is engaging in behaviors away from the key. The running rates showed that, for the most part, when the birds pecked the key, they did so at a relatively constant speed, despite substantial differences in overall rates between the two training stimuli and among the various test stimuli.

These data are compatible with those offered by Blough (1963), who performed an inter-response time (IRT) analysis of the keypecking response as a function of the shift from VI 4 to extinction. As extinction progressed, the distribution of IRTs remained approximately the same, i.e., the peak duration remained at approximately 0.4 seconds, although the number of long IRTs (from a few seconds to several minutes) increased. Shaub (1967) also found that

changes in overall rates during discrimination training and generalization training reflected changes in the long IRT class rather than a shift in the IRT distribution as a whole. Observational data from the current investigation strongly suggest that these longer IRTs are the result of the intrusion of specific behaviors other than keypecking. Thus the effect of altering the discriminative stimulus appears to be that of altering the proportion of time in which the conditioned response occurs rather than having the effect of speeding up, or slowing down, the rate of occurrence of discrete keypecks.

Perhaps the most parsimonious description of changes in the conditioned response is consideration of the changes in the amount of time allocated to this class of behaviors. This method of description needs, however, to be modified in the case of behavioral contrast. If the increase in overall rate of keypecking were solely a function of increases in time allocated to this behavior class, the running rates should have remained constant. Results showed this not to be the case as the running rates increased substantially in the initial phases of differential responding.

Recent evidence has accumulated which suggests that rather than simple acceleration of homogeneous members of the class of keypecking behaviors, positive behavioral contrast might be attributed to an addition of keypecks which differ from other keypecks with respect to their controlling

stimuli. Rachlin (1973) has noted that the "transition from a stimulus signalling a period of low reinforcement value to a stimulus signalling a period of high reinforcement value excites certain responses irrespective of other contingencies." Stadden and Simmelhag (1971) suggested that in the case of food delivery to a hungry pigeon, these responses may be "food-elicited (consummatory) activities," specifically, the keypecking response. Williams and Williams (1969) and Schwartz and Williams (1972) have also shown that these pecking responses may be maintained even when their occurrence prevents the delivery of food, i.e., they are sustained despite contingent non-reinforcement on the negative automaintenance procedure.

Gamzu and Schwartz (1973) found that when experimentally naive pigeons were exposed to equal presentations of free food in two components of a multiple schedule, little or no keypecking was obtained. When the two component stimuli were correlated with different schedules of food presentations, however, high rates of keypecking occurred in the presence of the stimulus correlated with the higher rate of food delivery. They suggested that the differential procedure established a stimulus-reinforcer contingency where the key stimulus served as a differential signal for food presentation. The fact that all birds pecked the key, despite the absence of any explicit contingency to do so, supports their contention that food delivery served to enhance the pecking response and that the

stimulus-reinforcer contingency served to determine the location of this response. Gamzu and Schwartz noted "it may be that in all procedures in which stimulus-reinforcer and response-reinforcer contingencies influence the same class of behaviors (e.g., keypecking in pigeons), the two types of contingencies have a mutually enhancing effect."

Rachlin has concluded that in the multiple schedule these extra "unconditional" responses are "superimposed on the instrumental responses and generate an increased rate of responding during the component." The absence of behavioral contrast with responses other than the keypeck (e.g., pigeons' bar pressing, Westbrook, 1973) would appear to strengthen this position. Thus, in those situations where behavioral contrast was obtained it may be that the addition of such a stimulus-reinforcer contingency produces extra keypecking responses which could be responsible for that portion of the increases in overall rate of keypecking not adequately accounted for by the increase in time allocated to the keypeck class of behaviors.

We turn now to a discussion of differential performance in terms of topographically distinct classes of behaviors. The results of this study clearly indicate that in a simple discrimination task, the organism engages in a variety of highly active behaviors when not engaging in the response conditioned to the S+. It appears that the effect of such training is to establish control of the keypeck

response by the S+ and control of these other behaviors by the S-. This conclusion is based upon the finding that these non-keypeck behaviors occupied a considerable portion of the S- intervals during discrimination training and that they systematically increased as the orientation of the line was rotated away from the S+ value and toward the S- value during generalization testing.

