Utah State University

DigitalCommons@USU

The Development of S+ and S- Rules in Matching-To-Sample by Pigeons Through Prior Autoshaping

Mark S. Innocenti
Utah State University

Follow this and additional works at: https://digitalcommons.usu.edu/etd

Part of the Psychology Commons

Utah State University
MERRILL-CAZIER LIBRARY

THE DEVELOPMENT OF S+ AND S- RULES IN

MATCHING-TO-SAMPLE BY PIGEONS

THROUGH PRIOR AUTOSHAPING

by

Mark S. Innocenti

A thesis submitted in partial fulfillment

of the requirements for the degree

of

MASTER OF SCIENCE

in

Psychology

Approved:

UTAH STATE UNIVERSITY
Logan, Utah
1983

ACKNOWLEDGMENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

ABSTRACT

The Development of S+ and S- Rules in Matching-To-Sample

by Pigeons Through Prior Autoshaping

by

Mark S. Innocenti, Master of Science

Utah State University, 1983

Major Professor: J. Grayson Osborne
Department: Psychology

The purpose of this study was to develop behavior by the pigeon
illustrative of S+ and S- rules and to examine if behavior consistent
with a concept rule interpretation developed. In order to examine
this possibility six groups of pigeons (N=31) were provided different
histories of autoshaping. Histories involved the identity of the
color of the lighted center key and one side key of three horizontally
mounted pigeon keys. Center key onset was followed three seconds
later by onset of either outer key. Outer key onset was followed six
seconds later by food presentation (explicitly paired) or 45 seconds
later, during the inter-trial interval (explicitly unpaired). The
foregoing reinforcement conditions were factored into two stimulus
conditions, one where the center and side keys were lit by the same
hue (identity) and one where the center and side key were lit by
different hues (nonidentity). Two groups received identity stimulus

sequences with explicitly unpaired food presentation. Two groups were exposed to nonidentity stimulus sequences with explicitly unpaired food presentation. One group received sessions combining exposure to both the explicitly paired identity and explicitly unpaired nonidentity trials. One group received no pretraining. Following pretraining, all birds were placed in a simultaneous matching-to-sample task utilizing the same hues used during pretraining. After reaching criterion on matching-to-sample, on a random ratio 3 schedule of reinforcement, birds were exposed to transfer tests, with a novel hue, to assess for S+ rules, S- rules, and a concept rule. The results indicated that there were no significant differences among groups in terms of their acquisition of matching-to-sample or in terms of their performance on transfer tests. All birds' responding during transfer conditions provided evidence of S+ rules, but neither demonstration of S- rules nor concept rule performance was evidenced. During autoshaping, birds in the identity, explicitly paired groups responded primarily to the center key, suggesting that the stimulus on the outer key was not a salient stimulus for the identity discrimination. For birds in the nonidentity, explicitly unpaired groups neither the center nor outer key controlled responding. For the group combining identity, explicitly paired and nonidentity, explicitly unpaired trials, the birds failed to form a discrimination between types of trials.

(104 Pages)

INTRODUCTION

Philosophers have long debated how learning occurs. Only since the end of the 19th century, however, has the science of psychology been involved in the systematic study of how an organism learns (e.g., Thorndike, 1911). Though many research questions have been studied, many more questions remain. One area in which questions remain, and with which this thesis will be concerned, is in the area of conditional discriminations.

In a simple discrimination an organism is presented with two or more choices where the correct choice can be ascertained on the basis of a single stimulus that preceeds the response temporally and, in effect, cues the organism to respond or not respond. A conditional discrimination differs from a simple discrimination in that a correct response can only be made by relying on the relations among two or more stimuli and the context in which they appear (Cumming & Berryman, 1965).

Matching-to-sample is an experimental procedure that meets the criteria for a conditional discrimination. In the matching-to-sample paradigm the organism is presented with a standard (ST) stimulus which is contiguously followed by two or more comparison (CO) stimuli to one of which the organism must respond. While there are a series of problems such as this, in matching-to-sample the correct response is

to the CO that matches, that is, is identical to the ST.

When placed in the matching-to-sample task pigeons respond in a predictable pattern. Their initial performance is typically below chance levels (chance being defined as 50% correct responding), subsequently rises to chance levels for a period of time, and finally, rises to high levels of correct responding (Cumming & Berryman, 1965).

At high levels of correct responding the discrimination is considered learned and it appears as though the pigeon is demonstrating an acquired concept of sameness or identity. If this assumption is tested by presenting the pigeon with trials consisting of a novel stimulus as the ST and correct CO, with another familiar, incorrect stimulus as CO, it is observed that responding returns to chance levels (Cumming & Berryman, 1965; Farthing & Opuda, 1974). The concept of identity has not been learned. This result is surprising in that pigeons have demonstrated the ability to form other conceptual discriminations. Pigeons have demonstrated conceptual discriminations for identifying humans (Herrnstein & Loveland,1964; Siegel & Honig, 1970), for a same/different discrimination (Malott & Malott, 1970), and in other areas (e.g., Honig, 1965; Poole & Lander, 1971).

At present, acquisition of matching-to-sample by pigeons is best described by the multiple-rule or stimulus-response chains model. Research by Carter and Werner (1978) and by Farthing and Opuda (1974) has provided strong support for this contention. This model states

that the ST serves an instructional function (Cumming & Berryman, 1965) which then leads to a response to a specific CO. In pigeons this rule appears to be based on positive instances (S+ rules) occurring in the discrimination (Carter & Werner, 1978; Farthing & Opuda, 1974).

Other researchers have presented conditional discrimination data which they claim demonstrates conceptual behavior by the pigeon (Urcuioli, 1977; Urcuioli & Nevin, 1975; Zentall & Hogan, 1978). These studies fail to clearly demonstrate conceptual behavior due to methodological concerns resulting from their discrimination training techniques (e.g., Zentall & Hogan, 1978) and from their techniques for assessing transfer effects (e.g., Urcuioli, 1977; Urcuioli & Nevin, 1975), but behavior that is concept-like is evident. One factor that these studies have in common is a methodology that explicitly presents negative instances of the concept being trained.

The presentation of negative instances of a concept helps to demonstrate concept-like behavior in pigeons. Mackintosh (1974) has discussed acquisition of a simultaneous conditional discrimination (e.g., matching-to-sample) as involving the separate acquisition of approach responses to positive instances of the discrimination (S+ rules) and avoidance responses to negative instances of the discrimination (S- rules). Studies on discrimination learning with humans and primates have suggested the importance of explicitly training negative instances (Bourne & Guy, 1968; Harlow & Hicks,

1957). Recent research has clearly demonstrated that humans utilize both S+ and S- rules in acquiring a conditional discrimination (Dixon & Dixon, 1978; Stromer & Osborne, 1982).

Based on the conditional discrimination data from humans and from pigeon studies where concept-like behavior was exhibited it can be postulated that the typical procedure by which pigeons are trained a matching-to-sample discrimination does not allow for the development of S- rules. If this is the case, it would be interesting to determine whether a procedure can be devised whereby S- rules are developed and conceptual behavior is exhibited by the pigeon. One method for accomplishing this may be through autoshaping (Brown & Jenkins, 1968) prior to matching-to-sample training. Autoshaping as a procedure refers to the presentation of a potential reinforcer (e.g., food or water) immediately following the termination of a stimulus, such as a key light, independent of the organism's behavior. In pigeons this procedure reliably establishes the key pecking response (Schwartz & Gamzu, 1977).

Autoshaping as a method to enhance the learning of S+ and S-rules in a conditional discrimination has a basis in research on classical conditioning, in that autoshaping contains components of operant conditioning and classical conditioning (Schwartz & Gamzu, 1977). Bauer and Lawrence (1954) demonstrated that classical conditioning affects performance on a simultaneous discrimination. Looney, Cohen, Brady, and Cohen (1977) demonstrated that a conditional

discrimination could be acquired through the elicitation of a response directed toward a conditioned stimulus. Lubeck (1982), in fact, preceded matching-to-sample training with an autoshaping procedure where combinations of stimluli were either predictive, not predictive, or randomly predictive of reinforcement. He found that prior exposure to matching stimuli predictive of reinforcement alternating with exposure to nonmatching stimuli not predictive of reinforcement lead to faster acquisition of matching-to-sample than did any other group in his study. Lubeck conducted no transfer tests to assess what rules (if any) were being utilized or if an identity concept had developed.

The present research attempted to determine, through transfer tests, to what rules pigeon behavior conforms when matching-to-sample training is preceded by autoshaping different stimulus combinations varying in predictiveness of food reinforcement.

REVIEW OF LITERATURE

Since the early 1900's psychologists concerned with the study of behavior have been interested in the effect a prior discriminative stimulus exerts on an organism's behavior (e.g., Spence, 1936). Initially, concern focused on the effects of simple discriminative stimuli on tasks involving two choices. These were exemplified by studies utilizing rats as subjects in T-mazes and on jumping stands (MacKintosh, 1974, Ch.10). This line of study led to the questioning of the effect that a complex discriminative stimulus may have on an organism's behavior.

Conditional Discriminations

A conditional discrimination involves the presentation of stimuli to an organism in a discrimination task (Lashley, 1938). In a conditional discrimination, relations among the discriminative stimuli depend upon the stimulus context in which they appear (Cumming & Berryman, 1965). That is, an organism cannot determine what the experimenter has chosen as the correct response on the basis of a single stimulus, but must rely on at least two stimuli to respond correctly.

Lashley's (1938) experiment will serve as an example. Lashley presented rats, on a jumping stand, with two equilateral triangles, one inverted ond one upright, as stimuli. Both triangles were presented on every trial but the background on which the triangles were presented was either black or contained horizontal stripes. If the background was black the rats were reinforced for jumping toward the upright triangle. When the background was striped rats were reinforced for jumping toward the inverted triangle. Rats were exposed to one background for 20 trials and then switched to the other background for 20 trials; This alternation continued throughout the experiment. As trials progressed, the rats learned to jump toward the reinforced triangle without error, thus demonstrating a conditional discrimination.

Lashley was not the first to use the conditional discrimination paradigm. Anecdotal reports of its use during the late 18th Century with a human (Itard, 1932) and early studies conducted on conceptual behavior with nonhuman primates (Revesz, 1925; Yerkes, 1935) predated Lashley, but Lashley was the first to attempt to identify some of the properties of the controlling stimuli and the extent of their generalization to novel stimuli.

Matching-to-sample. The research with which this thesis is primarily concerned is with the behavior of pigeons in the matching-to-sample conditional discrimination and, therefore, the procedure typically used in matching research with pigeons will be

described more fully. In matching-to-sample, as exemplified by
Cumming and Berryman (1965), utilizing hues as stimuli, a red
stimulus, the ST, is presented to the pigeon in a 3-key operant
chamber. A response to the ST, referred to as an observing response,
is followed by the presentation of red and green CO stimuli to the
organism; the ST remains observable to the pigeon during this time. A
response to the red CO results in reinforcement, while a response to
the green CO results in an inter-trial interval (ITI); responses to
the ST have no effect. This procedure can be diagrammed (Cumming &
Berryman, 1965) as:

$$ST(red)-- R(observing\ response) \longrightarrow \begin{cases} CO(red)--R(red)-->S^{R+}-->ITI \\ ST(red) --> 0 \\ CO(green)-- R(green) -->ITI \end{cases}$$

This procedure is referred to as simultaneous matching because both
the ST and CO are observable simultaneously to the organism. Another
notation (Cumming & Berryman, 1961; Carter & Werner, 1978) for
visually presenting the matching procedure which will be used in this
thesis, is: R(R*,G). The letter outside the parentheses represents
the ST stimulus (red). The letters within the parentheses represent
the COs (red and green). The asterisk represents the reinforced
stimulus (red).

There are numerous variations of the simultaneous matching
procedure. The ST can be turned off after an observing response,
either immediately or with a variable delay as the CO stimuli are

turned on (Berryman, Cumming, & Nevin, 1963). These are respectively referred to as zero-delay and variable-delay matching. The number of observing responses required to the ST to produce the COs can also be varied, including the condition in which no response is required (Eckerman, Lanson, & Cumming, 1968). In addition to varying the parameters of the matching procedure, the contingencies that specify the correct response can be altered. Reinforcement may occur to responses to the CO different from the ST, called oddity matching (Cumming & Berryman, 1965; Zentall & Hogan, 1974, 1976), or to responses to a CO related arbitrarily to the ST, called symbolic, nonidentity, or arbitrary matching (Holmes, 1979; Rodewald, 1974; Stromer & Osborne, 1982). (See Cumming and Berryman, 1965, for a more detailed discussion of these variations).

Models of Conditional
Discrimination Learning

Lashley's (1938) work on conditional discriminations initiated the investigation of how a discrimination is acquired. There are currently three models that conceptualize the acquisition of matching by pigeons. (See Carter and Werner, 1978, for a comprehensive review of these models and research conducted on them.)

Configurational model. The configurational model is the simplest model. It assumes that the entire stimulus array controls responding. The model states that when the pigeon is presented with R(R*,G), the

pigeon responds to red-left because of the configuration or physical arrangement of the stimuli. A response to a red CO when the configuration is R(G,R*), is not equivalent to the previous case. The pigeon is not responding to some learned relation between the stimuli, but is responding this way because of learning to respond left when presented with the specific physical arrangement of the first case and respond right when presented with the specific physical arrangement of the second case. If the pigeon responds this way in a 3-hue simultaneous matching discrimination it would require that the pigeon learn 12 different configurations before the discrimination could be mastered. (The 12 configurations are all possible arrangements of 3 stimuli.)

Multiple-rule model. The multiple-rule or stimulus-response chains model suggests that the pigeon is learning S+ and/or S- rules and acquires a discrimination as a result of using one or both types of these rules. A rule can be considered a cognitive strategy for attempting to solve the discrimination, which can be ascertained from the organism's performance on the discrimination task. In this model the ST performs an instructional function (Cumming & Berryman, 1965). The ST serves as the stimulus that determines the response the pigeon will make, and the discrimination is acquired as a result of learning the stimulus-response chains between the stimuli that act as STs and those that act as COs. That is, the pigeons learn rules that relate the ST and COs.

An S+ rule would be exemplified in a matching procedure by the pigeon learning that if the ST is red, then red should be responded to as the CO. An S- rule would be exemplified where the pigeon learns that if red is the ST, then green as a CO should be avoided. Applying this model to 3-hue simultaneous matching there would be three S+ rules that could be learned and/or six S- rules (Table 1).

Single-rule model. The single-rule model or conceptual model is the third model by which matching is described. In this model the subject learns to respond to the overall relational property that distinguishes correct responding in the conditional discrimination problem. With the 3-hue simultaneous matching procedure the rule to be learned would be sameness - always respond to the CO which is the same as the ST.

