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DETERMINANTS OF REFRAINMENT FROM EATING IN THE PRESENCE OF FOOD: EFFECTS OF FOOD PRESENTATION DURATION AND PROBABILITY OF FOOD WITHDRAWAL GIVEN APPROACH

City University of New York PH.D. 1986

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by

BARRY STERN

A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York.

1986

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Abstract

DETERMINANTS OF REFRAINMENT FROM EATING IN THE PRESENCE OF FOOD: EFFECTS OF FOOD PRESENTATION DURATION AND PROBABILITY OF FOOD WITHDRAWAL GIVEN APPROACH

by

Barry Stern

Advisor: Professor Brett K. Cole

A discrete-trials procedure initially described by Cole, Coll, and Schoenfeld (1982) was implemented in an effort to teach pigeons to selectively refrain from eating from a filled, raised food hopper. Refrainment during a first hopper presentation (S1) resulted in the onset of a houselight in the presence of which a keypeck resulted in a second hopper presentation (S2) during which 3 sec of eating was permitted.

Coll (1983) demonstrated that if attempts to eat during S1 (i.e., S1 approaches) always resulted in the immediate withdrawal of the hopper such that it was impossible for the pigeon to obtain any grain, the procedure produced reliable S1 refrainment.

A major purpose of the current study was to assess the necessity and sufficiency of this S1 withdrawal requirement. Thirty animals were randomly divided into 5 groups of 6 animals each, and assigned an initial

probability of S1 withdrawal given approach (Groups p=.5, .8, .9, .95, and 1.0). If hopper withdrawal was not scheduled, 3 sec of S1 eating was permitted.

Criterion S1 durations were increased in 1 sec increments from 1 to 10 sec when refrainment had occurred on 80% of the trials during one or more previous sessions. Initial acquisition was considered completed once an animal responded at the 80% criterion at an S1 duration of 10 sec.

The number of animals completing initial acquisition increased with increases in p: Group p=.5 / 0 animals, p=.8 / 1 animal, p=.9 / 3 animals, p=.95 and p=1.0 / 6 animals each. All animals failing to complete initial acquisition at their initial p values did so at higher p values.

P was then systematically decreased for animals in Groups p=.95 and p=1.0. Refrainment settled at or near zero for all animals at various p's > 0. Subsequent p increases were ineffective in producing reacquisition at any values less than p=1.0 although criterion responding had previously occurred at these values while p was being decreased.

A maintenance requirement of criterion responding for 10 consecutive days following initial acquisition (Groups p=.5, .8, and .9) or reacquisition (Groups p=.95 and p=1.0) was met for all except one animal.

The personal obstacles which stood in the way of the successful completion of this document have been overcome only with the support of virtually everyone I have been in contact with throughout the past few years. The people mentioned below have provided an even more special contribution to this work and to my life.

Dr. Gerald D. Lachter's contagious enthusiasm for the type of work I have made my own provided the initial impetus for pursuing my graduate studies. Dr. Guadalupe Coll gave me much intellectual and emotional support during the early phases of the experiment. Dr. Bruce L. Brown provided kind support during my decision to switch research areas. I'd also like to express appreciation to my wife Peggy, who has provided cheerful support during the final phases of this process and given up many of her weekend plans.

Finally, I'd like to express appreciation to Dr. Brett K. Cole for introducing me to the area which was to become my dissertation topic and for spending each Friday morning for the past year or so gently teaching me to focus my thoughts regarding my topic and convincing me that, yes, there would be an end.

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Introduction

Various researchers use terms similar or identical to "self-control" or "impulse control" to describe behavior which in some manner delays food presentation to hungry organisms in experimental settings (e.g., Ainslie, 1974; Grosch and Neuringer, 1981; Grossbard and Mazur, 1986; Logue and Pena-Correal, 1984; Mazur and Logue, 1978; Rachlin, 1974; Rachlin and Green, 1972). In such paradigms, behavior is viewed as the outcome of a choice between the opportunity to obtain an immediate reinforcer versus a delayed, yet potentially preferable one. Once the organism opts for the more temporally distant reinforcer, "self-control" is said to have occurred. These paradigms have in common the fact that food is always consumed when presented.

Alternatively, paradigms in which food is presented to hungry organisms and yet, under certain conditions, consumption does not occur until a behavioral criterion has been met have also been labelled "self-control" (Cole, Coll, and Schoenfeld, 1982; Coll, 1983) or "self-reinforcement" (Bandura and Mahoney, 1974; Mahoney and Bandura, 1972). The present study is concerned with those conditions engendering such refrainment in the presence of food.

This latter conceptualization of self-control is perhaps most easily illustrated with an example: As a

hidden observer in an experiment designed to modify the eating behavior of an obese individual you are informed only that the person will be subjected to a 24 hour fast which will precede a 15 minute observation period and that a supply of corned beef sandwiches will be placed upon the table in the small room in which the experiment is to take place. Upon querying the experimenter as to the particular food selection you find that the subject had previously been asked for a list of favorite foods and that corned beef had topped the list. As the observation period begins, you see the subject being escorted into the experimental room and asked if he presently feels hungry. Upon the subject's affirmative response he is informed that he is welcome to enjoy as much corned beef as he'd like while he awaits his escort's return. The subject promptly sits down in the only chair in the room, which is placed directly in front of the sandwiches. You observe that the subject fails to consume any corned beef although it is nearly 15 minutes before the escort returns.

The fact that the food is there for the taking and yet the subject refrains from its ingestion leads one to summarize the subject's behavior as self-controlled. This refrainment is unexpected. Rather, the circumstances one sees; the presence of the food and the individual ready and able to eat, suggest that eating is inevitable.

For the prediction to be otherwise, i.e., for "self-control" to occur, one must identify variables that

will successfully promote and maintain not eating in the presence of food, and demonstrate that without manipulation of these variables the food is sufficient to compel eating. One can identify an analogue to the human example when one moves into the operant laboratory, where the typical usage of food deprived animals ensures that, with proper magazine training, eating will reliably occur each time food is presented.

Thus, an animal analogue of the "unrestrained eater" is created each time an operant experiment using a food deprivation operation and food as a reinforcer is conducted. The magazine training is considered a prerequisite for the experimental conditions which follow. In typical experiments one would have no reason to attempt to extinguish the eating response in the presence of the available filled food magazine, but should such an outcome be needed one might merely identify the animal's approach to food sufficiently to withdraw the food before it could be ingested. Eventually one might expect any cues which had formerly served as the occasion for hopper approach to lose their behavioral effects.

Mere failure to approach food in a situation is a necessary but not sufficient requirement for invoking the term self-control. For example, one would not describe a naive animal as self-controlled simply because those cues indicating food availability do not as yet control hopper approach. In order for behavior to be appropriately

described as self-controlled it must further be demonstrated that, under similar conditions, the same animal has reliably obtained the food. The task of establishing self-control therefore involves training an organism to alternately eat and not eat food that is present.

The enterprise might be aided by the use of a stimulus control operation. In the absence of a cue, e.g., a houselight, food approach might be met with hopper withdrawal, while, in the presence of the cue, eating following hopper approach can be permitted. If one were to alternate these 2 conditions, refrainment during the absence of the cue need not occur. However, refrainment can be differentially reinforced by presenting the condition in which eating is permitted only after a refrainment criterion has been met in the absence of the cue. An animal that reliably refrained from food approach when the cue was absent, but readily approached and ate when the cue was present could be described appropriately as demonstrating self-control.

As stated at the outset of the introduction, this is but one type of paradigm which has been labelled "self-control". The appropriateness of the descriptive terminology in the above literature will not be debated here (but has been examined by Catania, 1975). However, given that the labels for these various procedures lack unanimity, utilization of the term "self-control" will be

minimal hereafter. Instead, the text will maintain a consistent elaboration of the crucial aspects of the current procedural components, namely, the conditions which control eating and refrainment from eating in the presence of food. As stated earlier, in a situation where eating has been made likely and reliable, refrainment from eating in the presence of food is then unlikely and unreliable. The major task of the procedural steps discussed earlier is therefore to establish control over reliable and predictable periods of refrainment from eating in the presence of food. The text will indicate that concern by using, "refrainment" where appropriate rather than "self-control" which collectively subsumes reliable and predictable instances of both refrainment and eating. Use of the term "refrainment" will also serve to clarify the distinction between the current procedure and others using the term "self-control".

Cole, Coll, and Schoenfeld (1982) trained this stimulus-specific refrainment in pigeons using a procedure similar to that described above. The most effective variant of the procedure involved a discrete-trials situation in which each reinforced trial contained 2 hopper presentations. During the first presentation (S1), pigeons were required to refrain from approaching the raised hopper. If this refrainment occurred for a prespecified time period, the hopper was lowered and the houselight simultaneously illuminated. A single keypeck

then resulted in a second hopper presentation (S2) whereupon the pigeon was allowed 3 sec access to grain. Hopper approaches during S1 were detected by a photocell and met with immediate food withdrawal (i.e., before grain could be consumed). In addition, the houselight remained off and S2 cancelled on such trials. Thus, the animal could obtain food only by refrainment during S1.

Coll (1983) extended the above findings by conducting a systematic examination of 2 parameters of the procedure. The roles of S2 occurrence and the keypeck requirement were investigated during acquisition and maintenance. Both variables were manipulated probabilistically, i.e., there was a randomly selected predictable proportion of trials where, given S1 refrainment, either S2 occurrence was scheduled or the keypeck requirement preceding S2 was in effect. A baseline group was included where the values of both these variables were initially set at p=1.0 (i.e., during each trial featuring S1 refrainment, a keypeck was required which inevitably resulted in S2 occurrence). For animals in other groups, if the probability of the keypeck requirement was less than 1.0, the probability of S2 occurrence remained at 1.0 and vice-versa.

All 18 animals exposed to S2 probabilities equal to or greater than .375 learned to refrain from approaching S1. However, at p values of .25 or less (i.e., 25% or less of the trials had S2 occurrence scheduled following a keypeck), 14 of 18 animals failed to refrain from S1

approach. A different picture emerged for the probability of the keypeck requirement. At all p values less than 1.0 (varying between .75 and 0) only 11 of 30 animals (with no more than 3 of 6 in any group) successfully refrained from S1 approach. To summarize, the development of refrainment was reliable for all animals in each group of 6 at a keypeck requirement probability value of 1.0 and at S2 probability values greater than or equal to .375.

Differences also emerged in the historical effects of these 2 variables. All 14 birds which failed to learn refrainment at low S2 probabilities were later trained successfully at an S2 probability of 1.0. However, only 3 of the 19 birds failing to refrain at the 5 keypeck probabilities less than 1.0 were sucessfully trained to refrain even when subsequently subjected to a keypeck probability of 1.0.

The present study is an attempt to further extend the systematic examination of the necessity and sufficiency of two procedural components. In studies thus far, approach during S1 has always been met with hopper withdrawal. A co. dition in which hopper withdrawal would never occur is essentially a continuation of magazine training and therefore one would not expect an animal to learn refrainment during S1. Always and never withdrawing the hopper following approach represent extremes on a continuum which can be represented probabilistically, i.e., the probability (p) of S1 withdrawal given an

approach. At higher p values, the discrimination between the eating and not eating conditions is enhanced due to the differential consequences for approaching S1 vs. S2; at lower values the converse is true. Therefore, a primary concern of the current experiment is to delineate the role of p of S1 withdrawal in the acquisition of refrainment. While a relatively high p value might be necessary to establish refrainment, lesser values might serve to maintain it. Following the initial acquisition of refrainment, the p values will be decreased for some animals in an attempt to abolish the discrimination.[1]

1. A precondition for the "abolishment" of a discrimination as used by Skinner (1938) was the establishment of differential responding in the presence of 2 cues paired with mutually exclusive reinforcement contingencies. By later reinforcing responses in the presence of the cue which had previously served as an S-delta (one in which all responses had gone unreinforced), this differential responding disappeared and the discrimination was said to be "abolished". Under certain conditions, the current procedure engenders refrainment only during S1 (i.e., in the absence of the houselight), while hopper approach continues during S2 (i.e., in the presence of the houselight). It is therefore appropriate to refer to the situation in which an organism which had previously demonstrated refrainment in the presence of S1 but now approaches both S1 and S2 as one in which a discrimination has been abolished.

In addition to p, another critical aspect of the procedure is the S1 duration. For the magazine trained animal, approach is precluded by making the S1 duration shorter than the minimal time necessary for hopper approach. At an infinitely long S1 value, approach is virtually ensured. However, the relationship between the S1 duration and p in acquisition and maintenance remains to be explored. For example, while exposure to a particular set of S1 and p values might be sufficient to maintain refrainment for those animals already demonstrating it, it is not necessarily the case that these two values would result in acquisition. In addition, since the keypeck requirement in the Coll (1983) study was necessary for the acquisition but not the maintenance of refrainment, the possibility exists that similar historical effects with regard to the current variables might emerge.

Method

Subjects

Thirty naive adult female White Carneaux pigeons were maintained at 80% (+ - 20 grams) of their free-feeding weights. Grit and water were constantly available in the home cages.

Apparatus

Two Lehigh Valley pigeon chambers (Model #132-02) were modified in order to detect eating attempts. The hopper mechanism and housing were repositioned such that the front of the hopper was approximately 3/4 in. from the rear of the intelligence panel when operated. A photocell attached to the rear of the intelligence panel at the hopper aperture sensed the pigeons' head entries thereby enabling the hopper to be withdrawn before food was obtained. This reconfiguration of the chamber had previously been shown to allow the removal of food before it could be eaten whenever such an outcome was appropriate (Cole, Coll, and Schoenfeld, 1982).

Three milky-white translucent response keys and the houselight were illuminated under appropriate conditions as described below. Occasional extraneous noise was masked by a constantly operating ventilating fan. Solid state digital logic circuitry controlled the occurrence of experimental events and data were recorded on totalizing

and printing counters.

Procedure

I. Preliminary Training

A. Punchboard Training

A punchboard (Cumming, 1955) greatly reduced the amount of hand-shaping necessary to train pigeons to keypeck. This punchboard consisted of flakeboard 1/2 in. thick, 8 1/2 in. wide, and 11 in. long. Nine 1 in. diameter, 5/6 in. deep circular depressions were drilled into the flakeboard and were configured in 3 rows of 3 depressions each. A metal sheet, 1/16 in. thick, 8 1/2 in. wide, and 11 inches long had 9 holes drilled into it such that each hole was of equal diameter and fit precisely over each depression in the flakeboard.

The daily ration of food necessary to keep each animal at its 80% weight was distributed in approximately equal amounts in all 9 depressions. A piece of onion skin typing paper was then placed over the entire flakeboard and the metal sheet was screwed into the punchboard such that the holes in the metal sheet fit over the depressions in the punchboard. For the first session or two, slight tears were made in the typing paper to expose the grain underneath and the punchboard was placed in the home cage until the pigeon had obtained all the available grain by pecking at each of the depressions. Following that, the filled punchboard was simply placed in the home cage with

untorn paper until animals had rapidly (i.e., within approximately 5 min) completed the food. If this rapid completion occurred for 3 sessions, pigeons were placed on magazine training.

B. Magazine Training

One of the 2 operant chambers was reserved for use exclusively during magazine and keypeck training. During magazine training, the houselight was constantly illuminated and the response keys were darkened and covered with black masking tape. Each session consisted of 50 food presentations which were determined by a Random Time 40 sec ($\underline{t}$=20 sec, $\underline{p}$=.5) schedule. Timing of food presentation duration began from the point at which an animal's hopper approach was signalled by a break in the photobeam. For the first trial, this duration was 20 sec; on the second trial reinforcer duration was 10 sec. From trial #3 onward, and during subsequent sessions, each food duration was 3 sec. Magazine training continued until the animal was eating quickly following each hopper presentation. In most cases, this occurred within a single session; however, for a limited number of animals it was necessary to continue magazine training for another session or, at most, two.

C. Keypeck Training

For the duration of keypeck training, all 3 keys were

uncovered and lit and the houselight was on. Each center keypeck resulted in 3 sec food presentation, timed from the initial photobeam break. The success of punchboard training was indicated by the fact that 24 of the 30 animals were keypecking without any further training within 1 session. For the remaining 6 animals, shaping via the method of successive approximations (Keller and Schoenfeld, 1950) was accomplished in a maximum of 3 sessions. Keypeck training was complete once an animal had keypecked for three 50 trial sessions.