An alternative interpretation of these data is, however, that the incompatible behaviors are not controlled by the presence of the S- but by the absence of the S+, i.e., they are behaviors which occur whenever the keypecking response does not occur. The logical extension of this interpretation is, of course, that any means of reducing the keypecking response should result in the occurrence of the incompatible behaviors and vice versa. The effects of extended training for birds 112, 103, and 104 appear, however, not to support such an interpretation as the substantial decrease in the systematic behaviors and/or the general timeout behaviors were not accompanied by the return of the keypeck.

The next point to be considered is the attempt to specify the relationship between the gross behaviors and the explicit timeout keypeck responses. The specific hypothesis suggested that the gross behaviors and the timeout keypecks may be considered members of a functionally equivalent class of behaviors defined by the consequence of

removal of the S-. The high degree of overlap between the systematic patterns of behavior and the general timeout behaviors tentatively suggests that the birds may indeed have been engaging in activities which served to remove them from the direct illumination of the stimulus lamp. It is important to note that in no case did the subjects systematically engage in non-keypeck behaviors which did not also meet the general timeout criterion, at some point in the execution of each of those behaviors, e.g., turning around, pacing along the walls of the chamber, etc.

Although only two birds (101 and 103) pecked the timeout key with any degree of regularity, two aspects of these data provide further support for the hypothesis that the general timeout behaviors and the timeout keypecks are affected by similar variables. Results of the generalization test revealed that both classes of behaviors systematically decreased as a function of variation in the orientation of the line away from the S- training value. Results of extended discrimination training revealed that, in the case of 101, both classes of behaviors remained at a relatively high level of occurrence throughout the experiment and showed similar degrees of variability across experimental sessions. In the case of 103, both classes of behaviors decreased towards the latter stages of training.

Staddon and Simmelhag have provided some additional theoretical support for the contention that the systematic

patterns of behavior, general timeout behaviors and timeout keypecks are functionally equivalent members of a class of behaviors defined by common controlling variables (e.g., low probabilities of reinforcement) and by the behavioral outcome of escape from stimuli associated with the low probability of reinforcement. The systematic patterns of behavior and the general timeout behaviors observed in the present experiment qualify for Staddon and Simmelhag's classification of "interim behavior" both in terms of topographical characteristics (see Table 2, Chapter III) and in terms of their relationship to the probability of food (both occurred during periods in which the probability of food delivery was low). According to Staddon and Simmelhag (p. 14), these interim behaviors "reflect the same causal factors" as adjunctive behaviors (Falk, 1966), behaviors which include, among others, polydipsia (excessive drinking), schedule-induced aggression (e.g., attacking another pigeon), and pecking an available timeout key. The important similarity between the interim and adjunctive behaviors is the fact that they are all observed during periods of low probability of food delivery: interim behaviors (Staddon and Simmelhag, 1971), polydipsia (e.g., Falk, 1966), schedule-induced aggression (e.g., Azrin, Hutchinson, and Hake, 1966; Flory, 1969; Richards and Rilling, 1972), and timeout keypecking (e.g., Appel, 1963; Brown and Flory, 1972; Terrace, 1971).

Falk (1971) considers the type of adjunctive be-
havior to be interchangeable, depending upon the avail-
ability of the appropriate stimuli such as drinking appara-
tus, target pigeon, or timeout key. Where such objects are
not available, the organism may engage in interim behaviors
of the nature of those observed by Staddon and Simmelhag
and those observed in the present study. The important
point is, however, that regardless of the specific mode of
behavior this class of behavior may reflect the general
property of the aversive characteristics of the schedule
conditions where there occurs a transition from periods of
high probability of food delivery to periods of low prob-
ability of food delivery.