TABLE 1

Stimulus Combinations in 3-Hue Matching and Oddity

Matching	Oddity
R(R*,G)	R(R,G*)
R(R*,B)	R(R,B*)
G(G*,B)	G(G,B*)
G(G*,R)	G(G,R*)
B(B*,G)	B(B,G*)
B(B*,R)	B(B,R*)

Key: R=red; B=blue; G=green

Transfer As A Method To Examine
Models Of Conditional Discrimination

The acquisition of matching-to-sample tells us little, if
anything, about which model the pigeon's behavior conforms to. A
method to determine what type of control the stimuli exert, and,
therefore, what model best describes the behavior exhibited, is
through the presentation of novel stimuli in a transfer task. An
example of a transfer task is the substitution of a novel (yellow)
stimulus for the familiar (red) stimulus used in training the original
discrimination. The responding of the pigeon to trials where the
novel stimulus is presented are the trials that indicate the control
exerted by the various stimuli on the pigeon's behavior in
matching-to-sample.

The configurational model assumes that chance levels of
responding occur during transfer with the presentation of a novel
stimulus because the new stimulus changes the physical arrangement of
the configuration.

In the multiple-rule model, transfer effects depend upon the
rule(s) used and what stimulus the novel stimulus is substituted for.
If S+ rules are evidenced by the pigeon's behavior, the presentation
of the novel stimulus as an incorrect CO should have no effect on the
pigeon's performance. This is exemplified by case 1 of Table 2. The
pigeon by using S+ rules, when presented with this novel
configuration, continues to observe th ST for its instructional

function and as a result would respond to the CO identical to the ST. The pigeon learns "if green, then green" and responds correctly regardless of the incorrect CO. If the novel stimulus was presented as both the ST and correct CO then performance should be disrupted. Case 2 of Table 2 represents this example. The pigeon having never observed yellow as an ST has not learned the instructional function of this stimulus. By not having learned "if yellow, then yellow" the pigeon's responding would be disrupted.

TABLE 2

Stimulus Configurations for Originally Trained Configuration and Novel Transfer Configuration, with Yellow Hue Substituted for Red.

	Original	Novel
Case 1:	$\overline{G(G^\star,R)}$ --------->	$\overline{G(G^\star,Y)}$
Case 2:	$R(R^\star,G)$ --------->	$Y(Y^\star,G)$

Key: G=green; R=red; Y=yellow.

Conversely, if the pigeon's behavior exemplified S- rules, when presented with a novel incorrect CO, a disruption in performance would be expected. In case 1 of Table 2 as an example, if the pigeon has learned the S- rules "if green, avoid red" and "if green, avoid blue" it would not have acquired a similar rule for the novel yellow stimulus. The presentation of a novel ST and novel correct CO would also be expected to disrupt performance. In this example, case 2 of Table 2, the pigeon has never been exposed to a yellow ST and, as a

result, could not have acquired a rule for its instructional function.

The single-rule model predicts that a novel stimulus, regardless of position would cause no disruption in the pigeon's performance. This is a result of the pigeon responding to the overall relation between the stimuli (i.e., identity or nonidentity). Responding to the overall relation between the stimuli is equivalent to conceptual behavior.

The majority of studies indicate that pigeons do not exhibit concept-like behavior in matching-to-sample (Carter & Werner, 1978; Cohen, 1969; Cumming & Berryman, 1965; Farthing & Opuda, 1974). In fact, they exhibit chance performance during transfer tasks with novel stimuli for the most part. This result is surprising in that pigeons have demonstrated their ability to form other concept-like conditional discriminations. Herrnstein and Loveland (1964) taught pigeons to discriminate humans from nonhumans, and this was reaffirmed by Siegel and Honig (1970). Pigeons have been taught the concepts pigeon (Poole & Lander, 1971), same/different (Malott & Malott, 1970; Malott, Malott, Svinicki, & Ponicki, 1971), and small versus large differences on a wavelength continuum (Honig, 1965). The fact that pigeons are capable of concept-like behavior suggests that it may be something about how pigeons acquire matching-to-sample that may prevent them from demonstrating concept-like behavior in the matching-to-sample task.

The Stimulus-Response Chains Model

The most prevalent finding is that the pigeon's behavior during the transfer task conforms to the performance predicted by the multiple-rule or stimulus-response chains model for matching-to-sample. More specifically, S+ rules appear to describe the pigeon's primary mode of responding on matching-to-sample (Carter & Werner, 1978).

Cumming and Berryman (1961) reported that after pigeons had acquired 3-hue simultaneous matching, a novel yellow hue was substituted for the original blue hue in all trials during one session. During this session pigeons reverted to a position preference whenever the ST was yellow, resulting in chance performance. Cumming and Berryman did not report data on the birds' performance on specific trials.

Cumming and Berryman (1965) analyzed data from the performance of pigeons on various matching tasks (e.g., matching, oddity, symbolic matching, delay matching, etc.). Their results indicated that the ST appeared to have an instructional or selective function. They stated that their results implied the use of stimulus-response chains in acquiring a matching discrimination.

Farthing and Opuda (1974) conducted a study which clearly shows the effect of novel stimuli on pigeons' behavior in matching-to-sample. They found that when a novel stimulus was

substituted for the incorrect CO there was no effect on matching performance; this was true whether the novel stimulus was intradimensional or interdimensional to the one trained. On trials where the novel stimulus was the ST the pigeons responded at chance levels. This occurred even when birds received exposure to the novel stimulus prior to its use in the matching task. Farthing and Opuda's results support the stimulus-response chains model for S+ rules rather than a configurational or single-rule model.

Carter and Werner (1978) present convincing data that pigeons' behavior conforms to a stimulus-response chains model in matching-to-sample and provides evidence for S+ rules. They compared the rate of acquisition of 2-hue and 3-hue matching as well as 3-hue matching and 3-hue oddity. Rate of acquisition was found to be directly related to the number of S+ rules to be learned. That is, 3-hue oddity took twice as long to acquire when compared to 3-hue matching because in the oddity situation there are six S+ rules to be learned versus the matching situation where there are only three S+ rules to be learned (Table 1).

Clearly then, pigeons' behavior in matching-to-sample conforms to the use of multiple S+ rules. Pigeons learn to regard the ST as an instructional stimulus guiding their response. An S+ rule is learned for each stimulus that may be presented as the ST, prior to demonstrating accurate matching.

Studies Supporting The Single-Rule Model

The studies that support a single-rule or conceptual model for the performance of pigeons in matching are fewer and open to more criticism. Zentall and Hogan (1974, 1976) present evidence that they consider is indicative that pigeons learn a same/different concept. Zentall and Hogan (1974) trained pigeons on a 2-hue simultaneous matching or oddity procedure to acquisition and then transferred half the birds from each group to the other task (e.g., matching to oddity) while presenting all birds with two novel stimuli. They found that nonshifted (matching to matching) birds performed more accurately then shifted birds (matching to oddity) over the first five transfer sessions. They then repeated the manipulation using brightness values as training stimuli and hues as transfer stimuli. They obtained similar results. In their discussion Zentall and Hogan supported a stimulus-response chains model of acquisition but also stated they had demonstrated concept learning as indicated by the superior performance of the nonshifted birds during the second task.

Zentall and Hogan (1976) essentially replicated their earlier study using geometric forms during training and hues during transfer. They again obtained similar results but stated that their results indicated that the pigeons had shown evidence of learning the relations same, different, or both with the new stimuli.

Carter (1976) in a reply to Zentall and Hogan (1976) criticized their work on three points: Zentall and Hogan's birds did not demonstrate above chance performance during the first transfer session. Their data indicate negative rather than positive transfer. Zentall and Hogan failed to include proper control groups (e.g., subjects trained with hues initially). Carter's first two criticisms apply equally to the 1974 and 1976 papers by Zentall and Hogan. What Zentall and Hogan (1974, 1976) appear to have demonstrated is something similar to the acquisition of a learning set (Harlow, 1949; Levine, 1965). Also, with repeated reversals of a discrimination the rate of acquisition increases with each reversal (French, 1965).

Zentall and Hogan (1978) presented the results of a study where concept-like behavior was demonstrated by pigeons. In this study, based on a factorial design, some pigeons were trained on 2-hue matching, others on 2-hue oddity. Half the birds from each group were presented with negative instance trials. A negative instance was a trial during matching training where the subject was presented with an ST and then two COs that did not match the ST. For oddity training, a negative instance consisted of a trial where the two CO's both matched the ST. After some birds received negative instances, half from each group were shifted to the other procedure (matching to oddity) with two new stimuli. Once the new discrimination had been acquired, all birds were given negative instance training. In turn, this was followed by half the birds receiving adaptation training which

consisted of single stimulus presentations of novel hues interspersed among regular trials. This was followed by half of each group being shifted to a new task and all receiving two novel stimuli. During this last phase, three of the nonshifted birds attained above 90% accuracy with the novel stimuli on the first session.

Zentall and Hogan (1978) concluded that this result demonstrated concept learning of same/different, but they stated the following: "...sample-specific rules or response chains play a major role in matching and oddity learning, and the assessment and comparison of same/different concept learning must be done under conditions that clearly separate the sample-specific learning from the concept learning."(p.186)

From Zentall and Hogan's (1978) results it is difficult to differentiate what factors had a major effect in the demonstration of concept-like performance. Of the three birds that demonstrated clear concept-like behavior one had received the initial shifting of tasks, the others had not. One bird received the initial phase with negative instances. Two had received adaptation training before receiving nonshifted transfer during the final phase. It is difficult therefore to factor out the necessary and/or sufficient conditions for developing concept-like performance, other than nonshifted task transfer in the final phase.

Urcuioli and Nevin (1975) demonstrated behavior in the pigeon that appeared to conform to the single-rule model. Their procedure was a variation on 3-hue simultaneous matching-to-sample. A 3-key operant chamber was utilized during matching, but, after the subject had made an observing response to the ST, only one of the CO keys, with a hue stimulus, was presented. If the CO matched the ST then a response to the CO led to reinforcement. If the CO did not match, the subject was required to wait 4.8 seconds without pecking the CO before entering an ITI. Pecks to the incorrect CO reset the 4.8 second interval. Urcuioli and Nevin's procedure essentially trained their birds to withold responding to an incorrect CO. After acquisition, they conducted four transfer tests in which a novel hue was substituted for different original hues. They found that response latencies were shortest on matching trials with novel stimuli and were equally as short as the matching latencies with the original training stimuli. During transfer, latencies for nonmatching trials were longer than for matching trials and increased as a function of the separation between the nonmatching hues along the wavelength continuum. Urcuioli and Nevin considered that this procedure demonstrated conceptual behavior because the birds' performance during transfer was the same as that during matching training. They stated that conceptual behavior occurred as a result of explicitly training the pigeons not to peck nonmatching hues.

Variables Common To The Demonstration
Of Concept-Like Behavior

It is clear that pigeons' behavior in matching conforms to that
predicted by the stimulus-response chains model, specifically multiple
S+ rules (Carter & Werner, 1978; Farthing & Opuda, 1974), and that
pigeons do not clearly exhibit behavior in matching predicted by the
single-rule model (Cumming & Berryman, 1961, 1965; Farthing & Opuda,
1974). In some instances, though, pigeons do appear to form concepts
in matching-to-sample (Urcuioli & Nevin, 1975; Zentall & Hogan, 1978).
Logically, it would appear that learning both positive (S+ rules) and
negative (S- rules) instances of a concept would be a prerequisite to
demonstrating concept-like behavior. With humans, conceptual behavior
is acquired more readily from positive rather than negative instances
(Smoke, 1933). However, Bourne and Guy (1968) have indicated that
with humans in a rule-learning task a mixed sequence of presentation,
both positive and negative instances, was consistently superior to
either type of instance presented individually. It has been suggested
that these conflicting findings are the result of the level of
inferential strategies involved with the positive and negative
instances (Bourne & Dominowski, 1972). With humans, positive,
negative, and mixed instances of equal inferential complexity have not
been compared (Zentall & Hogan, 1978), thus making predictions to
studies of pigeons matching unsound. The findings do suggest,
however, that both positive and negative instances play a role in
concept learning.

More recently, studies on symbolic matching with humans have demonstrated that both S+ and S- rules are utilized in acquiring a conditional discrimination (Dixon & Dixon, 1978; Stromer & Osborne, 1982). Dixon and Dixon's (1978) procedure exemplifies the methodology of studies demonstrating the use of S- rules by humans. They trained normal, preschool-aged children on a symbolic matching task using two sets of geometric forms as stimuli. After acquisition, a novel CO was substituted in place of the previously correct CO, while the original ST remained unchanged. During these trials subjects consistently responded away from the previously incorrect CO and toward the novel, also incorrect CO. (Subsequent experiments ruled out the possibility of stimulus novelty controlling responding.) The subject's behavior conformed to the S- rule in that the ST served to inform them which stimulus to avoid.

Stromer and Osborne (1982) extended Dixon and Dixon's (1978) results. Stromer and Osborne trained mentally retarded adolescents on a symbolic matching task using geometric forms. They then conducted nine tests involving stimulus equivalences (A-B matching to B-A matching) with novel stimuli presented in various configurations with the original stimuli. Stromer and Osborne's data indicated that subjects learned complimentary sets of S+ and S- rules. These rules were evident in the A-B configurations or the equivalent B-A stimulus configurations.

The symbolic matching studies with humans imply that concept-like behavior is demonstrated as a result of learning concurrent S+ and S- rules. This implies that a conceptual discrimination is the result of learning two rules. Humans appear to learn the rules governing the correct choice in a discrimination as well as those governing an incorrect choice. Intuitively, as well as experimentally, this appears reasonable. When teaching a young child the concept dog, one must indicate instances of dog and instances of not dog. In writing an objective definition for use in an applied behavioral program nonexamples of the behavior are frequently cited as well as examples of the behavior (Ascione, 1977). Logically then it would appear that the demonstration of conceptual behavior by any organism would be presaged by the learning of positive instances of the discrimination, evidenced as S+ rules, and negative instances of the discrimination, evidenced as S- rules. Similarly, for a pigeon to demonstrate concept-like behavior in matching-to-sample it would appear necessary to develop S+ and S- rules as a prerequisite. Perhaps by examining the studies where concept-like behavior by pigeons was obtained some procedural similarities can be observed that will substantiate this inference.

In the procedure used by Urcuioli and Nevin (1975) the pigeons were explicitly trained not to peck nonmatching hues. This technique could force the pigeons to develop S- rules. This training may be responsible for pigeons learning both S+ and S- rules and thus

evidencing concept-like behavior in matching-to-sample.

Urcuioli (1977) conducted a study using the same training procedure as Urcuioli and Nevin (1975) but with an oddity discrimination. The use of this procedure again led to the development of concept-like behavior for the concept, different. This result provides more support for Urcuioli and Nevin's suggestion that explicit training not to peck the negative instance leads to concept-like behavior in the pigeon.

Zentall and Hogan (1978) presented all subjects with negative instance trials. They did not impose a contingency on their negative instances. The negative instance display remained on until three seconds had elapsed or until a response was made, resulting in an ITI. This procedure, therefore, could also have had the effect of exposing the pigeons to trials that aided in the development of S- rules and later resulted in the demonstration of concept-like behavior.

It is apparent from examining the factors common to studies of matching that demonstrated concept-like performance (Urcuioli, 1977; Urcuioli & Nevin, 1975; Zentall & Hogan, 1978) that all involved the explicit presentation of negative instances. That is, trials that illustrated a noninstance of the concept. These observations, and the data demonstrating the use of both S+ and S- rules in human matching behavior, strongly suggest that explicit training of both S+ and S- rules should lead to the demonstration of concept-like behavior in

pigeon matching-to-sample.