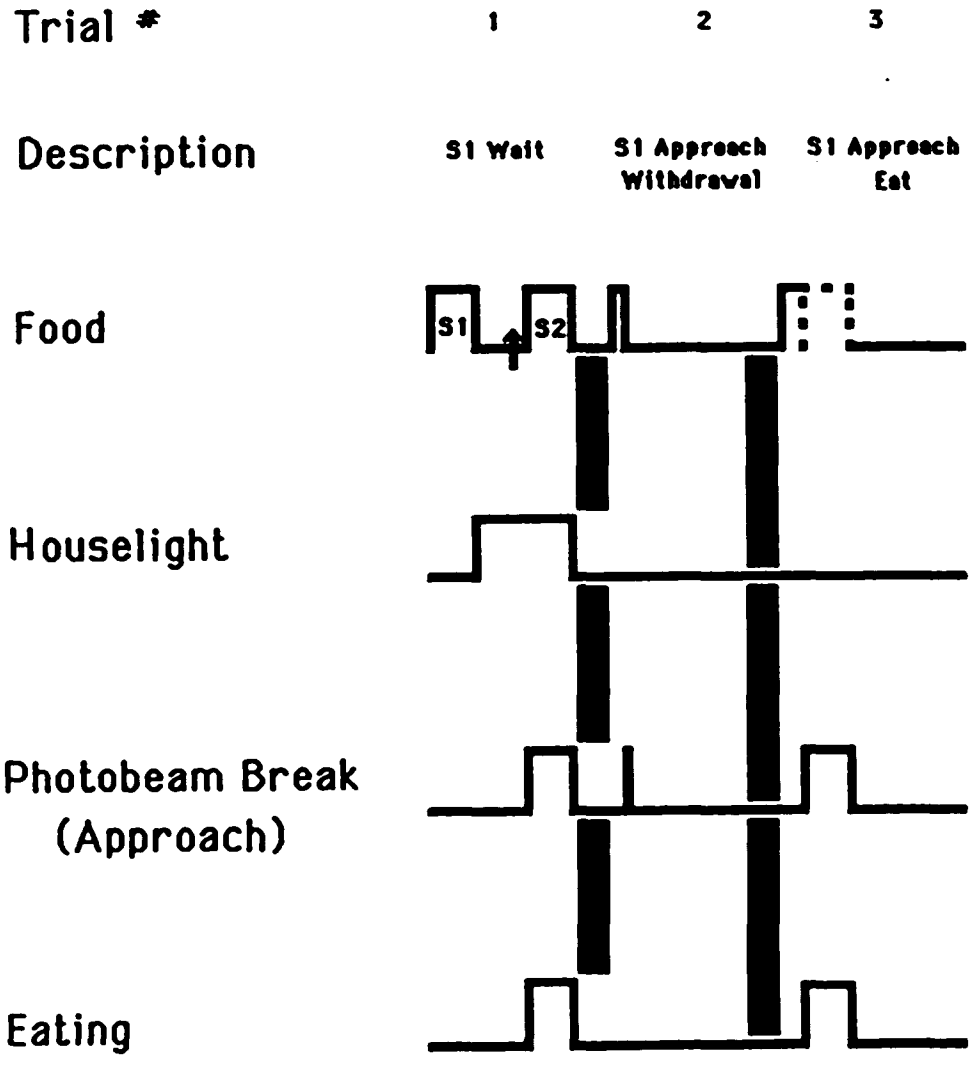
II. Refrainment Training

A. Trial Sequence

Each refrainment session was initiated by the illumination of the three white keylights which remained on continuously until the completion of the session. A 1 sec period was then followed by 50 trials, each of which was separated by a 1 sec intertrial interval (ITI). Trial onset was signalled by a hopper presentation. In the unlikely event that an animal's head was in the hopper aperture (thereby breaking the photobeam) when a trial was scheduled to begin, trial onset was postponed until 1 sec following head withdrawal.

Figure 1 is an event diagram of 3 consecutive trials comprising a portion of a hypothetical session. Trial numbers and descriptions are noted by the top 2 rows of the figure. Each of the 4 rows below represent, in top to

Figure 1. Event diagram of 3 hypothetical session trials. Each event is noted to the left of each of the 4 lines; vertical displacement of any line indicates the occurrence of that event. Trial #1 indicates a case in which the animal waited throughout S1 presentation, pecked the center key (indicated by the vertical arrow positioned on the food event line), and subsequently ate for 3 sec during S2. During Trials #2 and #3 S1 approach occurred, although this approach was rewarded with food only during Trial #3. Inter-trial intervals are noted by the thick black vertical lines.


Trial #
1
2
3
Description
S1 Wait
S1 Approach
Withdrawal
S1 Approach
Eat
Food
S1
S2
Houselight
Photobeam Break
(Approach)
Eating

bottom order, food presentation, houselight illumination, the photobeam break (indicating food approach), and the eating response. Vertical displacement of any horizontal line within a row indicates the occurrence of that event. ITI periods are denoted by the thick black vertical line between trials. Although the photobeam break is depicted as separate from eating, it should be noted that eating onset and termination were respectively inferred as occurring slightly after and before the photobeam signal changed state.

Trial #1 represents the sequence of events occurring during any trial for which the animal waited during the initial presentation of the food hopper. Trial onset was signalled by a hopper presentation (S1) for an initial duration of 1 sec. S1 duration on such trials was always held constant within a session and varied between 1 and 10 sec based on performance criteria met in prior sessions. Details regarding changes in S1 duration are presented below. Once the waiting criterion had been met, the hopper was withdrawn and the houselight simultaneously illuminated. A center keypeck (indicated by the vertical arrow in the food presentation row) was then required which caused the hopper to reappear immediately for a second time (S2) during which eating was permitted for 3 sec, timed from the initial break of the photobeam. Center keypecks at other times were recorded but had no affect on the presentation of stimuli. In the event that

an animal waited for the entire S1 duration but attempted to eat instead of keypeck following this period, the houselight was immediately turned off and the S2 presentation was cancelled (i.e., the subsequent ITI began).

Trials #2 and #3 both represent approaches to food during S1 presentation. In both cases, S2 did not occur, the houselight was not turned on, and a keypeck was not required to terminate the trial. The trials differ with respect to the state of a probability generator probed at the onset of each of the 50 trials. The status of the probability generator determined whether or not S1 withdrawal was to occur given an approach on that trial. If S1 withdrawal was scheduled (as shown in trial #2), the attempt to eat was followed by the immediate withdrawal of the hopper such that it was impossible for the animal to obtain any grain. The unavailability of food following S1 approach during trial 2 is noted by the flat horizontal eating event line throughout trial #2 in the figure. Any remaining S1 duration following approach was timed out with food absent before proceeding to the next ITI. In the event that S1 withdrawal was not scheduled (as shown in trial #3), 3 sec of food access (timed from the initial photobeam break) was allowed before hopper withdrawal. If the 3 sec food access exceeded the current S1 duration, ITI onset was postponed until the full 3 sec eating period transpired. If S1 time remained following the 3 sec

eating period, that remainder of S1 was timed to expiration following hopper withdrawal before the next ITI began.

Thus, 3 sec food access was possible following S1 offset on any trial via refrainment for the duration of the S1 period. If the probability of S1 withdrawal given an S1 approach (p) was set to 1.0, the sole way an animal could procure food was to display this refrainment during S1, peck the center key in the presence of the houselight and then eat during S2 for 3 sec (i.e., each trial resembled those presented as trials #1 or #2 depending upon the occurrence of S1 approach). If p=0, (i.e., each trial could resemble only those depicted as either #1 or #3) 3 sec food access was possible regardless of the occurrence of an S1 approach. P therefore expresses the likelihood of trial #2 occurrence given an S1 approach; it follows that 1 - p expresses the likelihood that a Type #3 trial (and therefore 3 sec of eating during the S1 instead of the S2 period) might occur given an S1 approach. Therefore, as long as p>0, an animal would be most likely to obtain the 3 sec of food access on any given trial via refrainment during S1, since there was at least some possibility that a #2 type trial was programmed to occur given an S1 approach.

B. Group Structure and Performance-Based Criteria

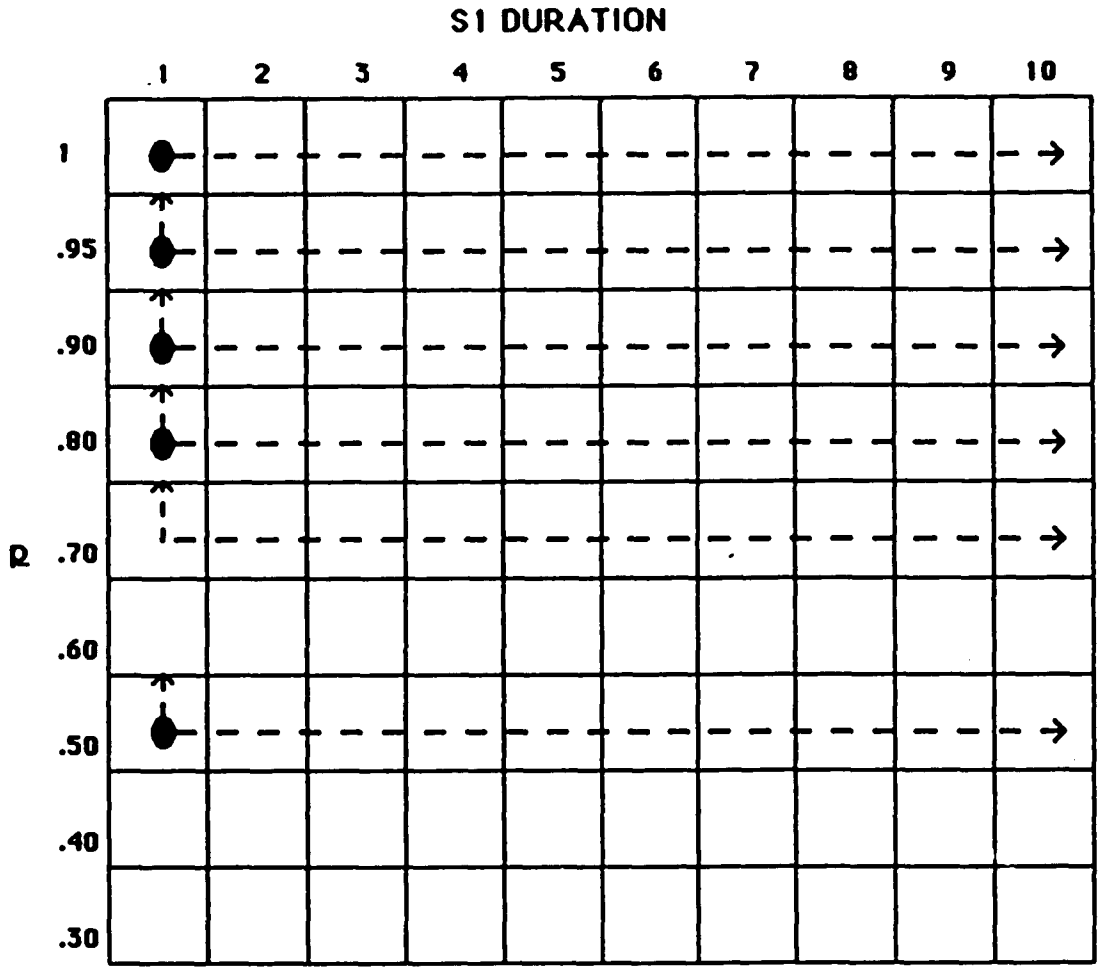
The animals were randomly divided into 5 groups of 6

animals each. In the description to follow, each group is identified by the initial p (Groups p=.5, .8, .9, .95, and 1.0). In addition, p could vary for individual subjects within a group. Changes in p occurred on the basis of whether or not criterion responding had occurred during 1 or more preceding sessions as described below. An animal was considered to have reached criterion response level if it waited during S1 (i.e., refrained from approaching) on 40 or more of the 50 trials (equal to or greater than 80%) within a session.

1) Initial Acquisition

Figure 2 presents a matrix representing the 2 parameters in the study. The movement of any animal or group of animals through the experimental conditions can be described by reference to the coordinates of this matrix. Information regarding the progression of groups through the parameters are denoted by broken lines. Beginning with 1 sec, each of the 10 columns moving from left to right represents a 1 sec increment in S1 duration. Each row, in top to bottom order, represents a decrement in p; the specific p is noted directly beside each row. The direction of movement is indicated by the arrowheads positioned on the solid or broken line within the matrix. Any discontinuity in the line of one box or more indicates a point omitted for that group with the arrowhead directly preceding such a break indicating the location of the next

Figure 2. Matrix representing the S1 and p parameters. Filled circles represent the starting points for animals in each of the 5 groups (i.e., Groups p=.5, .8, .9, .95, and 1.0). The broken lines with arrowheads indicating the direction of movement show the progression through the parameter coordinates during initial acquisition.

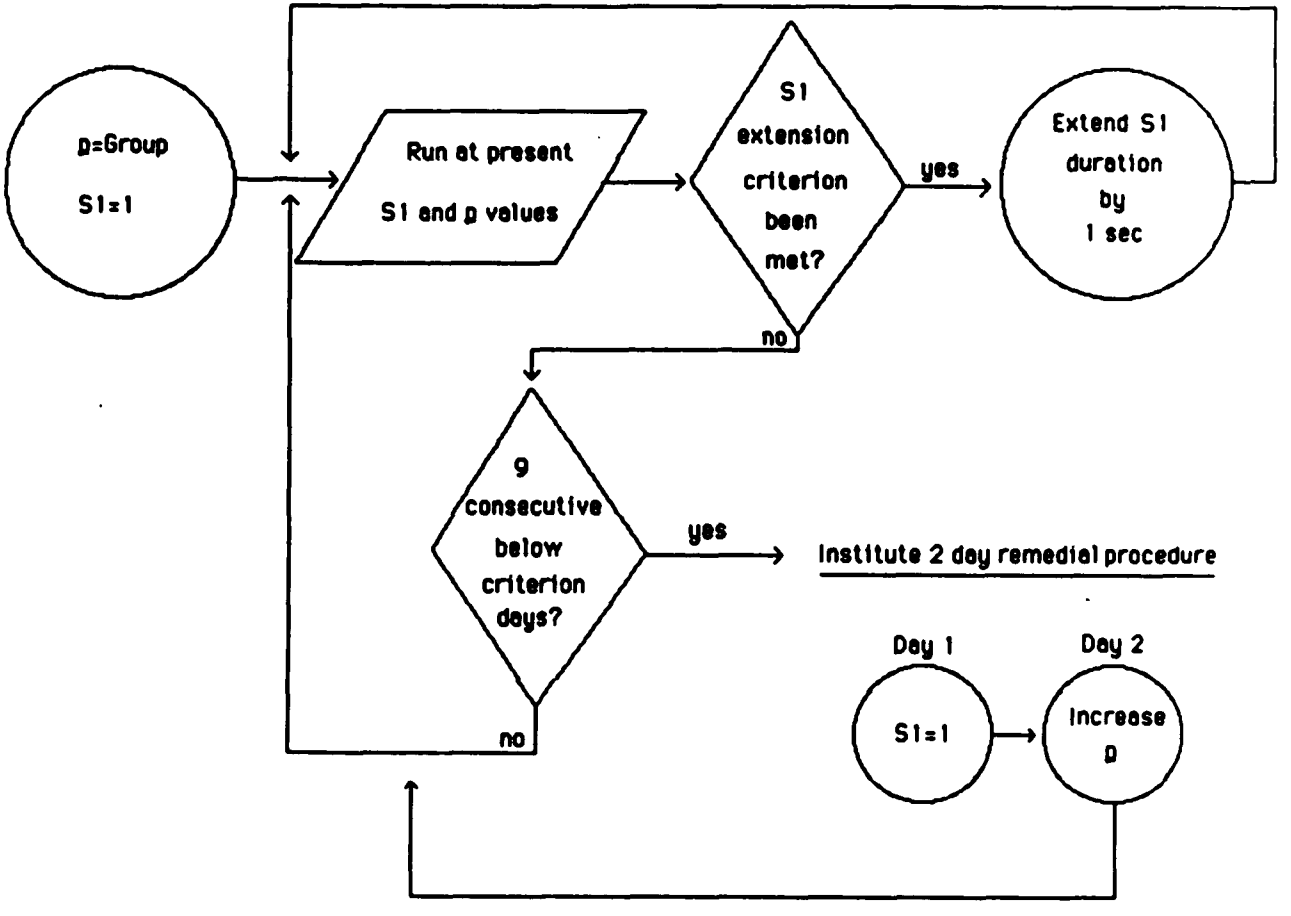

S1 DURATION
1
2
3
4
5
6
7
8
9
10
p
1
.95
.90
.80
.70
.60
.50
.40
.30

point.

The starting points and possible sequences of experimental conditions for initial acquisition are presented in Figure 2. The filled circles represent the starting points for animals in each of the 5 groups. The initial point for each animal was at an S1 duration of 1 sec and p equal to the starting value for that group. The broken horizontal lines extending towards longer S1 durations illustrate that the S1 duration could be extended to 10 sec while p was held constant at any value of .5 or above, excluding p=.6. An animal was required to reach criterion for 1 session at an S1 duration of 10 sec in order for this phase to be successfully terminated. Otherwise, as the broken vertical lines with the upward arrows indicate, p was increased at an S1 duration of 1 sec to the next higher p value indicated in the matrix.