Due to the infrequency of the timeout keypeck of the
present investigation, however, any conclusion regarding the
precise relationship (i.e., substitutability) between the
gross behaviors and the timeout keypecks demands more than
these tenuous correlational data. What is clearly needed is
some type of direct manipulation of the timeout contingencies
in various experimental situations. For example, a stronger
test of the hypothesis might include systematically in-
creasing the area of the chamber which is directly illuminated
by the discrimination stimuli. This would have the effect
of requiring increasingly more specific locations in which the
animal could acquire timeout from the S-. A related varia-
tion would be to employ auditory stimuli, the removal of which

would require a highly specific response. If the gross behaviors of the organism showed no effects of such manipulation, the hypothesis that they have a relationship to the S- similar to that of the timeout keypeck would not be supported.

Another manipulation might be to vary the location of the timeout key. If, for example, the key were located in an area which was outside the area of direct illumination by the discriminative stimuli, the occurrence of timeout keypecks would weaken the argument that the timeout keypecks and the general timeout behaviors were members of functionally equivalent classes of behaviors.

Important questions concern the infrequency of the timeout keypeck responses. Why, for example, did they fail to be maintained for birds 102 and 104 and why, in the two cases where they were maintained, did it take so long for them to occur with any degree of regularity? Previous studies (Terrace, 1971; Rilling et al., 1969) have shown that the timeout responses occurred immediately following the introduction of the S-. A tentative explanation lies in a possible relationship between the size of the chamber and the form of the systematic patterns of behavior. The chamber used in the present experiment was somewhat larger than the usual experimental chambers (e.g., those used in the above-mentioned studies). It is conceivable that the large chamber allowed for a greater variety of behaviors

which were incompatible with the pecking responses. In additon, the location of the timeout key in relation to the main key in both the standard chamber and that used in this study (separated by approximately 7.62 cm) is such that the bird is required to approach the main key in order to peck the timeout key. The combination of these two factors may have contributed to the low level of timeout keypecking in that perhaps being able to move completely away from the manipulanda wall was more reinforcing (in terms of escape from the aversive stimulus) than remaining at the wall which contained the timeout key <u>and</u> the S-.

Several aspects of the data support this hypothesis. (a) In the early stages of discrimination training, 101 engaged in turning behaviors and these behaviors decreased once the timeout keypeck was established. (b) Terrace (1971) reported that 75 percent of the timeout keypeck occurred in the first third of each S- presentation and Rilling <u>et al.</u>, (1969) found a similar distribution of timeout keypecks. Results of the present investigation found the timeout keypecks to be more frequent in the <u>last</u> two-thirds of the intervals rather than the first. Again, the possible contributing factor was the size of the chamber, which may have been more conducive to behaviors away from the manipulanda wall. This is supported by the fact that 101 and 103

engaged in turning behaviors prior to the first timeout

keypeck response in 63 percent and 44 percent of those in-

tervals, respectively, in which such a response occurred.

(c) Although both 102 and 104 had pecked the timeout key

at least once (i.e., they had been exposed to the conse-

quences of such a response), they instead engaged in high

levels of systematic behaviors and general timeout be-

haviors which were incompatible with pecking either the main

key or the timeout key.

A recent study by Coughlin (1973) has provided some

evidence lending credence to the hypothesis that the degree

of availability of other modes of behavior is an important

variable in the occurrence of timeout keypeck responses.

In that study it was found that birds who received a mild

shock when keypecks were made to the S- pecked an available

timeout key <u>less</u> often than the group whose responses to the

S- were not followed by the shock. It had been expected

that the addition of the shock contingency would have in-

creased the aversiveness of the S- and, therefore, the num-

ber of timeout responses would have been greater for the

Shock group than for the No Shock group. In attempting to

account for this finding, Coughlin noted that turning away

from the key was frequently observed and that "it may be that

turning away from the key was a more efficient mode of es-

cape" than pecking the timeout key which had to be repeated

every 30 seconds. He concluded that "perhaps the reason the

Shock birds made fewer timeout responses was that they were making more, or longer, escape responses."