Development Of S- Rules

As it appears necessary to develop both S+ and S- rules in order to demonstrate concept-like behavior, a procedure to accomplish this must be developed. There are a number of ways in which this could be accomplished. One method would be to simply present the pigeon with negative instances as done by Zentall and Hogan (1978). This procedure is deficient in that it does not require the subject to explicitly not respond to the negative instance. The presentation of a negative instance without a contingency may not aid in developing S-rules because the pigeon is not required to attend or avoid the negative instance display. Zentall and Hogan's data do not permit conclusions to be drawn regarding any definite effect of the presentation of a negative instance alone.

Another procedure that has been demonstrated to aid in the development of S- rules is training pigeons to withold responses to negative instances (Urcuioli, 1977; Urcuioli & Nevin, 1975). In this procedure, when presented with a negative instance the pigeon must withhold responding for a certain period of time before entering an ITI. Responses to the negative instance reset the delay period, increasing the time before entering the ITI and increasing the time between reinforcements. This procedure resulted in the demonstration

of positive transfer to novel, positive instances of the discrimination but the results of positive transfer to novel, negative instances was less conclusive. Pigeons frequently responded during negative instance trials regardless of the contingency. Also, latency of response to novel negative instance trials was related to the separation between the novel hue and the original hue along the wavelength continuum. For example, when the novel hue differed little from the original hue on the continuum, response latencies were equivalent during transfer. If the novel hue differed greatly from the original hue in the continuum, response latencies were shorter than training latencies during transfer. These factors tended to confound a clear demonstration of concept-like behavior.

The use of a correction procedure, which is not typically seen in the pigeon matching-to-sample literature (Carter & Werner, 1978), may facilitate the development of S- rules. Responding to the negative instance is, in effect, punished by forcing reexposure to the same configuration until a correct response occurs. A similar procedure would be the direct punishment, by contingent aversive stimulation, of responses to the negative instance. With these procedures the possibility of developing S- rules is present, but, conversely, these procedures may only develop S+ rules at a quicker rate. The efficacy of these procedures cannot be predicted in advance and research in matching-to-sample providing support for them is lacking.

Autoshaping (Brown & Jenkins, 1968), prior to matching-to-sample training, could be another method of developing S- rules. Mackintosh (1974) has suggested that components of classical conditioning play a role in visual discriminations. Bauer and Lawrence (1954) demonstrated that classical conditioning played a role in a simultaneous T-maze discrimination with rats. Autoshaping, which combines components of classical and operant conditioning, may be a parsimonious method for developing S- rules in pigeons. A study by Looney, Cohen, Brady, and Cohen (1977) provides support for this contention. In their procedure pigeons were trained on a differential autoshaping procedure in which both components of two-stimulus sequences predicted delivery or nondelivery of food. The first stimulus of the sequence was either a red or green stimulus presented on a response key. The second stimulus was either a vertical or horizontal line presented on the same response key. Using this procedure the pigeons' rate of key pecking to the second stimulus of the sequence showed the differential responding characteristic of conditional discrimination performance. That is, more responding to positive instances, the horizontal line paired with green and vertical line paired with red, and less responding to negative instances, the vertical line with the green and the horizontal line with red. This research demonstrated that a response requirement was not necessary to generate conditional discrimination behavior with pigeons. Looney et al. suggested that a classical conditioning procedure can generate behavior similar to that found in an operantly trained conditional

discrimination.

In fact, prior autoshaping of identity (positive instances) and nonidentity (negative instances) trials has been demonstrated to result in faster acquisition of matching-to-sample with pigeons when compared to autoshaping of identity or nonidentity trials alone (Lubeck, 1982). This finding indicates that the effects of autoshaping on the development of S- rules warrants further study.

Effect Of Prior Autoshaping On Matching

Lubeck (1982) conducted a study where pigeons were exposed to various autoshaping procedures before being trained on a matching-to-sample task. Lubeck exposed some birds to 500 identity trials where reinforcement was explicitly paired with the matching stimuli. That is, the ST was presented and briefly following that the matching, identical, CO was presented. This configuration was followed by access to food regardless of the bird's behavior. Another group was exposed to 500 nonidentity trials where reinforcement was never paired with the stimuli, that is, was explicitly unpaired (Rescorla, 1967). This is similar to the above example except that a nonmatching CO followed the ST and access to food occurred in the middle of the ITI. A third group received 250 nonidentity trials explicitly unpaired with reinforcement and 250 identity trials explicitly paired with reinforcement. Other control groups were run

but their results were not significant and will not aid the present
discussion.

After transferring these birds to a matching-to-sample task, with
the same stimuli, Lubeck found significantly faster acquisition by the
group that had received the combination of the identity trials
explicitly paired with reinforcement and nonidentity trials explicitly
unpaired with reinforcement. The other groups acquired the matching
task at similar but slower rates. Lubeck did not conduct any probes
with novel stimuli and the question of what effect this prior training
had on the control by individual stimuli in the matching-to-sample
task was not answered.

It could be predicted that the prior autoshaping with identity
and nonidentity trials had the effect of facilitating the rapid
development of S+ and S- rules during matching, which led to faster
acquisition of matching-to-sample. If this were the case then
appropriate tests (Dixon & Dixon, 1978; Farthing & Opuda, 1974) may
demonstrate the acquisition of concept-like behavior or, at least,
behavior predictive of S- rules.

STATEMENT OF PROBLEM

Pigeons have demonstrated the ability to form concept-like discriminations (Herrnstein & Loveland, 1964; Malott & Malott, 1970; Malott et al., 1971; Poole & Lander, 1971; Siegel & Honig, 1970). In matching-to-sample pigeons typically do not demonstrate concept-like performance (Carter & Werner, 1978; Cumming & Berryman, 1965; Farthing & Opuda, 1974). Studies indicate that pigeons' behavior conforms to a multiple-rule model based on positive instances (S+ rules) when acquiring a matching-to-sample discrimination (Carter & Werner, 1978; Farthing & Opuda, 1974). Conversely, humans acquire a symbolic matching discrimination utilizing both positive (S+) and negative (S-) rules (Dixon & Dixon, 1978; Stromer & Osborne, 1982). The most parsimonious contention is that the typical procedure by which matching-to-sample is trained in pigeons does not allow for the development of S- rules, which may lead to the demonstration of concept-like behavior by pigeons. This contention is supported by matching-to-sample studies (Urcuioli, 1977; Urcuioli & Nevin, 1975; Zentall & Hogan, 1978) where attempts were made to develop S- rules and the pigeons' behavior during transfer tests was concept-like. The purpose of the present study was to develop behavior by the pigeon illustrative of S+ and S- rule usage and to examine if behavior consistent with a concept rule interpretation developed. This purpose was accomplished by preceding matching-to-sample training with

autoshaping of explicitly paired or explicitly unpaired food
presentation conditions, factored into identity and nonidentity
stimulus conditions (Lubeck, 1982). Rule behavior was assessed during
transfer tests with a novel hue, after acquiring matching-to-sample,
according to procedures developed by Farthing and Opuda (1974) and
Dixon and Dixon (1978).

METHODOLOGY

Subjects

The subjects were 31 locally obtained (Cache County, Utah) barn
pigeons. Twenty-eight of the pigeons had served as control subjects
in a poison based avoidance learning study (Pounds, 1982). None of
these subjects had been exposed to avoidance learning trials where
color was used as the stimulus averted to. The remaining three
pigeons were experimentally naive. Pigeons were maintained at 80% of
their free feeding weight using Purina Pigeon Checkers, which also
served as the reinforcer. Water was freely available in the home
cage.

Apparatus

The experimental chamber (29 cm high by 29 cm long by 25 cm wide)
was located in a sound and light attenuating enclosed chamber.
Circulation was controlled by an exhaust fan (12 cm by 13.5 cm)
located in the upper left corner of the chamber. The intelligence
panel consisted of three identical pigeon response keys (2.5 cm in
diameter). The standard key (ST) was centered on the panel 9.5 cm
from the ceiling. The two comparison keys (COs) were located 5.5 cm
to either side of the ST. Directly below (8.8 cm) the ST was a 4.7 cm
by 5.0 cm opening for a food hopper. Located behind each key was an

Industrial Electronic Engineers (IEE) one plane readout projector.
Kodak Wratten filters, numbers 70, 72B, 74, and 75, provided the
experimental stimuli. These filters respectively represented hues of
predominant wavelengths, in nanometers (nm), of: 678, 605.7, 538, and
490.5. Luminosity was controlled for by daily, random alternation of
the white light sources (6.3V, 15A light bulbs). All equipment was
controlled using a PDP 8/L computer (Digital Equipment Corporation)
with SKED programming (State Systems). Chamber illumination was
provided by a shielded houselight (6.3V, 15A) located in the center of
the intelligence panel, one cm below the ceiling.

Design

The research consisted of six experimental groups of five
subjects each, although one group contained six subjects. Subjects
were randomly assigned to groups. Subjects in five groups were given
five phases of training called: hopper training, single stimulus food
training, group specific training, matching-to-sample training, and
transfer. One group served as a control group and received all phases
except group specific training. The description of hopper training,
single stimulus food training, matching-to-sample training, and
transfer to be described applies to all groups.

One group, Group 5, contained six subjects. An extra subject was
included in this group because one of the original five subjects did

not appear as though it would reach the matching-to-sample criterion to begin transfer testing. To be able to provide transfer probe data on five birds, an extra pigeon was added to this group. The inclusion of the sixth pigeon was unnecessary, as all birds attained the matching-to-sample criterion. The sixth bird's data were utilized in all analyses.

Procedures

Hopper training. Subjects were placed in the experimental chamber with the houselight illuminated. The hopper was raised and full of food. The subject was allowed to feed from the hopper for a total of 10 seconds. Following this the hopper was lowered and immediately raised. Subjects were then allowed to feed for 3 seconds. The length of time the hopper remained raised for all subsequent hopper presentations remained fixed at 3 seconds. The hopperlight was only illuminated when the hopper was raised. The presentation time between each hopper access period was gradually increased in 10-second increments until the inter-food period was 90 seconds. The subjects were exposed to three 90-second inter-food intervals, following which the next phase of training began on the next session.

Single stimulus food training. Sessions began with the onset of the houselight and initiated a 90-second inter-trial interval (ITI). Following the ITI, either the 678, 538, or 490.5 nm stimulus (training

hues) was illuminated on the ST. Choice of hue stimulus was randomly determined. The ST remained illuminated for 3 seconds and was immediately followed by the raised hopper. The ITI began when the hopper was lowered. A session consisted of 60 stimulus-hopper pairings. No response contingency was in effect during these sessions. The number of trials with at least one key peck during the stimulus illumination and the total number of pecks were recorded. Single stimulus food training was terminated when the subject responded with a minimum of one key peck to at least half the trials presented during a session. Subjects were then given training specific to their group placement, followed by matching-to-sample training and transfer.

Parameters of group specific training. The following parameters remained constant for each subject during group specific training. Group 6 was the only exception to this, in that Group 6 served as a control group and did not receive any group specific training per se. Sessions began with the houselight onset and a 90-second ITI. The ITI was followed by the illumination of the ST by one of the training hues. The ST remained illuminated for 3 seconds. After 3 seconds one of the COs was illuminated for 6 seconds. The ST remained illuminated during this time. The hue of the CO was group dependent. During group specific training no response-reinforcement contingency was in effect.

During this phase each subject's responses to the ST when presented individually and responses to ST and COs during the simultaneous presentation of stimuli were recorded. In addition, the ITI was divided into 45-second segments and responses during the first and last part of each ITI were recorded.

Group 1: Identity, explicitly paired (IEP). Throughout, each group is identified first by the relation between the ST and CO, and then by the relation between the stimuli and food presentation.

For this group, the hue of the CO simultaneously presented with the ST was the same as that of the ST. This defines the identity condition. The position of the CO was randomly determined on each trial. Termination of the stimuli was immediately followed by the raised hopper and the ITI. Sessions consisted of 60 explicit pairings of the identity stimulus sequence with hopper access. Subjects in this group received 300 identity stimulus sequences explicitly paired with food (5 sessions), followed by matching-to-sample training.

Group 2: Nonidentity, explicitly unpaired (NEU). The subjects in this group were exposed to autoshaped nonidentity stimulus sequences explicitly unpaired with reinforcement (Rescorla, 1967). With this group the hue of the CO was different from that of the ST. This sequence defines the nonidentity condition. The position and hue of the CO was randomly determined on each trial. The termination of the stimuli presented was followed by the ITI. The raised hopper was

presented during the 45th second of the ITI. The first hopper presentation occurred during the second ITI of a session. Subjects in this group were exposed to 300 nonidentity stimulus sequence presentations explicitly unpaired with the raised hopper (5 sessions).

Group 3: Identity, explicitly paired and nonidentity, explicitly, unpaired (IEPNEU). Subjects in this group were exposed to both the identity stimulus sequence and nonidentity stimulus sequence via autoshaping. This group was essentially a combination of Groups 1 and 2. Subjects in this group were exposed on half the trials during a session to a CO of the identical hue to the one presented on the ST (identity stimulus sequence). The termination of this sequence was followed by the raising of the hopper and the ITI. On the remaining trials, the CO did not match the hue on the ST (nonidentity stimulus sequence). For this sequence, termination of the stimuli was followed by the ITI with the hopper being raised on the 45th second of the ITI. The position and hue of the stimulus on the CO in the nonidentity stimulus sequence was randomly determined for each trial. Sessions consisted of 30 identity stimulus sequences explicitly paired with the raised hopper, and 30 nonidentity stimulus sequences explicitly unpaired with the raised hopper. Type of sequence presented was randomly determined. These sessions terminated after the session with the 300th identity stimulus sequence and 300th nonidentity stimulus sequence.

Group 4: Identity, explicitly paired - 600 (IEP600). Because
training in Group 3 involved exposure to 600 stimulus sequences and
600 exposures to the raised hopper, it was necessary to include a
group trained with 600 identity stimulus sequences explicitly paired
with the raised hopper to control for the number of stimulus sequences
and the number of reinforcers the subjects were exposed to. This
group received training identical to Group 1, except that subjects in
this group were exposed to 10 sessions of the identity stimulus
sequence explicitly paired with the raised hopper.

Group 5: Nonidentity, explicitly unpaired - 600 (NEU600). As a
result of Group 3's exposure to 600 stimulus sequences it was
necessary to include a group receiving nonidentity stimulus sequences
for an equal number of exposures. This group was identical to Group
2, except that this group received 10 sessions of nonidentity stimulus
sequences explicitly unpaired with the raised hopper.

Group 6: Control. Subjects in this group were not exposed to
stimulus sequences of any kind. This group progressed directly from
single stimulus food training to matching-to-sample training.

Matching-to-sample training. Following group specific training,
all subjects received training in simultaneous 3-hue
matching-to-sample. The same hues served as stimuli. Sessions began
with the houselight onset and a 15-second ITI. The ITI remained at
this value through this and following phases. When the ITI

terminated, the ST was illuminated. A single response to the ST illuminated the COs; the ST remained visible and accessible. One of the COs matched the ST (identity). The other CO was different than the ST (nonidentity). Hues utilized as STs and COs were randomly determined. Position of matching and nonmatching COs were also randomly determined. A response to the matching CO resulted in the presentation of the raised hopper, followed by the ITI. A response to the nonmatching CO resulted in the ITI. Responses to the ST, during presentation of the COs, had no scheduled effect.

