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Conditions influencing the cessation of eating in the presence of food

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CONDITIONS INFLUENCING THE CESSATION OF EATING IN THE PRESENCE OF FOOD

by

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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.

1988

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Abstract

CONDITIONS INFLUENCING THE CESSATION OF EATING IN THE PRESENCE OF FOOD

by

Lorraine A. Gahles

Advisor: Professor Brett K. Cole

The conditions influencing the cessation of eating were explored using a discrete trial training procedure in which the subject was required, in the presence of discriminative stimuli, to put its head into the hopper opening and take it out. A sequence of two successive repetitions of this head-in/head-out response was followed by the presentation of a keylight. Pecking the lighted key resulted in a 3 second presentation of a grain-filled hopper (Sr). Each food presentation was followed by an intertrial interval (ITI) of 3 seconds during which all

lights were extinguished. In an attempt to increase the probability of head withdrawal in the presence of food, several contingencies were imposed. First, correct withdrawals always resulted in the opportunity to peck and be reinforced, while failures to withdraw never resulted in this opportunity. Further, failure to withdraw produced a correction trial in which the head-in/out response was required in the absence of food and was followed by the opportunity to peck and be reinforced. In addition, failures to withdraw could, under some conditions, result in the onset of a 40 second ITI followed by a correction trial.

Experimental conditions varied the probability of food insertion during the 2nd link of the trial ($\underline{p}$=.25 or 1.0) and the duration of the ITI following a 2nd link limited hold error (nonwithdrawal from food) at 40 or 3 seconds. These contingencies were presented at various stages of training.

Ten pigeons were randomly divided into three groups of 3, 3 and 4 subjects each. Group 1 (3 subjects) received a .25 probability of food insertion in the 2nd link with a 3 second ITI during the first exposure to food in link 2. Group 2 (3 subjects) received a 1.0 probability of food insertion in the 2nd link with a 3 second ITI during the first exposure to food in link 2. Group 3 (4 subjects) received a 1.0 probability of food insertion in the 2nd link with a 40 second ITI for a limited hold food error during the first exposure to food in link 2.

Results indicated that the highest relative frequency of correct withdrawals from food was seen during the 1st exposure to food in link 2 when the 1.0 probability of food insertion during the 2nd link was combined with the 40 second ITI for a limited hold food error.

It was concluded that partial control over cessation of eating can be obtained by employing delayed consequences for non-cessation of eating (extended 40 second ITI for a limited hold food error) during the first condition of exposure to food in link 2.

Acknowledgements

I would like to acknowledge Dr. Brett Cole, my mentor, who not only taught me the rigor of scientific thinking but also its joy.

I would also like to thank my committee members Drs. Nancy Hemmes and Claire Poulson for their helpful comments throughout; my outside readers, Drs. David Roll and Sherm Tatz for their thoughtful contribution; and Rita Santelia who helped with running the experiment.

Lastly, I am indebted to my mother, father, brothers and sisters, especially Kathy, who not only listened to my anxieties, but also congratulated me on all the little successes along the way, and to my friends, Soledad and Luis, who helped me long into the night.

Table of Contents

List of Tables

List of Figures

Introduction

In an attempt to gain experimental control of ingestive behavior in free feeding situations, it is helpful to reduce the behavior to its simplest elements. Two fundamental activities account for what, how much and how often ingestion of a substance occurs: one, the initiation of ingestion, or when one begins to consume a substance; and two, the cessation of ingestion, or when one withdraws from and/or stops consuming the substance.

When voluntary control of ingestion is considered, it is assumed that the substance to be ingested is freely available and that the control of initiating ingestion would be indicated by refraining from consuming the available substance for a given period of time. Control over the initiation of ingestion has been described by three major procedural models.

The first has been called a refrainment

procedure and requires waiting in the presence of food. (Cole, Coll and Schoenfeld, 1982; Coll, 1983; Stern, 1986).

The second type of procedure, called self-reinforcement, requires performance of a behavior incompatible with eating in the presence of food before eating it. (Bandura and Mahoney, 1974;Mahoney and Bandura, 1972).

The last model is called "self-control" or"impulse control" and utilizes a choice paradigm requiring that the subject forego an immediate reinforcer by choosing a delayed but larger reinforcer (Rachlin and Green, 1972; Ainslie, 1974; Logue and Pena-Correal, 1984; Grosch and Neuringer, 1981).

Some of the conditions influencing the control of initiating ingestion have been identified for each model. For example, Cole et al. (1982) and Coll (1983) found that in order to establish reliable refrainment in the presence of food, approaches to food before the temporal refrainment criterion had been met had to be extinguished. To accomplish this, a discrete trial procedure was used in which a sequence of two hopper presentations of food was followed by an intertrial interval of 3 seconds. The first hopper presentation (SR1) was introduced for a period of time. If the subject did not approach during this time, the hopper was removed, the houselight came on, and a peck to the center key produced the second hopper presentation (SR2) of 3 seconds during which the subject could eat. When approach occurred before the criterion time period had elapsed, food was withdrawn before eating could occur, the time cycle continued, and the next intertrial interval (ITI) began followed by the beginning of a new trial. Stern (1986) replicated the procedure and extended the findings while showing that food removal given approach had to be programmed for 95% of such responses in order to establish reliable refrainment from food. In addition, food removal probabilities less than .95 (between .95 and 0) reliably reduced pretrained refrainment to near 0 levels of occurrence and in most cases subjects had to be returned to the most stringent values used in training (1.0 probability of food removal given approach) before refrainment could be reestablished. In other words, once animals were allowed to eat in a situation in which they had previously learned not to eat, the prior discrimination was abolished quickly and was not easily reacquired.

These data suggest that one can teach an organism to approach food but not eat for an arbitrary period of time, if one sets up a chained discrimination in which behavior in one situation allows the organism to enter into the next situation. For example, cued criterion waiting in the presence of food in the first link allows the organism to enter the next cued link where the food may be eaten. If approach occurs during the first link, food is removed before it can be eaten. Thus, one has set up a discrimination based on a chained sequence in which differential contingencies provide food as a consequence for waiting and no food as a consequence for not waiting but trying to ingest. One can see that getting food for not waiting (approach) in the Stern (1986) experiment changes the differential contingencies. Under these conditions the prior discrimination is likely to be abolished. That is, the organism begins to receive food for approach intermittently in the first link, which not only disrupts the chained sequence by allowing food in each link, thus making each independent of the sequence, but also removes the differential contingencies by making each link the same (food is the consequence for approach and for non-approach). It is no wonder that an organism will continue to approach and try to ingest the substance in the future, as long as these new contingencies remain in effect. In fact,it is this reliable control over approach behaviors leading to eating which Skinner (1938, p. 373) observed in his early work on the "eating curve".

> " The behavior of approaching and picking up a bit of food is so common in the behavior of an adult rat and so uniform from one rat to another that it is likely to be looked upon (mistakenly) as unconditioned. In the adult rat the behavior is so well established that its conditioned status is practically beyond experimental manipulation. In order to investigate the effect of ingestion upon a controlled conditioned reflex reinforced with food it is necessary to attach a new and arbitrary initial reflex to the ingestive chain...".

Thus, Skinner began investigating the arbitrary initial member of the ingestive chain in order to show that hunger could be measured by the behavior which led up to it.

The topic of controlled ingestion uses the same behavior but attempts to ask a different question. That is, what are the variables necessary to control the onset or cessation of eating? As in Skinner's early work we know that deprivation is one variable that contributes to the pattern of eating. But what principles of learning will establish control over the beginning and end of the ingestive period? Or can we gain control over the behavior which lead up to ingesting and even ingestion itself?

Rachlin and Green (1972) have determined some of the relevant variables influencing the beginning of ingestion by viewing the situation as a choice between obtaining something now or later. Their main findings show that an organism will choose an immediate, though smaller reinforcer over a delayed, but larger reinforcer, if the choice point is temporally close to the availability of the reinforcer. Thus, if food is immediately available, the animal will choose it regardless of its size. In fact, Rachlin's equation suggests that when the delay to food is zero the value of the reinforcer is infinite. It would seem then, that if an organism is given a choice of food now or more food later while it is eating, Rachlin's equation suggests that the choice would always be for the immediate food. However, the amount will determine preference if the choice is made some temporal distance away from food availability. In other words, animals will choose larger but delayed food as the choice point becomes more temporally distant from food availability.

Mazur and Logue (1978) using the Rachlin and Green paradigm, showed that by starting with both small and large reinforcers at six seconds away from the choice point and gradually fading the small reinforcer to zero delay, some subjects continued to choose the large delayed reinforcer over the small immediate one, even at zero delay. Thus one could use the past history of choice and fading to overcome the animal's tendency to choose immediate food. But, Mazur and Logue warn that this is a lengthy procedure taking more than 11,000 trials to acquisition and that the experimental subjects varied in the extent to which they continued to choose the large, delayed reinforcer when the small reinforcer was at a zero delay.

The studies done by Cole et al.(1982), Coll (1983), and Stern (1986), showed that one could get 80% reliable refrainment from food for all subjects. These studies have in common the fact that they used a discrimination procedure in order to get control over the behavior leading up to ingestion. The experimental question was one of controlling the initiation of ingestion, or, in other words, refrainment.

However, if one views refrainment along a continuum, then the extreme endpoint would be absolute refrainment on every occasion. This endpoint becomes abstinence and indeed we expect this behavior with regard to many substances like alcohol, drugs etc.,but, when one considers food as the substance, then abstinence and a model of refrainment cannot serve as the sole paradigm for controlled ingestion. By necessity, with respect to food, one needs to control not only the initiation of ingestion but its cessation as well because ingestion of food can never be totally eliminated.

Based on the demonstration by Cole et al.(1982), Coll (1983), and Stern (1986) of experimental control over the initiation of ingestion through discrimination procedures, the present study sought to gain control over meal termination through similar procedures. Since, in the study of meal termination, the subject is permitted to initiate eating, extinction of approach cannot be used to gain control over the cessation of eating as in the Coll (1983), Stern (1986) and Bandura and Mahoney (1974) studies. Alternatively one might attempt to develop control over the movement of withdrawing from an area which usually contains food. If this movement is exhibited under the precise control of antecedent stimuli, one might expect these withdrawals to continue to occur to the controlling stimuli even when food is present.

It is for this reason that a procedure was adapted from response latency studies done by Stebbins and Lanson (1961;1962) and Stebbins (1962),in which the design of reaction time studies was used in operant conditioning procedures (see Method section), to assess the control of movement in the presence of antecedent stimuli. It was hoped that once some withdrawals from food occurred, a differential consequence could be attached to those specific behaviors so that cessation of eating would come under operant control. It has been previously shown by Fantino (1966) that the behavior of waiting to keypeck could be partially controlled both by food presented for waiting and by an extinction period which occurred after the ingestion of immediate food. The present procedure used similar contingencies. If the subject withdrew from the hopper opening while the food was present, a keypeck would result in three seconds of additional food. If the subject did not withdraw from eating, the consequence for nonwithdrawal in the presence of food was either a 3 second or a 40 second intertrial interval.

Given the above considerations, which will be described in more detail in the Method section, the present experiment was designed to assess the conditions influencing cessation of eating in the presence of food.

Method

Subjects

Ten naive adult female White Carneaux pigeons were maintained at 80% (+ or - 20 grams) of their free-feeding weights. Water and grit were continuously available in their home cages.

Apparatus

One Lehigh Valley pigeon test chamber (model 132-02) was modified in order to detect the head going in and out of the food hopper opening. A photocell was mounted at the rear of the intelligence panel at the entrance to the hopper opening to record these behaviors. The hopper mechanism was set back 3/4 inch from the rear of the intelligence panel to accomodate photocell placement. The panel contained three white translucent response keys; however only the center key, which could be illuminated with a white light, was operative.

The overall illumination in the chamber was provided by the hopper light which remained on continuously during each trial whether or not the hopper mechanism was activated. However, all lights were off, including the hopper light, during the intertrial interval (ITI). The following stimuli served as external cues: the white response key, the houselight, and white noise of 45 Db re SPL (sound pressure level) presented through a speaker located at the far left side of the intelligence panel. A ventilating fan produced additional constant noise.

The sessions were programmed using solid state digital logic circuitry and the data were recorded on electromechanical totalizing counters.

Procedure

Preliminary Training

Punchboard Training

When the subjects had reached 80% of their free-feeding weights, a punchboard training procedure was instituted (Cumming, 1955). This procedure had previously been found to be effective in facilitating key peck training. During this procedure, a punchboard was placed within the subjects' home cages until the subjects ate all the grain held by it. The punchboard was made of flakeboard and measured 1/2 inch thick, 8 1/2 inches wide and 11 inches high with nine depressions measuring 1 inch in diameter and arranged in a 3 by 3 matrix in the top six inches of the board. A metal sheet with holes aligned with the flakeboard depressions was secured over the flakeboard after the depressions had been filled with grain and covered with a sheet of onion skin paper. Subjects had to punch through the paper to get to the food within the depressions. At first, small tears were placed in the paper so that subjects could see the grain in the depressions. Once eating had occurred with lightly torn paper, the number of tears was reduced until all depressions were covered by untorn paper. When the eating occurred after breaking through untorn paper in all nine depressions for three successive days, subjects were advanced to magazine training. The food provided in the punchboard equaled what was required daily to maintain 80% free-feeding weights.

Magazine Training

During magazine training the houselight remained on continuously and the response keys were unlit and covered with masking tape. The food magazine was in the up position until the subject ate from it for at least 3 to 5 seconds. The magazine would then be timed to reappear at irregular intervals of 12 seconds on the average. The duration of each food presentation was 3 seconds. Training continued until the subject was eating within 1 to 2 seconds of the magazine presentation regardless of the subject's previous position in the chamber. Magazine training was considered complete once the subject had eaten reliably during 50 hopper presentations.

Keypeck Training

During this training the houselight was off and only the hopper light and center keylight remained on. Subjects who did not acquire the keypeck after 2 to 3 seconds of exposure to the lighted key were shaped to keypeck using the method of successive approximations (Keller and Schoenfeld, 1950). Once the center key was pecked, its light went off and the hopper came up for 3 seconds. The keylight remained off for the duration of the hopper presentation. Keypeck training was considered complete when the subject had attained a total of 300 continuous reinforcement (CRF) trials during the course of 3 sessions at 100 CRF each.

Movement Training

It became clear following the first group's training that some additional training in putting the head in the hopper opening was needed. Groups 2 and 3 received this movement training while group 1 did not. Group 1 went directly to the one link trial condition of the experiment and received some additional CRF trials directly before each session in the one link trial condition to enhance movement toward the hopper opening. This procedure was found to be lengthy and unreliable so that the movement training was instituted for the subjects of groups 2 and 3.

The movement training consisted of shaping the subject to put its head in the hopper opening. Successive approximations to this response were reinforced with food until the subject had put its head in the hopper opening at least 15 times in succession. During this training, the houselight was illuminated continuously while the response keys were darkened and inoperative, to prevent any responses to the key since keypecking had already been acquired. Some keypecks occurred during initial training but quickly ceased to occur. Once the subject was reliably showing the head-in response, it was ready for the one link trial training.

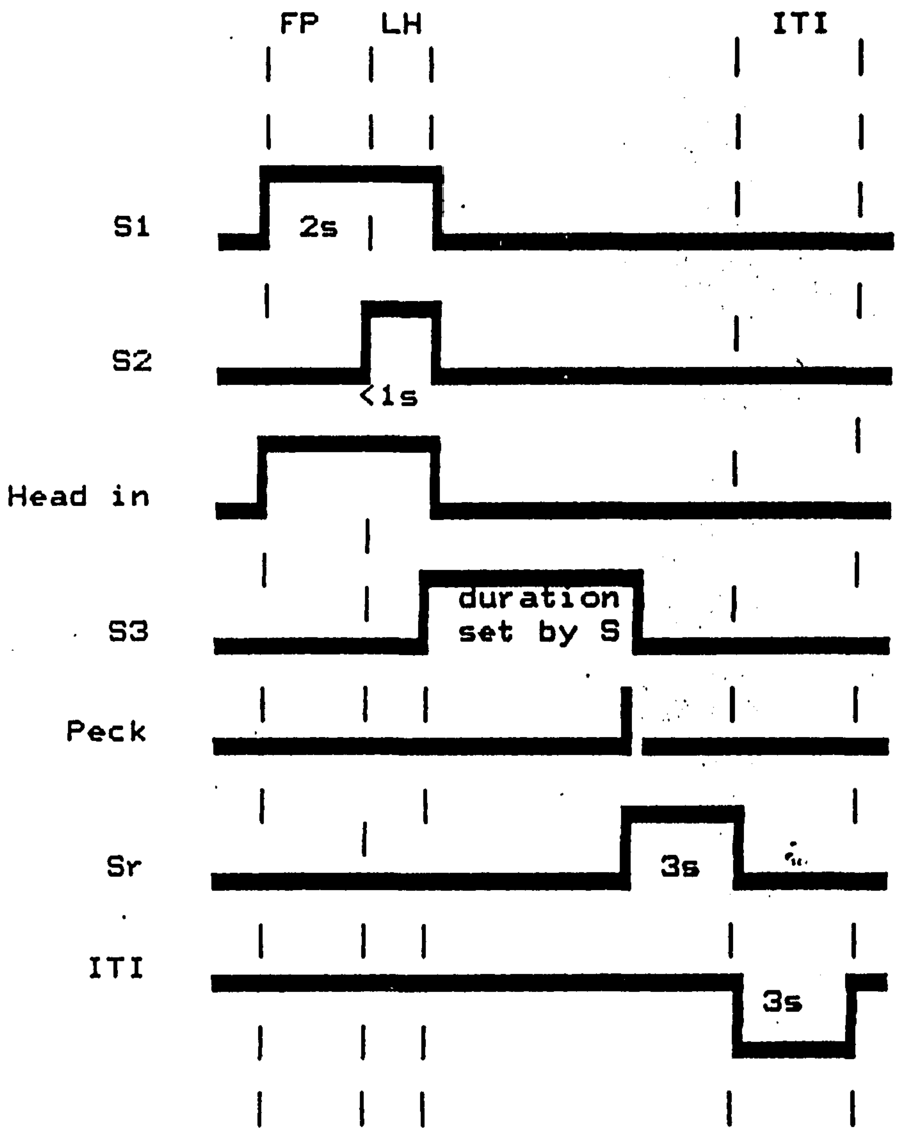
<u>One link trial training</u>

This training consisted of a one link discrete trial procedure in which the subjects were required to put their heads into the hopper opening and take their heads out of the opening in the presence of discriminative stimluli. When the houselight came on (S1) the subject was required to put its head in the opening and keep it there until the onset of white noise (S2) which signalled head-out. If the head came out during white noise (S2), the houselight and noise went off, the trial was labelled a correct trial and the subject was presented with a keylight (S3) in the presence of which a keypeck resulted in a 3 second presentation of a grain filled hopper (Sr). Each food presentation was followed by an ITI of 3 seconds during which all lights were extinguished, including the hopper light.