Figure 3 is a schematic of the criteria for the extension of the S1 duration and increases in p during initial acquisition. Following the initial session, each animal's prior performance dictated the appropriate running condition for the next session. The criteria for extension of the S1 duration were as follows: At a duration of 1 sec, 3 consecutive sessions of criterion responding (greater than or equal to 80%) were required in order for it to be extended to 2 sec; at durations between 2 and 9 sec, 1 session of criterion responding was required for the next 1 sec increment to occur. The

Figure 3. Schematic of the criteria for S1 duration extensions and p increments during initial acquisition. Changes were contingent on behavior during previous sessions.


p=Group
S1=1
Run at present
S1 and p values
S1
extension
criterion
been
met?
yes
Extend S1
duration
by
1 sec
no
9
consecutive
below
criterion
days?
yes
Institute 2 day remedial procedure
no
Day 1
Day 2
S1=1
Increase
p

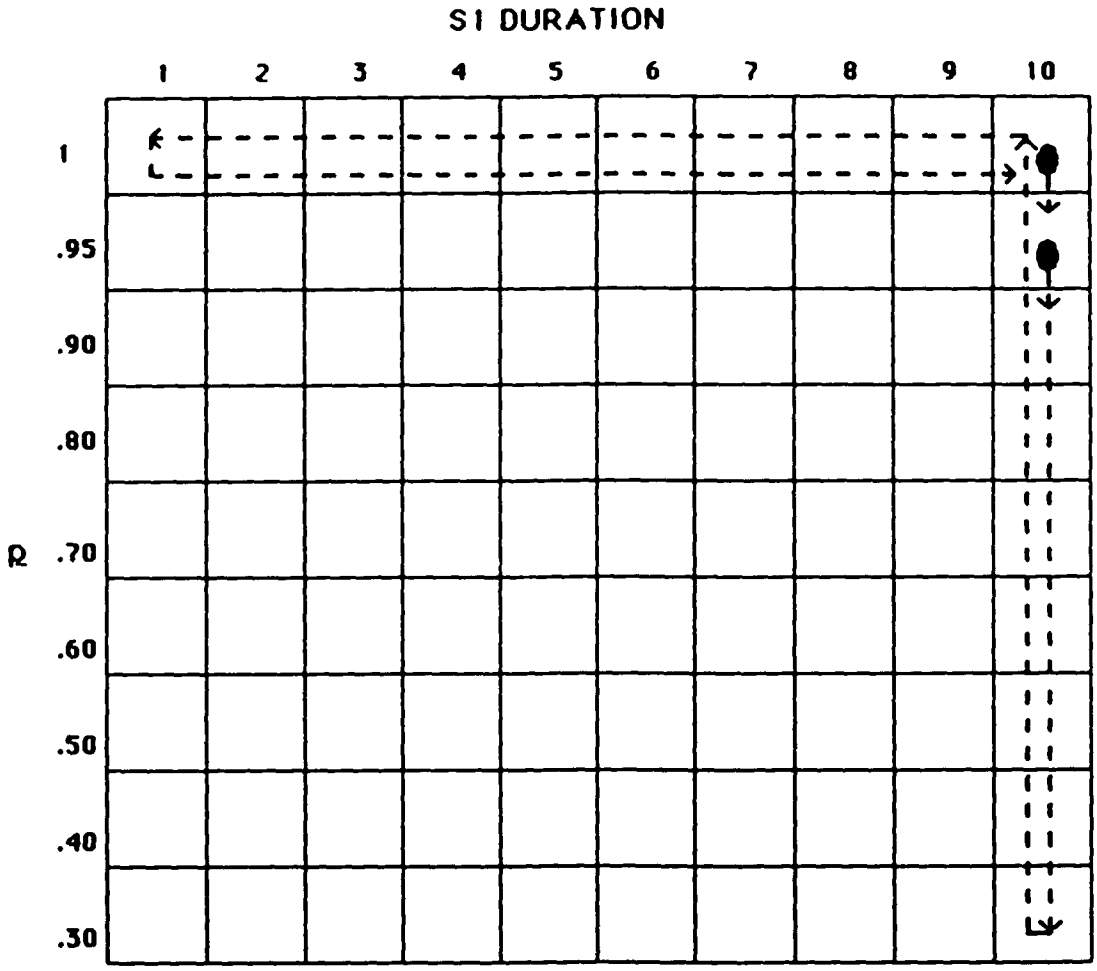
maximum S1 duration was 10 sec.

Each animal was allowed a maximum of 10 consecutive sessions below criterion at a given p before p was increased. If S1 duration had reached values greater than 1 sec and 9 consecutive sessions below criterion had been completed, the S1 duration was returned directly (i.e., without exposure to any intermediate values) to 1 sec for the tenth session (otherwise the entire 10 session block was run at an S1 duration of 1 sec). P was subsequently increased on the following session with the S1 duration held at 1 sec; this increase was made regardless of whether criterion responding had occurred on the tenth session when the S1 duration had been decreased to 1 sec. Once p=1.0 was reached, an animal was run continuously at that value until an S1 duration of 10 sec was reached. If 9 consecutive sessions below criterion had occurred at p=1.0, S1 duration was reduced to 1 sec for the tenth session, with the criteria for its extension remaining as above.

2) Abolishment and Reacquisition

After all animals in Groups p=.95 and p=1.0 had met or exceeded 80% S1 waits at an S1 duration of 10 sec for a single session, p was systematically reduced. The matrix in Figure 4 shows the progression of parameter coordinates for these animals. The filled starting circles show that p began at either p=.95 or p=1.0, depending upon the

Figure 4. Matrix representing the S1 and p parameters. Filled circles depict the starting points for animals in Groups p=.95 and p=1.0. The broken lines with arrowheads indicating the direction of movement show group progressions through the parameter coordinates during abolishment and reacquisition.


S1 DURATION
1
2
3
4
5
6
7
8
9
10
1
.95
.90
.80
.70
.60
.50
.40
.30
R

group. The broken vertical line with a downward arrow indicates that p was decreased while S1 duration remained at 10 sec.

In the event that an animal responded at or above the 80% criterion for 3 consecutive sessions, p was decreased to the next point shown on the matrix. Once an animal responded below criterion, it was given a maximum of 10 sessions at the current p in order to recover. The broken line extends to p=.3 in the matrix indicating the lowest point attained by any animal.

Once a subject had reached that p at which 10 consecutive sessions below criterion occurred, the value was increased through all the higher values shown in the matrix. This is indicated by the broken vertical line terminating in the upward arrow. An animal was given 10 sesions at each increasing p in order to obtain criterion responding.

Responding below criterion for 10 consecutive sessions at p=1.0 and S1=10 sec resulted in 1 sec between session S1 decreases until criterion was met or a 1 sec duration was reached. This stage of the procedure is shown by the broken horizontal line with the leftward-pointing arrow at p=1.0 in Figure 4. If criterion was achieved at an S1 duration less than 10 sec, the S1 value was extended until S1=10 sec was recovered. In this phase, as in initial acquisition, 3 consecutive criterion sessions at the initial S1 value resulted in a 1 sec

extension of the duration followed by 1 criterion session at all other durations until 10 sec was reached. Extension of the S1 duration is indicated by the broken horizontal line with the rightward-pointing arrow at p=1.0.

3) Maintenance

Each of the 30 animals was required to respond at or exceeding criterion for 10 consecutive sessions with the S1 duration at 10 sec in order for the experiment to be completed. The final day of either initial acquisition (Groups p=.5, .8, and .9) or abolishment and reacquisition (Groups p=.95 and 1) marked the first day of maintenance. Therefore, an additional 9 consecutive sessions of criterion responding were necessary in order for maintenance to be successfully completed.

In the event an animal responded below criterion for 10 consecutive sessions at S1=10 sec, the S1 duration was reduced directly from 10 to 1 sec. From that point, changes in S1 duration occurred in precisely the same fashion as during initial acquisition with the exception that 10 consecutive sessions of criterion responding at S1=10 sec were required in order to terminate the experiment.

Results

The results are divided into 2 major sections. The first section is a general exposition of the major trends revealed in all 3 phases of the experiment. Following this are more detailed data presentations from each phase.

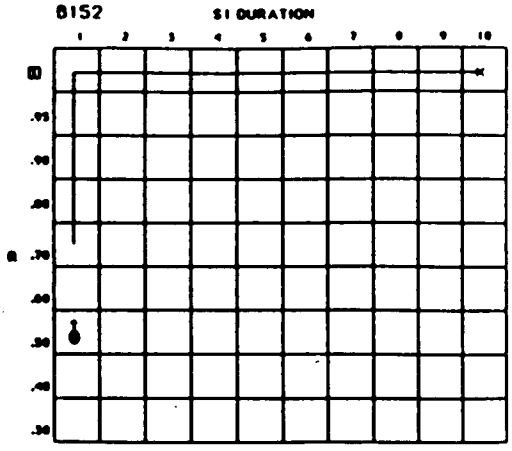
Table 1 presents an overview of the number of sessions required for each animal to complete the various experimental conditions. Missing values in any column indicate animals which failed to participate under given conditions.

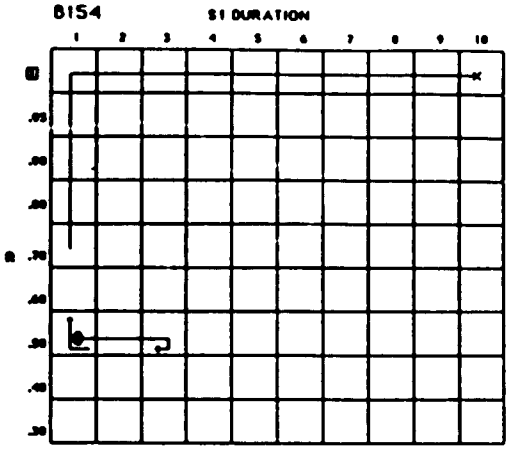
Figures 5-9 each present summary matrices for the 6 animals in Groups p=.5, .8, .9, .95 and 1.0 respectively and can be used to ascertain the particular progression of parameter coordinates for all animals. These matrices are read in an identical fashion to those presented in the procedure; however, since these matrices represent actual data from individual subjects, progressions through the coordinates are indicated by solid lines as opposed to the broken lines used previously. As in previous instances, rows represent variation in p and columns represent, in seconds, the S1 durations. Arrowheads indicate the appropriate directions of movement. Occasionally, filled boxes appear in the upper right corner of cells at p=1.0; these are germane to the reacquisition or maintenance phases of the experiment and will be discussed individually.

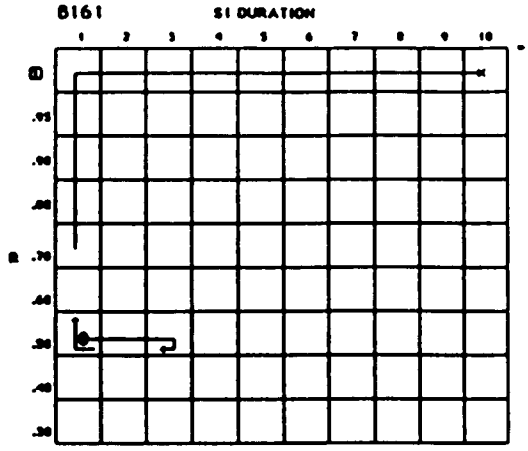
Table 1. The number of sessions during each experimental condition for all 30 animals. Columns 1 and 2 refer respectively to the Bird # and Group for each animal. Columns 3, 4, and 5 refer respectively to the number of sessions necessary to complete Initial Acquisition, Abolishment and Reacquisition, and Maintenance. Column 6 represents the total number of sessions for each animal. The p values enclosed in parentheses in Column 5 indicate the value at which Maintenance was completed. Missing values indicate failure to expose a particular animal to a phase and asterisks reflect termination of a condition prior to its successful completion (see text for details).

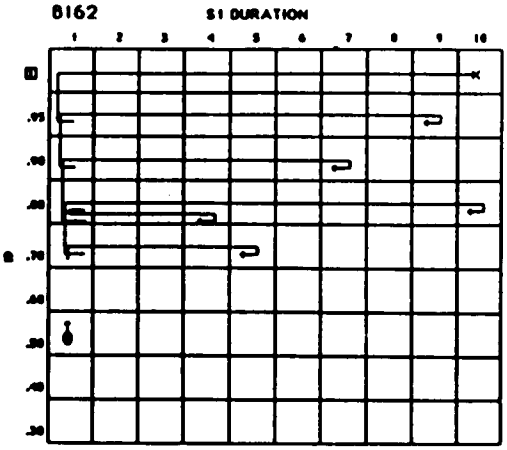
Bird #	Group	Init Acq	Ab & Reac	Main (p)	Total
152	.50	87	-	9 (1.00)	96
154	.50	83	-	12 (1.00)	95
161	.50	96	-	9 (1.00)	105
162	.50	154	-	9 (1.00)	163
164	.50	183	-	188*(1.00)	371
165	.50	73	-	9 (1.00)	82
16	.80	34	-	26 (.90)	60
17	.80	35	-	156 (1.00)	191
18	.80	69	-	44 (.95)	113
20	.80	20	-	9 (.80)	29
22	.80	39	-	9 (.95)	48
25	.80	84	-	9 (1.00)	93
15	.90	19	-	9 (.90)	28
19	.90	38	-	30 (1.00)	68
21	.90	39	-	9 (.95)	48
23	.90	21	-	9 (.90)	30
24	.90	74	-	13 (1.00)	87
153	.90	17	-	9 (.90)	26
157	.95	19	117	9 (1.00)	145
159	.95	22	81	9 (1.00)	112
160	.95	31	82	36 (1.00)	149
166	.95	23	105	9 (1.00)	137
167	.95	25	104	9 (1.00)	138
168	.95	25	135	9 (1.00)	169
151	1.00	24	76	13 (1.00)	113
155	1.00	23	81	9 (1.00)	113
156	1.00	22	91	9 (1.00)	122
158	1.00	23	105	9 (1.00)	137
163	1.00	28	107	9 (1.00)	144
170	1.00	21	302*	-	323

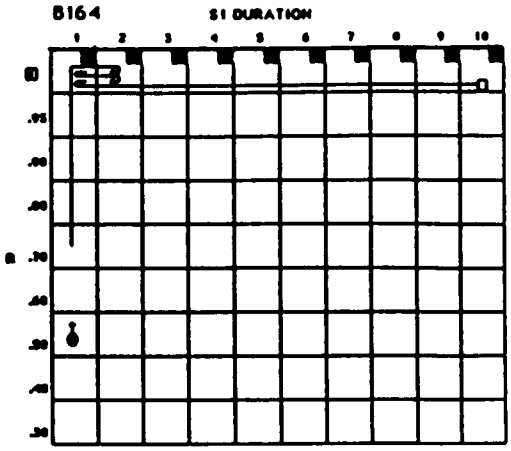
Figure 5. Matrices representing the S1 and p parameters. Filled circles depict the starting points for each animal in Group p=.5. The solid lines with arrowheads indicating the direction of movement show the progression of each animal through the parameter coordinates for all experimental conditions. The p value enclosed in a box indicates the value at which initial acquisition was completed. The filled boxes in the upper right corner of all cells at p=1.0 for B164 indicate that more determinations of those points than are indicated by the solid lines were made (see text for details). An "X" in the cell at p=1.0, S1=10 indicates successful completion of the maintenance condition. The open box in the cell at p=1.0, S1=10 for B164 indicates that maintenance was not successfully completed for this animal.


S152
S1 DURATION
1 2 3 4 5 6 7 8 9 10
R


S154
S1 DURATION
1 2 3 4 5 6 7 8 9 10
R


S161
S1 DURATION
1 2 3 4 5 6 7 8 9 10
R


S162
S1 DURATION
1 2 3 4 5 6 7 8 9 10
R


S164
S1 DURATION
1 2 3 4 5 6 7 8 9 10
R

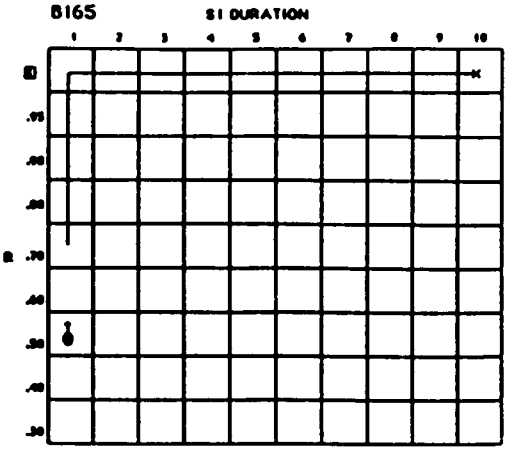
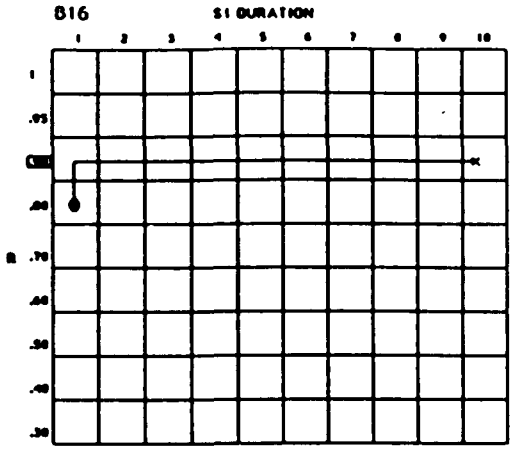
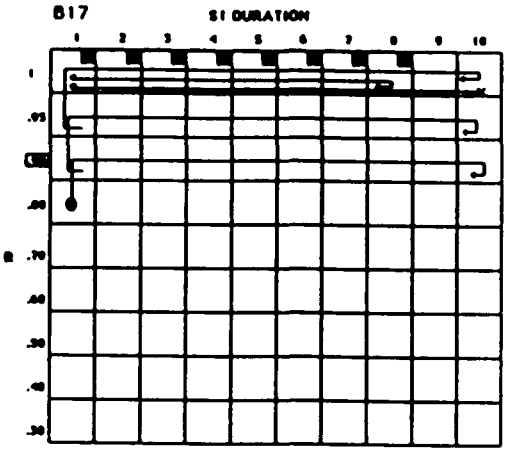
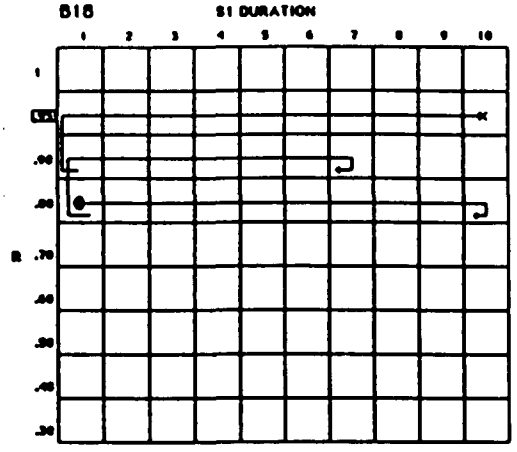
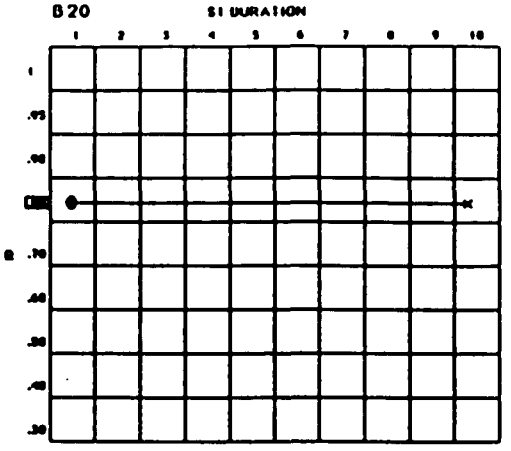