Initially, subjects were placed on a continuous reinforcement schedule (CRF) for access to the raised hopper (reinforcer) for responding to the matching CO. The CRF schedule remained in effect until a subject responded to the matching CO on 80% or more of the trials presented for two consecutive sessions. After meeting this criterion a subject was placed on a random ratio schedule where reinforcement occurred at a probability of 0.50 (RR2) for each response to the matching CO. Again, a criterion of responding to the matching CO on 80% or more of the trials presented for two consecutive sessions was in effect. Upon reaching this criterion the random ratio schedule was increased such that reinforcement occurred at a probability of 0.33 (RR3) for each response to the matching CO. This schedule remained in effect throughout this phase and for transfer sessions.

Each matching-to-sample training session consisted of 60 responses to the matching CO followed by the reinforcer. Responses to matching and nonmatching COs and number of responses to the ST were recorded.

Matching-to-sample training was terminated when a subject performed at or above 90% accuracy for responding to the matching CO on three consecutive sessions. To facilitate transfer testing a secondary criterion was established for terminating matching-to-sample training. This secondary criterion was defined as ten sessions where responding to the matching CO averaged at least 80%, after the subject initially attained 80% accuracy on the RR3 schedule where the range of correct responding was no greater than 12%. A criterion to determine termination of matching-to-sample training was included to insure high (and equal) rates of performance on the matching-to-sample discrimination prior to transfer testing. Both the primary and secondary criteria met this goal.

It should be noted that this procedure was not followed exactly in the case of one subject in the IEP group. Due to experimenter error this subject was exposed to one session of IEP group specific training after receiving one session of matching-to-sample training on the RR3 schedule. This event appeared to have no effect on the subject's performance during later sessions.

Transfer. Three types of transfer were assessed. Each type of transfer was assessed during 30 trials of a session over the course of three sessions. The type of transfer assessed was randomly determined for each of the three transfer sessions, with each type of transfer test conducted for only a single session. Within each group, an exclusion process was utilized with the randomization process, such that each group member did not have the same type of test during the first session, same type of test during the second session, etc. This was done to control for possible order effects occurring while assessing transfer.

No consequences were provided during transfer trials. To equate for total number of trials each subject was exposed to, when compared to matching-to-sample training, the number of raised hopper presentations for responses to the matching CO was reduced from 60 to 50. Placement of transfer trials within a session was randomly determined. The 605.7 nm hue served as the transfer stimulus. The transfer stimulus was presented for each of the training stimuli, in a randomly determined manner, during each session of this phase according to the placement described below. Therefore, the transfer stimulus was substituted for each training stimulus on 10 trials, to equal a total of 30 trials.

To test for S+ rules pigeons were presented with a training hue on the ST and on one CO. The transfer hue was presented on the other

TABLE 3

Stimulus Configurations for the Assessment of Transfer.
The Types of Transfer are: Concept Rule, S+ Rules, S- Rules.

Concept	S+ rules	S- rules
O(O*,R)	R(R*,O)	R(O*,G)
O(O*,G)	G(G*,O)	R(O*,B)
O(O*,B)	B(B*,O)	G(O*,R)
		G(O*,B)
		B(O*,R)
		B(O*,G)

Key: R=678 nm stimulus, O=605.7 nm stimulus, G=538 nm stimulus, and B=490.5 nm stimulus.

CO. Pigeons following S+ rules should respond to the matching CO without attending to the incorrect CO when, according to this model, the latter is not used as an informational stimulus. To determine if the pigeons' behavior conforms to an S- rule a training hue was presented on the ST with the choice of COs being another, nonmatching training hue and the transfer hue. In this case the response evidencing the S- rule is to the transfer hue. Responding in this manner indicates that the pigeon has learned what to avoid in the matching-to-sample discrimination. To test for a concept rule pigeons were presented with the transfer hue on the ST and on one of the COs, the other CO was illuminated by a training hue. To demonstrate a concept rule responding must occur to the CO with the transfer stimulus on it (see Table 3 for transfer test configurations).

During all transfer sessions the specific stimulus array presented and CO responded to were recorded. Also, accuracy of the

subject's performance to nontransfer matching-to-sample trials was recorded.

RESULTS

Single Stimulus Food Training

Each subject was exposed to the center key illuminated by one of the training hues, explicitly paired with the raised hopper, until a key peck occurred to 50% or more trials in one session (i.e., at least 30 trials responded to). All subjects met this criterion within six sessions: one subject required 6 sessions, one subject required 4 sessions, four subjects required 3 sessions, six subjects required 2 sessions, and nineteen subjects required only one session. The average number of trials to the first key peck was 39.5, with a range of 1 to 302 trials. Utilizing a criterion for reliable autoshaping of 3 consecutive trials with a response, subjects required an average of 49.2 trials, with a range of 5 to 307 trials, before attaining reliable autoshaping. An analysis of variance, one way classification (Hinkle, Wiersma, & Jurs, 1979), revealed that there was no significant difference among groups in the number of trials to reliable autoshaping ($\underline{F}[5,30]=0.97$, $\underline{p}>.05$).

The single stimulus food training data for each subject are presented in Table 7 of the Appendix. This table contains the trial numbers on which the first response occurred, the number of trials until reliable autoshaping was established, and the number of sessions.

Group Specific Training

All subjects, except those in the control group, were exposed to a type of group specific training. Two groups received identity trials explicitly paired with the raised food hopper; one group for 300 trials (IEP) and the other group for 600 trials (IEP600). Two groups received nonidentity trials explicitly unpaired with the food hopper; one group for 300 trials (NEU) and one group for 600 trials (NEU600). One group (IEPNEU) received a combination of the identity, explicitly paired and nonidentity, explicitly unpaired stimulus sequences for 300 trials of each type, for a total of 600 trials. For each group, trials were examined for responses occurring to the standard (ST) and the comparisons (COs) under the following categories: trials with responses to the ST when only the ST was illuminated (ST alone), trials with responses to the ST when both the ST and CO were illuminated (ST with CO), and trials with responses to the illuminated CO. For the IEPNEU group these variables were examined under both types of trials. The dependent variable for group specific training was trials in which one or more responses occurred to the key in the category under examination. This measure is more appropriate than rate of responding, which has been shown to be widely variable across subjects (Lubeck, 1982, p.42).

Identity, explicitly paired. Both groups that received identity trials explicitly paired with the raised food hopper are examined together. The mean number of trials with one or more responses is presented by session for the IEP and IEP600 groups in Table 4 and Figures 1 through 3. (See Table 8 of the Appendix for individual subject data.) Data are presented in terms of the foregoing catagories. Subjects' responding, in both groups, occurred almost exclusively to the ST; minimal responding occurred to the CO. This preferential responding occurred to the ST when presented alone and also to the ST when presented with the illluminated CO. For example, during the simultaneous presentation of ST and CO the response preference for the ST over the CO occurred at a ratio of 7.7 to 1 for trials with one or more responses, for the IEP group, and at a ratio of 17.6 to 1 for the IEP600 group.

Subjects in the IEP group responded to a mean of 56.7 trials (standard deviation of 2.4 trials), across sessions, when the ST was illuminated alone. (Each session consisted of 60 trials.) For responses to the ST, when the CO was illuminated simultaneously, subjects responded to a mean of 57.4 trials across sessions (standard deviation of 2.1 trials). In the IEP600 group the results were very similar (Figures 1 and 2). Subjects responded to the ST on a mean of 58.8 trials (standard deviation of 1.7 trials) when the ST was illuminated alone and on 59.3 trials (standard deviation of 0.8 trials) when the ST and CO were illuminated simultaneously.

For responses to the CO, when the ST and CO were illuminated simultaneously, subjects in the IEP group responded to a mean of 7.4 trials across sessions (standard deviation of 4.4 trials). Subjects in the IEP600 group responded to the CO stimulus at a mean of 3.4 (standard deviation of 2.0 trials) trials (Figure 4).

Nonidentity, explicitly unpaired. The NEU and NEU600 groups are considered together. Table 4 and Figures 1 through 3 present the data for these groups in terms of mean number of trials with one or more responses by session. Individual subject data are presented in Table 8 of the Appendix. Again, data are partitioned into the previously described categories. Subjects in these two groups performed similarly across sessions and by categories. During the first session of training, responding within each category was the highest of any session for both groups (Table 4). The number of trials containing a response diminished considerably on the next session. Trials containing a response remained at low levels for the following sessions in all categories (Figures 1, 2, and 3).

Number of trials containing a response remained consistent by category across sessions for both groups. The mean and standard deviation, in the NEU group, for trials containing a response to the ST when presented alone was 4.0 and 6.8. For the ST when presented with the CO, these were 3.3 and 5.1, and for the CO these were 3.8 and 5.8 (Table 4).

In the NEU600 group the mean and standard deviation, across sessions, for responding to the ST when presented alone, to the ST when presented with the CO, and to the CO were, respectively: 2.2 and 5.0, 2.0 and 4.1, and 2.0 and 4.0 (Table 4).

TABLE 4

Mean Number of Trials with One or More Responses, by Session, for the IEP, IEP600, NEU, and NEU600 Groups.

Session	IEP A	B	C	Session	NEU A	B	C
1	53.0	55.4	14.8	1	16.2	12.4	14.2
2	56.4	57.6	7.4	2	1.5	0.5	1.2
3	59.4	59.8	7.0	3	1.4	1.8	1.3
4	57.8	59.0	3.8	4	0.4	0.6	1.2
5	56.8	55.0	4.2	5	0.6	1.0	0.3
Mean	56.7	57.4	7.4	Mean	4.0	3.3	3.3
SD	2.4	2.1	4.4	SD	6.8	5.1	5.3

	IEP600				NEU600		
1	55.0	58.5	7.8	1	16.5	13.7	13.3
2	60.0	60.0	3.0	2	1.2	0.5	0.5
3	56.6	57.6	5.6	3	0.5	1.0	0.6
4	59.6	59.6	2.8	4	0.5	1.0	1.7
5	60.0	58.8	3.0	5	0.5	0.8	2.0
6	59.0	59.2	2.0	6	0.3	0.7	0.5
7	60.0	60.0	1.0	7	1.0	1.3	0.2
8	59.0	60.0	3.2	8	0.7	0.5	0.5
9	59.4	60.0	1.6	9	0.0	0.2	0.2
10	59.4	59.4	3.6	10	0.7	0.3	0.2
Mean	58.8	59.3	3.4	Mean	2.2	2.0	2.0
SD	1.7	0.8	2.0	SD	5.0	4.1	4.0

Key: A=responses to the ST while only the ST was illuminated. B=responses to the ST while both the ST and CO were illuminated. C=responses to the illuminated CO. The maximum number of trials possible during a session, for each response category, was 60. SD=standard deviation.

Figure 1. Mean number of trials containing a response to the ST while only the ST was illuminated. Data for the IEP, IEP600, NEU, and NEU600 groups are presented. Sixty trials were presented per session.