A trial was labelled as an error if: a) the subject put its head in before S1 came on; b) the subject took its head out before S2 came on; or c) the subject kept its head in beyond the offset of S2. All of the above resulted in immediate advancement to the ITI with both S3 and Sr cancelled. Figure 1 is an event diagram representing the one link trial.

With the onset of S1 and the head-in response, a timer was activated to program the onset of S2 after 2 seconds. The white noise (S2)

Figure 1 . Event diagram representing a 1 link trial. Vertical displacement of any line indicates the beginning and/or end of stimuli presented. The types of stimuli presented are labelled with the following symbols: S1 = houselight, S2 = white noise, and S3 = keylight. Horizontal lines represent the duration of the stimuli presented, however, figures are not scaled. Vertical dashed lines represent timers activated to count the number of seconds within the time period labelled: FP = foreperiod, LH = limited hold, and ITI = intertrial interval.

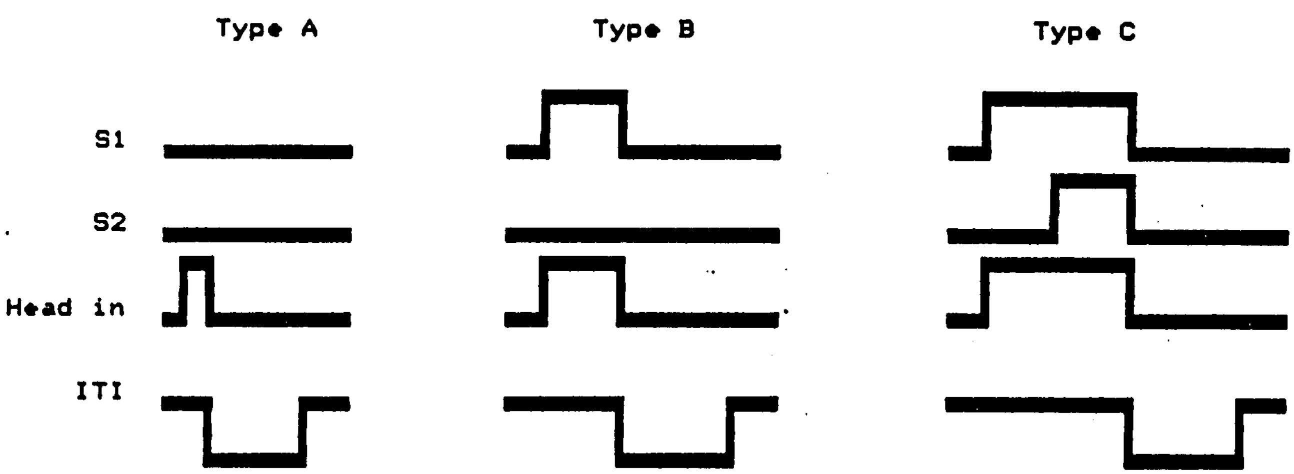

FP
LH
ITI
S1
2s
S2
<1s
Head in
S3
duration set by S
Peck
Sr
3s
ITI
3s

remained on until a head-out response occurred or for the duration of 1 second. This sequence of events was developed for the present experiment to increase the likelihood that head out occurred at a short latency following the onset of S2. Analogous procedures, used in response latency studies by Stebbins and Lanson (1961;1962) and Stebbins (1962), sought to employ a classical reaction time procedure to measure the latency of an operant following the onset of discriminative stimuli. In keeping with some of the vocabulary of these studies, the time between the onset of S1 and the onset of S2 may be called the foreperiod and the duration of S2, the limited hold.

In the present procedure, the subjects had to keep their heads in during the foreperiod and pull their heads out once S2 sounded but before the limited hold was over (before S2 ended). Errors a and b, as labelled above, were called preS2 errors and those of type c above were labelled limited hold errors. Figure 2 is an event diagram representing type a, b and c errors.

The foreperiod was initially set at 1 second and the limited hold at 2 seconds. These settings were maintained until preS2 errors dropped to 25 or fewer in two successive sessions. Once this criterion was reached, the settings were changed to a 2 second foreperiod and a 2 second limited hold and changed again after criterion responding was reached to a 3 second foreperiod and a 1 second limited hold. The last setting was changed after criterion responding to a 2 second foreperiod and a 1 second limited hold. Thus, subjects could spend 3 seconds maximum inside the hopper opening during the final stage of the one link trial training. Each session continued until the subject had received 20 reinforcers (presentations of grain followed by a correct withdrawal and a keypeck). The number of trials

Figure 2. Event diagram representing 1 link trial errors. Vertical displacement of any line indicates the beginning and/or end of stimuli presented. The types of stimuli presented are labelled with the following symbols: S1 = houselight, S2 = white noise. Horizontal lines represent the duration of the stimuli presented, however, figures are not scaled. Type A and B refer to the PreS2 errors that occur in a 1 link trial, while Type C refers to the Limited Hold error that occurs in a 1 link trial.


Type A
Type B
Type C
S1
S2
Head in
ITI

needed to produce twenty correct withdrawals and thus twenty reinforcers was based on each subject's behavior.

Cessation of Eating Training

During this training, the subject was now required to perform the head-in/head-out movement through the hopper opening twice in succession in order to produce S3 and the subsequent Sr. Figure 3 is an event diagram that represents this training. Only type b and c errors could be made in the 2nd link since S1 stayed on until the head pulled out or S2 ended. These errors resulted in immediate advancement to the ITI of 3 seconds followed by a one link sequence in which S1 signalled head-in and an appropriate head-out to S2 was followed by S3, peck and Sr. This one link sequence following link 2 errors was called a correction trial and figures 4 and 5 are event diagrams representing the correction trial following type b and c errors respectively.

Figure 3. Event diagram representing a 2 link trial. Vertical displacement of any line indicates the beginning and/or end of stimuli presented. The types of stimuli presented are labelled with the following symbols: S1 = houselight, S2 = white noise, and S3 = keylight. Horizontal lines represent the duration of the stimuli presented, however, figures are not scaled. Vertical dashed lines represent timers activated to count the number of seconds within the time period labelled: FP = foreperiod, LH = limited hold, and ITI = intertrial interval.

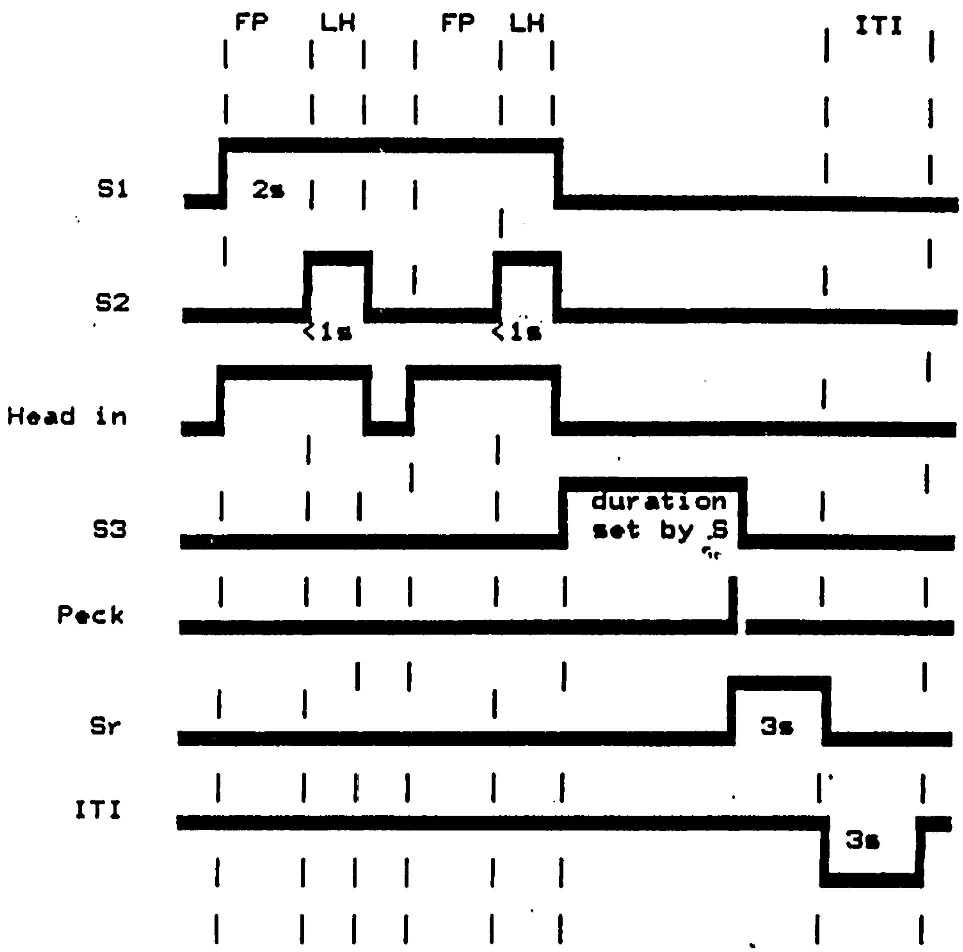
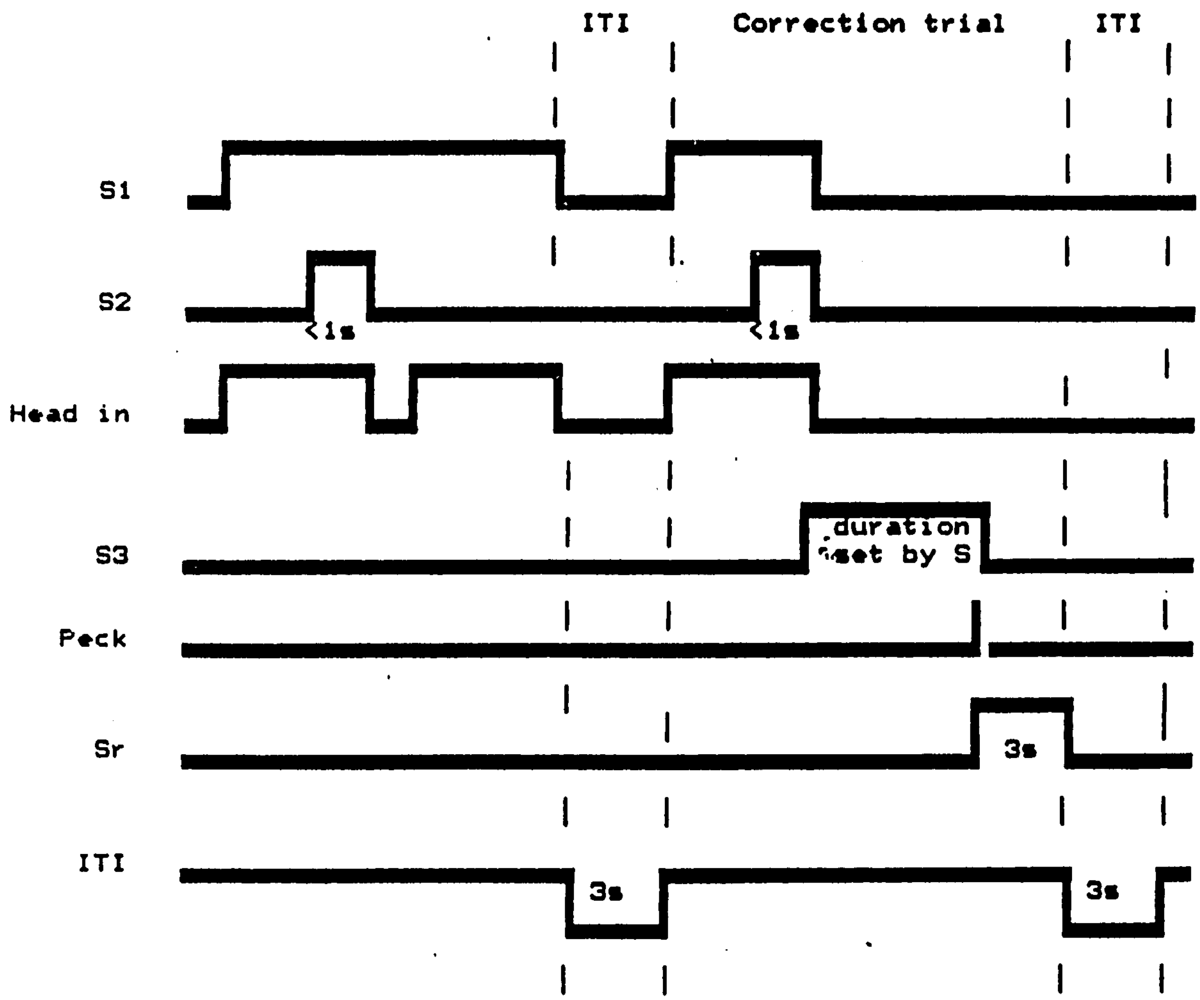
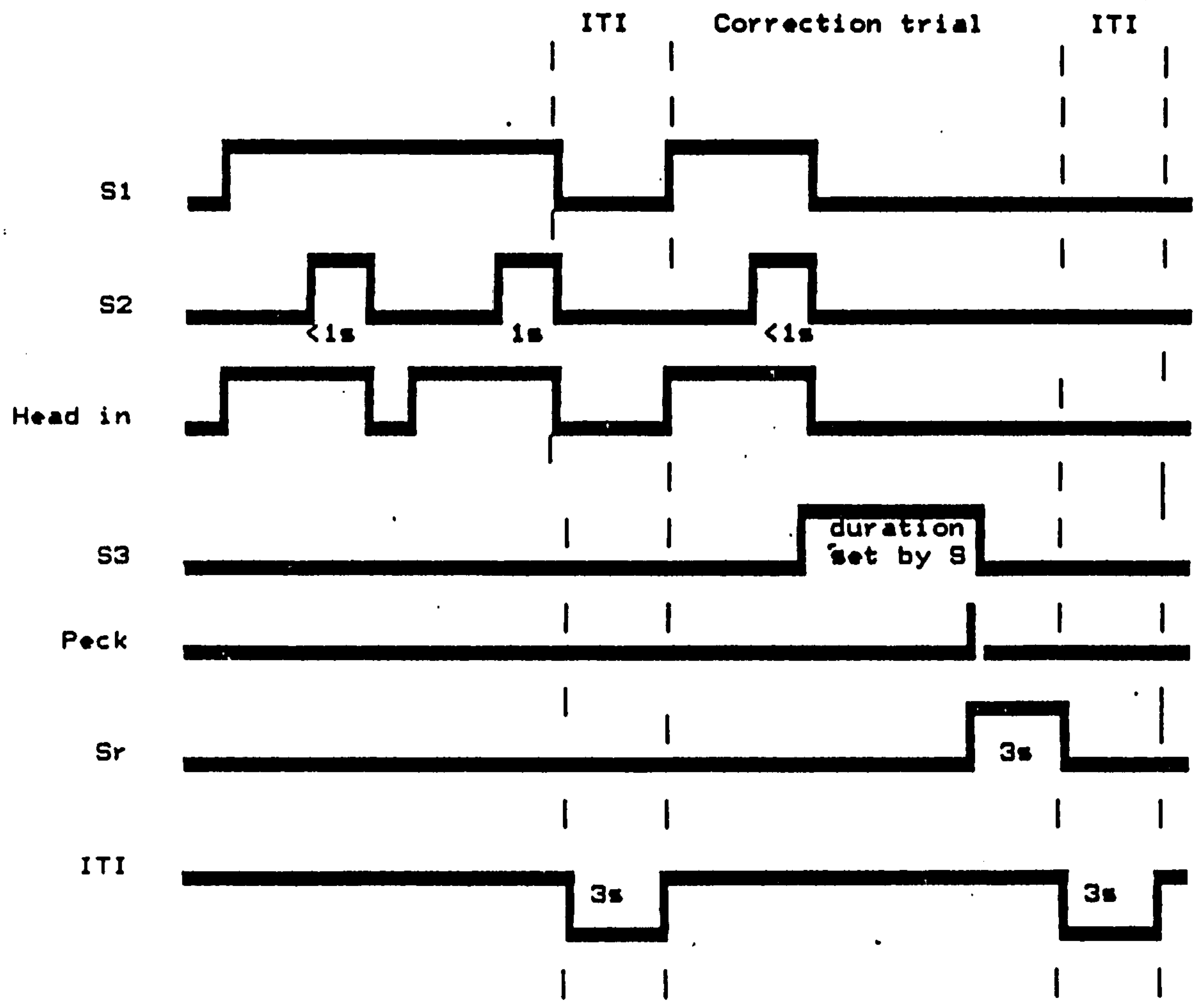

FP
LH
FP
LH
ITI
S1
2s
S2
<1s
<1s
Head in
S3
duration set by S
Peck
Sr
3s
ITI
3s

Figure 4. Event diagram representing a 2nd link type b error. Vertical displacement of any line indicates the beginning and/or end of stimuli presented. The types of stimuli presented are labelled with the following symbols: S1 = houselight, S2 = white noise, S3 = keylight. Horizontal lines represent the duration of the stimuli presented, however, figures are not scaled. Type B refers to the PreS2 errors that occur in a 2nd link trial. Vertical dashed lines represent timers activated to count the number of seconds within the time period labelled : . FP = foreperiod, LH = limited hold, and ITI intertrial interval. The event following the first ITI is labelled a correction trial.



ITI
Correction trial
ITI
S1
S2
<1s
<1s
Head in
S3
duration set by S
Peck
Sr
3s
ITI
3s
3s

Figure 5. Event diagram representing a 2nd link type c error. Vertical displacement of any line indicates the beginning and/or end of stimuli presented. The types of stimuli presented are labelled with the following symbols: S1 = houselight, S2 = white noise, S3 = keylight. Horizontal lines represent the duration of the stimuli presented, however, figures are not scaled. Type C refers to the limited hold errors that occur in a 2nd link trial. Vertical dashed lines represent timers activated to count the number of seconds within the time period labelled : . FP = foreperiod, LH = limited hold, and ITI intertrial interval. The event following the first ITI is labelled a correction trial.


ITI
Correction trial
ITI
S1
S2
<1s
1s
<1s
Head in
S3
duration set by S
Peck
Sr
3s
ITI
3s
3s

This training was considered a baseline condition, after which the subjects were randomly divided into three groups that received differential conditions with regard to the two independent variables explored. The two variables investigated were:

1) the probability of food insertion during the 2nd S1-S2 sequence (2nd link). The effects of two probabilities were assessed: 1.0 and .25. Figure 6 is an event diagram representing these conditions. Groups received these variables as either a first condition or as a later condition.