With respect to the present investigation, it may be that the birds were similarly engaged in these behaviors which were located away from the main key and the timeout key and that removal of the S- did not require repeated timeout key responses every 10 seconds. The fact that birds 101 and 103 engaged in these turning behaviors prior to the first timeout keypeck, the fact that 102 and 104 engaged in systematic patterns of behavior other than pecking either key, and the higher frequency of timeout keypecks in the last two-thirds of the S- intervals all point to the conclusion that when a chamber constrains these active forms of behaviors, it may become more "efficient" to remain at the manipulanda wall and repeatedly peck the timeout key.

In an attempt to ascertain the importance of the size of the chamber, a follow-up study was performed with bird 104. It will be recalled that this bird's systematic pattern of behavior was turning to the right side of the chamber, away from both the main key and the timeout key. This behavior remained at a very high level of occurrence throughout the experiment although the degree of overlap with the criterion for the general timeout response class had decreased substantially by the latter stages of the experiment.

After termination of the main experiment, a 40.6 x 40.6 cm panel was inserted 1.27 cm to the right of the main

key, thus reducing the chamber to 25.4 x 40.6 x 40.6 cm.
Since generalization testing had revealed that only the
15 degree stimulus still occasioned high rates of key-
pecking, this stimulus was selected as the new S- with the
expectation that as the keypecking decreased, the timeout
keypeck response would develop in lieu of the original
systematic patterns of behavior which were made considerably
more difficult as a result of reducing the size of the cham-
ber. Results of this follow-up investigation showed that
the timeout keypecks did occur, although at a very low fre-
quency with 0, 3, 1, and 0 timeout keypecks occurring in
the four days of discrimination training, respectively.
The remaining portions of the S- intervals were filled with
behaviors very similar to those observed in the original ex-
periment; the bird was seen to turn to the right and then to
continue on to the rear of the chamber! A possible explana-
tion for the low occurrence of the timeout keypecks is that
the original discrimination training had established cer-
tain high probability modes of behavior and despite the in-
creased difficulty of engaging in such behaviors due to
the reduction of the size of the chamber, these behaviors
were still strong enough to override those factors which nor-
mally serve to shape the development and reinforce the main-
tenance of the timeout keypecking response. Since this
manipulation did lead to some timeout responses, however,

further investigations of the effects of experimental space on the timeout keypeck seem warranted.

The present investigation found that decreases in the conditioned response of keypecking were accompanied by increases in highly active behaviors, e.g., turning away from the key, wing flapping, pacing along the walls of the chamber, etc. These results have some indirect implications for the concept of inhibition. Hearst (1972, p. 24) has noted that "if . . . the suppressive action of [an S-] proved to be rather specific to the original situation and response, a more limited and presumably peripheralistic conception of the underlying mechanisms for conditioned inhibition would seem required. Explanations based on the establishment of specific competing or antagonistic behaviors during the [S- period] would gain support, and would appear to offer the most objective and parsimonious accounts of the results." The results of the present investigation indicate that under these experimental conditions, the suppressive effects of the S- are indeed specific to the conditioned response and do not appear to produce an overall lowering of the general activity level of the organism. These results also add empirical support for Schoenfeld and Farmer's (1970, p. 223) contention that "because there are no 'empty' places in the behavior stream, to 'inhibit' responding anywhere in it is to replace one response with another."

One of the difficulties with an interference theory of extinction is, however, in specifying the nature of and the motivational factors underlying those behaviors which compete with the response explicitly conditioned to the S+. As Hilgard and Marquis (1940, p. 117) have stated, "the interference interpretation of extinction, if it is not to imply adaptation or other weakening independent of interference, must discover a source for strengthening those responses which are antagonistic to the conditioned response."

Up to this point, maintenance of the behaviors other than keypecking (i.e., systematic patterns of behavior, general timeout behaviors, and the timeout keypeck), has been discussed in terms of negative reinforcement. As mentioned earlier, Terrace (1971, 1972) and Rilling et al. (1969, 1973) contended that the timeout keypeck response is maintained by the consequence of escape from an aversive S-.