Figure 2. Mean number of trials containing a response to the ST while both the ST and CO were illuminated. Data for the IEP, IEP600, NEU, and NEU600 groups are presented. Sixty trials were presented per session.
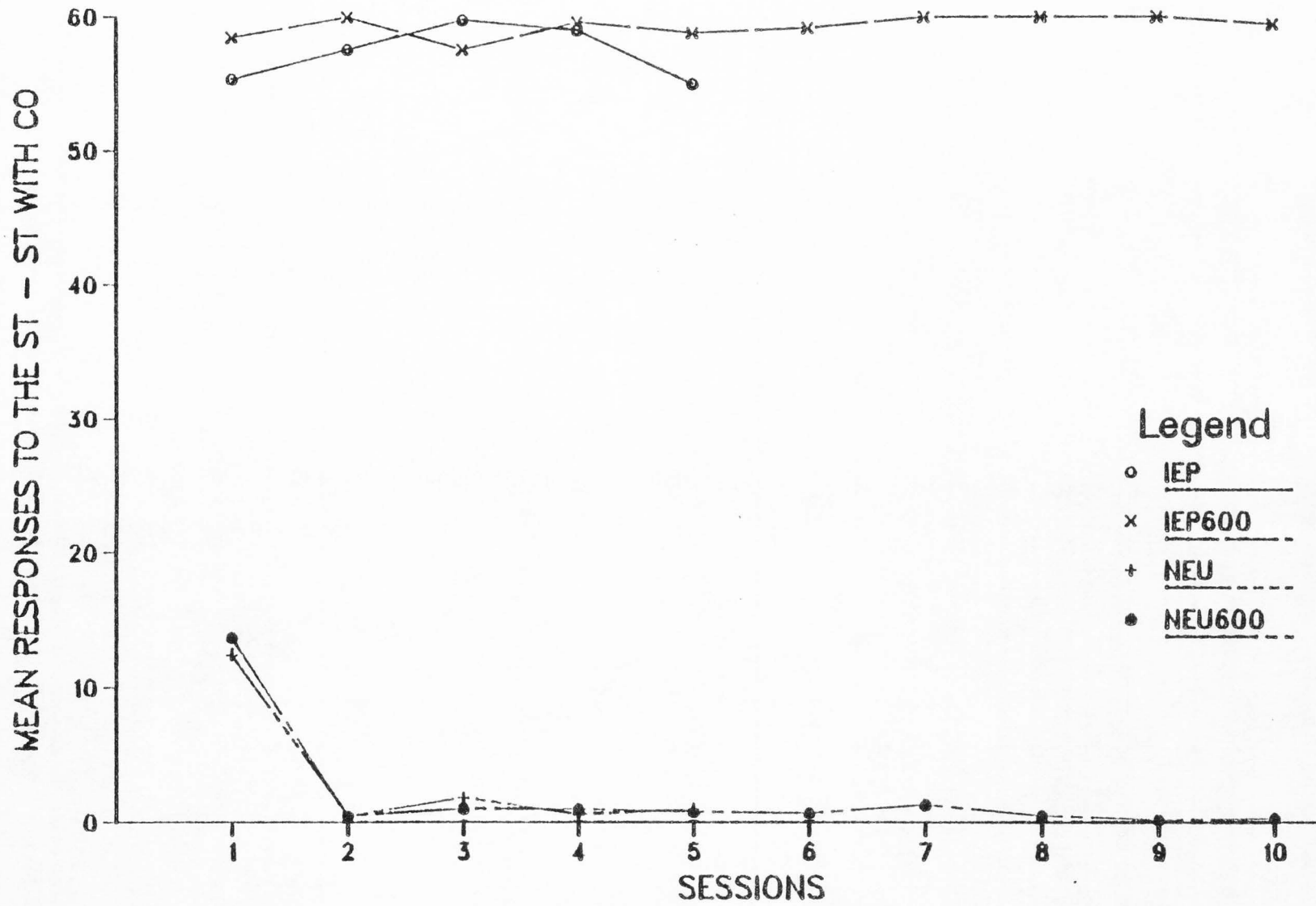
Figure 3. Mean number of trials containing a response to the illuminated CO. Data for the IEP, IEP600, NEU, and NEU600 groups are presented. Sixty trials were presented per session.
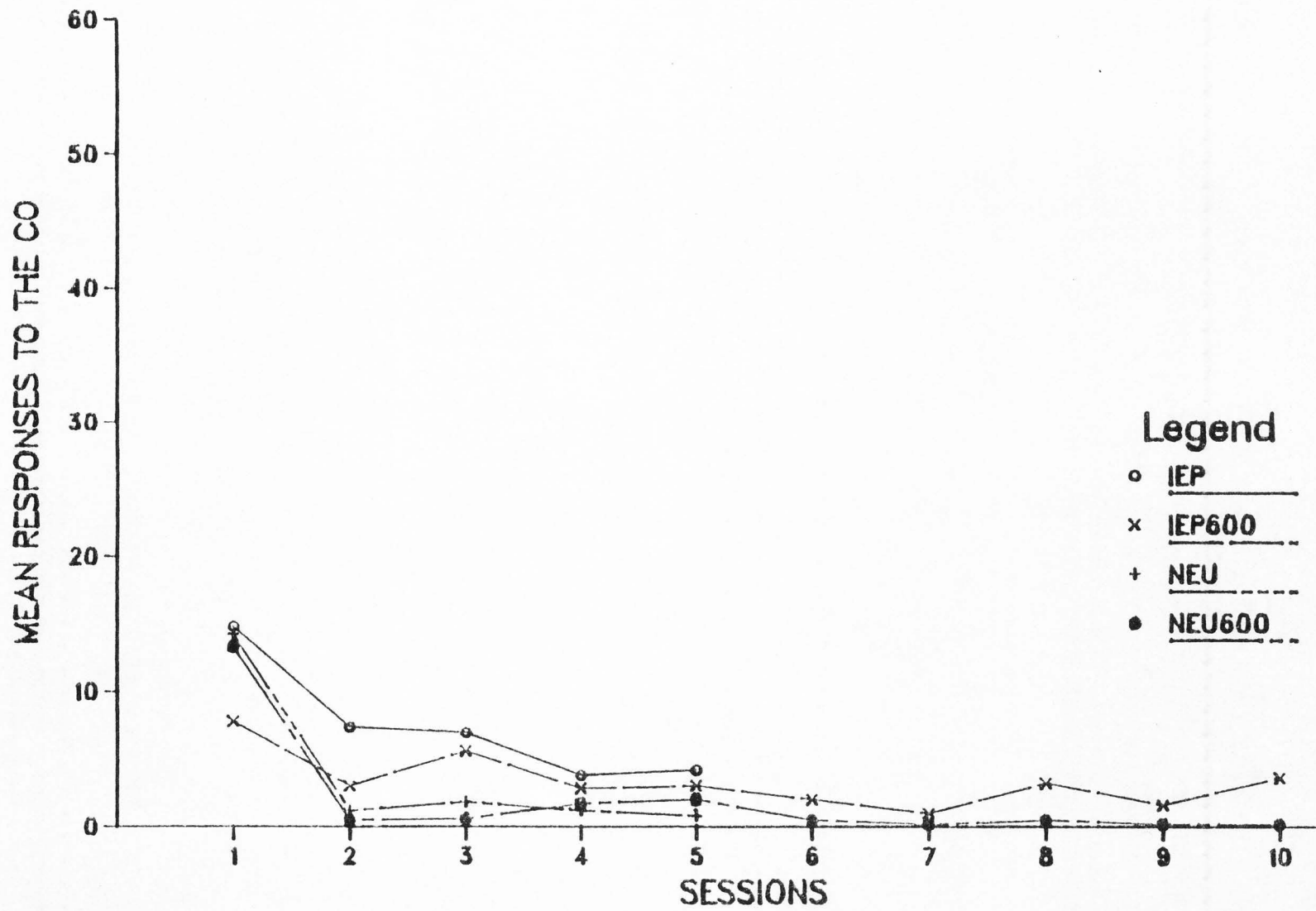
Identity, explicitly paired and nonidentity, explicitly unpaired.
Group specific training data for the IEPNEU group is presented in
Table 5 and Figures 4 through 6. Data are presented for response
categories by session in terms of mean number of trials with one or
more responses. Data for each type of trial (i.e., IEP trials and NEU
trials) are presented separately. Individual subject data are
presented in Table 9 of the Appendix. These data show that no
difference was found between subjects' responding on the two types of
trials. A t-test for dependent samples was conducted between trial
types for each reponse category. This analysis found no difference
between the subjects' trials containing a response to the ST when
presented alone ($t[9]=0.71$, $p>.05$), for responses to the ST when
presented simultaneously with the CO ($t[9]=-1.41$, $p>.05$), or for
responses to the CO ($t[9]=-1.47$, $p>.05$).

Subjects' performance in the IEPNEU group was most like that
exhibited by the IEP and IEP600 groups. All three groups were
characterized by the majority of responses occurring to the ST,
regardless whether the ST was presented alone or presented
simultaneously with the CO (Figures 4 and 5). Few responses occurred
to the CO at any time (Figure 6).

TABLE 5

Mean Number of Trials with One or More Responses,
by Session, for the IEPNEU Group.

Session	Identity explicitly paired trials			Nonidentity explicitly unpaired trials		
	A	B	C	A	B	C
1	23.2	24.0	4.6	24.2	24.4	6.2
2	28.2	23.0	3.6	27.4	23.0	5.0
3	27.4	27.4	2.4	28.0	28.0	2.4
4	28.4	28.0	2.3	28.4	28.4	2.6
5	27.8	28.2	2.3	28.4	29.0	3.2
6	28.2	28.4	2.4	26.6	26.6	2.6
7	27.0	27.6	2.2	29.2	29.6	1.3
8	25.6	27.6	1.6	26.4	28.2	1.3
9	26.4	28.4	1.4	27.6	28.8	1.4
10	28.2	29.2	1.0	29.2	29.6	0.6
Mean	27.0	27.7	2.5	27.5	28.1	2.3
SD	1.6	1.4	1.1	1.5	1.6	1.7

A=responses to the ST while only the ST was illuminated.
B=responses to the ST while both the ST and CO were illuminated.
C=responses to the illuminated CO. The maximum number of trials
possible during a session, for each response category was thirty.
SD=standard deviation.

Responses During The ITI

In order to examine the possibility that the nonidentity,
explicitly unpaired training may have produced a delayed response,
data were obtained on responding during the inter-trial interval (ITI)
for both IEP groups and both NEU groups. For the IEP and NEU groups
the ITI was divided into two 45-second segments. This division was
chosen because it represents the point at which the food hopper was
raised for the NEU groups. If delayed responding occurred for the NEU

Figure 4. Mean number of trials containing a response to the ST while only the ST was illuminated. Data are presented for the IEPNEU group for identity, explicitly paired trials and nonidentity, explicitly unpaired trials. Thirty trials of each type were presented each session.
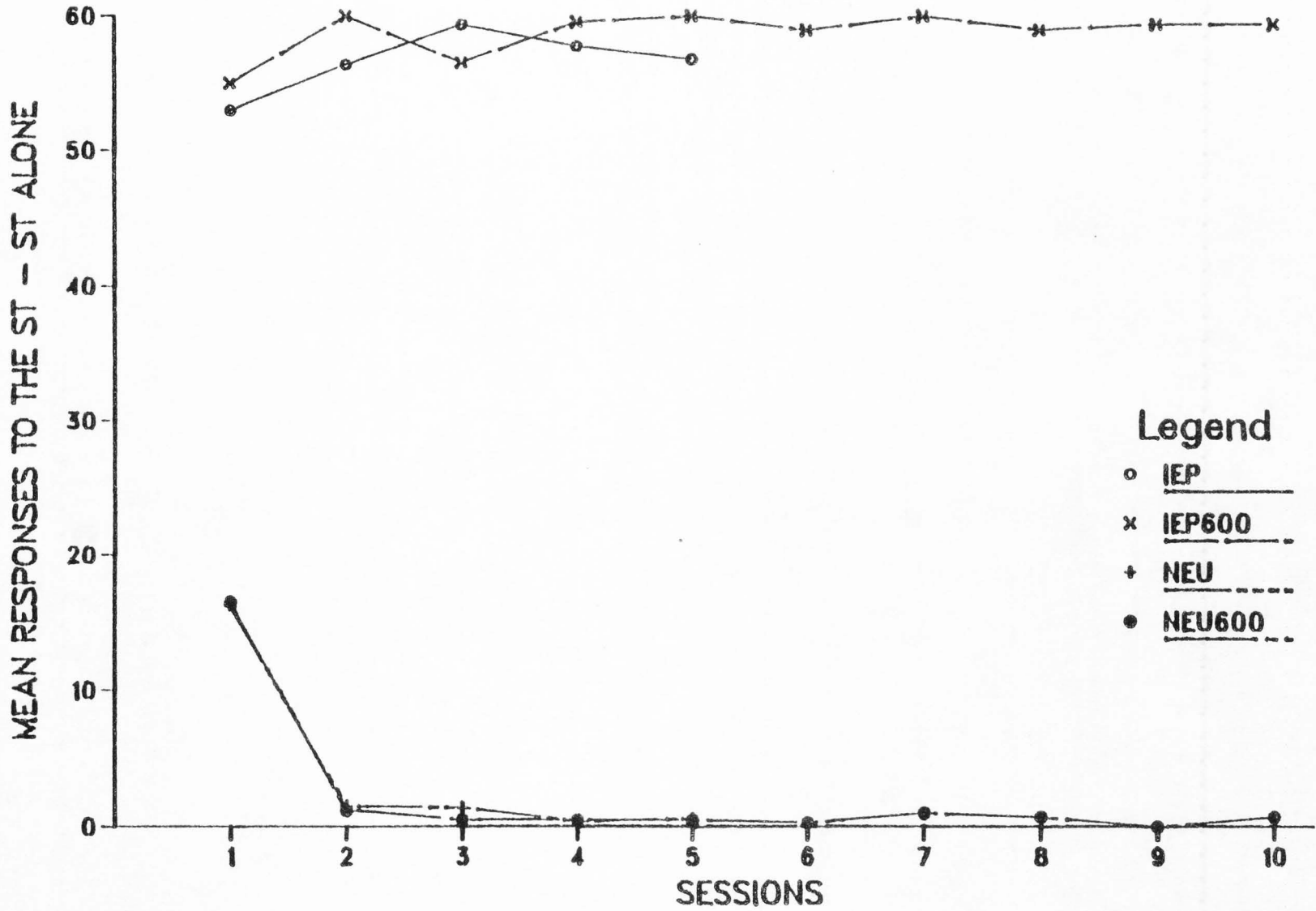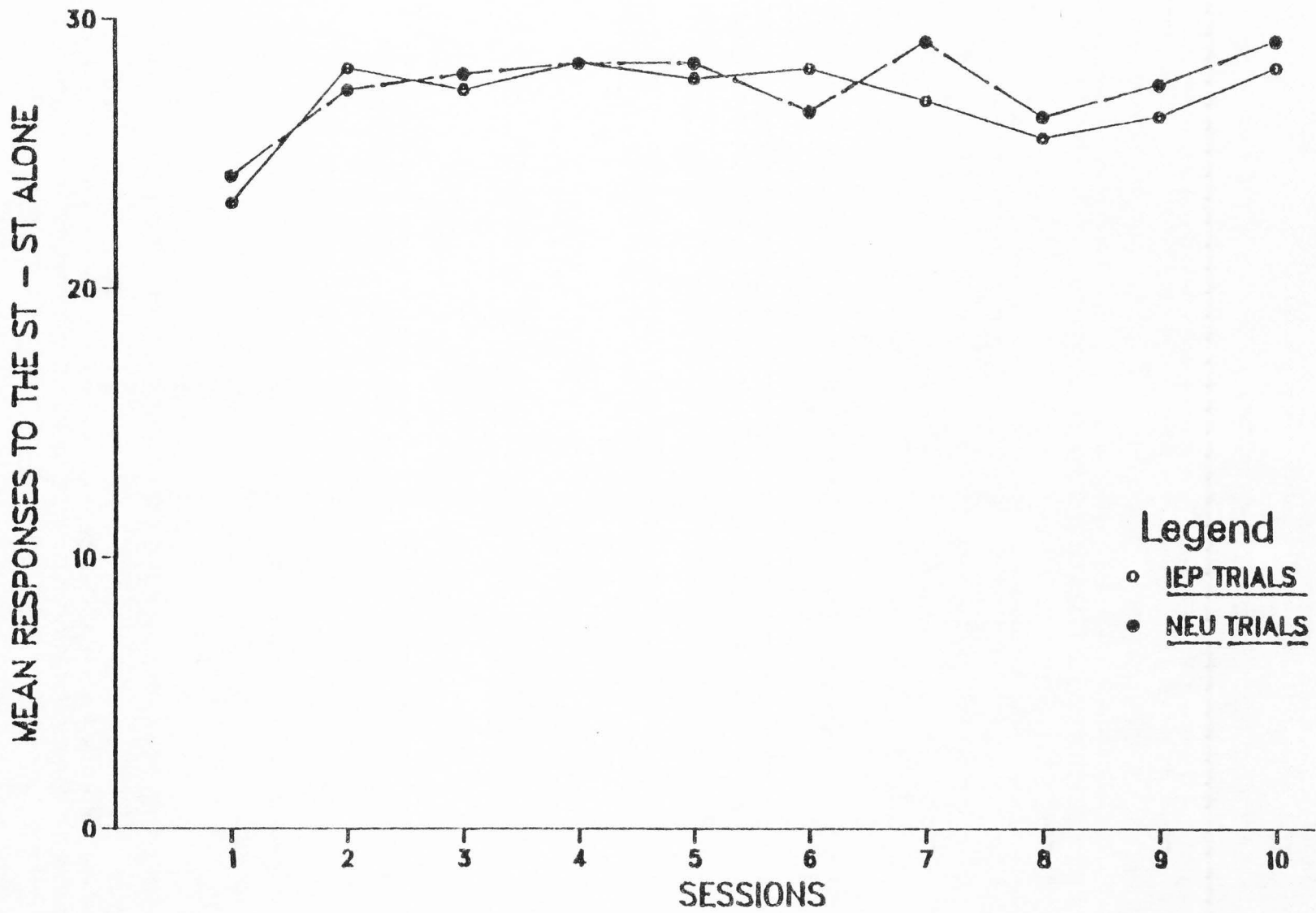
Figure 5. Mean number of trials containing a response to the ST while both the ST and CO were illuminated. Data are presented for the IEPNEU group for identity, explicitly paired and nonidentity, explicitly unpaired trials. Thirty trials of each type were presented each session.
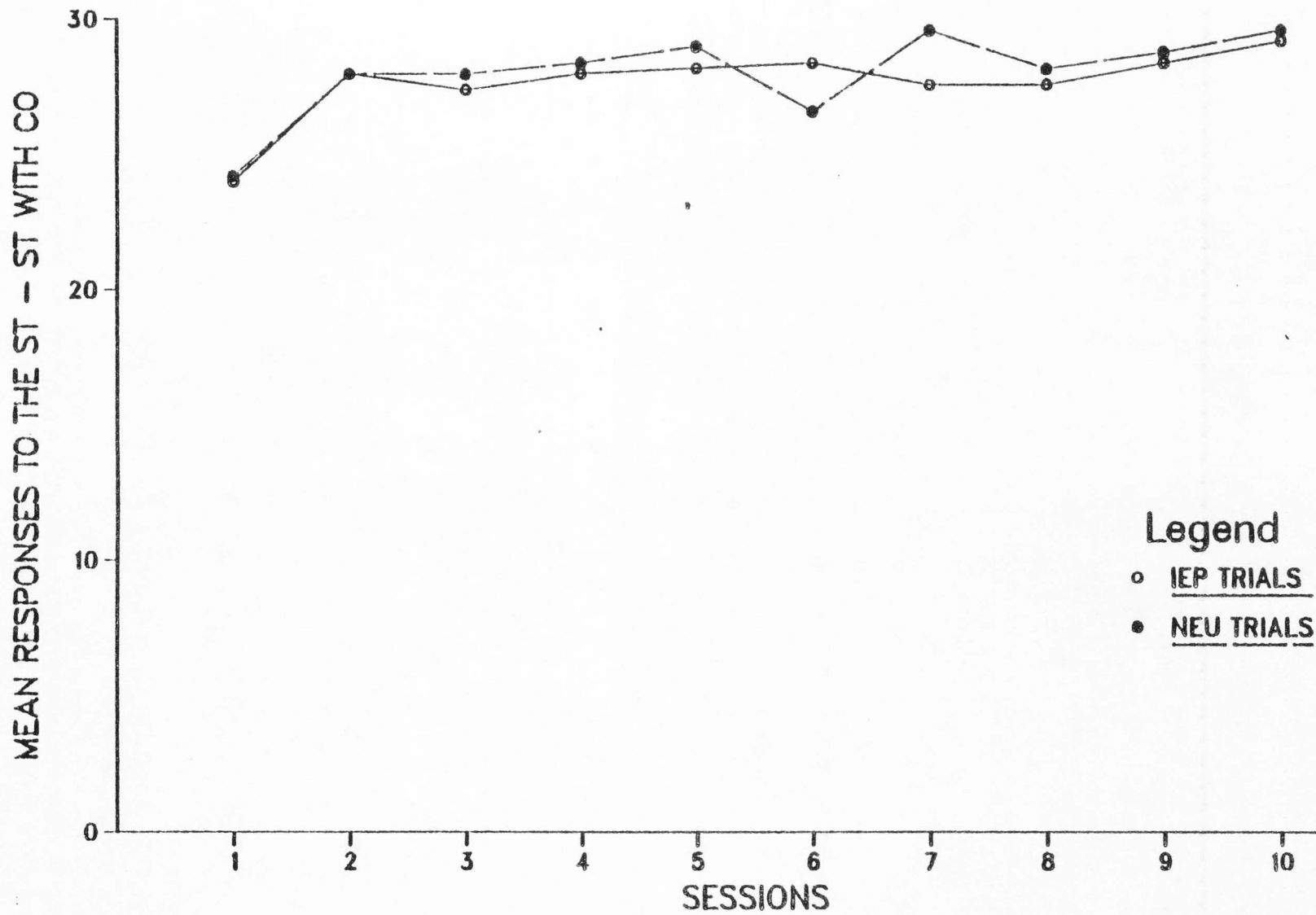
Figure 6. Mean number of trials containing a response to the illuminated CO. Data are presented for the IEPNEU group for identity, explicitly paired and nonidentity, explicitly unpaired trials. Thirty trials of each type were presented each session.
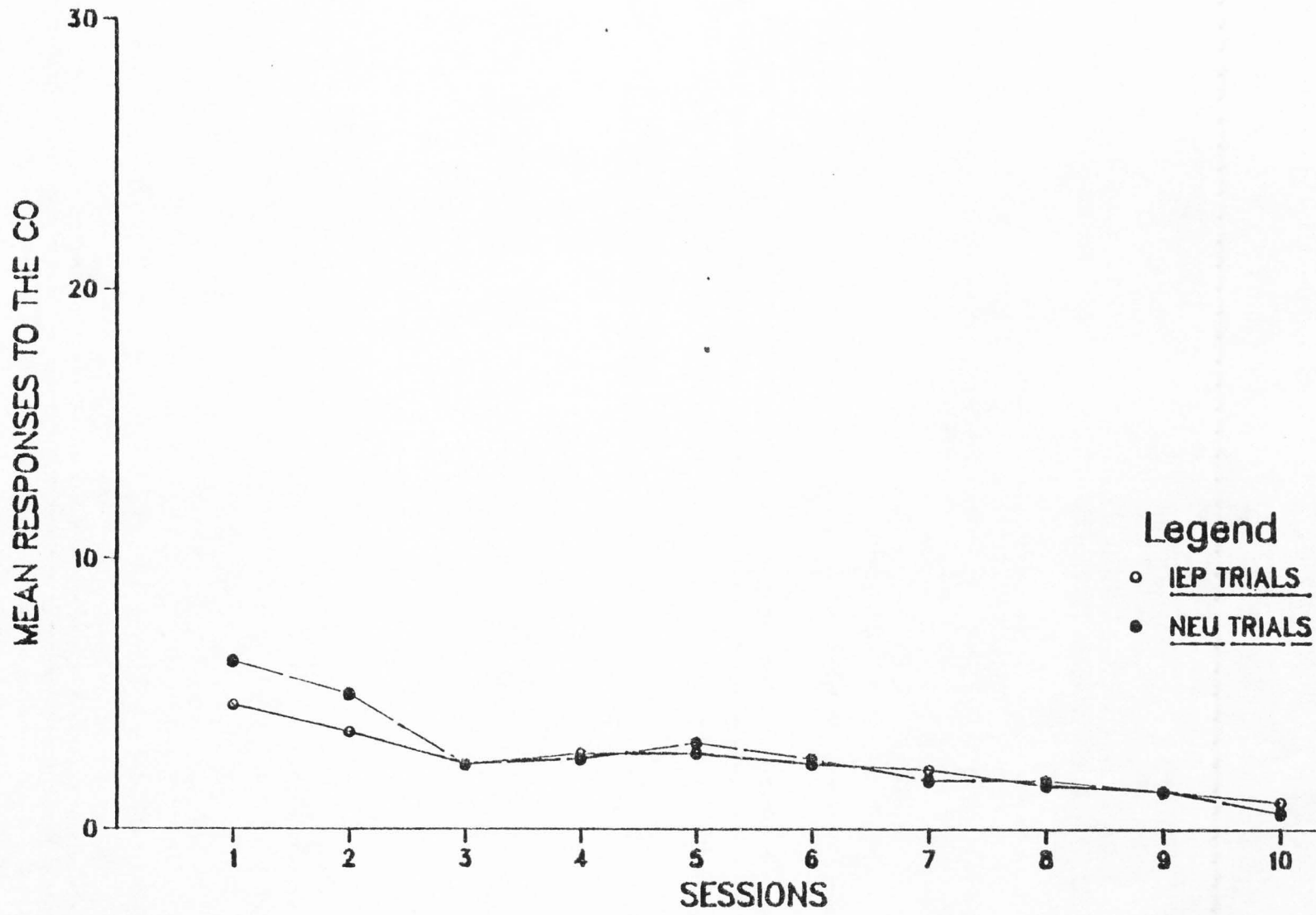
groups due to some inadvertent contingency its appearance would either occur before or after the food hopper being raised.