2) The extension of the ITI to 40 s following 2nd link limited hold food errors (non-withdrawal of the head from food during the S2 and before its completion). The ITI remained at 3 seconds for all other errors. Figure 7 is an event diagram showing the extension of the ITI to 40 s. The effect of extending the ITI was assessed at different points in training: during the first condition (group 3) and during later conditions

Figure 6. Event diagram representing a 2 link trial in which food is inserted in the 2nd link at a given probability value. Vertical displacement of any line indicates the beginning and/or end of stimuli presented. The types of stimuli presented are labelled with the following symbols: S1 = houselight, S2 = white noise, and S3 = keylight. Horizontal lines represent the duration of the stimuli presented, however, figures are not scaled. Vertical dashed lines represent timers activated to count the number of seconds within the time period labelled: FP = foreperiod, LH = limited hold, and ITI = intertrial interval.

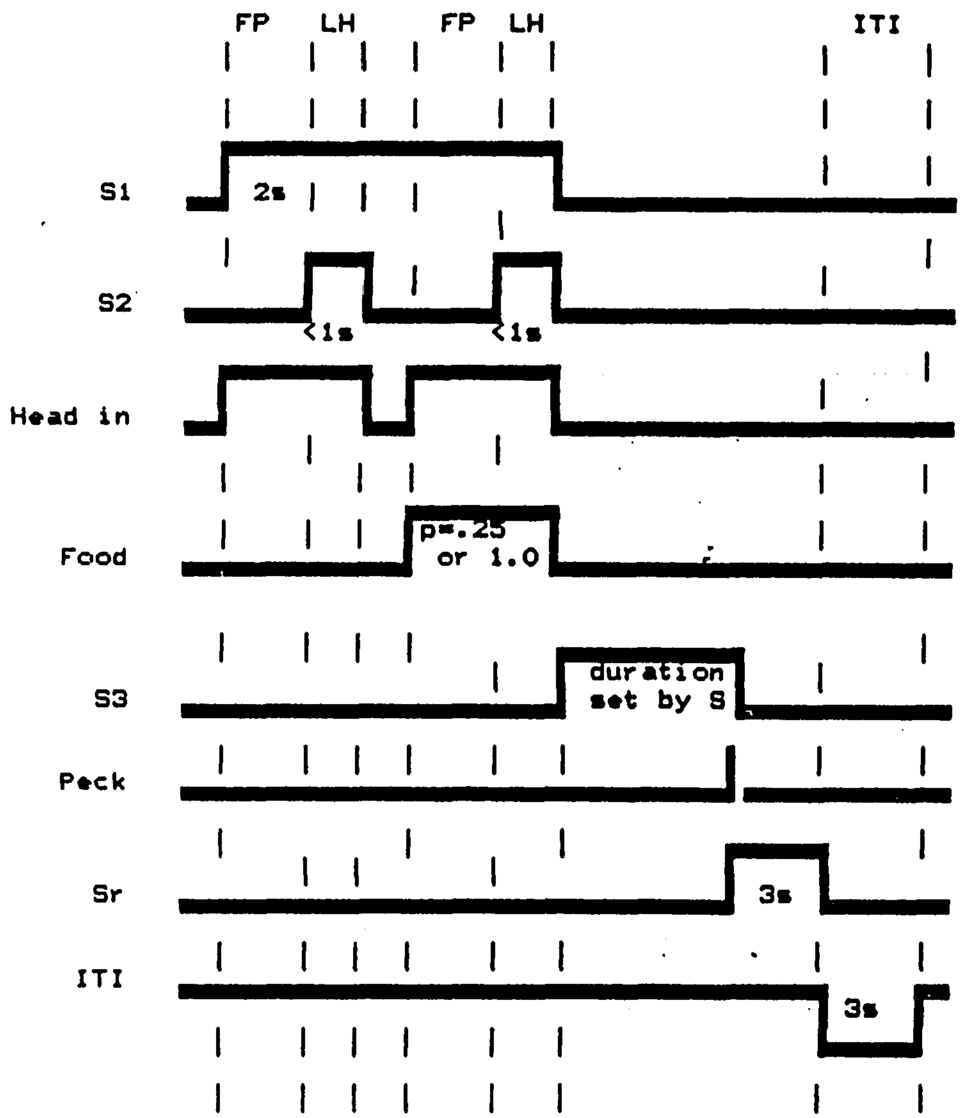
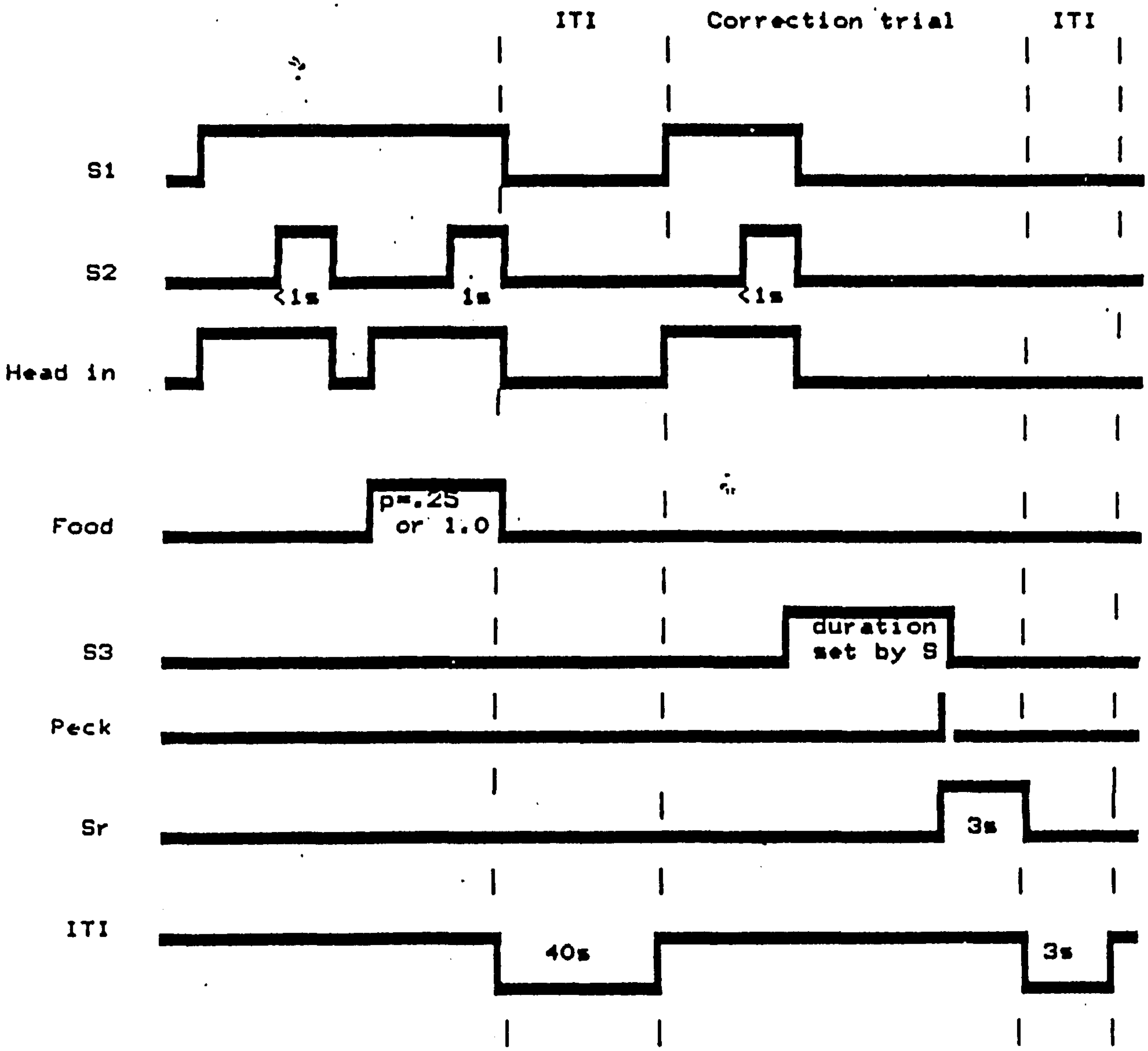

FP
LH
FP
LH
ITI
S1
2s
S2
<1s
<1s
Head in
Food
p=.25
or 1.0
S3
duration
set by S
Peck
Sr
3s
ITI
3s

Figure 7. Event diagram representing a 2 link trial in which food is inserted in the 2nd link at a given probability value and a limited hold food error occurs. The error, indicated by is in bold, refers to the behavior of keeping the head in the hopper for the full one second limited hold in the presence of food in the 2nd link. This error is followed by an extended 40 s. ITI as indicated in the diagram and the correction trial. Vertical displacement of any line indicates the beginning and/or end of stimuli presented. The types of stimuli presented are labelled with the following symbols: S1 = houselight, S2 = white noise, and S3 = keylight. Horizontal lines represent the duration of the stimuli presented, however, figures are not scaled. Vertical dashed lines represent timers activated to count the number of seconds within the time period labelled: ITI = intertrial interval.


ITI
Correction trial
ITI
S1
S2
<1s
1s
<1s
Head in
Food
p=.25
or 1.0
S3
duration
set by S
Peck
Sr
3s
ITI
40s
3s

(groups 1 and 2).

Ten subjects were randomly assigned into three groups. Group 1 (3 subjects) received the .25 probability of food in the 2nd link during the first condition. Group 2 (3 subjects) received the 1.0 probability of food in the 2nd link during the first condition and Group 3 (4 subjects) received the 1.0 probability of food in the 2nd link plus the extended 40 s. ITI contingent on 2nd link limited hold food errors during the first condition.

During cessation of eating training, when food was inserted in the 2nd link, the hopper would be scheduled to operate following the first head-out response. The hopper remained in the up position until the 2nd head-out occurred or until the limited hold timed out. If the subject pulled its head out during the 2nd link S2 while food was present, the head-out response was labelled a correct withdrawal from food. If the subject did not withdraw from food (head in beyond S2 offset) the response was considered a limted hold food error. In addition, once food was presented in the 2nd link, a third error was detected and recorded thereafter. This third error, called a cancellation error, cancelled the hopper in mid-operation and resulted in the advancement to the 3 s. ITI. The cancellation error occurred if the subject put its head into the hopper opening before the hopper was in the up position.

All groups received several conditions in which either the probability of food insertion was varied across conditions or the extended ITI of 40 s. was presented. Table 1 shows the sequence of conditions and the number of sessions in each condition for group 1, while Table 2 shows the conditions and number of sessions for group 2. Table 3 shows the sequence of conditions and the number of sessions for group 3.

Table 1

The Number of Session and Experimental Conditions for Group 1

Condition	p(food)	ITI duration	# of sessions
0/3	0	3 s	10
.25/3	.25	3 s	12
0/3	0	3 s	5
1.0/3	1.0	3 s	10
0/3	0	3 s	10
.25/3	.25	3 s	5
.25/40	.25	40 s	10
1.0/40	1.0	40 s	20
1.0/3	1.0	3 s	10

Table 2

<u>The Number of Session and Experimental Condition for Group 2</u>

Condition	p(food)	ITI duration	# of sessions
0/3	0	3 s	10
1.0/3	1.0	3 s	10
1.0/40	1.0	40 s	40
1.0/3	1.0	3 s	10

Table 3

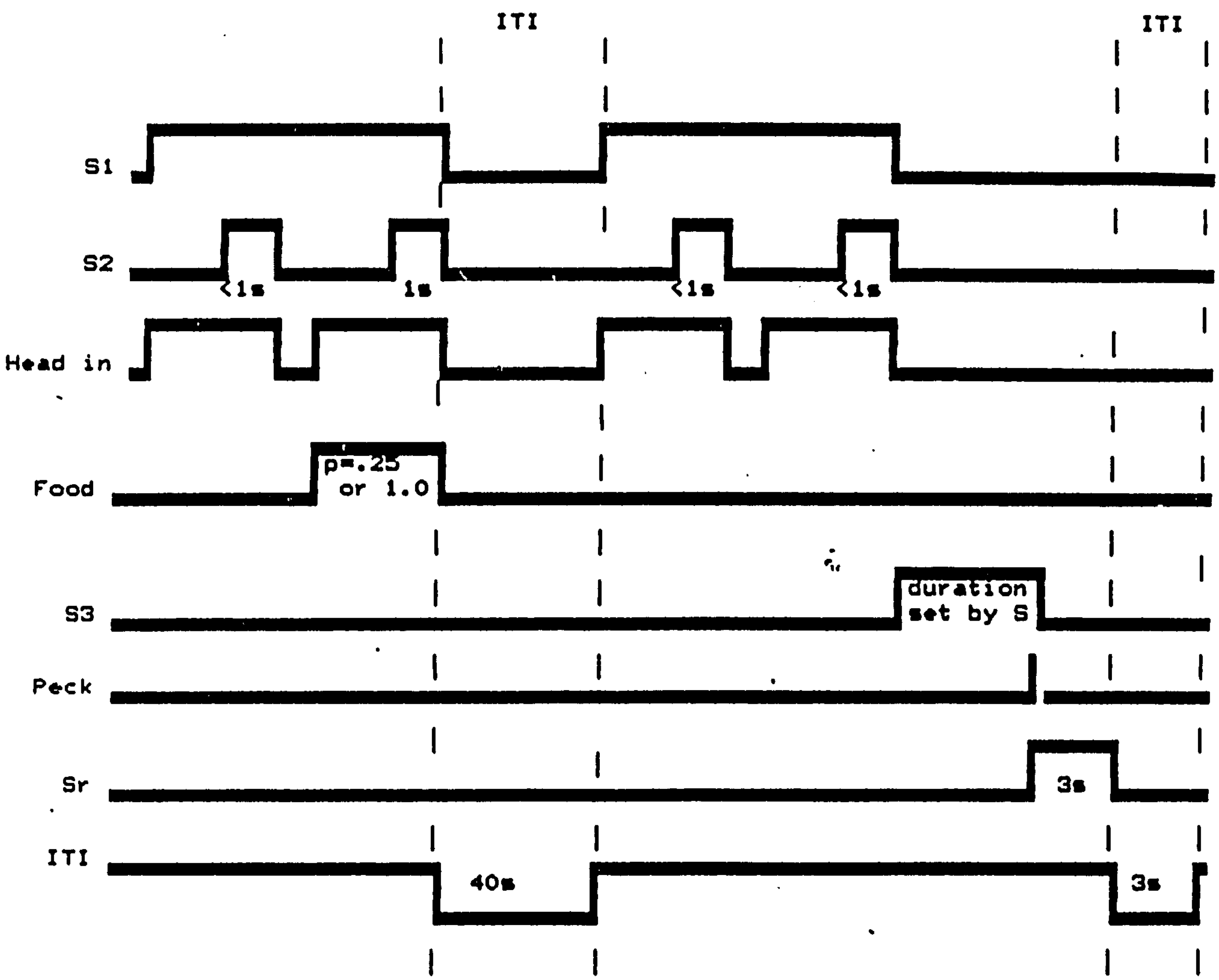
The Number of Session and Experimental Condition for Group 3

Condition	p(food)	ITI duration	# of sessions
0/3	0	3 s	10
1.0/40	1.0	40 s	30
1.0/3	1.0	3 s	8

Removal of Correction Trial

Group 4 was formed using 3 subjects taken from the pool of the three groups but chosen on the basis of their previous relative frequency of correct withdrawals in the last condition (1.0/3). One subject, who showed a low relative frequency of correct withdrawals, and two subjects, who showed relative frequency of correct withdrawals in the middle range, were chosen. The subjects in group 4 were exposed to a slightly modified procedure in which the correction trial, which followed either a cancellation or limited hold food error, was not presented. Thus, either of the above errors resulted in immediate advancement to the scheduled ITI for that error followed by the beginning of a new trial (1st link). Figure 8 is an event diagram representing this sequence. During this condition, only a correct withdrawal from food was followed by the keylight and the subsequent reinforcer. This procedure was used

Figure 8. Event diagram representing a 2 link trial in which food is inserted in the 2nd link at a given probability value and a limited hold food error occurs. The error, indicated by is in bold, refers to the behavior of keeping the head in the hopper for the full one second limited hold in the presence of food in the 2nd link. This error is followed by an extended 40 s. ITI as indicated in the diagram. However, in this diagram, the correction trial is removed, thus, the 40 s. ITI is followed by the beginning of a new 2 link trial. Vertical displacement of any line indicates the beginning and/or end of stimuli presented. The types of stimuli presented are labelled with the following symbols: S1 = houselight, S2 = white noise, and S3 = keylight. Horizontal lines represent the duration of the stimuli presented, however, figures are not scaled. Vertical dashed lines represent timers activated to count the number of seconds within the time period labelled: ITI = intertrial interval.


ITI
ITI
S1
S2
<1s
1s
<1s
<1s
Head in
Food
p=.25
or 1.0
S3
duration
set by S
Peck
Sr
3s
ITI
40s
3s

to assess the influence of the correction trial on the maintenance of stimulus control in the 1st link and on the maintenance of the relative frequency of correct withdrawals in the presence of food (2nd link).

Table 4 is a summary table that presents the main conditions for all groups.