S165
S1 DURATION
1 2 3 4 5 6 7 8 9 10
R

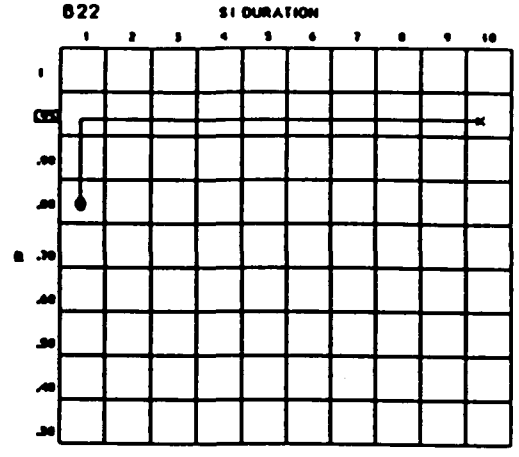
Figure 6. Matrices representing the Si and p parameters. Filled circles depict the starting points for each animal in Group p=.8. The solid lines with arrowheads indicating the direction of movement show the progression of each animal through the parameter coordinates for all experimental conditions. The p value enclosed in a box indicates the value at which initial acquisition was completed. The filled boxes in the upper right corner of Sec 1-8 at p=1.0 for B17 indicate that more determinations of those points than are indicated by the solid lines were made (see text for details). An "X" in any cell at Si=10 indicates successful completion of the maintenance condition.


B16
S1 DURATION
1 2 3 4 5 6 7 8 9 10
1
.95
.90
.80
R .70
.60
.50
.40
.30


B17
S1 DURATION
1 2 3 4 5 6 7 8 9 10
1
.95
.90
.80
R .70
.60
.50
.40
.30


B18
S1 DURATION
1 2 3 4 5 6 7 8 9 10
1
.95
.90
.80
R .70
.60
.50
.40
.30


B20
S1 DURATION
1 2 3 4 5 6 7 8 9 10
1
.95
.90
.80
R .70
.60
.50
.40
.30


B22
S1 DURATION
1 2 3 4 5 6 7 8 9 10
1
.95
.90
.80
R .70
.60
.50
.40
.30

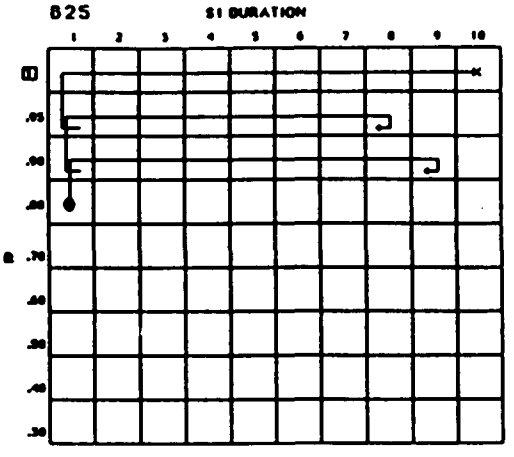
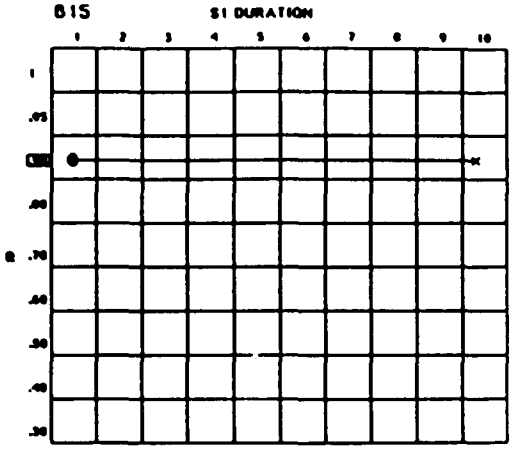
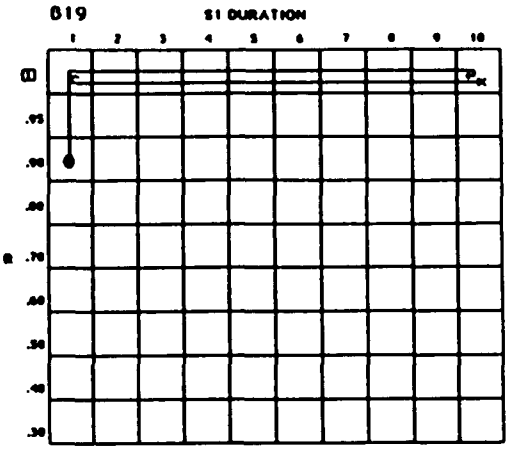
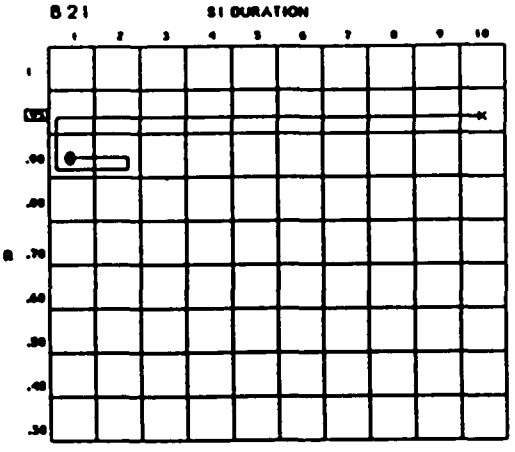
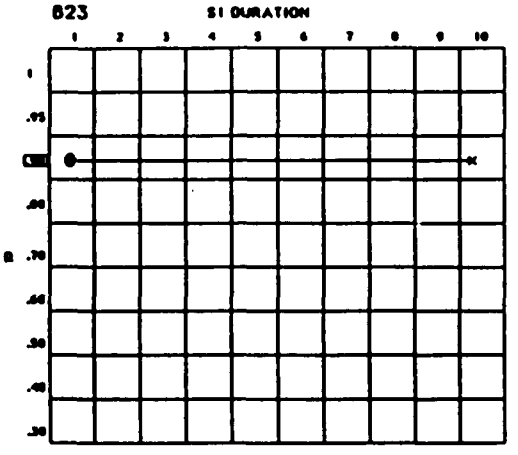

B25
S1 DURATION
1 2 3 4 5 6 7 8 9 10
1
.95
.90
.80
R .70
.60
.50
.40
.30

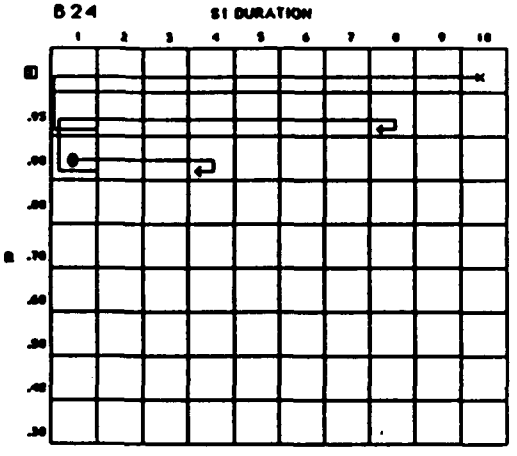
Figure 7. Matrices representing the Si and p parameters. Filled circles depict the starting points for each animal in Group p=.9. The solid lines with arrowheads indicating the direction of movement show the progression of each animal through the parameter coordinates for all experimental conditions. The p value enclosed in a box indicates the value at which initial acquisition was completed. An "X" in any cell at Si=10 indicates successful completion of the maintenance condition.


B15
S1 DURATION
1 2 3 4 5 6 7 8 9 10
1
.95
.90
.80
.70
.60
.50
.40
.30


B19
S1 DURATION
1 2 3 4 5 6 7 8 9 10
1
.95
.90
.80
.70
.60
.50
.40
.30


B21
S1 DURATION
1 2 3 4 5 6 7 8 9 10
1
.95
.90
.80
.70
.60
.50
.40
.30


B23
S1 DURATION
1 2 3 4 5 6 7 8 9 10
1
.95
.90
.80
.70
.60
.50
.40
.30


B24
S1 DURATION
1 2 3 4 5 6 7 8 9 10
1
.95
.90
.80
.70
.60
.50
.40
.30

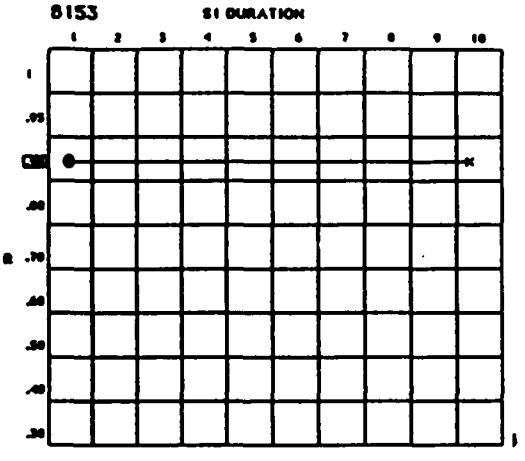
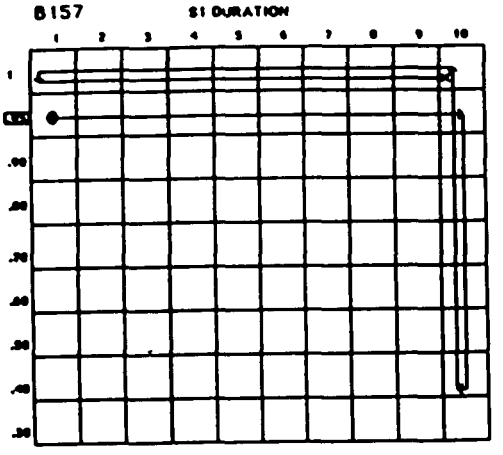
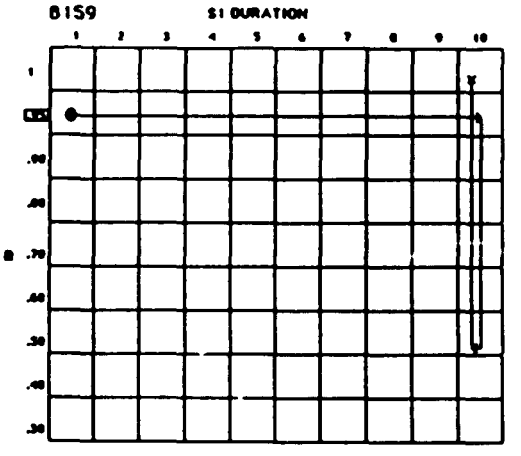
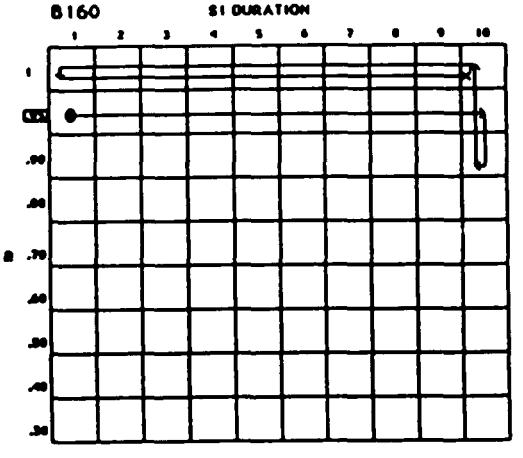
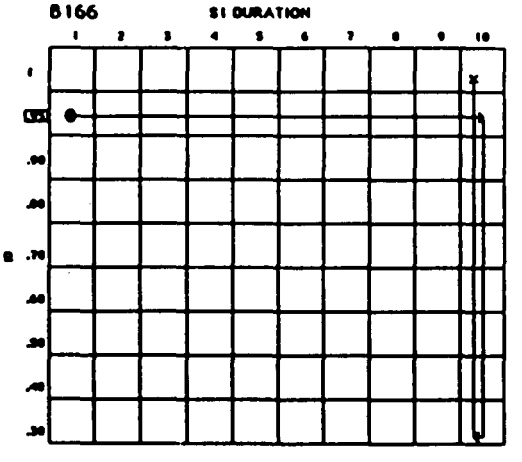

B153
S1 DURATION
1 2 3 4 5 6 7 8 9 10
1
.95
.90
.80
.70
.60
.50
.40
.30

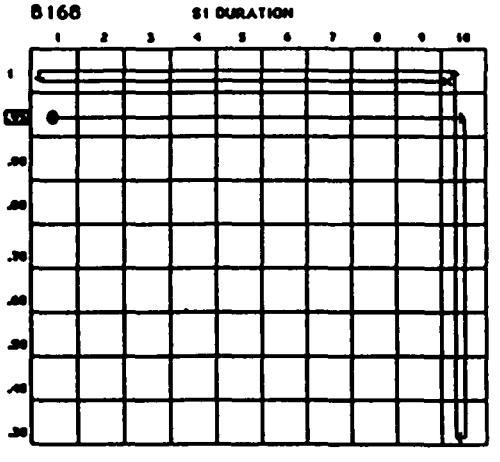
Figure 8. Matrices representing the SI and p parameters. Filled circles represent the starting points for each animal in Group p=.95. The solid lines with arrowheads indicating the direction of movement show the progression of each animal through the parameter coordinates for all experimental conditions. The p value enclosed in a box indicates the value at which initial acquisition was completed. The filled boxes in the upper right corner of Sec 1-8 at p=1.0 for B167 indicate that more determinations of those points than are indicated by the solid lines were made (see text for details). An "X" in any cell at SI=10 indicates successful completion of the maintenance condition.


B157
S1 DURATION


B159
S1 DURATION


B160
S1 DURATION


B166
S1 DURATION


B168
S1 DURATION

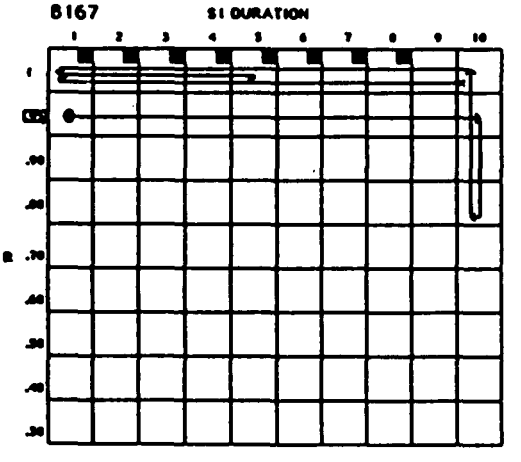
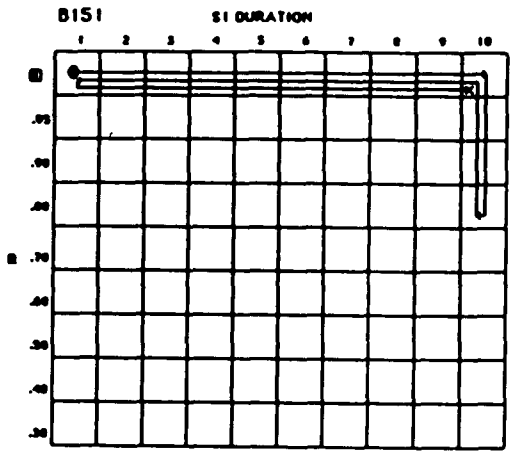
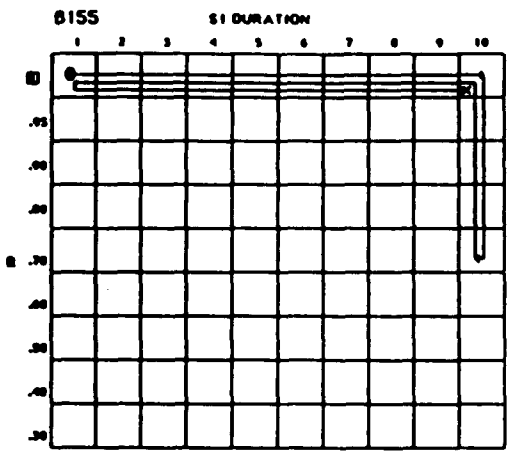
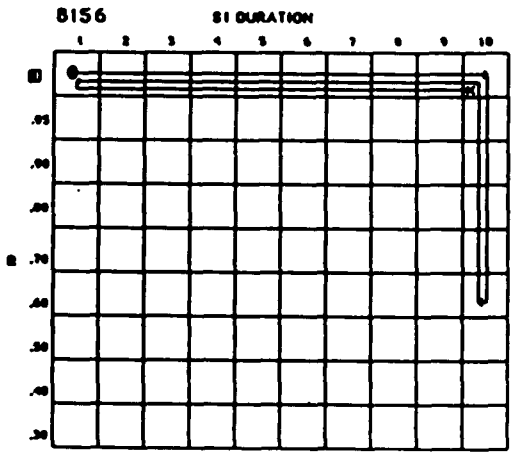
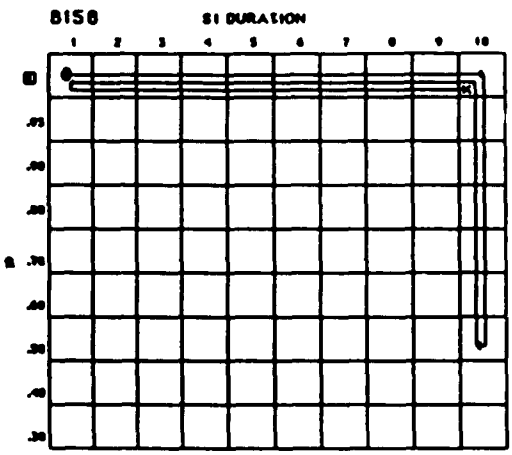