Data were obtained during the ITI for all subjects in the NEU groups but for only six subjects in the IEP groups, three in the IEP group and three in the IEP600 group. These data were not obtained for all subjects due to experimenter error. (See Table 10 of the Appendix for ITI data.) For each 45-second segment of the ITI the total number of segments with one or more responses was obtained. IEP groups were combined, as were NEU groups, for this analysis on the basis of their similarities during group specific training. Session means from the first 45-second segment for each type of group were compared. A t-test was conducted and no difference was found ($t[15]=0.03$, $p>.05$) between subjects' responding in the first 45-second segment as a result of group specific training. A t-test conducted on data from the latter 45-second segment of the ITI also found no significant difference ($t[15]=0.70$, $p>.05$) between type of group specific training.

Matching-To-Sample

All groups received 3-hue simultaneous matching-to-sample after group specific training. Data on the subjects' matching-to-sample performance are discussed either in terms of number of sessions required to reach specified criteria or in terms of trials completed

correctly during a session expressed in percentages.

Percentages are utilized as a relative measure to control for the
varying number of trials each subject received as the reinforcement
schedules for correct matching increased from continuous reinforcement
(CRF) to a random ratio 3 (RR3). Performance data on
matching-to-sample for each subject by group are presented in Figures
7 through 12.

Acquisition of matching-to-sample. Matching-to-sample
performance was first examined to determine if acquisition varied
among groups. Acquisition was defined as at least 90% correct
responding for three sessions of the RR3 schedule. Since the
performance of eight subjects did not approach this criterion, a
secondary criterion was established to facilitate transfer testing
while insuring a stable, above chance level of correctness. This
secondary criterion was defined as ten sessions where correct matching
averaged at least 80%, after the subject initially attained 80%
accuracy on the RR3 schedule, and if the range of correct responding
was no greater than 12%. Of the eight subjects who met this secondary
criterion one was in the IEP group, one was in the IEP600 group, two
were in the NEU group, three were in the NEU600 group, and one was in
the IEPNEU group. The means for these subjects over the ten criterion
sessions of the RR3 schedule and their range of performance are
presented in Table 6.