Table 4

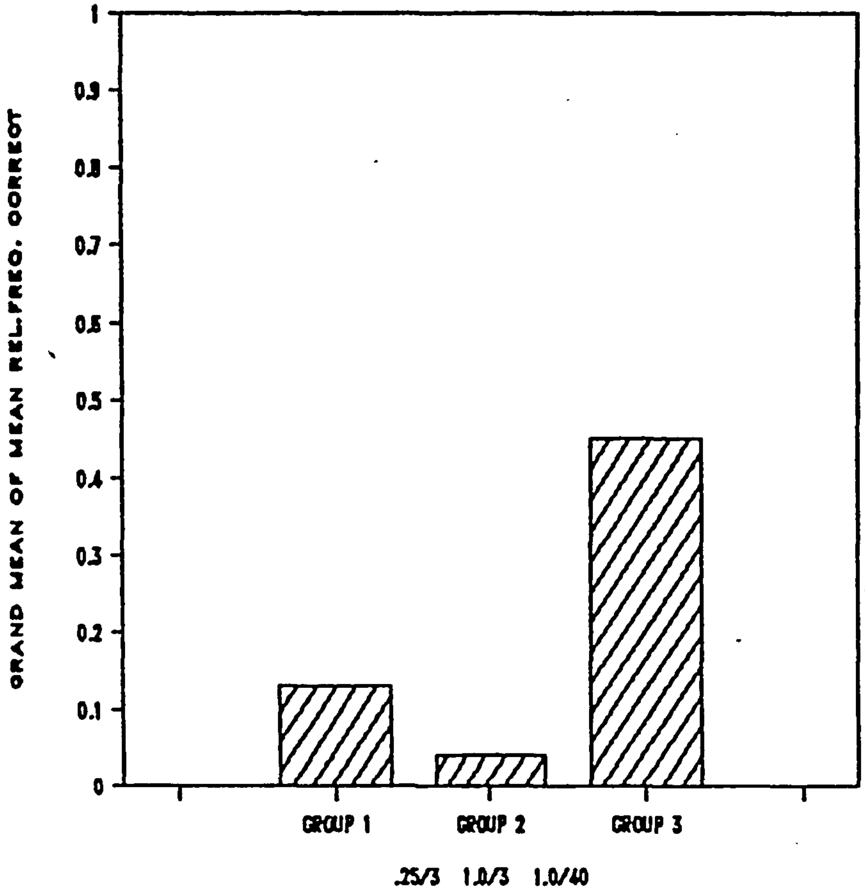
<u>The Main Conditions to which Each Group was Exposed</u>

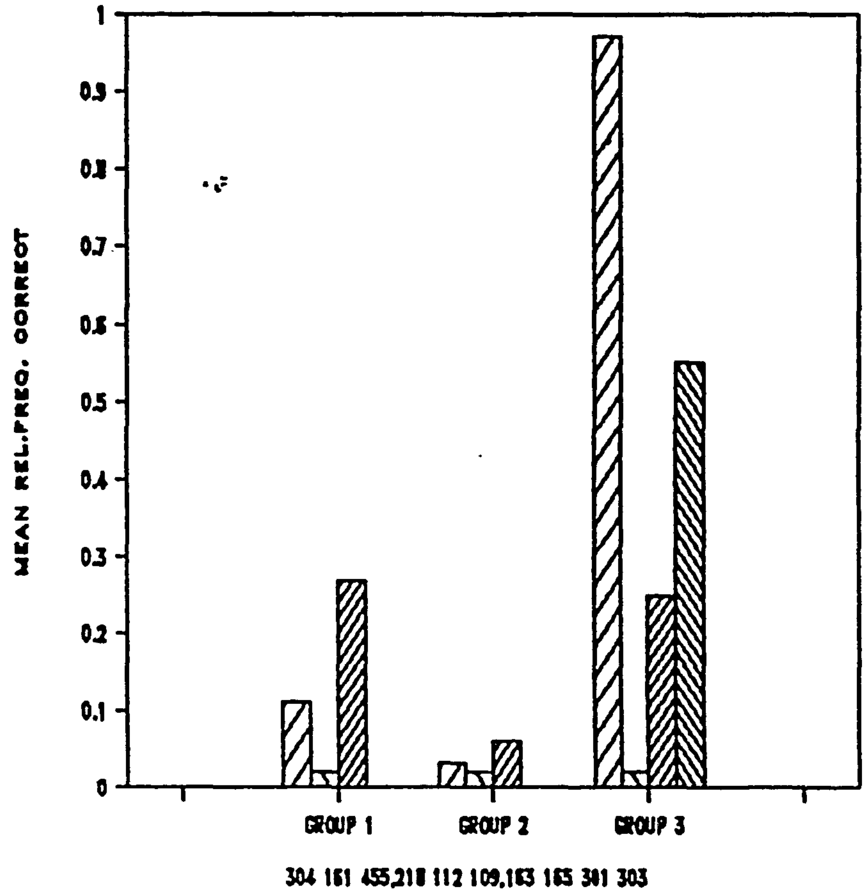
Group #	Conditions						
1	.25/3	1.0/3	.25/3	.25/40	1.0/40	1.0/3	
2		1.0/3			1.0/40	1.0/3	
3					1.0/40	1.0/3	
4					1.0/40	1.0/3	1.0/40 no cor

Results

Figure 9a shows a comparison of the grand mean of the average relative frequency of correct withdrawals in the presence of food for each group during the first condition in which food was presented in link 2. The average relative frequencies were based on data from all sessions for each subject during each condition. The number of sessions for each condition varied across groups. This information is presented in the Tables (see Method section). For group 1, the first exposure to food in link 2 occurred at a .25 probability and a 3 second intertrial interval (ITI) followed all errors. For group 2, the first exposure to food insertion in the 2nd link was at a probability of 1.0, with a 3 second ITI for all errors. For group 3, the first exposure to food in link 2 was at a probability of 1.0. For this group the ITI, following only a limited hold food error, was 40 seconds in duration.

Figure 9 a and b. a) The grand mean of the mean relative frequency of correct withdrawals from food per group during the first exposure to food in link 2. b) Individual subject mean relative frequencies of correct withdrawals from food during the first exposure to food in link 2.


GRAND MEAN OF MEAN REL.FREQ. CORRECT
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
GROUP 1
GROUP 2
GROUP 3
.25/3 1.0/3 1.0/40


MEAN REL.FREQ. CORRECT
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
GROUP 1
GROUP 2
GROUP 3
304 161 455,218 112 109,183 185 341 303

As can be seen by the figure, group 3 exhibited substantially more correct withdrawals in the presence of food than did either of the other two groups. Probability of food insertion (either .25 or 1.0) did not influence the probability of correct withdrawals from food. However, a 40 sec. ITI following a food error seemed to increase the likelihood of correct withdrawals when p(food insertion) = 1.0.

Figure 9b presents the individual subject's mean relative frequency of correct withdrawals for each group during their first exposure to food in link 2. Here one can see that three out of four subjects contributed substantially to the group 3 grand mean with the lowest of the 3 showing equivalent relative frequencies to the single highest responder of the other six subjects seen in both groups 1 and 2.

Both the group and individual data show that the 1.0/40 sec. condition during the first exposure to food in link 2 (group 3) results in

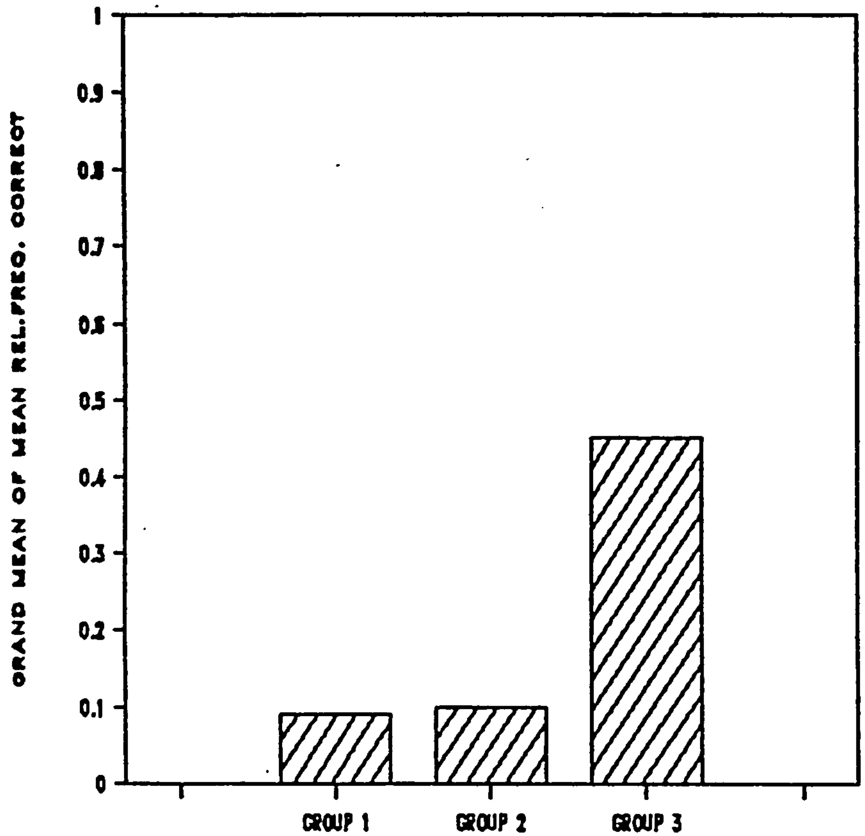
a) more subjects exhibiting correct withdrawals and b) these correct withdrawals occuring at a higher frequency.

Figure 10a shows the effects of exposure to the 1.0/40 sec. condition following prior exposure to other conditions of food presentation in link 2. Groups 1 and 2 were exposed to this condition after having been previously exposed to the .25/3 and the 1.0/3 sec. conditons. It is readily apparent, that 1.0/40 sec. had its greatest effect when it was presented prior to other conditions of food presentation in link 2.

Figure 10b shows,for individual subjects, the mean relative frequency of correct withdrawals from food at 1.0/40 sec.

Figures 11 a and b and 12 a and b present both group grand means and the individual subject means of the relative frequency of correct withdrawals for those groups (both 1 and 2) that were exposed to a 1.0/3 sec. condition prior to the 1.0/40 sec. condition. Both figure 11a and

Figure 10 a and b. a) The grand mean of the mean relative frequency of correct withdrawals from food in the 1.0/40 sec. condition, during a later exposure to food in link 2, for groups 1 and 2 and during the first exposure to food in link 2 for group 3. b) Individual subject mean relative frequencies of correct withdrawals from food in the 1.0/40 sec. condition, during a later exposure to food in link 2, for groups 1 and 2 and during the first exposure to food in link 2 for group 3.


GRAND MEAN OF MEAN REL.FREQ. CORRECT
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
GROUP 1
GROUP 2
GROUP 3

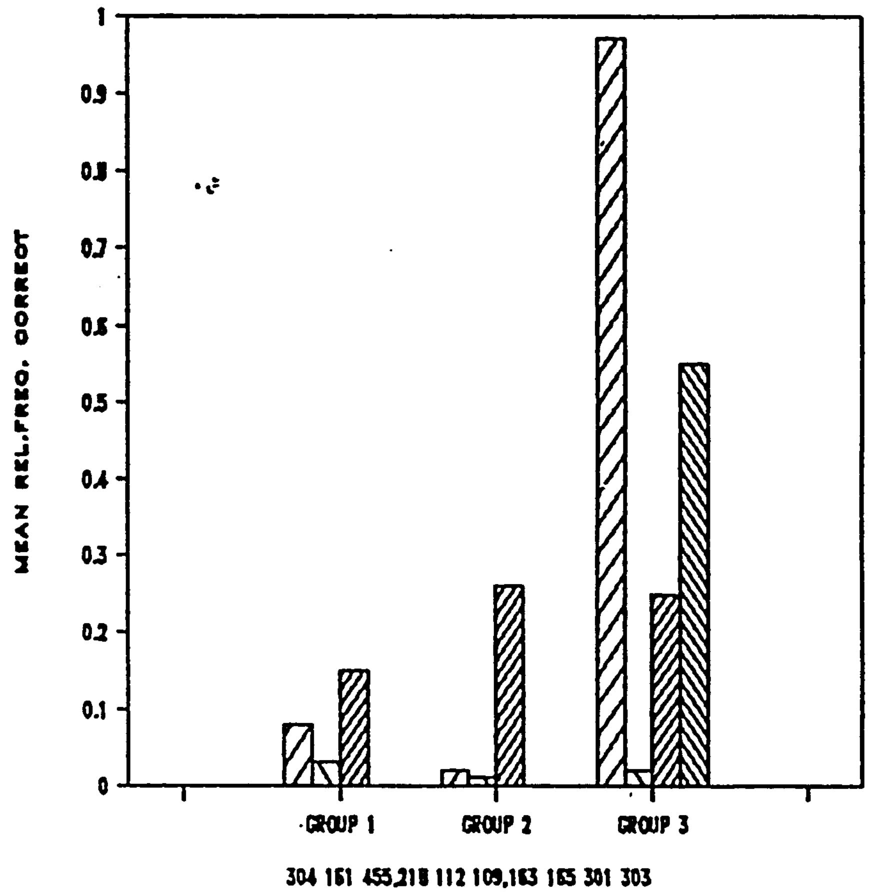
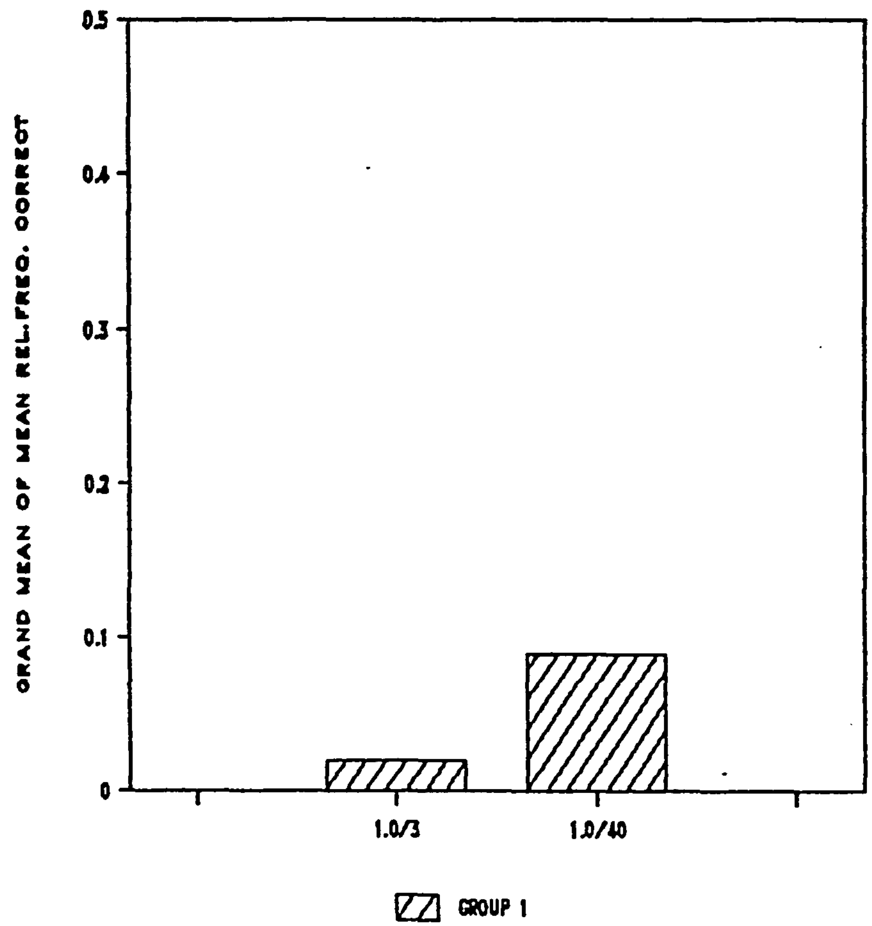

MEAN REL.FREQ. CORRECT
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
GROUP 1
GROUP 2
GROUP 3
304 161 455,218 112 109,163 165 301 303

Figure 11 a and b. a) The grand mean of the mean relative frequency of correct withdrawals from food for group 1 in the 1.0/3 sec. as compared to the 1.0/40 sec. condition. b) Individual subject mean relative frequencies of correct withdrawals from food for group 1 in the 1.0/3 sec. as compared to the 1.0/40 sec. condition.


GRAND MEAN OF MEAN REL.FREQ. CORRECT
0.5
0.4
0.3
0.2
0.1
0
1.0/3
1.0/40
GROUP 1

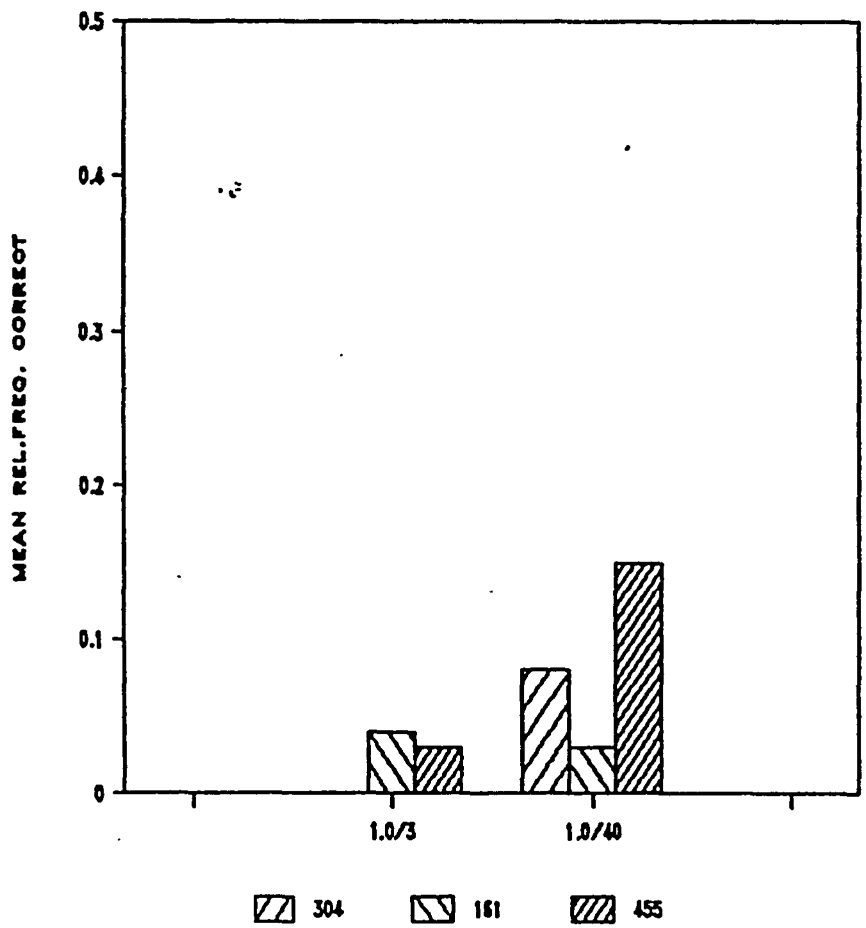
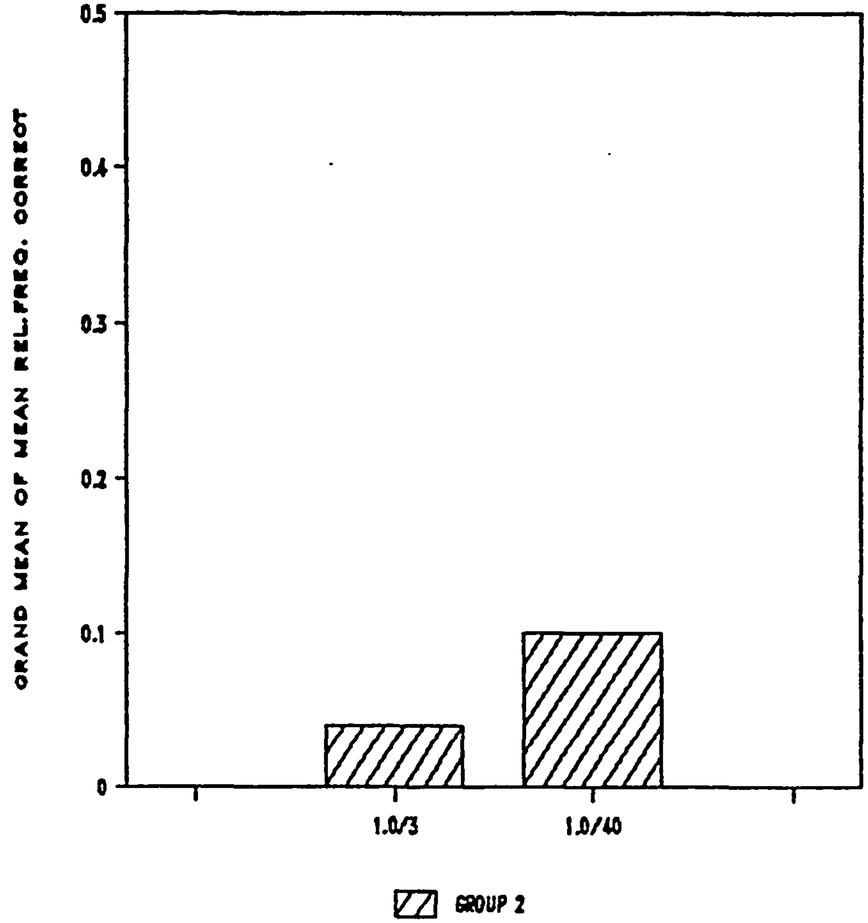
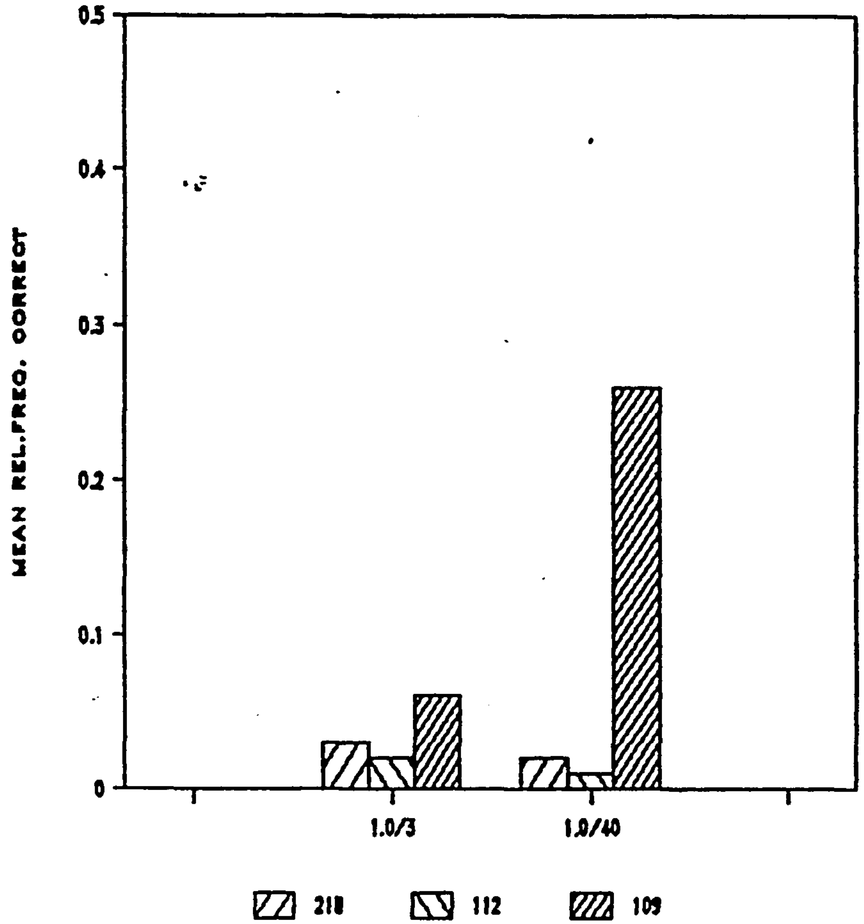