B167
S1 DURATION

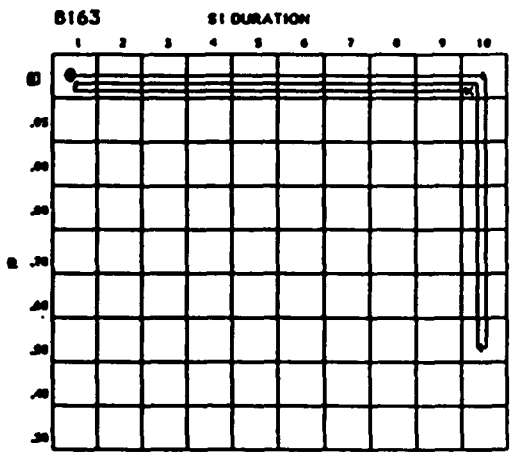
Figure 9. Matrices representing the S1 and p parameters. Filled circles depict the starting points for each animal in Group p=1.0. The solid lines with arrowheads indicating the direction of movement show the progression of each animal through the parameter coordinates for all experimental conditions. The p value enclosed in a box indicates the value at which initial acquisition was completed. The filled boxes in the upper right corner of Sec 1-7 at p=1.0 for B170 indicate that more determinations of those points than are indicated by the solid lines were made (see text for details). An "X" in the cell at p=1.0, S1=10 indicates successful completion of the maintenance condition. The open box in the cell at p=1.0, S1=9 for B170 indicates that reacquisition was not successfully completed for this animal.

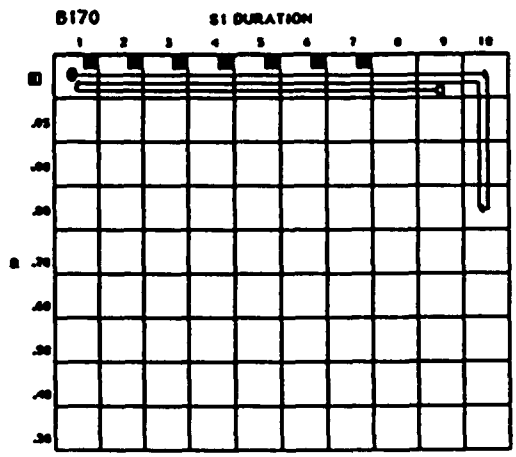

B151
S1 DURATION
1 2 3 4 5 6 7 8 9 10


B155
S1 DURATION
1 2 3 4 5 6 7 8 9 10


B156
S1 DURATION
1 2 3 4 5 6 7 8 9 10


B158
S1 DURATION
1 2 3 4 5 6 7 8 9 10


B163
S1 DURATION
1 2 3 4 5 6 7 8 9 10


B170
S1 DURATION
1 2 3 4 5 6 7 8 9 10

I. Overview of Major Trends

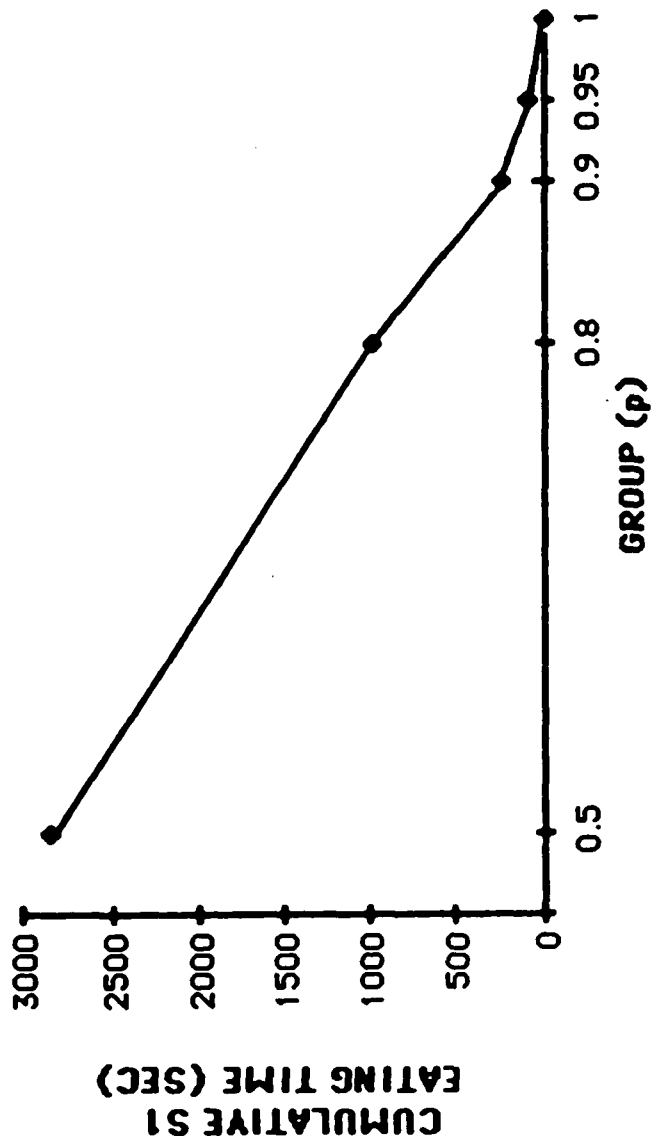
A. Initial Acquisition

The filled circles at S1=1 sec and p=Group Values in the matrices shown in Figures 5-9 indicate the starting points for each animal. The p's enclosed in boxes to the left of the matrices indicate the point at which initial acquisition (i.e., 1 session at a minimum of 80% refrainment at S1=10 sec) was completed.

Striking evidence for the reliability of the procedure in the regulation of eating behavior is evinced by the fact that all 30 animals completed initial acquisition. The horizontal lines of various extents between 1 and 10 sec indicate that some animals experienced S1 duration increments at p values less than that at which initial acquisition was completed.

Figure 10 shows the total S1 eating time cumulated separately within each group for all 30 animals at their initial p's with S1=1 sec. Total S1 eating time varied inversely with increases in p. It was hoped, that by requiring the animals to respond at or above criterion for 3 consecutive sessions at an S1 duration of 1 sec, each animal other than those in Group p=1.0 would have the opportunity to eat for a minimum of 3 sec during the S1 period (i.e., each animal would at some point be reinforced for an S1 approach). This goal was achieved even in Group p=.95 where the S1 eating opportunities were

Figure 10. Cumulative SI eating time as a function of group. Each point represents total eating time for those sessions at SI=1 sec cumulated across the 6 animals in a given group at their original p values.


CUMULATIVE S1
EATING TIME (SEC)
3000
2500
2000
1500
1000
500
0
0.5
0.8
0.9
0.95
1
GROUP (p)

the most limited over the range studied. The minimum amount of S1 eating time was 3 sec for B168 in Group p=.95 while the maximum was 747.5 sec for B152 in Group p=.5.

Figure 11 presents the number of animals in each group completing initial acquisition at their original p values. Generally, there was a positive relationship between increases in p and the number of animals finishing at the initial value. Only 1 out of the 12 animals at p=.5 and .8 completed initial acquisition at their original p values; at values of p=.9 or above, 15 of the 18 animals finished at their respective values.

Figure 12 displays mean, median, and individual S1 eating times for those animals represented in Figure 11. It is difficult to spot a clear trend in these data which suggests that p exerts its effects in terms of the number of animals finishing initial acquisition at their original values and not in between-subjects differences for those animals completing initial acquisition at different initial values. The zero values for Group p=1.0 are forced in that this group did not receive an opportunity to eat during S1, however the greatest mean eating time for the 3 groups offered S1 opportunities to eat occurred in Group p=.95 (59.6 sec), which had the least available S1 eating opportunities.

Therefore, the relatively large between-group change in p between Group p=.5 (0 animals completing initial acquisition at that value) and Group p=.8 (1 animal

Figure 11. The number of animals completing initial acquisition at their original p values as a function of group.

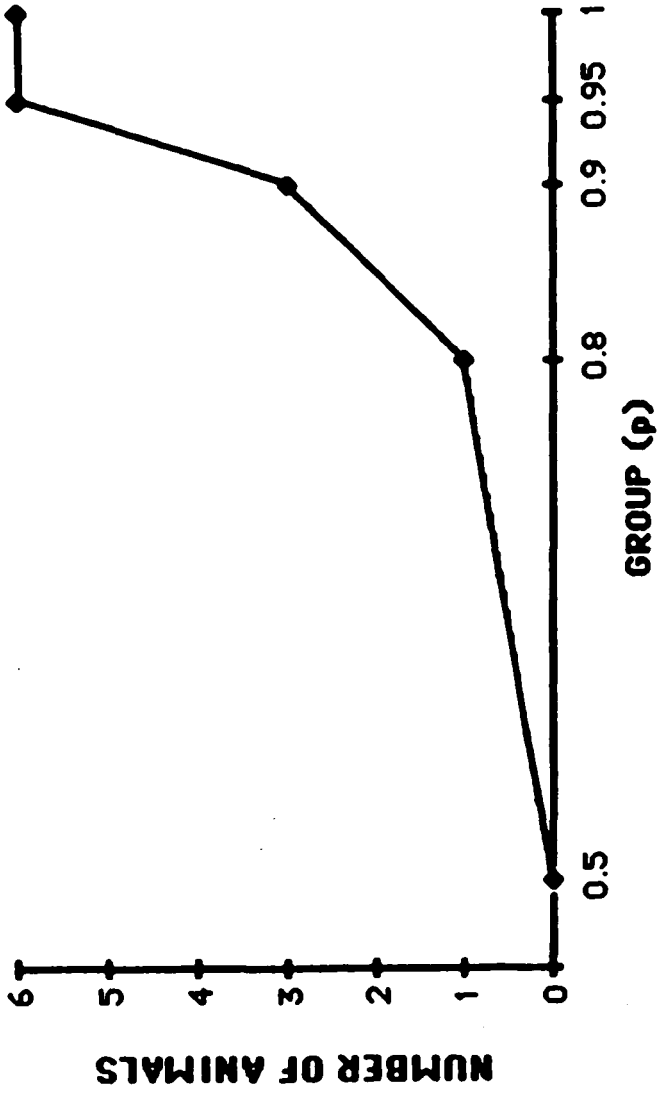
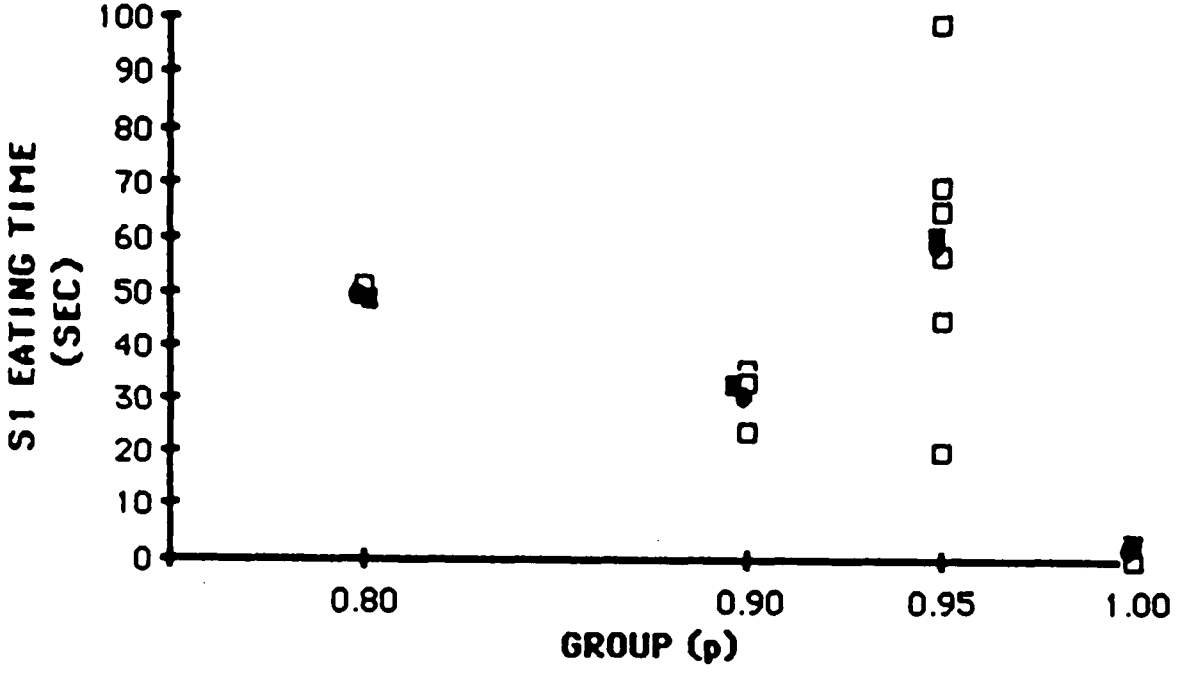

NUMBER OF ANIMALS
0
1
2
3
4
5
6
GROUP (p)
0.5
0.8
0.9
0.95
1

Figure 12. Mean (filled circles), median (filled squares), and individual subject's (open squares) S1 eating time during initial acquisition for the 15 animals completing initial acquisition at their original p values.


S1 EATING TIME (SEC)
100
90
80
70
60
50
40
30
20
10
0
0.80
0.90
0.95
1.00
GROUP (p)

completing at the original value) had only a minimal behavioral effect. At either of these values the procedure may be described as being unreliable in that it cannot, with any assuredness, be stated that a given animal exposed to either of these p's would be likely to complete initial acquisition. Smaller changes between Groups p=.95 and p=1.0 also had small effects since all animals in both groups completed this phase at their respective initial values. At either of these values the procedure may be described as maximally reliable. Yet, behavior was extremely sensitive to changes in p throughout a range tending towards the higher end of the continuum (i.e., between p=.8 and p=.95). These data therefore suggest that, at least within the range of the current SI durations, there would be no reason to explore any new p values other than to delineate the function presented in Figure 10 more precisely.

B. Abolishment and Reacquisition

The vertical lines through the 10 sec column in the matrices in Figures 8 and 9 indicate the within subject p manipulations conducted for the 12 animals in Groups p=.95 and 1 following completion of initial acquisition. Initially, the stability of refrainment during SI was assessed. This was accomplished by decreasing p, thereby increasing the likelihood that an attempt to eat during SI would be successful (i.e., increasing the likelihood of

the hypothetical Type #3 trial described in the procedure).

The fact that refrainment during S1 did not persevere indefinitely under such conditions is evidenced by the eventual failure of all 12 animals to achieve criterion responding for 3 consecutive sessions. As can be seen from the matrices, the actual values at which the deterioration occurred varied between subjects. At the upper extreme was B160, which experienced decreases to p=.9 prior to the consistent occurrence of sub-criterion responding. At the other extreme was B166 and B168, which both surpassed criterion until p=.3 had been reached.

Once responding had dropped below the 80% criterion, increments in p occurred in an effort to retrain refrainment. The matrices show that these increments exposed subjects to the identical points at which criterion responding had previously been achieved. Despite 10 sessions of exposure to each of these same coordinates, criterion responding did not occur again for any animal until p=1.0 had been reached. This presents striking evidence for the persistence of a pattern of unrestrained S1 approach once such approach had been produced.

Horizontal lines indicating a decrement in S1 duration at p=1.0 represent the difficulty in retraining refrainment even at this value. Ten of the 12 animals (excepting B159 and B166) experienced decrements in S1

duration until S1 had reached the minimum value of 1 sec in order to facilitate reacquisition. Following multiple unsuccessful attempts to complete reacquisition, a decision was made to terminate the experiment for B170. (The filled boxes in Figure 9 indicate that more variations in S1 duration occurred than are depicted by the horizontal lines. The open box, which in the present case appears in the 9 sec cell, indicates the longest S1 duration an animal was exposed to in a particular portion of the experiment).

Thus, it was possible to abolish the pattern of S1 refrainment; once this had occurred criterion responding was not easily restored. This was evidenced by all subjects demonstrating sub-criterion behavior during exposure to coordinates at which criterion responding had previously occurred until p=1.0 had been attained. The most extreme example of this phenomenon was B170, a subject for which extended training failed to reach the reacquisition criterion. (Data for this subject were therefore not obtained during maintenance).