Figure 7. Responses correct, in percent, by session for each subject in the IEP group on matching-to-sample. (*=session for bird 2 where food hopper was inoperative during part of session.)
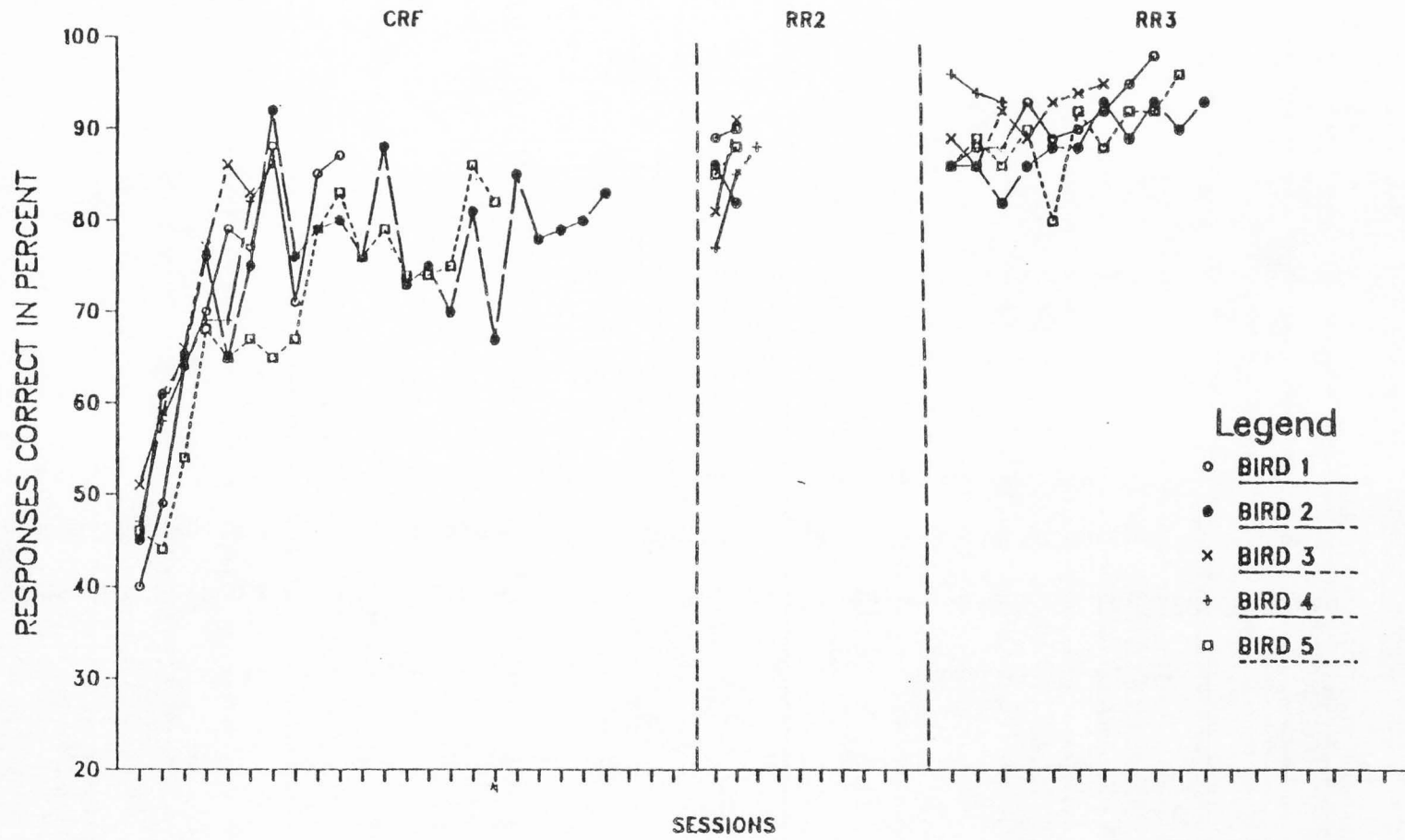
Figure 8. Responses correct, in percent, by session for each subject in the IEP600 group on matching-to-sample. (a=session with missing data for bird 4 due to computer malfunction. *=session for bird 5 where one stimulus light was out for part of session.)
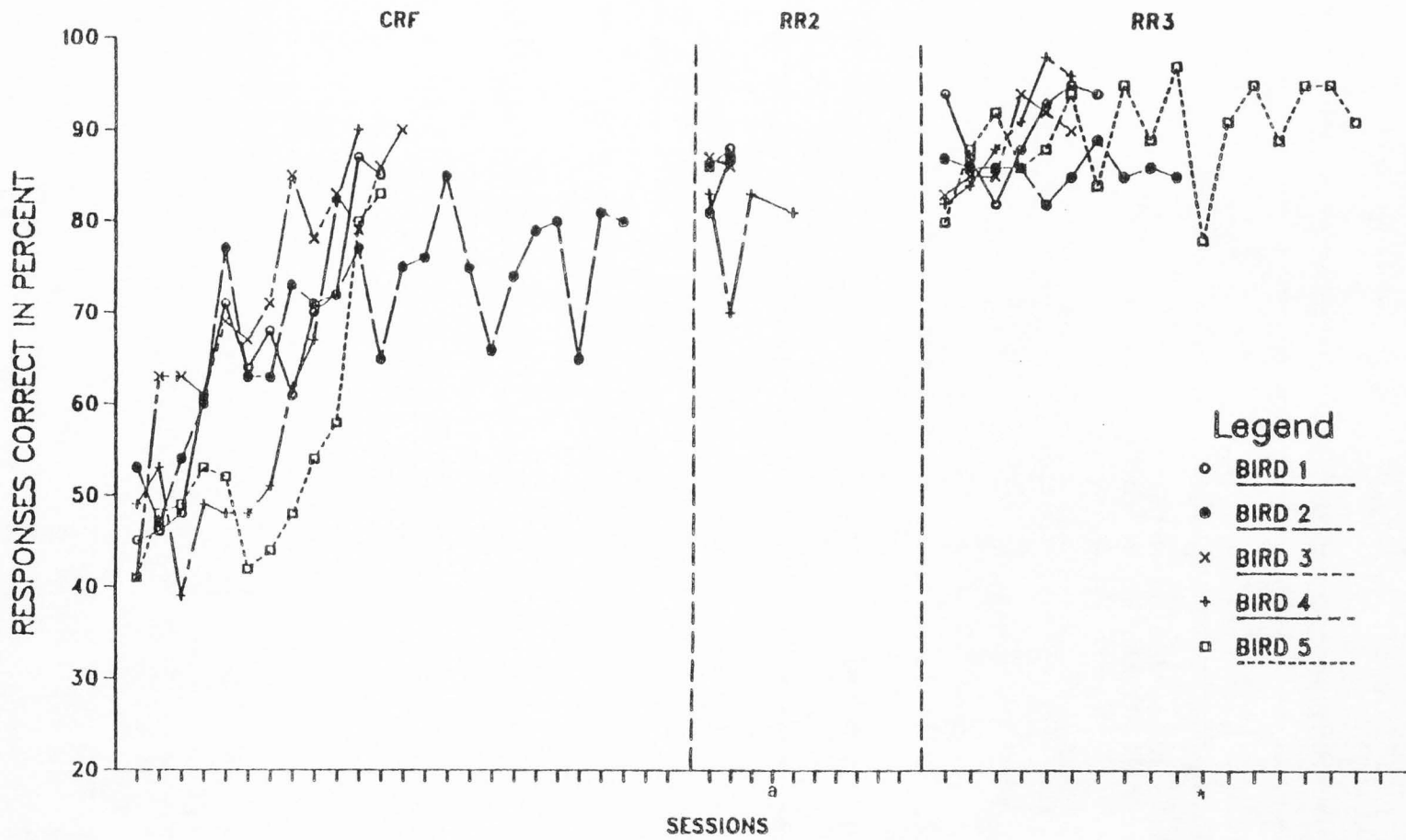
Figure 9. Responses correct, in percent, by session for each subject in the NEU group on matching-to-sample. (*=session for bird 1 where CO response key malfunctioned.)
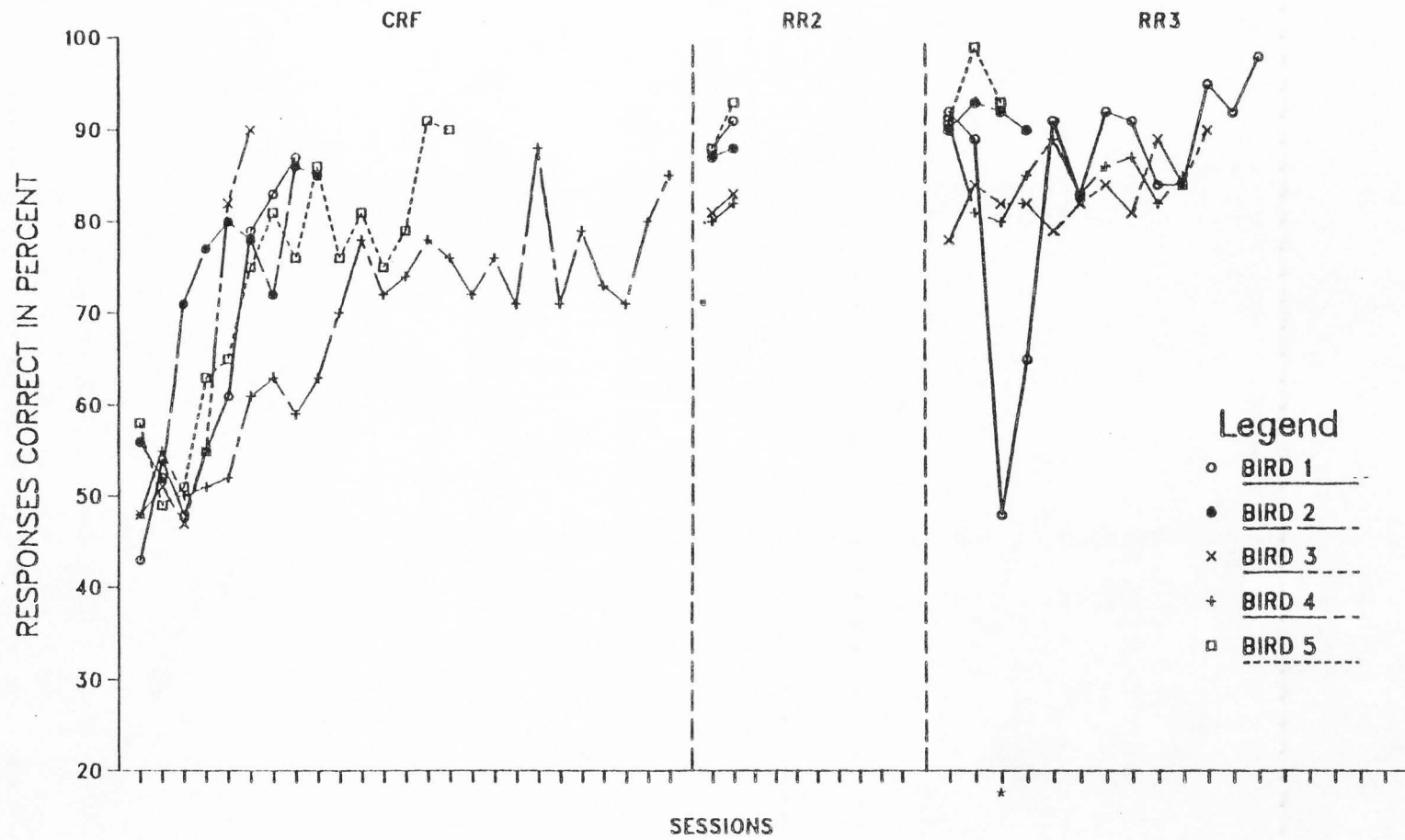
Figure 10. Responses correct, in percent, by session for each subject in the NEU600 group on matching-to-sample. (a=session for bird 4 with missing data due to computer malfunction. *=session for bird 3 where stimulus light was out for part of session.)
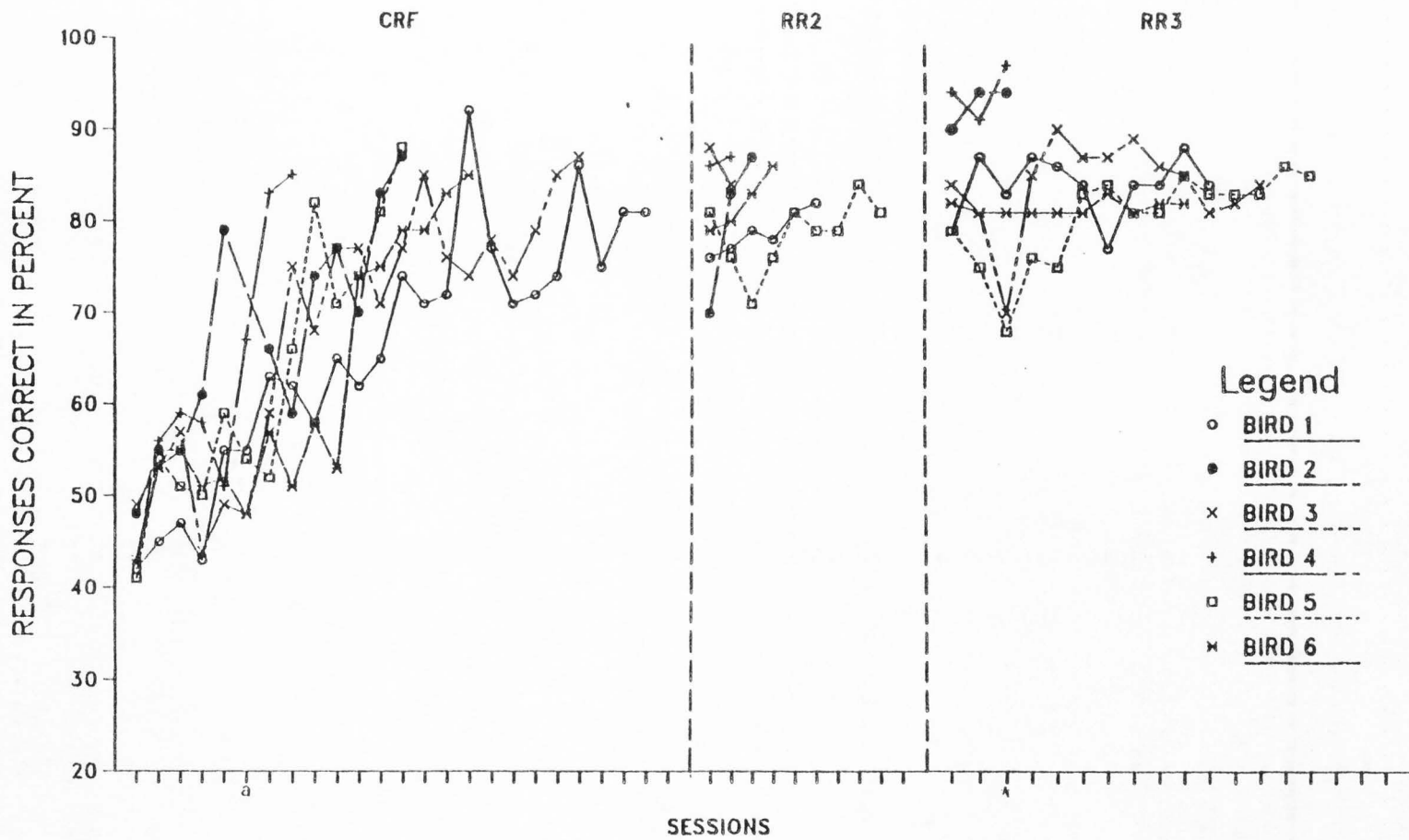
Figure 11. Responses correct, in percent, by session for each subject in the IEPNEU group

on matching-to-sample. (a=session for bird 1 with missing data due to computer malfunction.