MEAN REL.FREQ. CORRECT
0.5
0.4
0.3
0.2
0.1
0
1.0/3
1.0/40
304
161
455

Figure 12 a and b. a) The grand mean of the mean relative frequency of correct withdrawals from food for group 2 in the 1.0/3 sec. as compared to the 1.0/40 sec. condition. b) Individual subjects mean relative frequencies of correct withdrawals from food for group 2 in the 1.0/3 sec. as compared to the 1.0/40 sec. condition.


GRAND MEAN OF MEAN REL.FREQ. CORRECT
0
0.1
0.2
0.3
0.4
0.5
1.0/3
1.0/40
GROUP 2


MEAN REL.FREQ. CORRECT
0
0.1
0.2
0.3
0.4
0.5
1.0/3
1.0/40
218
112
109

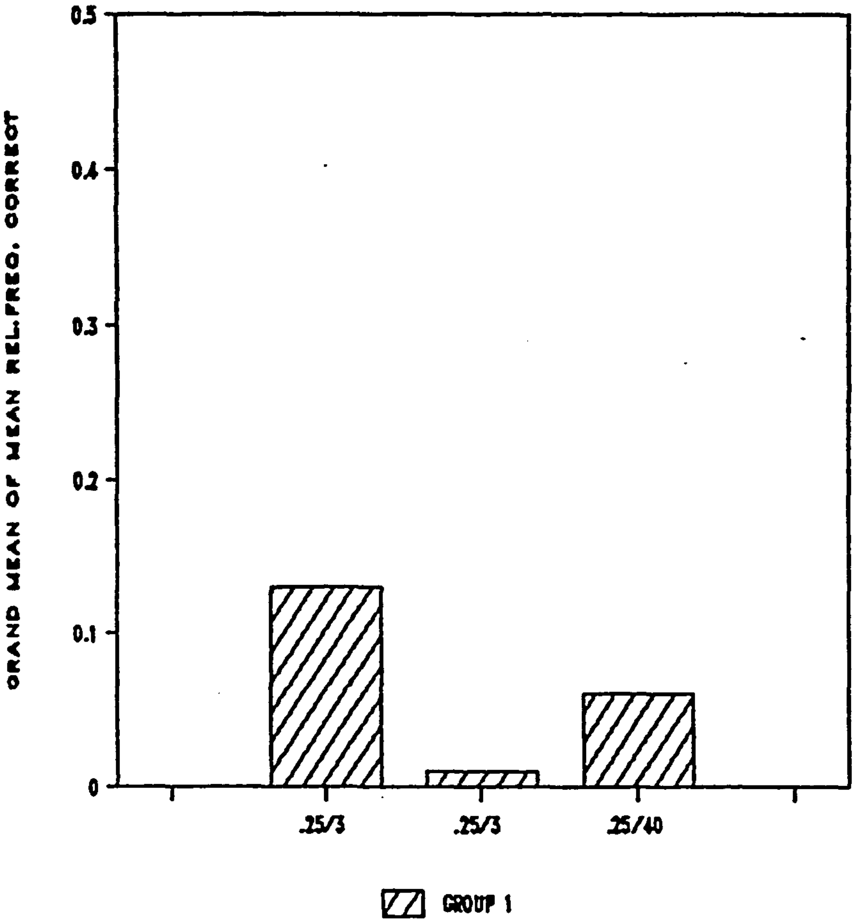
12a show that the relative frequency of correct withdrawals increased when the 1.0/40 sec. condition was introduced. In fact, for group 1, as shown in figure 11b, two out of the three subjects increased correct withdrawals, with subject 304 moving from a previous frequency of zero to an increased value of 8% once the 1.0/40 sec. condition was presented.

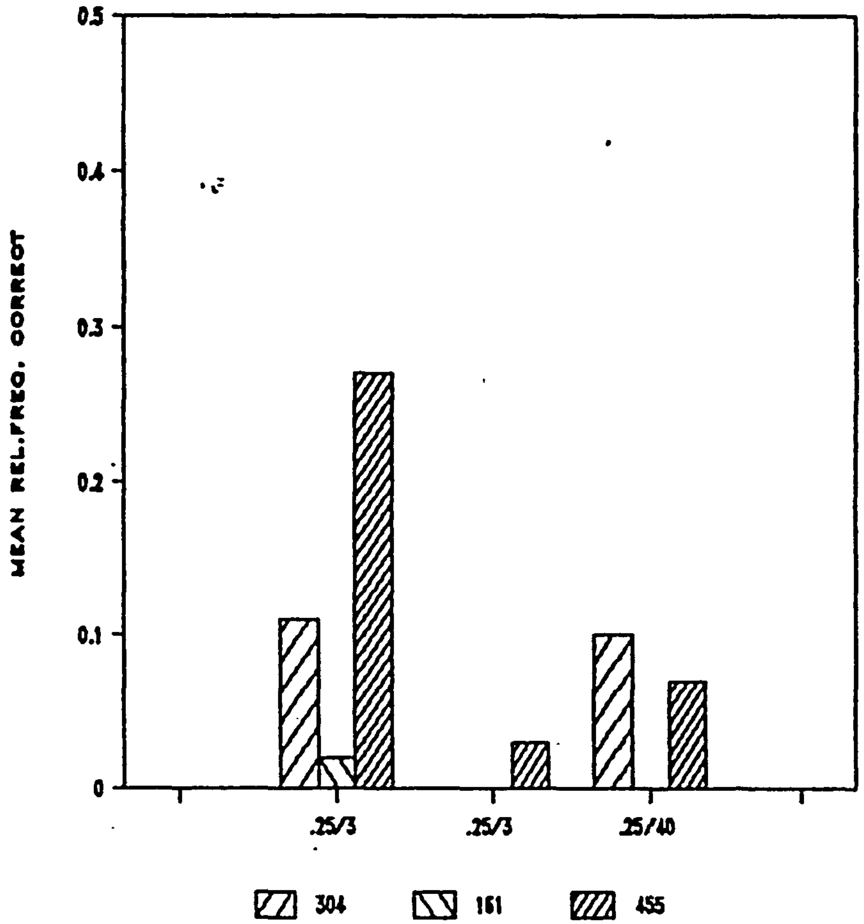
Figure 12b shows that the average increase seen in correct withdrawals at the 1.0/40 sec. condition as compared to the 1.0/3 sec. condition is, for group 2, largely based on the contribution of subject 109 whose correct withdrawals increased substantially once the 40 sec. ITI was added for limited hold food errors.

These four figures (11 a and b, 12 a and b) show that during a later exposure the 1.0/40 sec. as a second condition had a greater effect on increasing the likelihood of correct withdrawals than did the 1.0/3 sec. as a second condition.

Figure 13 a and b present the data for group

Figure 13 a and b. a) The grand mean of the mean relative frequency of correct withdrawals from food for group 1 across conditions (.25/3 sec. in the first exposure to food in link 2, .25/3 sec. in a later exposure to food in link 2, and the .25/40 sec. in a later exposure to food in link 2). b) Individual subject mean relative frequencies of correct withdrawals from food for group 1 across conditions (.25/3 sec. in the first exposure to food in link 2, .25/3 sec. in a later exposure to food in link 2, and the .25/40 sec. in a later exposure to food in link 2).


GRAND MEAN OF MEAN REL.FREQ. CORRECT
0
0.1
0.2
0.3
0.4
0.5
.25/3
.25/3
.25/40
GROUP 1


MEAN REL.FREQ. CORRECT
0
0.1
0.2
0.3
0.4
0.5
.25/3
.25/3
.25/40
304
161
455

1 during three of the conditions to which it was exposed: 1) the .25 probability of food insertion with the 3 sec. ITI as a first exposure, 2) the .25 probability of food insertion with the 3 sec. ITI as a later exposure, and 3) the .25 probability of food insertion with the 40 sec. ITI as a later exposure. One can see in Figure 13 a, that correct withdrawals occurred 13% of the time during the first exposure but declined to 1% during a later exposure and then rose to 6% with the imposition of the .25 combined with the 40 sec. ITI. Figure 13 b shows that two out of three individual subjects produced correct withdrawals throughout the first exposure, decreasing to only 1 subject during a later exposure at the same .25/3 sec. condition. However, once the .25/40 sec. condition was added, both subjects who responded initially in the first exposure to food in link 2, increased correct withdrawals to between 8% and 10%.

These results show that the 40 sec. ITI had an effect during a later condtion of food presentation when concurrent with the .25 probability condition.

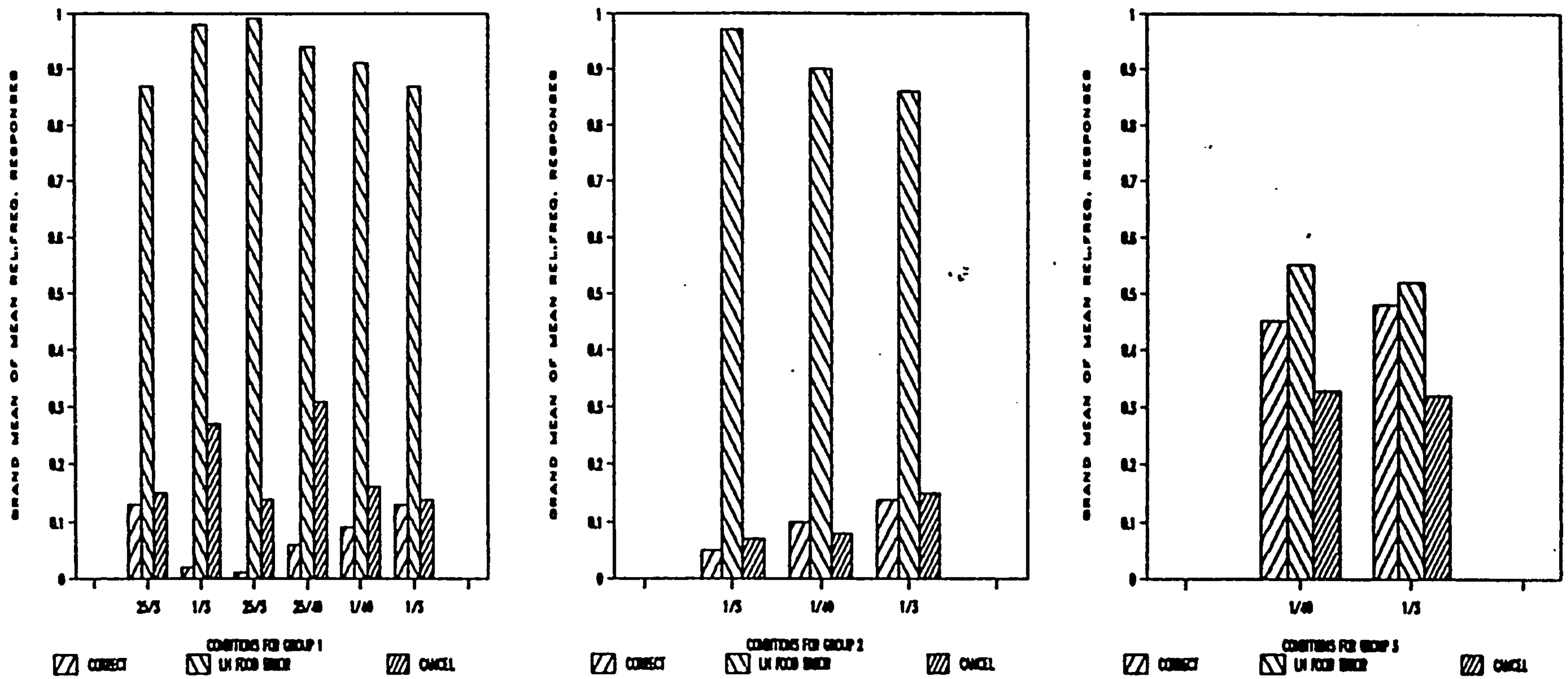
All of the correct withdrawal data have shown that such withdrawals occurred at a higher relative frequency when an extended ITI was presented for nonwithdrawal from food during the first condition of food presentation in link 2 and during later conditions of food presentation. Indeed, group 1 (.25/3 sec. condition as a first exposure to food in link 2) showed a deterioration of correct withdrawals when the .25/3 sec. condition was reintroduced following exposure to other conditions. The deterioration was reversed when the .25/40 sec. condition was presented. Although an increase in responding was seen during a later stage of training for both the .25 and 1.0 values when combined with the 40 sec. ITI, the greatest effect on correct withdrawals from food was seen when the 1.0

probability value was presented in combination with the 40 sec. ITI during the first exposure to food in link 2.

The focus so far in this section has been on correct withdrawals, but within each link there were 3 possible ways a subject could respond: 1) by withdrawing from food even though the food remained for an additional second (labelled a correct withdrawal), 2) by staying in the hopper opening and continuing to eat for the remainder of the additional 1 sec. (labelled a limited hold food error), and 3) by going into the hopper opening just before the food was presented thus cancelling the hopper presentation in that link (labelled a cancellation error).

Figure 14 a, b and c presents the grand mean of the average relative frequency of all three categories of behavior within the 2nd link when food was present (correct withdrawals, food errors and cancellation errors), for groups 1, 2 and 3 across the conditions to which each group

Figure 14 a, b and c. a) The grand mean of the mean relative frequency of correct withdrawals from food, limited hold food errors and cancellation errors for group 1 across all conditions (.25/3 sec., 1.0/3 sec., .25/3 sec., .25/40 sec., 1.0/40 sec., 1.0/3 sec.). b) The grand mean of the mean relative frequency of correct withdrawals from food, limited hold food errors and cancellation errors for group 2 across all conditions (1.0/3 sec., 1.0/40 sec., 1.0/3 sec.). c) The grand mean of the mean relative frequency of correct withdrawals from food, limited hold food errors and cancellation errors for group 3 across all conditions (1.0/40 sec., 1.0/3 sec.).


GRAND MEAN OF MEAN REL.FREQ. RESPONSES
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
25/5 1/5 25/5 25/40 1/40 1/5
CONDITIONS FOR GROUP 1
1/5 1/40 1/5
CONDITIONS FOR GROUP 2
1/40 1/5
CONDITIONS FOR GROUP 3
CORRECT
CANCEL

was exposed.

As can be seen in Figure 14 a, correct withdrawals for group 1 occurred at 13% during the first exposure to food in link 2, deteriorated in the next two conditions (1.0/3 sec. and .25/3 sec.) to 1%, increased slightly in the next condition (.25/40 sec.) to 6% and increased still further in the last two conditions (1.0/40 sec. and 1.0/3 sec.) to 9% and 13% respectively. In this case, one can see that the deterioration as mentioned above reverses with the .25/40 sec. condition and correct withdrawals continue to increase with the subsequent presentation of the 1.0/40 sec. condition and with the 1.0/3 sec. condition.

One can also see that the relative frequency of food errors was high during the first exposure to food in link 2 and increased during the next two conditions (1.0/3 sec. and .25/3 sec.) but subsequently decreased during the last three conditions (.25/40 sec., 1.0/40 sec. and 1.0/3 sec.), reflecting the fact that the correct withdrawals and the food errors are complementary measures.

On the other hand, cancellation errors eliminate the food presentation and so these relative frequencies are based on cancellation occurences divided by the scheduled number of food presentations. Group 1 shows that cancellation errors occurred within the range of 10% to 30% across all conditions and showed no apparent trend.