This position is not, however, without opposition. Coughlin (1973) has provided some recent evidence which suggests that the timeout keypeck response may not be an uncontaminated measure of the aversiveness of the S-; he has contended that positive reinforcement of stimulus change may be an important factor responsible for maintaining timeout responding. Appel (1963) and Rilling et al. (1969) have also acknowledged this possibility.

Despite attempts to control for the effects of stimulus change (e.g., Terrace, 1971), it is conceivable that the systematic patterns of behavior, general timeout behaviors, and the timeout keypeck are all maintained by positive reinforcement of stimulus change: e.g., the combined changes in proprioceptive stimulation resulting from locomotor activities and changes in exteroceptive stimulation such as changes in the level of illumination. The present experiment will not permit clarification of this controversy which awaits further investigation. A major difficulty is, however, the ubiquitous nature of "stimulus change" making clear separation of the two factors (changes in stimulation and escape from an aversive stimulus) extremely difficult if not impossible.

Staddon and Simmelhag (1971, p. 37) have again provided an interesting conceptualization which may defuse this controversy by incorporating both factors into an account of interim and adjunctive behaviors. Their analysis makes the initial assumption that there is adaptive utility in an animal budgeting its time effectively.

> In these terms, a time, or stimulus, reliably associated with the absence of a given reinforcer provides information just as useful as a time perfectly correlated with the delivery of that reinforcer, since it permits the animal to attend to present and future needs other than the one associated with the absent reinforcer. However, other potentialities of the environment cannot usually be sampled as long as the animal remains in the vicinity of the unavailable reinforcer. One might expect, therefore, that natural selection will have fostered the development of a mechanism to ensure that animals avoid places at times when, on the basis of past

experience, they have learned that reinforcement is not forthcoming.

Thus the mechanism which removes the animal from the situation in which no reinforcement is currently available serves to permit the animal to sample other available reinforcers. In the case where the animal is confined in a small experimental chamber, these other reinforcers might be limited to changes in proprioceptive stimulation provided by locomotor activities, or to changes in illumination, etc.

With extended exposure to the schedule conditions, it may be that these interim and adjunctive behaviors are controlled by the schedule and are maintained directly by these other reinforcers. The following comments by Falk (1971, p. 583) provide further elaboration of such an account:

> . . . interpretation of the bouts of adjunctive behavior based upon notions about the animal being confused, disappointed, harassed, teased, or frustrated by an intermittent food schedule are untenable. There are methodological problems concerning the confirmability of such notions. But more cogently, it is difficult to maintain that a rat subjected to a fixed-interval 90-sec schedule for several months is still reacting with an innocent disappointment and incredulity, which might describe its initial transition from a fixed-ratio 1 in some circles, by consoling itself with [bouts of adjunctive behavior]. Rather than being a response to an uncertain feeding situation, the behavior seems rather to be a precise product of the imposed controlling conditions. Adjunctive behavior, then, is a result of schedule control, not a transition state into, or a confusional state concerning such control.

Such an analysis would appear to be compatible with the results of the present study where in all but two of the subjects, the systematic patterns of behavior remained at a substantial level throughout the experiment as did the timeout keypecks for bird 101. These data are difficult to reconcile with the notion that they are simply maintained by escape from an averse stimulus.

In conclusion, it is clear that decreases in the conditioned response can be described as decreases in the amount of time devoted to this behavior relative to other specifiable activities in an organism's behavioral repertoire. As the amount of S- time occupied by the conditioned response declines, the amount of time occupied by these other specific behaviors correspondingly increases. While there were similar effects of extended discrimination training and generalization testing upon these gross behaviors and the timeout keypeck response, which suggest a direct relationship with the S-, determination of the precise nature of this relationship will await further investigation. What is evident, on the basis of these observations, is that when the organism is not engaging in the conditioned response, a lot is happening and these other behaviors warrant serious attention in a complete analysis of discrimination learning.

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