C. Maintenance

Each animal was required to respond at criterion for 10 consecutive sessions at an S1 duration of 10 sec in order for maintenance to be completed. Since the end of initial acquisition (Groups p=.5, .8, and .9) or reacquisition (Groups p=.95 and p=1.0) simultaneously

marked the beginning of maintenance, an additional 9 sessions were necessary in order for this requirement to be satisfied.

The "X" in each matrix in Figures 5-9 denotes successful completion of the maintenance phase. Column 5 of Table 1 shows that 28 of the 29 remaining animals (excluding B164) completed maintenance successfully at values between p=.8 and p=1.0. For 20 of these 29 animals, the maintenance requirement was reached in the minimum 9 additional sessions.

II. Individual Subjects' Data from Selected Session Blocks

A. Initial Acquisition

1) Behavior at Initial p

Each panel in Figures 13-15 represents an individual subject's data for those animals completing initial acquisition at their original values. Functions present percent refrainment during S1 at durations between 1 and 10 sec for individual sessions. Beginning with a 1 sec duration for session 1, 1 sec increments in S1 durations are shown by discontinuities between the functions. Since each animal attained one session of criterion responding at S1=10, there are 10 functions displayed in each bird's panel. The various p's are indicated to the right on each figure.

Distinctions between animals completing initial acquisition at different p's are not obvious from these

Figure 13. Percent SI refrainment for each session during initial acquisition for the 1 animal in Group p=.80 (upper panel) and the 3 in Group p=.90 (lower panels) completing initial acquisition at their original p values. Proceeding from left to right in a panel, discontinuities between each of the 10 functions indicate a 1 sec increment in SI duration.

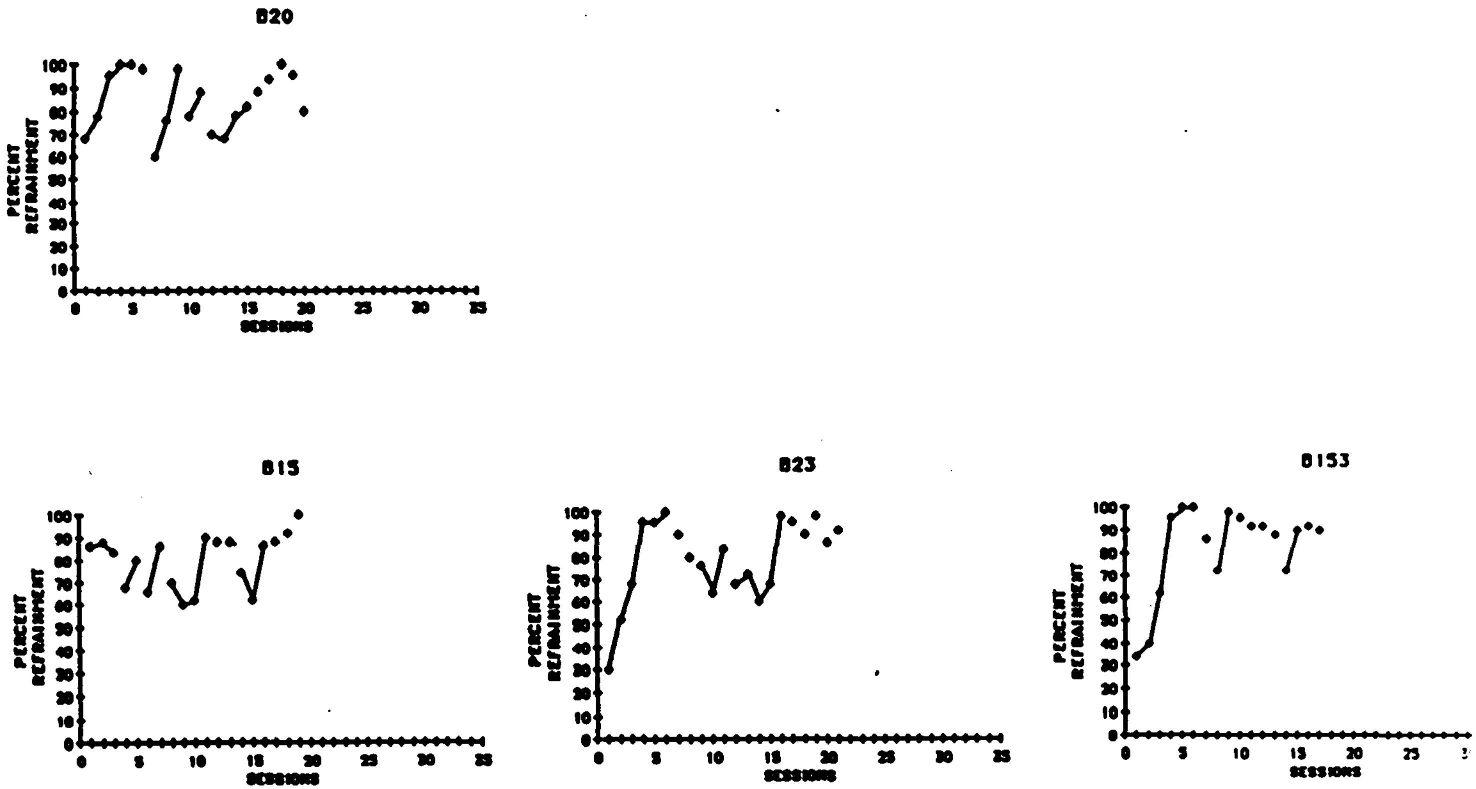
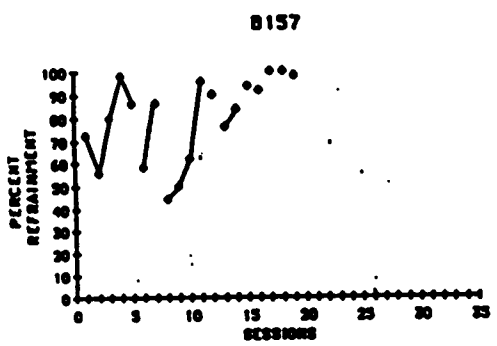
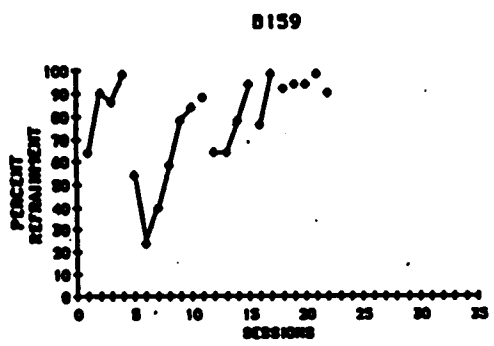
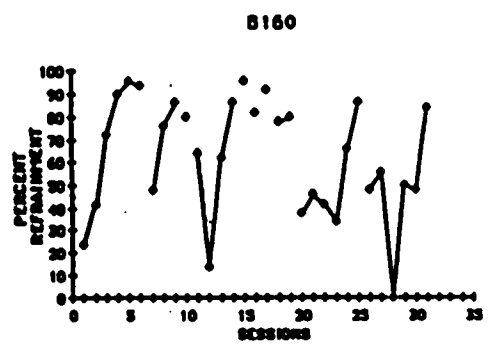
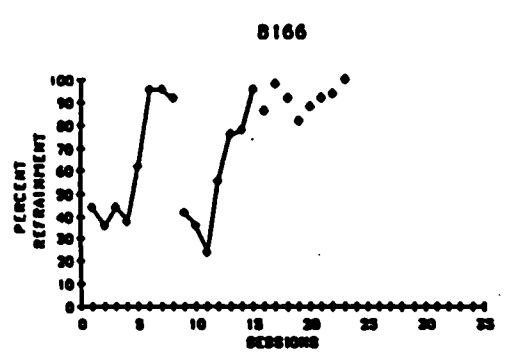

B20
PERCENT REFRAINMENT
SESSIONS
B15
PERCENT REFRAINMENT
SESSIONS
B23
PERCENT REFRAINMENT
SESSIONS
B153
PERCENT REFRAINMENT
SESSIONS

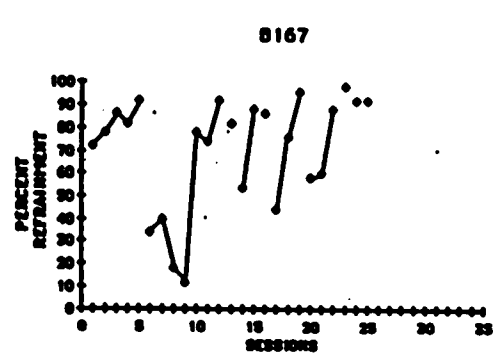
Figure 14. Percent SI refrainment for each session during initial acquisition for all 6 animals in Group p=.95. Proceeding from left to right in a panel, discontinuities between each of the 10 functions indicate a 1 sec increment in SI duration.


B157
PERCENT REFRAINMENT
SESSIONS


B159
PERCENT REFRAINMENT
SESSIONS


B160
PERCENT REFRAINMENT
SESSIONS


B166
PERCENT REFRAINMENT
SESSIONS


B167
PERCENT REFRAINMENT
SESSIONS

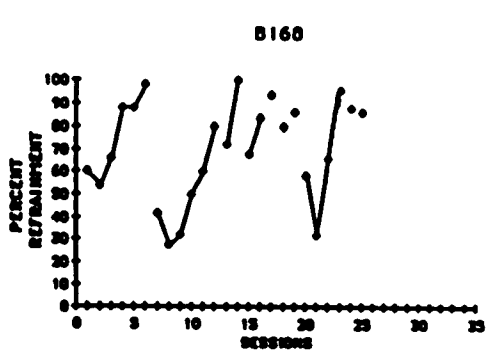
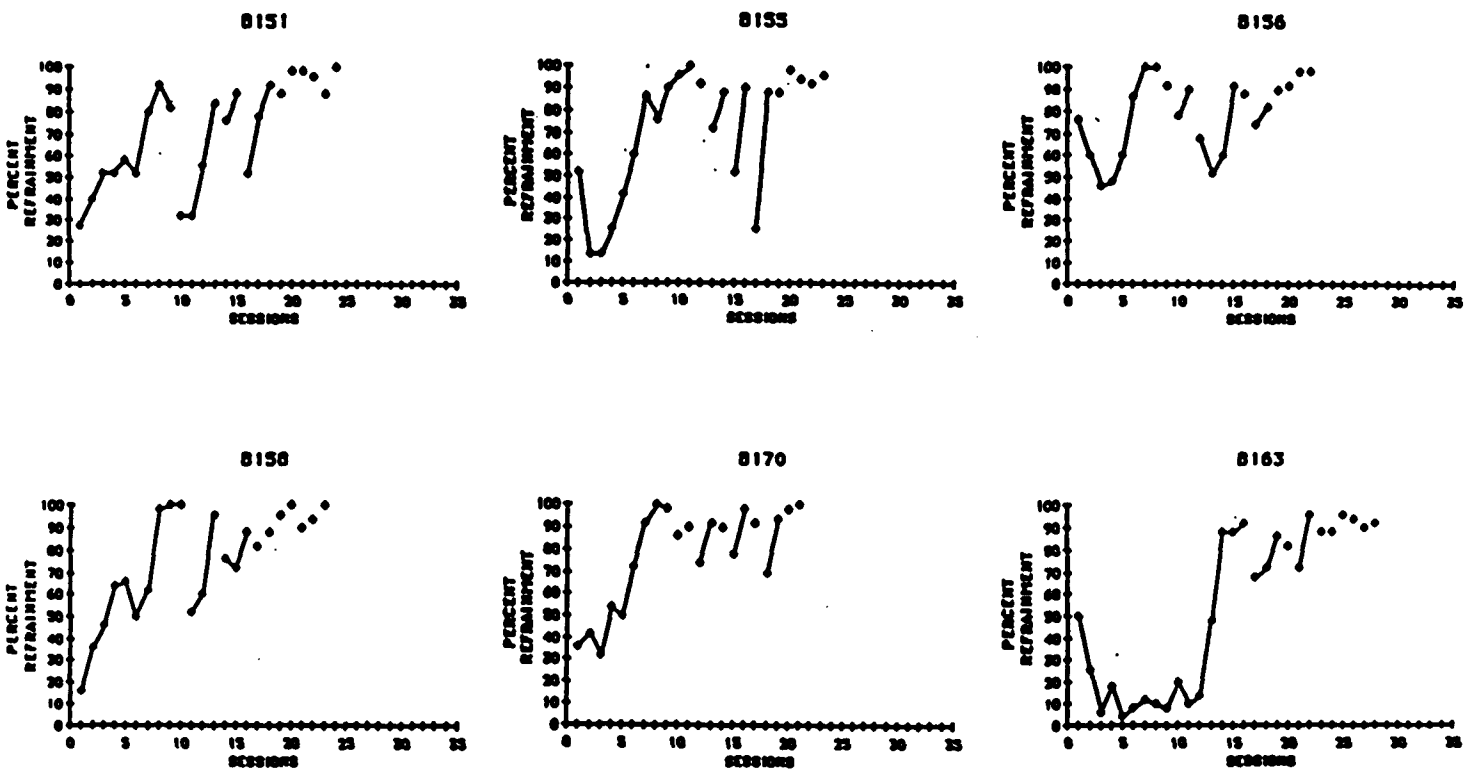

B168
PERCENT REFRAINMENT
SESSIONS

Figure 15. Percent S1 refrainment for each session during initial acquisition for all 6 animals in Group p=1.0. Proceeding from left to right in a panel, discontinuities between each of the 10 functions indicate a 1 sec increment in S1 duration.


S151
S153
S156
S158
S170
S163
PERCENT REFRAINMENT
SESSIONS

data. Table 2 presents the number of sessions required for these animals to attain criterion responding at all S1 durations up to 5 sec, durations between 6 and 10 sec, the difference between these 2 values, and the total number of sessions necessary to complete initial acquisition. Between-group comparisons of the total number of sessions until completion of initial acqusition did not reveal any obvious trends. The means for those animals completing initial acquisition at their original values for Groups p=.8, .9, .95, and 1.0 were, respectively, 20, 19, 24.2, and 20.2, sessions.

Although detailed profiles of individual animals varied from animal to animal, some commonalities were noticeable. With one exception (B15, Group p=.9), it took longer than the minimum 3 sessions to reach criterion responding at
S1=1 sec. After criterion responding was achieved at 1 sec, increments in S1 durations frequently resulted in a temporary increase in the number of S1 approaches. This disruption generally appeared to occur more consistently and for more prolonged periods at shorter S1 durations. This tendency for S1 duration increments to cause a more profound disruption at shorter values is presented in the difference column of Table 2, which shows that 15 of the 16 animals took longer to reach criterion responding at 5 sec than at 10 sec. It should be noted that, since the requisite performance for an animal was 3 sessions of

Table 2. The number of sessions required to progress from an S1 duration of 1 sec to 5 sec (Column 3), from a duration of 6 sec to 10 sec (Column 4), and the total number of sessions (Column 5) for the 16 animals completing initial acquisition at the original p. Bird numbers and Groups are shown in Columns 1 and 2 respectively. The difference between the number of sessions required to complete these two halves (i.e., the number of sessions to progress from Sec 1 to Sec 5 minus the number of sessions to progress from Sec 6 to Sec 10) is presented in Column 7. Relevant means are shown at the bottom of each column.

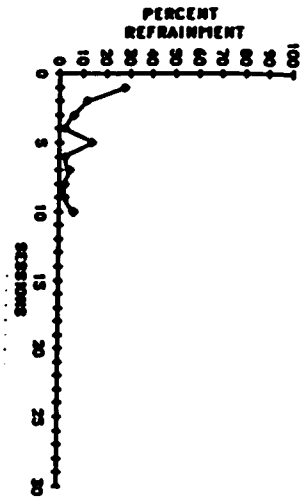
Bird #	Group	Sec 1-5	Sec 6-10	Total	Diff
20	.80	15	5	20	10
15	.90	12	7	19	5
23	.90	16	5	21	11
153	.90	11	6	17	5
157	.95	14	5	19	9
159	.95	17	5	22	12
160	.95	15	16	31	-1
166	.95	18	5	23	13
167	.95	16	9	25	7
168	.95	17	8	25	9
151	1.00	19	5	24	14
155	1.00	18	5	23	13
156	1.00	16	6	22	10
158	1.00	18	5	23	13
163	1.00	23	5	28	18
170	1.00	14	7	21	7
Mean		16.2	6.5	22.7	9.7

criterion responding at a duration of 1 sec and 1 session at all durations greater than 1, an animal performing optimally (i.e., reaching or exceeding criterion each session) would require 2 more sessions to reach 5 sec than to reach 10 sec. However, subtracting 2 sessions from each value in the difference column still indicates that all animals except B160 progressed more quickly through the longer half of the durations. Statistical comparison of the corrected session values for Seconds 1-5 (i.e., N-2) with the values for Seconds 6-10 indicates that these differences were reliable [$t(15)=6.86$, $p<.01$, two-tailed].