Figure 14 b presents the data for group 2. As already seen in group 1, there was an increase in the grand mean of the average relative frequency of correct withdrawals once the 1.0/40 sec. condition was presented. Similarly, the relative frequency of limited hold food errors decreased as the correct withdrawals increased but continued to occur as the predominant way of responding within a 2nd link with food (staying at a high range of 80% to 97%). Cancellation errors, although not as high as in group 1, fell within a range of 8% and 10%.

Figure 14 c presents the data for group 3. Here one can clearly see similarity in the distributions of both correct withdrawals and of limited hold food errors (45% and 55% respectively). This similarity increased when the group was exposed to the 1.0/3 sec. condition following the first exposure to link 2 food under the 1.0/40 sec. condition (48% and 52%). Cancellation errors remained the same for both conditions at 33% and 32% respectively.

Figure 14 a, b and c show, in general, that all three groups showed an increase in the mean relative frequency of correct withdrawals when the 1.0/40 sec. condition was introduced. However, limited hold food errors were immediately apparent from the first session on and predominated during most 2nd links with food especially for groups 1 and 2 where they remained within the range of 80% to 100%. There was no clear trend of cancellation errors displayed across groups or conditions except that they fell within a range of 7% and 33%.

Even though group 3 showed similar distributions of food errors and correct withdrawals, no growth was seen in correct withdrawals across sessions for those subjects showing relative frequencies in the low and middle range, suggesting that whatever the subjects were doing when that condition was begun, was stabilized and preserved more effectively than by any other condition. Figures 15, 16, 17, and 18 show this effect for each subject in group 3. As can be seen by the figures, subjects showing relative frequencies of correct withdrawals in the low, medium and high range stayed within a consistent range across sessions.

Figure 19 a, b and c presents the relationship between limited hold food errors and the other two limited hold errors that could be

Figure 15. The absolute number of responses (correct withdrawals from food, limited hold food errors and cancellation errors) during the 2nd link across sessions for subject 303 in group 3 during the first exposure to food in link 2.

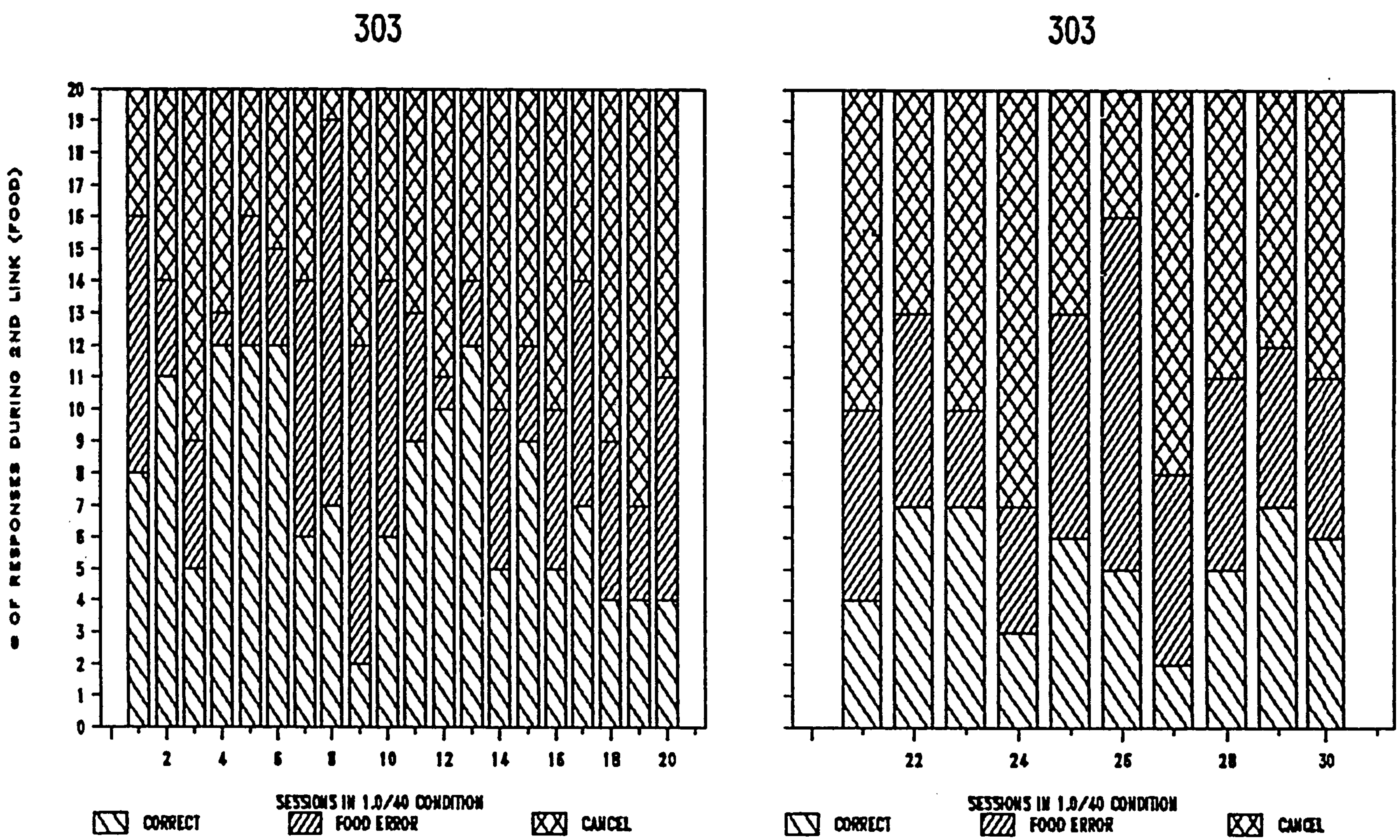

303
303
OF RESPONSES DURING 2ND LINK (FOOD)
SESSIONS IN 1.0/40 CONDITION
CORRECT
FOOD ERROR
CANCEL
SESSIONS IN 1.0/40 CONDITION
CORRECT
FOOD ERROR
CANCEL

Figure 16. The absolute number of responses (correct withdrawals from food, limited hold food errors and cancellation errors) during the 2nd link across sessions for subject 301 in group 3 during the first exposure to food in link 2.

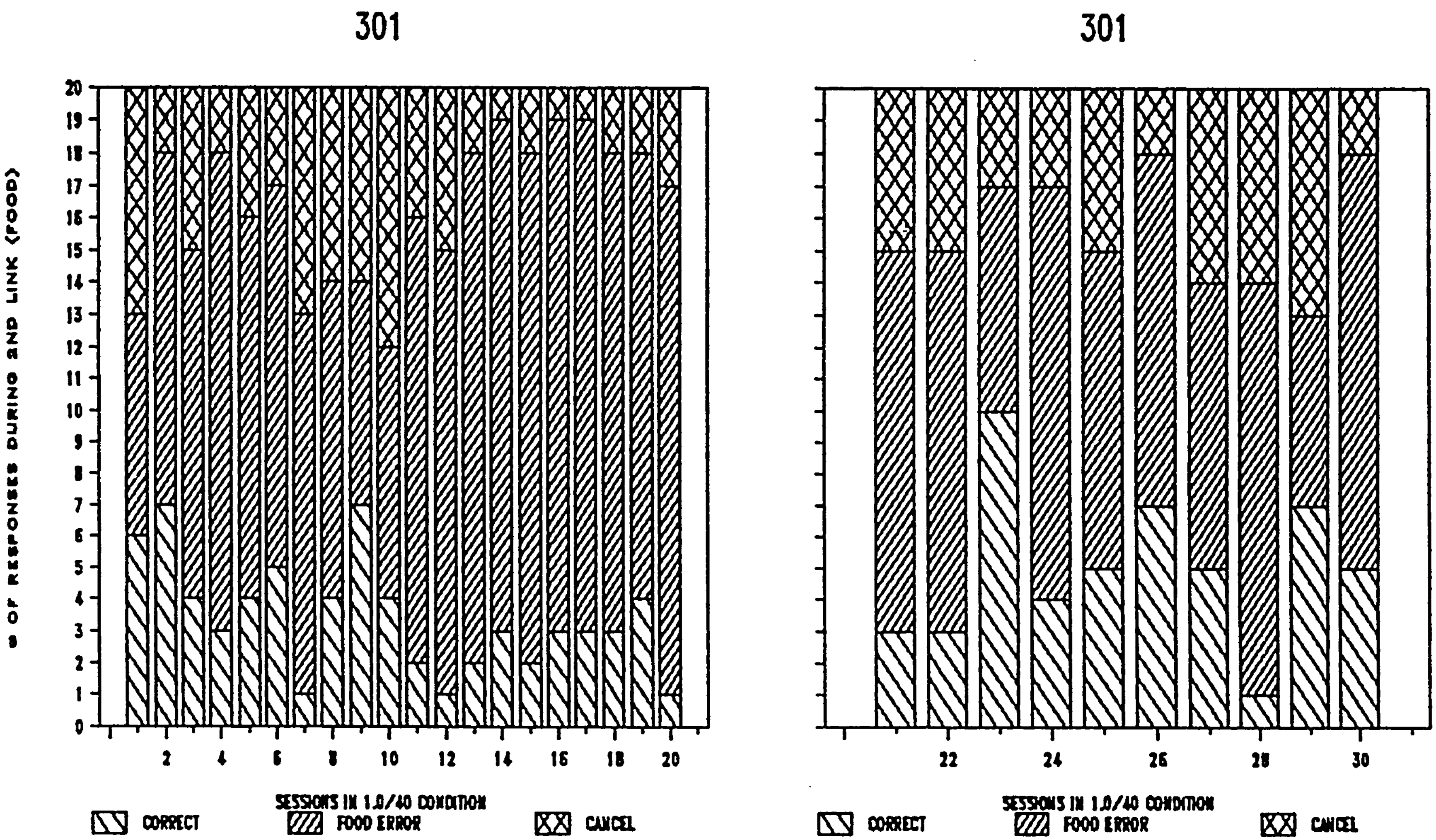
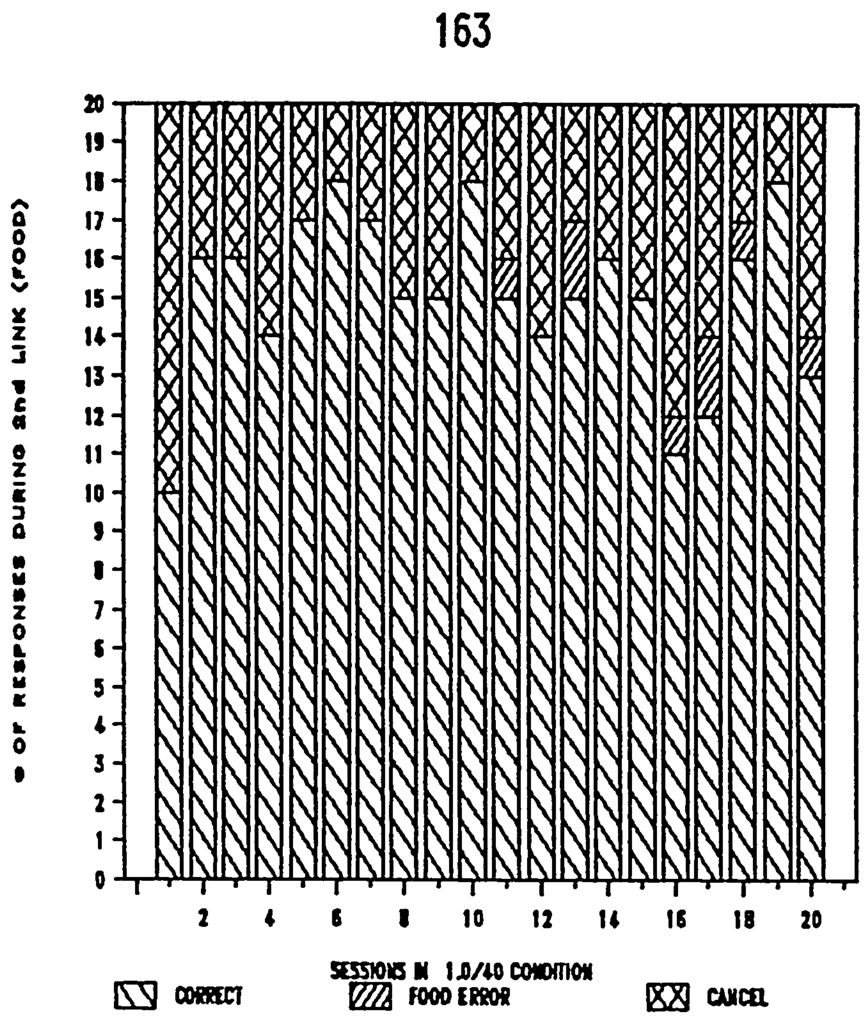

301
OF RESPONSES DURING 2ND LINK (FOOD)
SESSIONS IN 1.0/40 CONDITION
CORRECT
FOOD ERROR
CANCEL
301
SESSIONS IN 1.0/40 CONDITION
CORRECT
FOOD ERROR
CANCEL

Figure 17. The absolute number of responses (correct withdrawals from food, limited hold food errors and cancellation errors) during the 2nd link across sessions for subject 163 in group 3 during the first exposure to food in link 2.


163
OF RESPONSES DURING 2nd LINK (FOOD)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
2
4
6
8
10
12
14
16
18
20
SESSIONS IN 1.0/40 CONDITION
CORRECT
FOOD ERROR
CANCEL

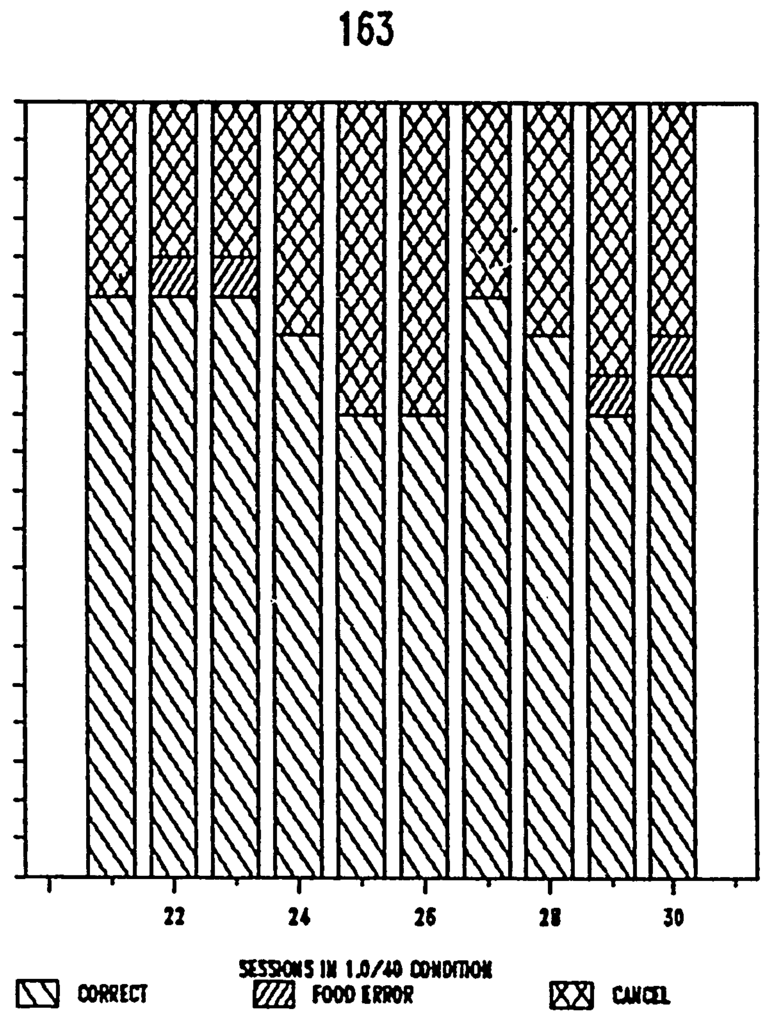

163
22
24
26
28
30
SESSIONS IN 1.0/40 CONDITION
CORRECT
FOOD ERROR
CANCEL

Figure 18. The absolute number of responses (correct withdrawals from food, limited hold food errors and cancellation errors) during the 2nd link across sessions for subject 165 in group 3 during the first exposure to food in link 2.