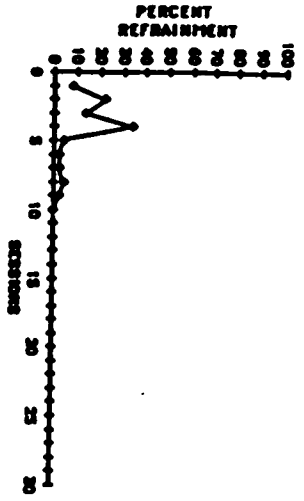
Figures 16-18 represent individual subjects' data at their respective initial p's for the 14 subjects failing to complete initial acquisition at the original value. As in Figures 13-15, each point presents percent refrainment during S1 for a session and discontinuities between functions represent changes in S1 durations. The open boxes contained in 5 of the panels indicate the return to an S1 duration of 1 sec which preceded an increment in p.

The most common occurrence (9 of the 14 animals) for those animals failing to complete initial acquisition at their original values was that an S1 duration of 1 sec was not exceeded. Only B18 (Group p=.8) met criterion at a value greater than 3 sec. An animal responding below criterion would typically exhibit extremely low levels of refrainment during S1 many times at or near zero percent. Occasionally, this low level would be preceded by a brief

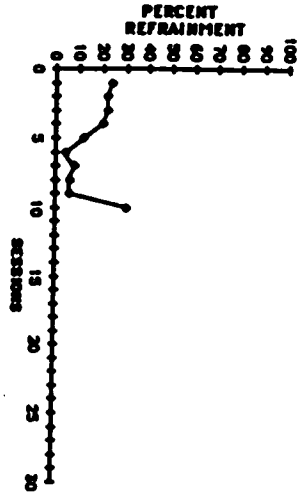
Figure 16. Percent S1 refrainment for each session at p=.5 during initial acquisition for all 6 animals in Group p=.5. Proceeding from left to right in a panel, discontinuities between each function indicate a 1 sec increment in S1 duration. Open squares represent a return to an S1 duration of 1 sec which preceded an increment in p.



822



818



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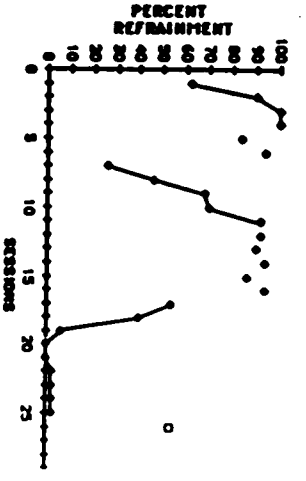
817



810

Figure 17. Percent S1 refrainment for each session at p=.8 during initial acquisition for the 5 animals in Group p=.8 which failed to complete initial acquisition at that value. Proceeding from left to right in a panel, discontinuities between each function indicate a 1 sec increment in S1 duration. Open squares represent a return to an S1 duration of 1 sec which preceded an increment in p.

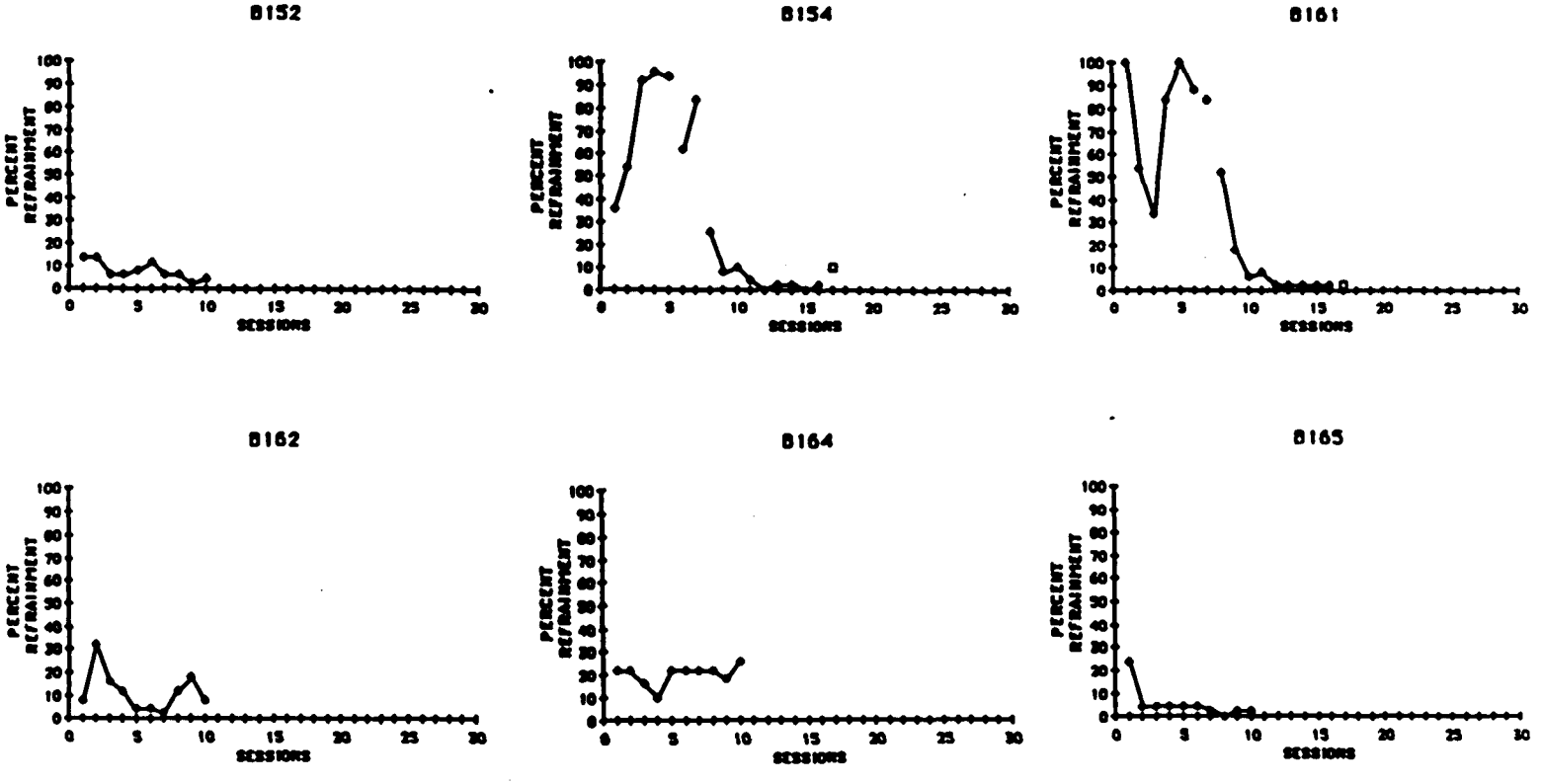
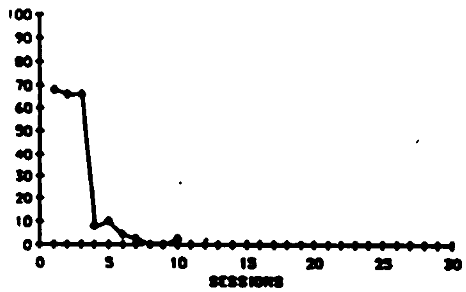
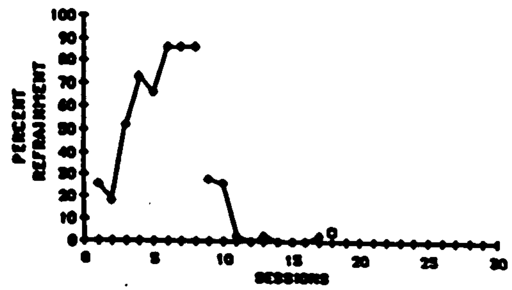

B152
B154
B161
B162
B164
B165
PERCENT REFRAINMENT
SESSIONS

Figure 18. Percent S1 refrainment for each session at p=.9 during initial acquisition for the 3 animals in Group p=.9 which failed to complete initial acquisition at that value. Proceeding from left to right in a panel, discontinuities between each function indicate a 1 sec increment in S1 duration. Open squares represent a return to an S1 duration of 1 sec which preceded an increment in p.

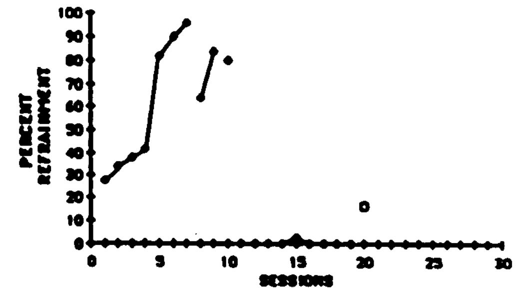
B19


100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
SESSIONS

B21


PERCENT
REFRAINMENT
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
SESSIONS

B24


PERCENT
REFRAINMENT
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
SESSIONS

period of near criterion responding (e.g., B19, Group p=.9) however, once criterion was not met, refrainment would eventually arrive and remain at a low level. Even for those 2 animals demonstrating the highest sub-criterion response level (B17, Group p=.8; B164, Group p=.5) this percentage was still well below criterion.

2) Increments in p

Table 3 presents initial acquisition data from these 14 animals. The format is similar to Table 2 with column 3 added to present the p value from which the data in columns 4 and 5 are chosen. Nine of the 14 animals reached p=1.0 before initial acquisition was completed. Four of the remaining 5 animals were in Group p=.8 with 2 (B16 and B17) completing initial acquisition at p=.9 and the other 2 (B18 and B22) at p=.95. The remaining animal, B21 (Group .9) completed initial acquisition at p=.95. Thus, initial acquisition took place only when p reached 1.0 for all 6 animals in Group p=.5.

The finding from the previous section that it typically required more sessions to attain criterion responding at an SI duration of 5 sec than at 10 sec was replicated. Subtracting 2 from each value in the difference column (in order to compensate for the 3 session requirement at an SI duration of 1 sec) reveals that 3 of the 14 animals (B18, B25, and B162) did not adhere to this pattern. Statistical analysis which again

Table 3. The number of sessions required to progress from an SI duration of 1 sec to 5 sec (Column 4), from a duration of 6 sec to 10 sec (Column 5), and the total number of sessions (Column 6) at the final p value during initial acquisition for the 14 animals failing to complete initial acquisition at the original p. Bird numbers and groups are shown in Columns 1 and 2 respectively. The p values from which the session values are derived are represented in Column 3. The difference between the number of sessions required to complete these two halves (i.e., the number of sessions to progress from Sec 1 to Sec 5 minus the number of sessions to progress from Sec 6 to Sec 10) is presented in Column 7. Relevant means are shown at the bottom of each column.

Bird #	Group	p	Sec 1-5	Sec 6-10	Total	Diff
152	.50	1.00	32	5	37	27
154	.50	1.00	21	5	26	16
161	.50	1.00	34	5	39	29
162	.50	1.00	8	7	15	1
164	.50	1.00	10	5	15	5
165	.50	1.00	18	5	23	13
16	.80	.90	18	6	24	12
17	.80	.90	15	10	25	5
18	.80	.95	9	14	23	-5
22	.80	.95	13	6	19	7
25	.80	1.00	12	17	29	-5
19	.90	1.00	13	5	18	8
21	.90	.95	15	6	21	9
24	.90	1.00	14	7	21	7
Mean			16.6	7.4	23.9	9.2

included the corrected values for the number of sessions to progress from 1-5 sec indicated this difference was also reliable [$t(13)=2.71$, $p<.02$, two-tailed]. Although the individual percent refrainment data are not shown in this case, increments in S1 durations again caused disruptions in the percentage of refrainment during S1 which were more profound at shorter than at longer S1 durations.

Figures 5 through 9 show that 8 of the 14 animals responded at or above criterion at p's less than those at which initial acquisition was completed. Of these 8 animals, 3 (B154, B161, and B162) were from Group p=.5, 3 were from Group p=.8 (B17, B18, and B25), and the remaining 2 were from Group p=.9 (B21 and B24). As p increased, individual profiles varied. Some animals (e.g., B24, B25, B162) achieved criterion responding at a variety of p values less than that at which initial acquisition occurred. The progress demonstrated by B162 at increased p values was so extensive that a decision was made to expose the animal twice consecutively to p=.8 in order to determine whether initial acquisition might occur at that value. As seen on the matrix, this second attempt resulted in exposure up to an S1 duration of 4 sec. Other animals (e.g., B21 and B161) demonstrated much less criterion responding at these lesser p values.

Groups p=.5, .8, and .9 were also represented by those 6 animals failing to experience S1 duration

increments at values less than that at which initial acquisition was completed. Three animals (B152, 164, and 165) were from Group p=.5, 2 (B16 and B22) from Group p=.8, and 1 (B19) from Group p=.9.

Some of the 9 animals reaching p=1.0 required extensive training at S1=1 once p=1.0 had been reached in order for increases in S1 duration to occur. Table 4 reveals that any animal requiring more than 10 sessions at this point in order to increment the S1 duration was from Group p=.5, which had been exposed to the greatest amount of S1 eating time. The one animal (B162) achieving criterion responding in the minimum 3 sessions had previously demonstrated the most extensive history of criterion responding at p values less than 1.0.

The animal experiencing the most difficulty in attaining criterion response level at the shortest S1 duration was B164, which required 53 sessions before attaining the 3 criterion sessions at the first point required for extension of the S1 duration. This first point had by then been reduced to .5 sec. Because of the difficulty this animal experienced during initial acquisition, 2 remedial procedures were attempted. The first one involved decreasing the shortest S1 durations at various points to .5, .7, .8, and .9 sec. There were 3 such attempts made prior to the successful completion of initial acquisition. Each attempt occurred directly after the preceding one had failed to produce performance

Table 4. Columns 1 and 2 represent respectively the Bird # and Group for the 9 animals requiring p increments until p=1.0 had been attained. The number of sessions required to reach criterion responding at SI=1 sec, p=1.0 is shown in Column 3.

Bird #	Group	# Sess To Criterion (S1=1,p=1)
152	.50	22
154	.50	15
161	.50	25
162	.50	3
164	.50	53
165	.50	12
25	.80	3
19	.90	8
24	.90	6

enabling the S1 duration to be extended beyond 2 sec. The first one involved decreasing the initial point to S1=.5 sec. The animal quickly achieved criterion response level for 3 consecutive sessions at this point. The second attempt required the animal to respond at criterion level for 3 sessions at S1=.5 sec and 1 session at S1=.8 sec. The third attempt required criterion responding for 3 consecutive sessions at S1 durations of .5, .7, .9, and 1 sec.

The second remedial procedure for B164 occurred twice following the completion of the above procedure and involved the institution of a manual training procedure. It was noted that this animal typically demonstrated a high key peck response rate during S1 periods as compared to the other subjects in the study. An attempt was made to alter this pattern by requiring the animal to move away from the intelligence panel prior to trial onset. The manual procedure was successful in this regard; B164 pecked the key at lower rates during S1 for the remainder of the experiment. The first attempt lasted only until the 3 criterion sessions at S1=1 sec had been achieved (i.e., after this point the automated procedure was reinstated); this resulted in the animal reaching criterion only at S1=1 sec. The second attempt lasted until criterion responding at S1=3 sec had been achieved. This time the animal completed initial acquisition (i.e., responded at criterion at S1=10 sec).

B. Abolishment and Reacquisition

Table 5 represents the number of times each of the 12 animals ate during S1 in the abolishment procedure for Groups p=.95 and p=1.0. Data are cumulated for all sessions beginning with the one immediately following the completion of initial acquisition (i.e., the first session of 80% refrainment during S1 at S1=10 sec) and ending with the session prior to the one which marked the first of 10 consecutive sessions of sub-criterion responding indicating the termination of the abolishment phase. The number of times a subject ate during S1 ranged between 0 and 12; between-groups differences were not reliable [t(10)=1.32, p>.05, two-tailed].

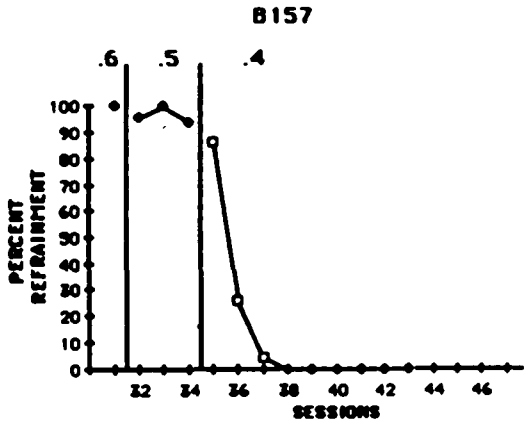
Figures 19 and 20 present representative blocks of sessions for each of the animals in Groups p=.95 and p=1.0 respectively. These blocks depict percent refrainment during S1 for sessions before, during, and after the first 3 consecutive sub-criterion sessions. The open squares represent the first 3 consecutive sub-criterion sessions. The solid vertical lines indicate changes in p.