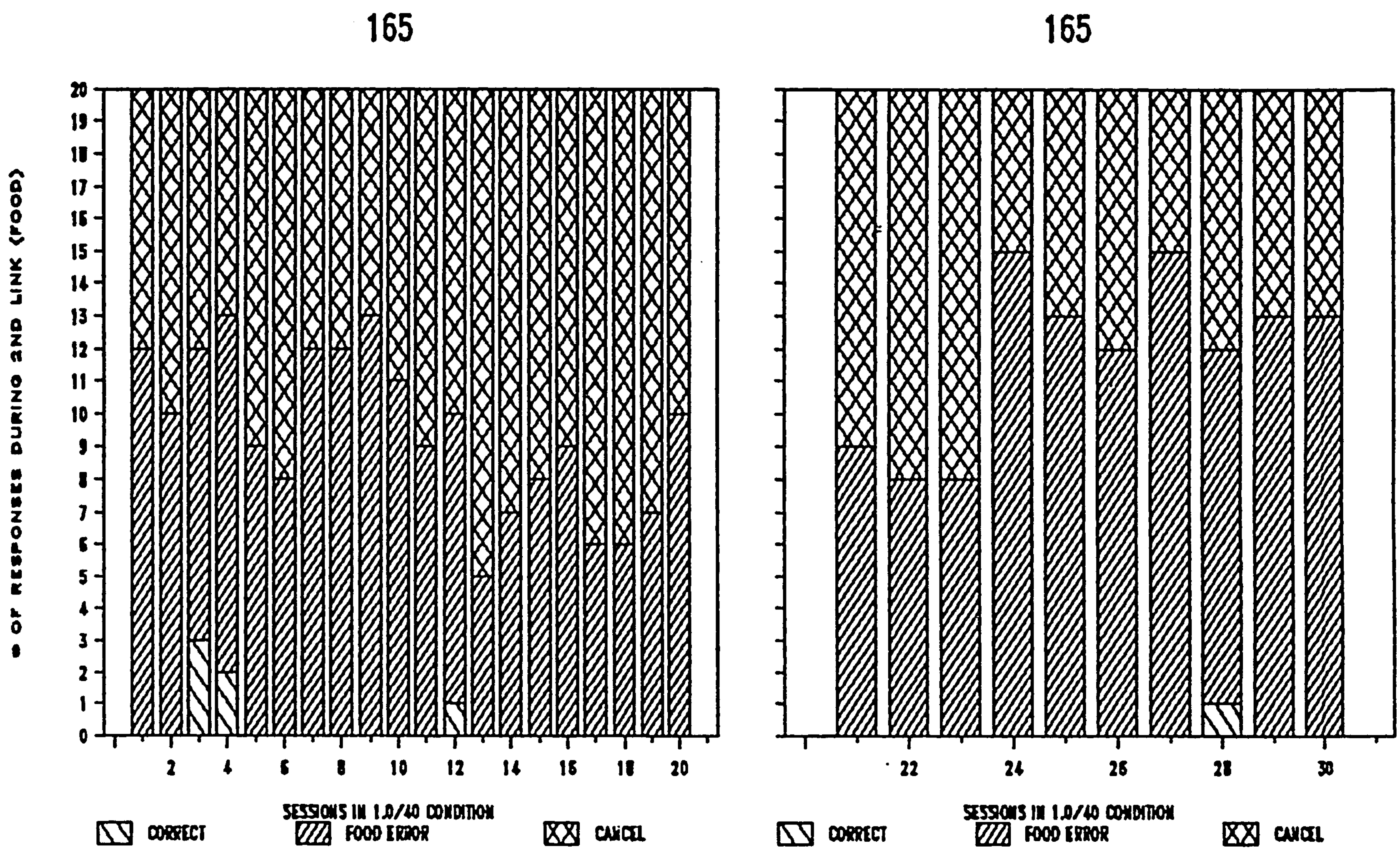
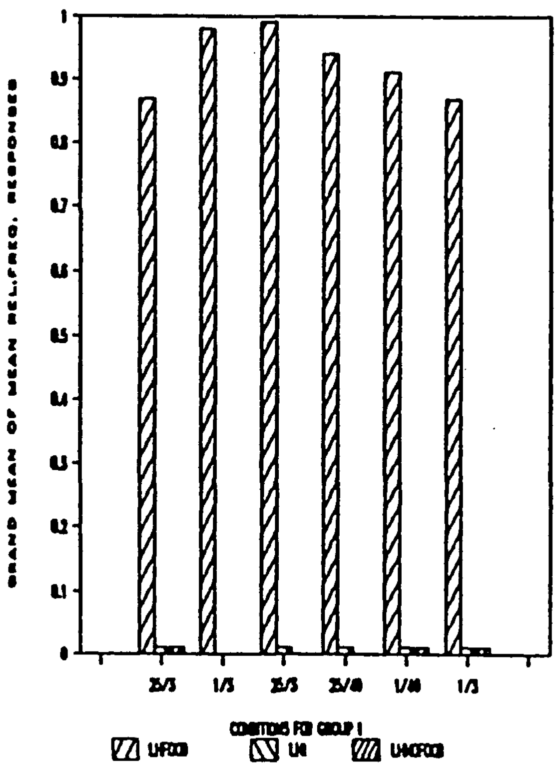
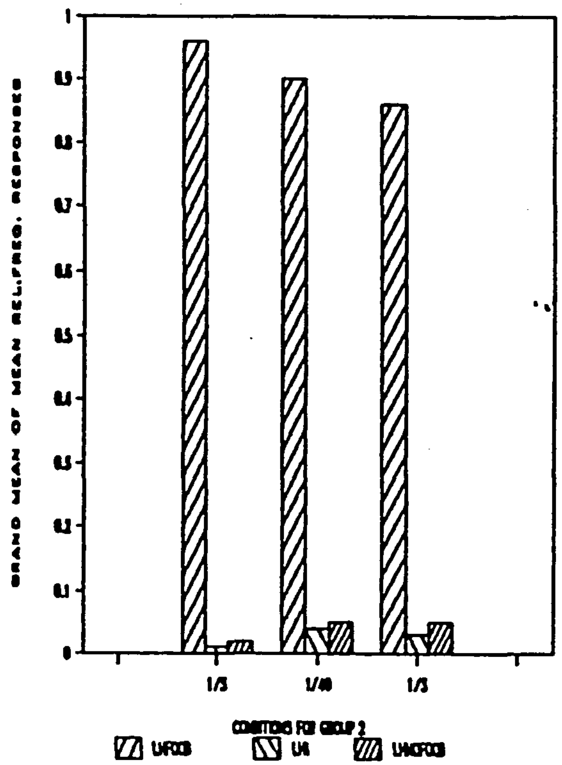
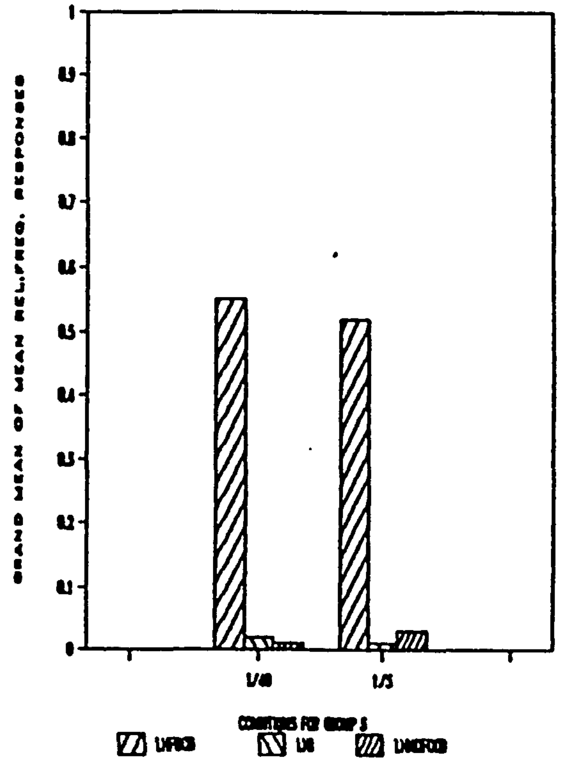

165
165
OF RESPONSES DURING 2ND LINK (FOOD)
SESSIONS IN 1.0/40 CONDITION
CORRECT
FOOD ERROR
CANCEL
SESSIONS IN 1.0/40 CONDITION
CORRECT
FOOD ERROR
CANCEL

Figure 19 a, b and c. a) The grand mean of the mean relative frequency of limited hold food errors as compared to limited hold 1st and 2nd link errors without food for group 1 across all conditions (.25/3 sec., 1.0/3 sec., .25/3 sec., .25/40 sec., 1.0/40 sec., 1.0/3 sec.). b) The grand mean of the mean relative frequency of limited hold food errors as compared to limited hold 1st and 2nd link errors without food for group 2 across all conditions (1.0/3 sec., 1.0/40 sec., 1.0/3 sec.). c) The grand mean of the mean relative frequency of limited hold food errors as compared to limited hold 1st and 2nd link errors without food for group 3 across all conditions (1.0/40 sec. and 1.0/3 sec.).


GRAND MEAN OF MEAN REL.FREQ. RESPONSES
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
CONDITIONS FOR GROUP 1


GRAND MEAN OF MEAN REL.FREQ. RESPONSES
CONDITIONS FOR GROUP 2


GRAND MEAN OF MEAN REL.FREQ. RESPONSES
CONDITIONS FOR GROUP 3

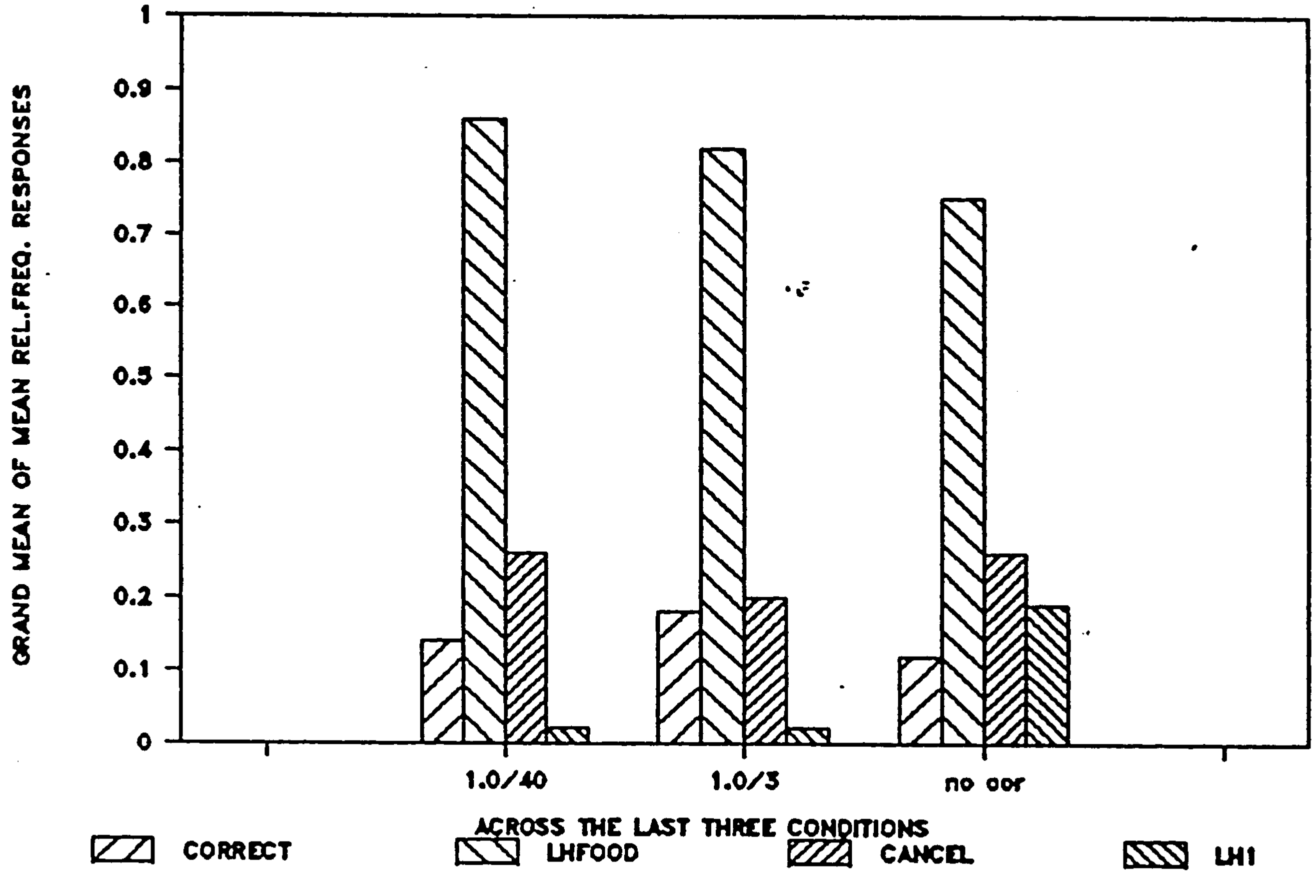
exhibited: limited hold errors in the 1st link (during which food was never presented) and limited hold errors in the 2nd link trials in which food was not presented. It was expected at the start of the experiment that once limited hold food errors occurred in the 2nd link when food was present, that these errors would influence the stimulus control that had been previously established. To test this prediction the 1st link was left without food so that one could have a comparison link within each session. This comparison or control link would provide the opportunity to detect the breakdown of stimulus control if it were to occur. The 2nd links could also occur without food but only under the following conditions: when the probability of food insertion was at .25 thus leaving some trials where there were two links without food; in a correction trial that followed a limited hold food error. During the latter condition a correct withdrawal would produce the keylight

(S3) in the presence of which a peck would be reinforced.

Figure 19 a, b and c shows that for all groups across all conditions limited hold 1st link and 2nd link (without food) errors were consistently low, occuring within the range of 0% and 5%. There was no growth seen in the error rate indicating that stimulus control was eliminated in the food link without increasing errors in the 1st link or the 2nd link (without food).

Figure 20 shows the last condition of the experiment (removal of the correction trial) which occurred for the three subjects selected to form group 4. The figure shows a comparison between the grand mean of the average relative frequency of correct withdrawals, limited hold food errors, cancellation errors and limited hold 1st link errors during the last three conditions to which all subjects were exposed. Of particular importance is the last condition which

Figure 20. A comparison between the grand mean of the mean relative frequency of correct withdrawals from food, limited hold food errors, cancellation errors and limited hold 1st link errors for group 4 during the last three conditions to which it was exposed (1.0/40 sec., 1.0/3 sec., and the no correction trial condition).

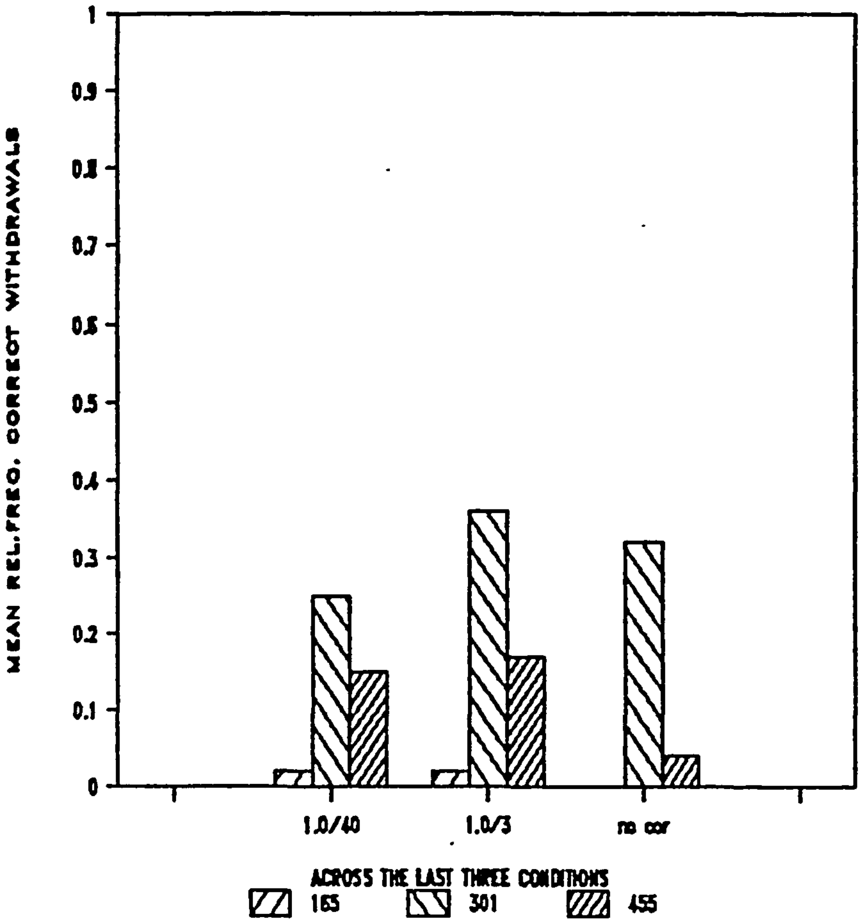


GRAND MEAN OF MEAN REL.FREQ. RESPONSES
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1.0/40
1.0/3
no cor
ACROSS THE LAST THREE CONDITIONS
CORRECT
LHFOOD
CANCEL
LH1

was called the removal of correction trial (no correction trial) condition. Here the procedure was changed so that limited hold food errors would not be followed by the single link correction trial. Rather, a new trial would immediately follow the ITI (see Figure 8). The significant finding in these data is that the limited hold 1st link errors increased substantially in this no correction trial condition, while leaving the other responses relatively unaffected. There was only a slight decrease in the mean relative frequency of correct withdrawals and food errors during the no correction trial condition.

Figures 21 and 22 a and b, present the mean relative frequency of correct withdrawals, limited hold food errors, cancellation errors and limited hold 1st link errors for the individual subjects across the last three conditions to which they were exposed. Figure 21 a shows that the mean relative frequency of correct

Figure 21 a and b. a) Individual subject mean relative frequencies of correct withdrawals from food during the last three conditions to which group 4 was exposed (1.0/40 sec., 1.0/3 sec., and no correction trial). b) Individual subject mean relative frequencies of limited hold food errors during the last three conditions to which group 4 was exposed (1.0/40 sec., 1.0/3 sec., and no correction trial).


MEAN REL.FREQ. CORRECT WITHDRAWALS
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1.0/40
1.0/3
no cor
ACROSS THE LAST THREE CONDITIONS
165
301
455

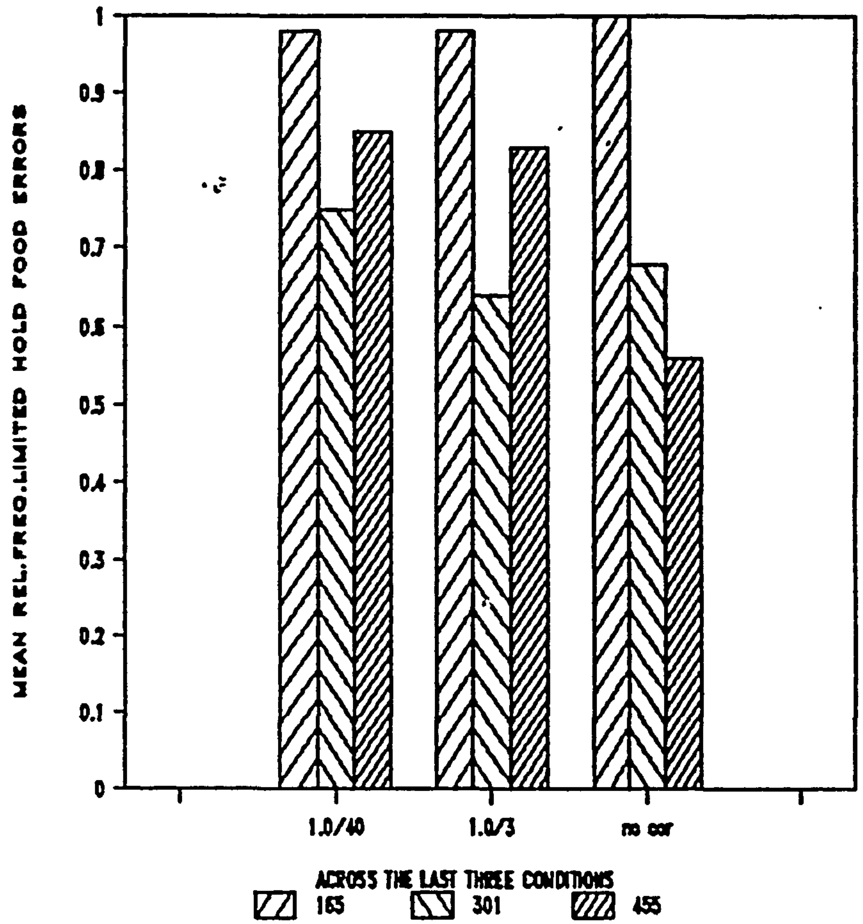
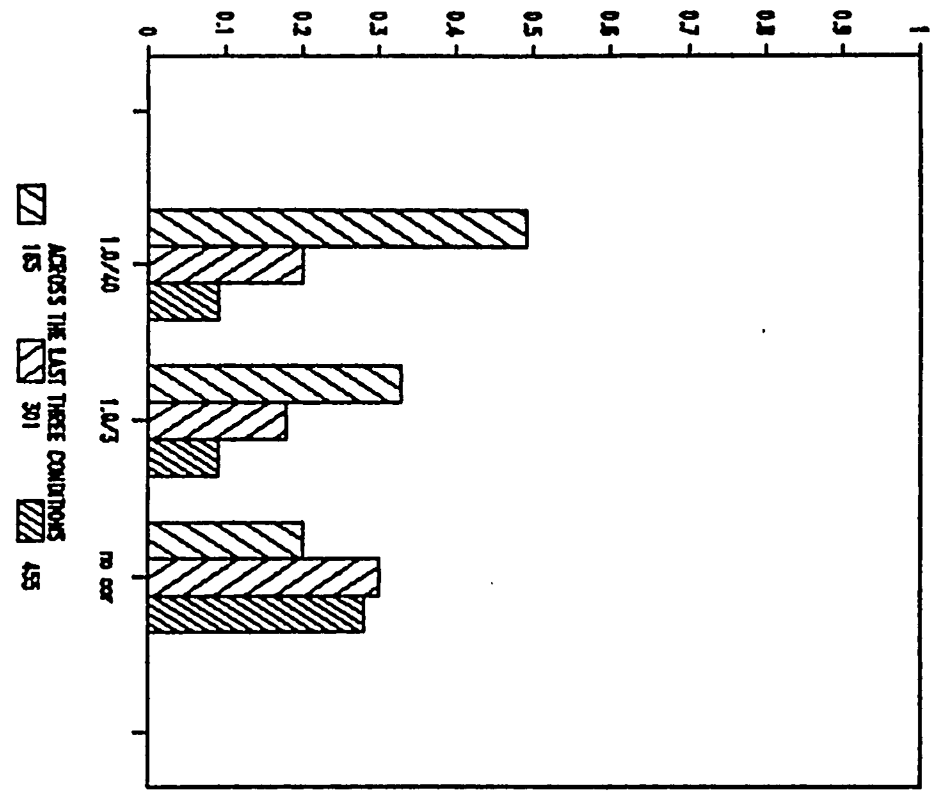
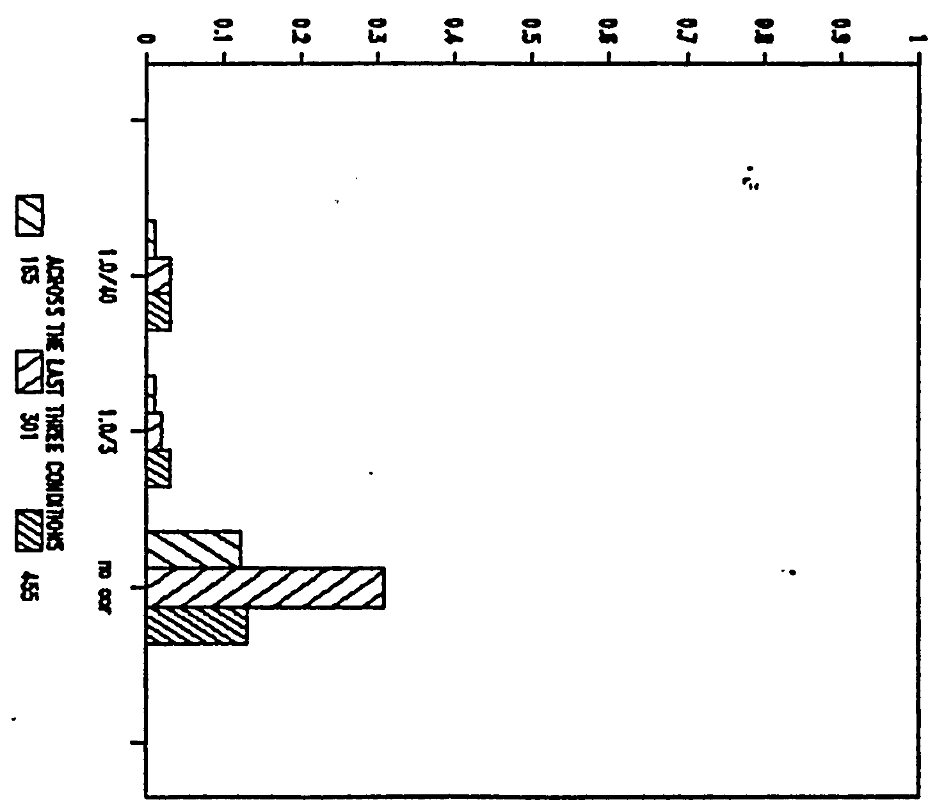

MEAN REL.FREQ.LIMITED HOLD FOOD ERRORS
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1.0/40
1.0/3
no cor
ACROSS THE LAST THREE CONDITIONS
165
301
455

Figure 22 a and b. a) Individual subject mean relative frequencies of cancellation errors during the last three conditions to which group 4 was exposed (1.0/40 sec., 1.0/3 sec., and no correction trial). b) Individual subject mean relative frequencies of limited hold 1st link errors during the last three conditions to which group 4 was exposed (1.0/40 sec., 1.0/3 sec., and no correction trial).

MEAN REL.FREQ. CANCELLATION ERRORS



MEAN REL.FREQ.LIMITED HOLD 1ST LINK ERR



withdrawals decreased for three out of the three subjects when the last condition was presented (no correction trial). Figure 21 b shows that the slight decrease as shown by the group grand mean of the average relative frequency of limited hold food errors is due to one subject (#455) whose substantial decrease in food errors offset the slight increases shown by the other two subjects in the last condition. In fact, #455 stopped responding and did not finish the last two sessions to which it was exposed. Figure 22 a shows that the average relative frequency of cancellation errors increased for two out of three subjects during the last condition. Figure 22 b shows that the limited hold 1st link errors increased substantially for all 3 subjects within group 4 during the last no correction trial condition.

The general findings seen in the last three figures (20, 21 and 22) are that the stimulus control seen in the 1st links and 2nd links (without food) as displayed by the virtual non-existence of limited hold errors in these links across conditions, was indeed disrupted when the correction trial was taken out. This shows that the opportunity for reinforcement following a correct withdrawal in a non-food link is needed to maintain stimulus control in the 1st link at a high level of accuracy. In addition, the fact that correct withdrawals from food did not deteriorate completely indicates that the correction trial was not necessary to sustain correct withdrawals from food once they were established.

Discussion

The present experiment was designed to assess the conditions influencing the cessation of ingestion. It was anticipated that by getting initial discriminative control over the movement of withdrawal in the absence of food, this prior training would increase the likelihood that withdrawals would continue to occur once food was added to the situation. If withdrawals did occur, they would be immediately reinforced.

The influence of different probabilities of food insertion in the 2nd link was tested in Groups 1 and 2. The values of $p=.25$ and $p=1.0$ were assessed during a first exposure to food to see whether intermittent or continuous food insertion was more effective in producing and maintaining correct withdrawals from food. The results showed that neither group exhibited substantial relative frequencies of correct withdrawals.

Group 3, however, did show a substantial relative frequency of correct withdrawals during its first exposure to food in link 2, as compared with groups 1 and 2. This group was exposed to a 1.0 probability of food insertion with a 40 sec. ITI following a limited hold food error during its first exposure to food in link 2. It seemed that both the 40 sec. ITI and the first condition of exposure to food in link 2 were needed in order to get the most substantial relative frequencies of correct withdrawals from food. The effect seen with the 40 sec. ITI following a limited hold food error is perhaps analogous to the finding of Fantino (1966). His work assessed the influence of an extinction period following the delivery of an immediate reinforcer (given for pecking the key) as opposed to a greater amount of reinforcement following a delayed keypeck. He found that subjects who were exposed to a 30 minute extinction period following immediate reinforcement and 3 feedings following a delayed peck, showed an increase in the percentage of delayed pecks exhibited especially at 1/2 and 1 sec. delays. However, as the required delay to keypeck increased to 3 sec., the percent of delays obtained decreased to less than 5% even under the 30 minute extinction condition. In other words, the decrease in the overall density of reinforcement (with the imposition of the 30 minute extinction period) had an effect on the delayed keypecks if the delay was within the range of 1/2 to 1 sec.

Fantino's results are consistent with the present study in that partial control over behavior was obtained when the consequence for that behavior was increased. In Fantino's work the consequence for not delaying a keypeck was 30 minutes of extinction following the ingestion of immediate food. In the present study the consequence for not withdrawing from food was a 40 second ITI following the ingestion of immediate food. The findings in both experiments showed that there was an increase in responding (percentage of delayed keypecks in Fantino's work, and an increase in the relative frequency of correct withdrawals in the present work) when there was a consequence for not emitting the behavior in question. In addition, both experiments used a period in which there was no opportunity for reinforcement (labelled an extinction period by Fantino and an ITI in the present work) which inadvertantly changed the overall density of reinforcement per session. It is unclear, then, whether the control over responding in both experiments was due to the decrease in the overall density of reinforcement or to the extinction period per se.

Although the relative frequency of correct withdrawals increased during the 40 second ITI conditions as opposed to other conditions, responding did not grow or reach 100%. This is also consistent with Fantino's findings in which the average percentage of responding seen did not go above 60% even with the most stringent penalty (a 30 min. extinction period following immediate reinforcement). This suggests that it might be more difficult to get control over a response that has two temporally competing consequences: an immediate reinforcement and a delayed extinction period.

That the relative frequency of correct withdrawals from food did not grow or reach 100% can be understood in the present experiment by the consideration of the potent competition of immediate food inherent in the procedure itself. For example, in the present study, the question was whether one could get an organism to stop eating. This necessarily implies a procedure in which the organism already has the food in its mouth. Under these conditions, one interpretation may be that food in the mouth elicits eating. Another explanation may be that the subject is already consuming an immediate reinforcer. In either case, the only consequence capable of being controlled by the experimenter is delayed until after the food is ingested. The present study introduced a period of extinction following non-withdrawal from food, and the results showed that one is able to get 45% correct withdrawals from food if the extinction period is presented during the subject's first exposure to link 2 food.

This 45% frequency of correct withdrawals from food may be attributable to the fact that extinction cannot be used to prevent non-withdrawal from occurring and therefore cannot prevent the organism from obtaining immediate reinforcement for non-withdrawal. Many researchers have documented the competition of an immediate reinforcer versus a delayed one on choice behavior (Rachlin and Green, 1972; Ainslie, 1974; Mazur and Logue, 1978; Logue et.al., 1984; and Logue and Pena-Correal, 1984). In fact, Rachlin and Green (1972) state that if

> ..."an alternative can be chosen it must also be capable of being rejected. Yet, an organism could not reject a reinforcement

> with no delay. To say D=O implies that the organism "has" the reinforcement. It is reasonable to consider preference to be infinite for a reinforcement already obtained."

The predominance of limited hold food errors seen in this experiment attests to the fact that when food is immediately available it serves as a potent reinforcer for non-withdrawal from food. The predicted direction of the equation stated by Rachlin is extended by these results but the boundaries of the equation, that is, when delay = 0 the value of the reinforcer is infinite, is not supported by the present study. In fact, some correct withdrawals from food occurred and persisted throughout the experiment with the strongest effect seen in group 3 during the first exposure to food in link 2. In other words, subjects learn to forego some immediate food if there is a substantial differential between the consequences of withdrawing and remaining.

However, most subjects under almost all conditions showed a proponderance of limited hold food errors. A possible explanation for the persistence of limited hold food errors may be not only the competition of food as an immediate reinforcer but also the competition of food as an eliciting stimulus for eating. It seems logical then that an effective way to eliminate the strong competition of an eliciting stimulus as well as an immediate reinforcer is to prevent the organism from obtaining it in the first place. In Rachlin's case, subjects were required to take an unalterable route chosen to be a sufficient temporal distance away from the availability of the reinforcer. In the Cole et al., 1982; Coll, 1983; and Stern, 1986 experiments, extinction was used to prevent the subject from obtaining the immediate reinforcer given unauthorized approach. In all of the above experiments, the procedures do not allow for immediate food to be obtained. However, in the Rachlin and Green procedure, the temporal distance parameter is used to enhance the likelihood of making a choice for the large but delayed reinforcer. As the choice time is made at a greater temporal distance from food availability, most subjects show a tendency to make more large,delayed reinforcer choices. However, this preference does not occur for all subjects. In the Cole et al., 1982; Coll, 1983; and Stern, 1986 experiments, however, 80% reliable refrainment can be obtained in all subjects.

Some work done by Mazur and Logue (1978); Logue, Rodriguez, Pena-Correal and Mauro (1984); and Logue and Pena-Correal (1984), has explored the effects of allowing the organism to change its choice as time draws closer to the availability of the reinforcer. These workers consistently found that original large reinforcer choices changed to preference for small, more immediate reinforcers as the delay to the small reinforcer was decreased. They found that the use of fading procedures helped to maintain original large, delayed reinforcer choices despite immediate reinforcer alternatives for experimental groups over control groups who hadn't received any fading. However, they do not find 100% choice for the large, delayed reinforcers within sessions or for all subjects. It seems then, that if a subject is allowed to obtain the small, immediate reinforcer, the subject will choose it most times despite an elaborate history using fading techniques. Logue et al.'s procedure does not use extinction to eliminate the possibility of obtaining a potent immediate reinforcer. This feature when exercised serves to strengthen approach behavior to gain small, immediate reinforcers on subsequent opportunities.

Based on the above experiments, it seems that the most reliable procedure to obtain refrainment from food (that is, not initiating ingestion) is one which employs extinction. This procedure developed and tested by Cole et al., 1982; Coll, 1983; and Stern, 1986, produced reliable refrainment in the presence of food for all subjects. These studies together with the present experiment show that one can gain precise control over approach behavior leading up to ingestion through the use of extinction for unauthorized approach more reliably than one can gain control over the termination of ingestion itself.

The fact that subjects initially and persistently made many limited hold food errors (between 80% to 100%) when exposed to food and very few (1% to 5%) limited hold errors when food was not present, suggests that the addition of the food in the 2nd link served not only as a potent reinforcer but may have served also as a conditional stimulus which cued the organism to continue eating (ie: to not withdraw from food). Thus, it seems that an additional discrimination emerged that was conditional upon the presence of food in the 2nd link. This is indicated by the persistence of stimulus control seen in the links without food despite the fact that non-withdrawal from food had been reinforced in the 2nd link with food.

In sum, it seems possible that food may have functioned in three different ways during link 2: 1) as an immediate reinforcer for nonwithdrawal, 2) as a conditional discriminative stimulus that signalled nonwithdrawal only in its presence, and 3) as a eliciting stimulus for eating.

The major findings of the present experiment may be summarized by the following statements:

1) The combination of the probability of food insertion at 1.0 with the 40 sec. ITI for non-withdrawal from food was needed during a first exposure to food in link 2 in order to produce substantial relative frequencies of correct withdrawals from food.

2) The highest relative frequency of correct withdrawals from food occurred for group 3 (ie: group 1 =.13; group 2 = .04 and group 3 = .45).

3) Comparisons between the limited hold food

errors and the limited hold 1st and 2nd links without food suggests that a conditional discrimination may have been acquired once food was added in the 2nd link.

4) The removal of the correction trial for group 4 did not eliminate the relative frequency of correct withdrawals from food for all subjects suggesting that the correction trial is not needed to maintain the relative frequency of correct withdrawals from food once established.

5) The increase seen in the limited hold 1st link errors following the removal of the correction trial in group 4 indicates that the correction trial was needed to maintain stimulus control of withdrawing in the non- food links. However, the breakdown in stimulus control in the 1st link (non-food) as evidenced by the increase in errors did not influence the relative frequency of correct withdrawals from food. This suggests that once food was added in the 2nd link, a conditional discrimination may have been

formed thus making each link independent of the other.

References

Ainslie, G.W. (1974). Impulse control in pigeons. *Journal of the Experimental Analysis of Behavior*, *21*, 485-489.

Bandura, A., and Mahoney, M.J. (1974). Maintenance and transfer to self-reinforcement functions. *Behavior Research and Therapy*, *12*, 89-97.

Cole, B.K., Coll, G., and Schoenfeld, W.N. (1982). The experimental analysis of "Self-Control". To be published in the Proceedings of the First Biennial International Symposium on the Science of Behavior: I Language and Behavior. Mexico City.

Coll, G. (1983). Investigation of two parameters that establish self-controlled eating in the pigeon. *Dissertation Abstracts International*, *44*, 3222B. (University Microfilms No. 8401892).

Cumming, W.W. (1955). Stimulus disparity and variable interval reinforcement schedule as related to a behavioral measure of similarity. Doctoral Dissertation, Columbia University. (University Microfilms No. 12305).

Fantino, E. (1966). Immediate reward followed by extinction vs. later reward without extinction. *Psychonomic Science*, *6*, 233-234.

Grosch, J., and Neuringer, A. (1981). Self-control in pigeons under the Mischel paradigm. *Journal of the Experimental Analysis of Behavior*, *35*, 3-21.

Keller, F.S., and Schoenfeld, W.N. (1950). *Principles of Psychology*. New York: Appleton-Century-Crofts.

Logue, A.W., and Pena-Correal, T.E. (1984). Responding during reinforcer delay in a self-control paradigm. *Journal of the Experimental Analysis of Behavior*, *41*, 267-277.

Logue, A.W., Rodriguez, M.L., Pena-Correal, T.E., and Mauro, B.C. (1984). Choice in a self-control paradigm: quantification of experience-based differences. *Journal of the Experimental Analysis of Behavior*, *41*, 53-67.

Mahoney, J.H., and Bandura, A. (1972). Self-reinforcement in pigeons. *Learning and Motivation*, *3*, 293-303.

Mazur, J.E., and Logue, A.W. (1978). Choice in a "self-control" paradigm: effects of a fading procedure. *Journal of the Experimental Analysis of Behavior*, *30*, 11-17.

Rachlin, H., and Green, L. (1972). Commitment, choice and self-control. *Journal of the ExperimentalAnalysis of Behavior*, *17*, 15-22.

Skinner, B.F. (1938). *The Behavior of Organisms*. New Jersey: Prentice-Hall Inc.

Stebbins, W.C., and Lanson, R.N. (1961). A technique for measuring the latency of a discriminative operant. *Journal of the Experimental Analysis of Behavior*, *4*, 149-155.

Stebbins, W.C., and Lanson, R.N. (1962). Response latency as a function of reinforcement schedule. *Journal of the Experimental Analysis of Behavior*, *5*, 299-304.

Stebbins, W.C. (1962). Response latency as a function of the amount of reinforcement. *Journal of the Experimental Analysis of Behavior*, *5*, 305-307.

Stern, B. (1986). Determinants of refrainments from eating in the presence of food: effects of food presentation duration and probability of food removalgiven approach. *Dissertation Abstracts International*, *47*, 3992B. (University Microfilms No. 8629745).