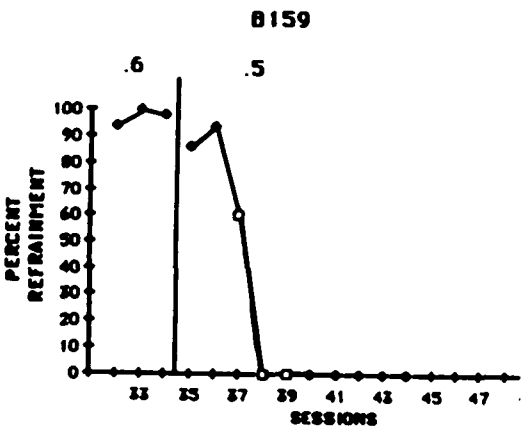
Despite the fact that animals varied in the actual values at which the refrainment percentage during S1 diminished, the pattern of behavior was strikingly similar. Percent refrainment typically began at levels much higher than 80%, but once refrainment began to decrease, it quickly fell abruptly to near zero percent

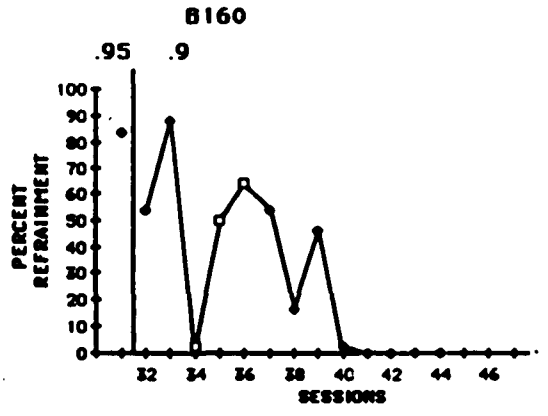
Table 5. The total number of S1 eats combined across sessions during abolishment for Groups .95 (left side) and 1 (right side) until the first of 10 consecutive sub-criterion sessions indicating the occurrence of abolishment. Bird numbers are indicated in Columns 1 and 3 and the total number of S1 eats in Columns 2 and 4.

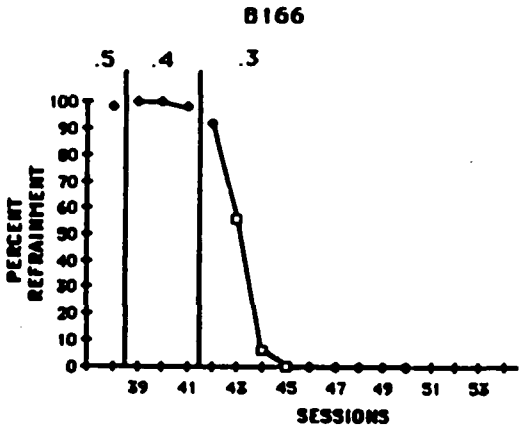
Group .95		Group 1	
Bird #	# S1 Eats	Bird #	# S1 Eats
157	7	151	4
159	7	155	10
160	0	156	1
166	4	158	3
167	12	163	2
168	9	170	2
Mean	6.5		3.7

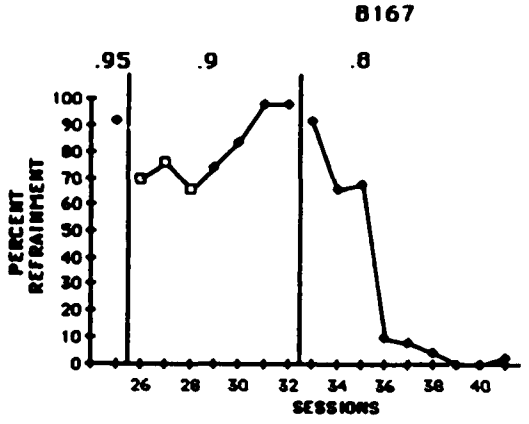
Figure 19. Percent SI refrainment for selected blocks of sessions during the abolishment of refrainment for Group p=.95. The 3 open squares represent the first 3 consecutive sub-criterion sessions. P values are indicated at the top of each panel. Vertical lines indicate the sessions included for a particular p value.


B157
.6
.5
.4
PERCENT REFRAINMENT
SESSIONS


B159
.6
.5
PERCENT REFRAINMENT
SESSIONS


B160
.95
.9
PERCENT REFRAINMENT
SESSIONS


B166
.5
.4
.3
PERCENT REFRAINMENT
SESSIONS


B167
.95
.9
.8
PERCENT REFRAINMENT
SESSIONS

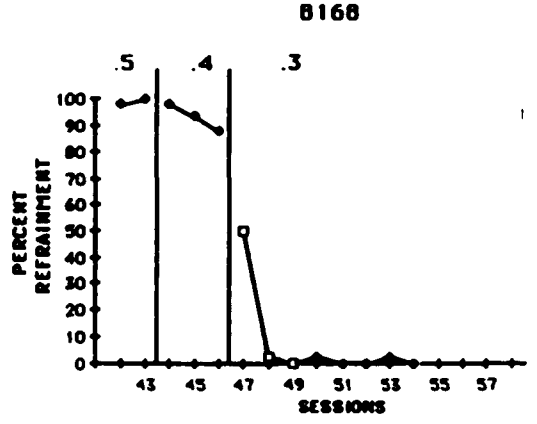
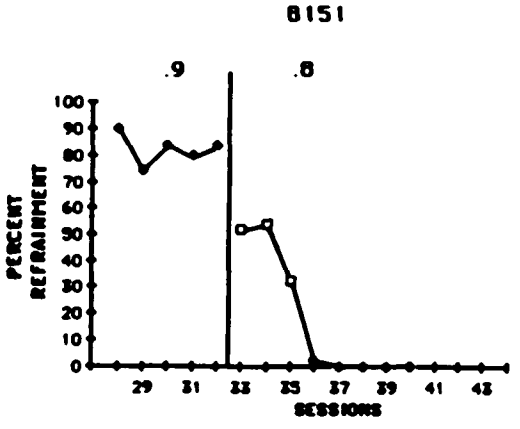
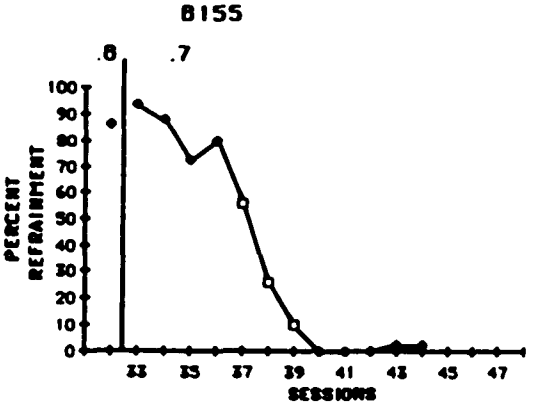
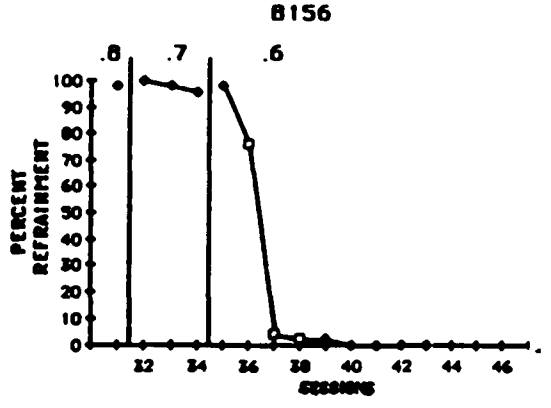
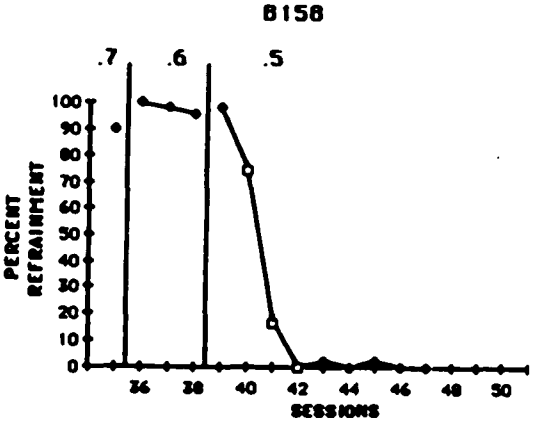

B168
.5
.4
.3
PERCENT REFRAINMENT
SESSIONS

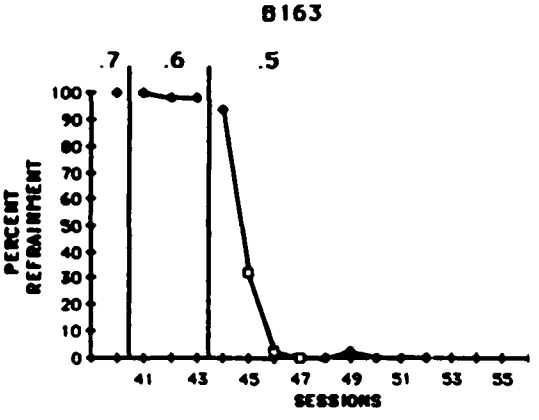
Figure 20. Percent SI refrainment for selected blocks of sessions during the abolishment of refrainment for Group p=1.0. The 3 open squares represent the first 3 consecutive sub-criterion sessions. P values are indicated at the top of each panel. Vertical lines indicate the sessions included for a particular p value.

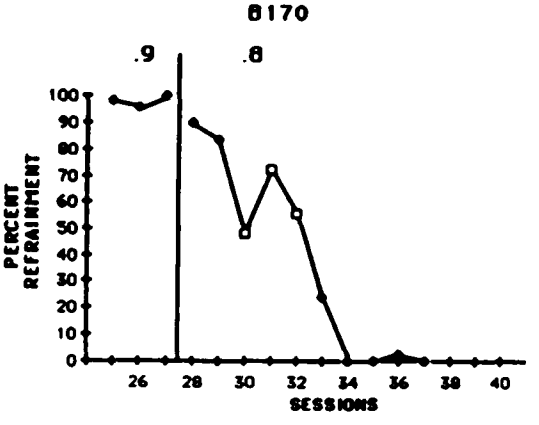

B151
.9
.8
PERCENT REFRAINMENT
SESSIONS


B155
.8
.7
PERCENT REFRAINMENT
SESSIONS


B156
.8
.7
.6
PERCENT REFRAINMENT
SESSIONS


B158
.7
.6
.5
PERCENT REFRAINMENT
SESSIONS


B163
.7
.6
.5
PERCENT REFRAINMENT
SESSIONS


B170
.9
.8
PERCENT REFRAINMENT
SESSIONS

levels. Only 2 subjects (B155 at p=.7 and B167 at p=.9) responded below criterion and subsequently returned to criterion. This return lasted only 1 session for B155, while for B167 (for whom deterioration had occurred at the highest value) movement to the next lower p value was possible.

Examination of the S1 refrainment data for the last few sessions reveals that all 12 animals ended at or near zero levels. This was consistent with the pattern of responding observed during the initial acquisition phase. There it was noted that animals responding below criterion also responded at extremely low levels, many times at or near zero (cf., Figures 16-18). The pattern of near zero refrainment percentage which emerged during the decrement phase was preserved until reacquisition at p=1.0.

C. Maintenance

The p value at which the maintenance portion of the experiment was conducted depended upon the value at which initial acquisition or reacquisition occurred. This meant that, of the 29 animals participating in maintenance, 21 were exposed at p=1, 3 at p=.95, 4 at p=.9, and 1 at p=.8.

The number of sessions required until the completion of maintenance was not clearly related to the p at which maintenance occurred. Two of the 8 animals (25%) at p values less than 1 (B16 and B25) required more than the minimum 9 sessions to satisfy the maintenance requirement.

Seven of the 21 animals (33%) at p=1 (B17, B19, B24, B151, B154, B160 and B164) also required greater than the minimum number of sessions in order for maintenance to be successfully completed.

Discussion

The current findings both confirm and extend those of Coll (1983). In both cases, animals were initially exposed to an S1 duration of 1 sec with 1 sec extensions occurring for meeting a criterion of 80% refrainment from eating during previous sessions. Group p=1.0 in the current experiment is a replication of the conditions for the baseline group in the Coll study. The fact that the 12 animals originally at p=1.0 in both studies completed initial acquisition is evidence for the reliability of the procedure in producing acquisition of refrainment. In addition, the failure in the current study to find any systematic difference between Groups p=.95 and p=1.0 indicates that a p value of 1.0 is a sufficient but not necessary condition for the acquisition of refrainment. Since all animals in Group .95 ate during S1, this is not simply an artifact of presenting a p value functionally equivalent to 1.0. However, these 2 values are the only ones at which the procedure will result in reliable acquisition of refrainment since the maximum likelihood of an animal developing refrainment at any values lower than p=.95 is 50% (i.e., 3 of 6 animals in Group p=.9).

Although the procedure can be an effective means of producing refrainment during S1, this pattern will inevitably deteriorate with subsequent decreases in p. The specific values at which the discrimination was

abolished differed among animals. However, the pattern of behavior that marked deterioration of refrainment across animals was remarkably similar. Pigeons demonstrating reliable refrainment at the beginning of the abolishment phase usually began well above the 80% SI refrainment criterion. This pattern was typically maintained until the p value at which abolishment occured was attained. At that point SI refrainment approached a near zero value within a few sessions.

This type of abrupt transition from extremly high levels of refrainment in the presence of food to low or near zero levels has been documented in the self-reinforcement paradigm using fewer animals (Mahoney and Bandura, 1972; Bandura and Mahoney, 1974). For example, Mahoney and Bandura (1972) attempted to disrupt a pattern of keypecking in the presence of food for 2 pigeons. The essential component of the self-reinforcement procedure involved training animals to peck in the presence of food by withdrawing the hopper in the event an attempt to eat was not preceded by at least 1 keypeck. Once this pattern of keypecking in the presence of food prior to eating had been attained, the hopper withdrawal contingency was removed and the resultant behavioral stability assessed. In addition, disruption was further facilitated for 1 animal via response prevention (i.e., either partially or completely covering the response key) and transgressive modeling (i.e., a magazine trained pigeon was placed into

the same chamber and ate copiously from the raised hopper without first pecking). For still another animal, the keypeck requirement was increased until feeding prior to pecking occurred. Instead of completely eliminating the hopper withdrawal contingency as in the above examples, Bandura and Mahoney (1974) gradually reduced the probability that eating without first pecking would result in hopper withdrawal for 2 pigeons. The result in all these cases was the same; the pattern of pecking in the presence of food prior to eating was eliminated. The manner in which this occurred was remarkably similar in all cases to the pattern of abolishment in the current study; the typical animal evinced a sudden decrease in refrainment which would, within a few sessions, settle at a near zero level.

This tendency to approach S1 on virtually every trial was not easily overcome. In spite of extensive exposure to a variety of S1 and p combinations at which criterion responding had previously occurred, no animal reacquired self-control until p=1.0 had been reached. In fact for all but 2 animals it was necessary to decrease the S1 duration to 1 sec for reacquisition to occur.

This profound influence of historical effects upon present behavior in the current paradigm has been previously documented. Coll (1983) demonstrated that the role of the keypeck requirement following S1 refrainment was largely dependent upon prior history. The keypeck

requirement could be completely eliminated for an animal demonstrating reliable (i.e., above criterion) SI refrainment without any concomitant loss of refrainment. However, absence of the keypeck requirement for an animal which had only been magazine trained previously was likely to have long lasting deleterious effects; not only was the acquisition of refrainment unlikely in the absence of the keypeck requirement, but, when the keypeck requirement was later inserted, acquisition remained unlikely. In the current study, these historical effects not only played the role described above during reacquisition, but were also clearly seen during initial acquisition with regard to between-group comparisons at increased p's. Contrary to the findings for Groups p=.8 and p=.9, all animals in Group p=.5 which did not finish initial acquisition at their original p's failed to complete initial acquisition until p had reached 1.0. Animals in this group had a more extensive history of sub-criterion responding than those in either Group p=.8 or p=.9. In addition, any animal which necessitated more than 10 days to achieve criterion at SI=1, p=1.0 was also from Group p=.5.

The role of experimental history with regard to the maintenance portion of the experiment was not obvious however; while it is suggestive that the 2 animals receiving the longest exposure to the maintenance condition were from the 2 lowest p's explored, 7 of the 12 animals in those 2 groups completed initial acquisition in the minimum

number of days. In addition, only 2 of 11 animals in Groups p=.95 and p=1.0 required more than 10 days to complete maintenance in spite of the fact that these animals had at that point completed the abolishment and reacquisition phase during which frequent S1 eating had occurred.

More generally, the importance of the current paradigm in providing a framework for determining the behavioral effects of such specifiable parameters as the S1 duration and p should not be overlooked.

The major findings of the current experiment allow for the following conclusions:

1) The studies by Cole et al. (1982) and Coll (1983) are supported by further verification of the effectiveness of a procedure which enables pigeons to refrain from eating from a raised hopper presented for a prolonged period of time.

2) A high p of S1 withdrawal given an approach (i.e., p=.95 or p=1) is necessary in order for the procedure to be characterized as reliably producing refrainment. P values less than .95 will in some cases result in acquisition of refrainment and the likelihood of this is positively related to p. However, the maximum likelihood of acquisition below p=.95 is 50% (3/6) for Group p=.9 and then sharply decreases at still lower values [16% (1/6) for Group p=.8 and 0% (0/6) for Group p=.5].

3) This pattern of refrainment will only temporarily

persist when p is decreased substantially. The abolishment procedure eliminates refrainment after only a few (i.e., a maximum of 12) occasions of eating during S1 eats and exhibits a characteristic pattern: a sudden decrease in refrainment to a near zero level.

4) After abolishment, this refrainment pattern is not easily reacquired. All animals were necessarily exposed to p increments until p=1.0 had been reached despite the fact that they were exposed to identical values at which refrainment had previously been demonstrated. In addition, for all but 2 of the animals for which reacquisition was successfully completed, it was necessary to decrease the S1 duration to 1 sec in order for reacquisition to begin.

5) Synthesis of the above conclusions indicates that, regardless of experimental history, the likelihood of producing reliable refrainment is most assured for any animal when the current procedure is applied at an S1 duration of 1 sec and a p of hopper withdrawal of 1.

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