*=session for bird 5 where stimulus light was out for part of session.)
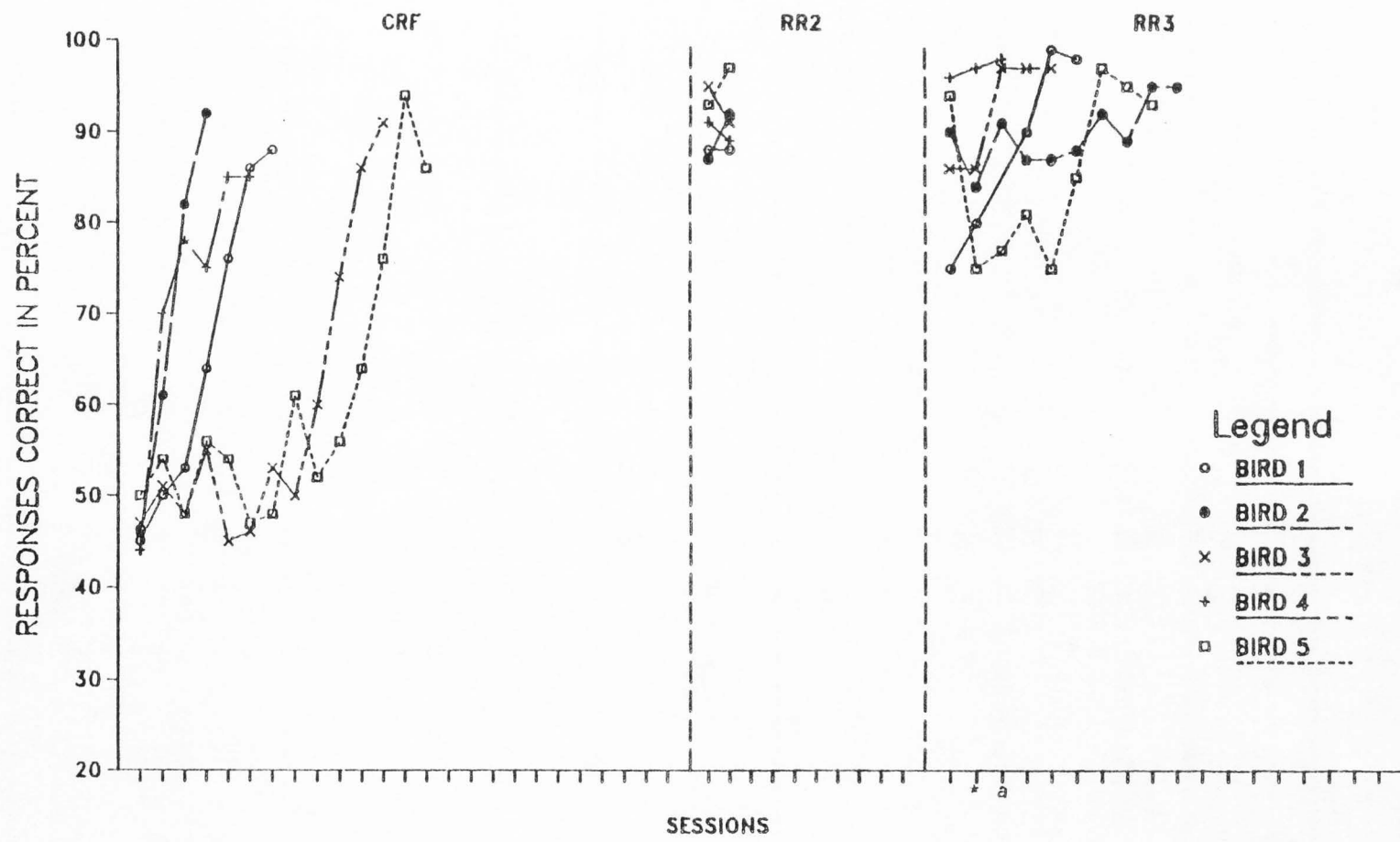
Figure 12.   Responses correct, in percent, by session for each subject in the control group on matching-to-sample.   (a=session for birds 4 and 1, respectively, with missing data due to computer malfunction.   *=session for bird 3 where stimulus light was out for part of session.)
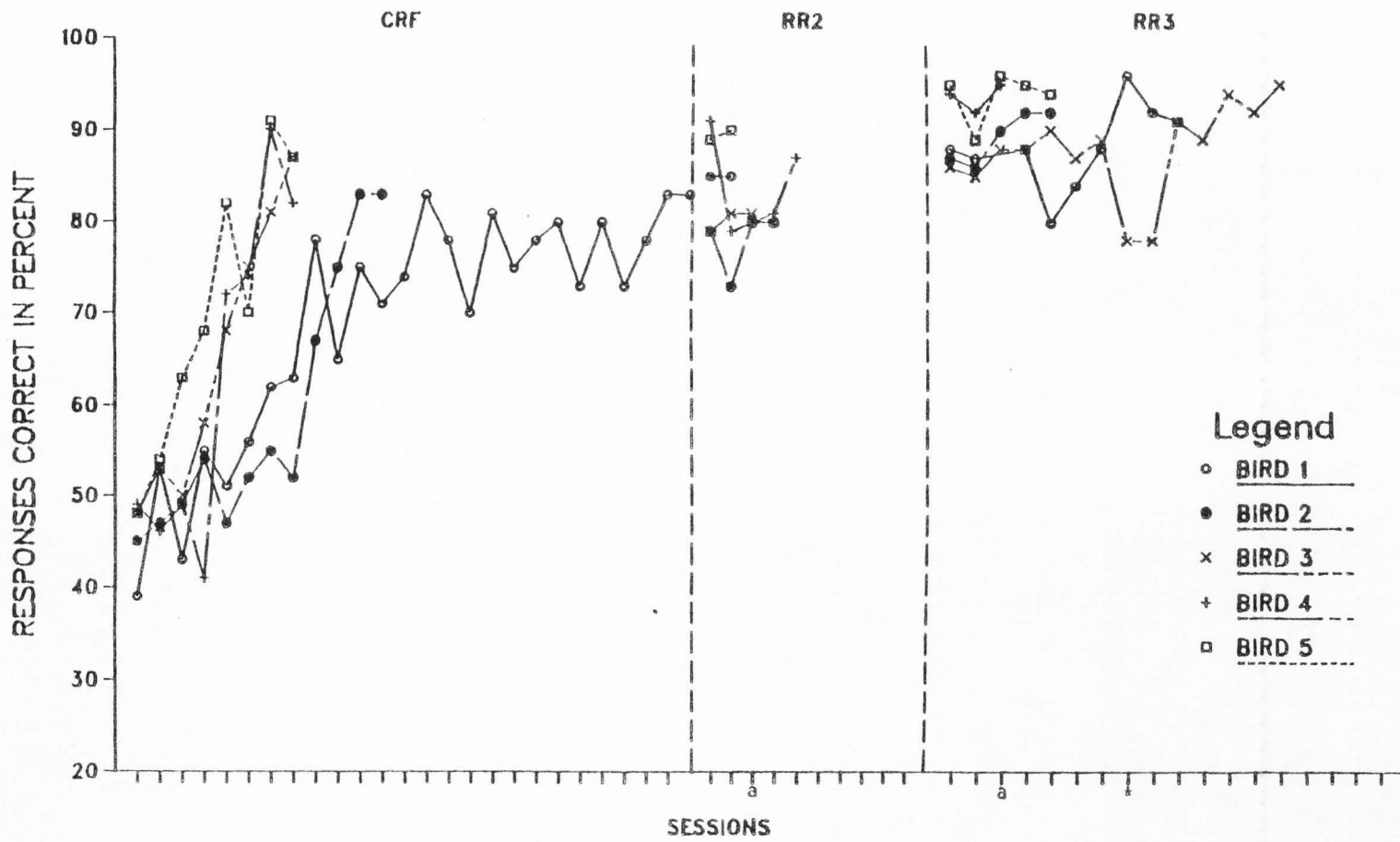
Figure 13. Mean number of sessions to the matching-to-sample acquisition criteria by group.
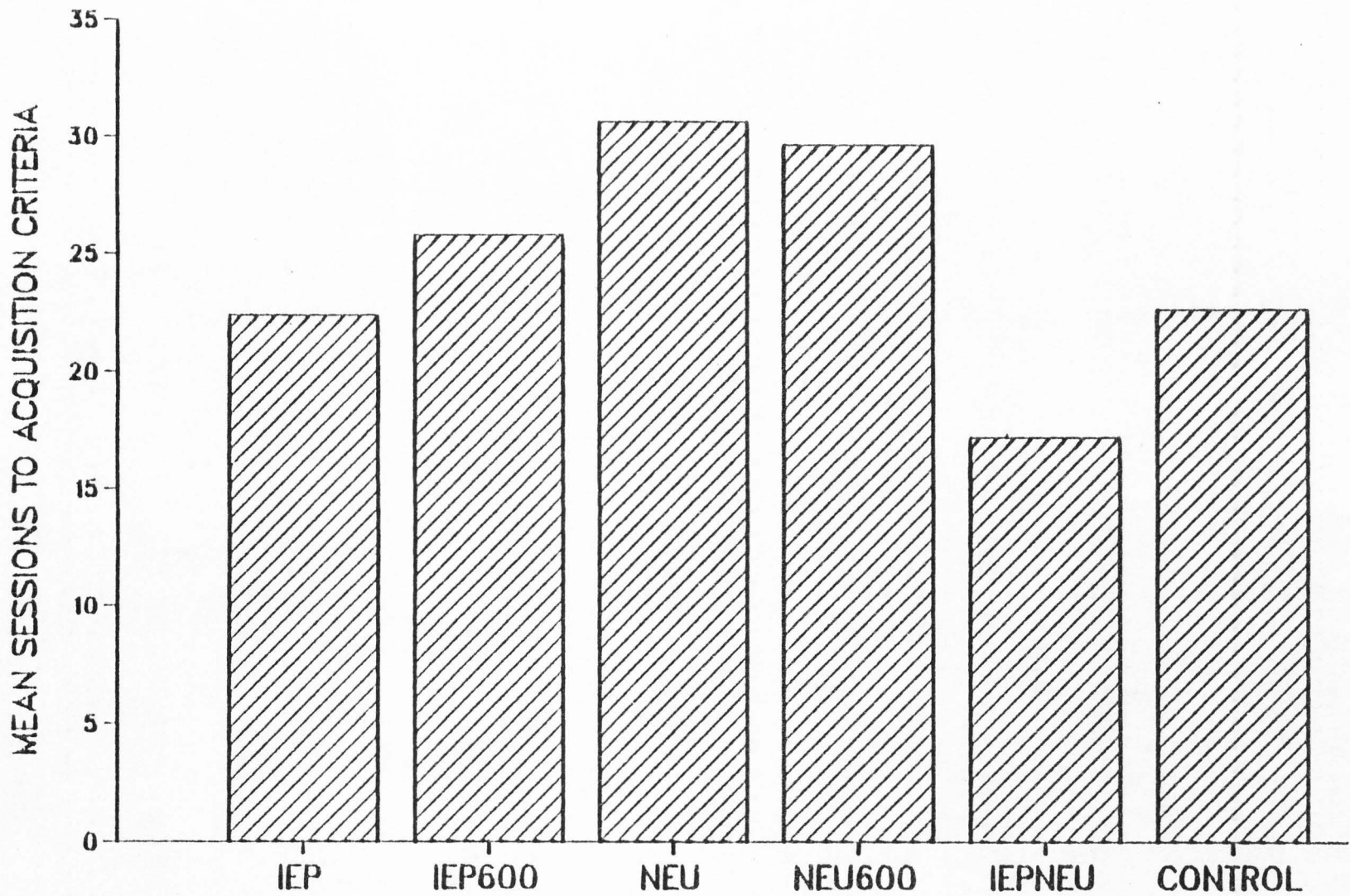
Table 6

Mean and Range of Subjects Meeting Criterion over the Ten
Criterion Sessions of Matching-To-Sample.

Group	Mean	Range
IEP	88.08%	82.4%-92.9%
IEP600	85.34%	81.6%-88.6%
NEU	84.77%	79.9%-90.9%
NEU	83.75%	79.3%-89.6%
NEU600	84.43%	77.3%-88.0%
NEU600	85.61%	82.1%-90.2%
NEU600	83.26%	80.6%-85.5%
IEPNEU	89.74%	83.8%-94.9%

In order to determine if the necessity of imposing the secondary criterion was a result of group specific training a Chi Square Test of Independence was performed (Hinkle et al., 1979). For this analysis data from both IEP groups were combined and data from both NEU groups were combined. This analysis indicated that no significant relation exisited between group membership and performance ($Chi^2[5]=1.21$, $p>.05$). From this, it appears that the imposition of the secondary criterion was independent of group specific training.

An analysis of variance, one way classification, was performed on the number of sessions it took subjects in each group to meet the acquisition criteria, either primary or secondary. Group performance data for the acquisition criteria are presented in Figure 13. This analysis revealed no significant difference among groups ($F[5,25]=1.21$, $p>.05$).

Since the addition of the secondary criterion for acquisition may have had some artifactual effect on the results of the above analysis, another analysis of variance, one way classification, was performed. This analysis was performed on the number of sessions it took subjects to reach the criterion for changing from the CRF schedule to the RR2 schedule. The criterion established for changing schedules was two sessions with correct matching of at least 80%. Once again, no significant difference ($F[5,25]=0.77$, $p>.05$) was found among groups using the schedule change criterion (Figures 7 through 12).

Transfer

Subjects in each group received three types of transfer trials designed to assess what rules of discrimination learning the subjects' performance most closely approximated. The rules to be assessed were an S+ rule, an S- rule, and a general rule which would account for concept-like performance (concept rule). Mean performance data for each of these transfer tests by group are presented in Figure 14. These data are presented in percentage form in accord with the other performance data presented. (See Table 11 of the Appendix for individual subject performance on the transfer tests.) It should be noted that one bird in the IEPNEU group did not receive a total of 30 transfer trials testing for S- rules, as did other subjects. Only 27 trials were presented during this session as a function of the computer's randomization process.

S+ rules. Subjects' behavior on these transfer trials indicates that this type of rule is evidenced by the probe trial responding of all subjects regardless of group. Group means ranged from 96.0% for the IEPNEU group to 99.34% for the IEP group (Figure 14). An analysis of variance, one way classification, was conducted on the subjects' probe trial responding in each group on the S+ rule transfer trials. No difference was found among groups ($F[5,25]=0.60$, $p>.05$).

S- rules. Performance indicative of the utilization of S- rules in a complex discrimination was not exhibited by any group. Group means ranged from 3.98% correct responding on S- rule probe trials for the control group to 22.66% for the IEP group (Figure 14). An analysis of variance, one way classification, was completed on the subjects' performance by group on S- rule transfer probe trials. This analysis found no difference among groups ($F[5,25]=0.39$, $p>.05$).

Subject's responding during this transfer test was characterized by choosing the familiar CO stimulus, designated incorrect because it did not match the ST, instead of the novel CO, designated as the correct response. The novel CO was designated correct because it did not have a history of previously being an incorrect stimulus given the matching-to-sample stimulus arrays used during training.

Figure 14. Mean percentage of correct responses on S+ rule, S- rule, and concept rule transfer tests by group.
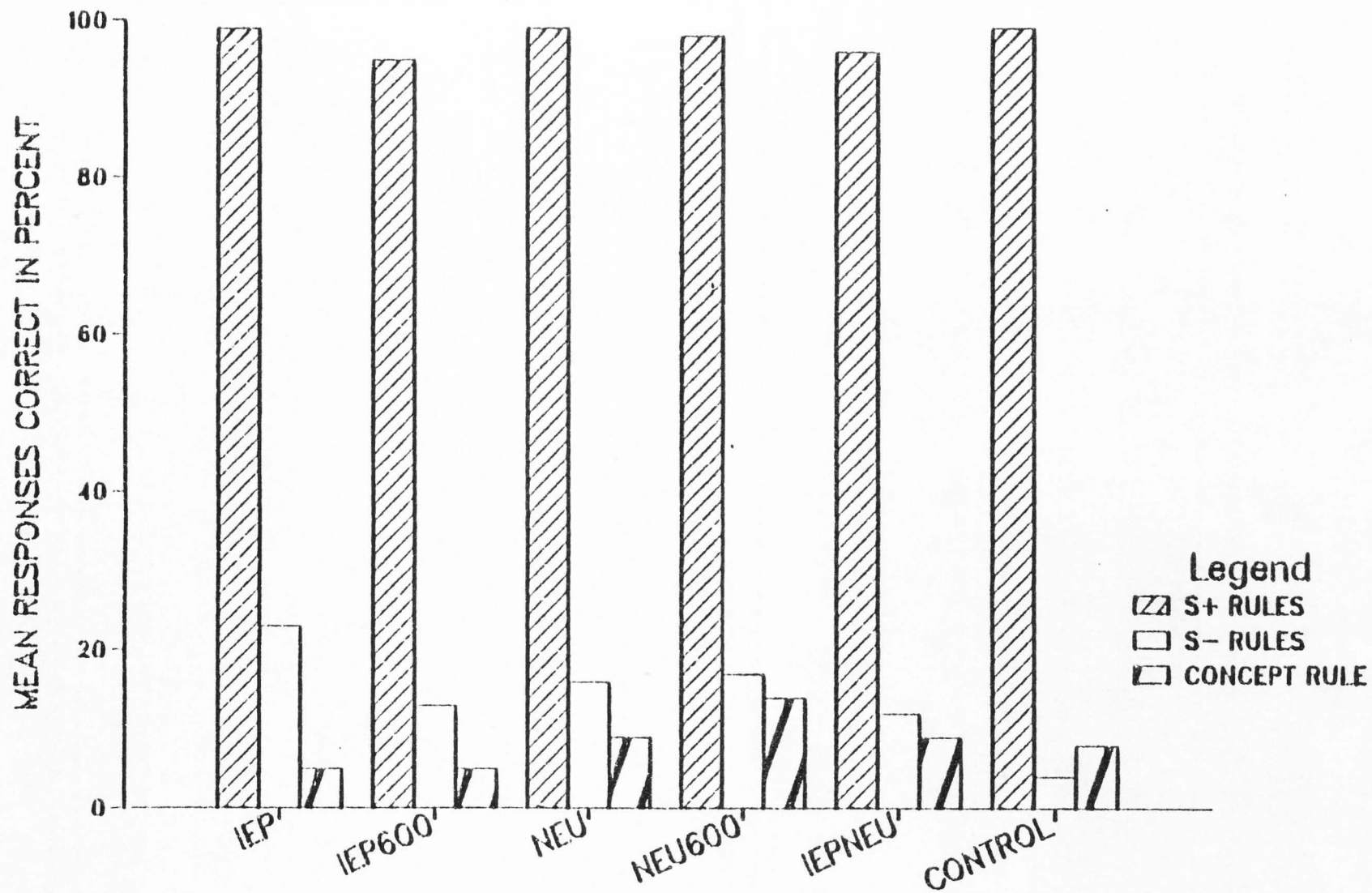
Concept rule. Performance indicative of concept-like behavior, or a concept rule, was not exhibited by subjects in any group. Group means ranged from 4.68% correct probe trial responding for the IEP600 group to 14.43% for the NEU600 group (Figure 14). An analysis of variance, one way classification, performed on the subjects' behavior during probe trials designd to assess for a concept rule found no difference among groups ($F[5,25]=0.39$, $p>.05$). During these transfer probe trials the subjects responded away from the correct, novel CO and toward the familiar, but incorrect, CO.

First session transfer. It is possible that learning the matching-to-sample discrimination may have obliterated any effect of the group specific training. If this were the case, then the point at which any between group differences might be observable is during the first session of the matching-to-sample discrimination. First session performance has been considered by some researchers (e.g., Zentall & Hogan, 1974, 1976) to be a legitimate way to assess conceptual behavior, provided some type of training has preceeded the transfer and positive transfer has resulted. The present data, however, suggest no differential effect as a result of group specific training. An analysis of variance, one way classification, conducted on first day matching-to-sample performance found no difference among groups ($F[5,25]=1.35$, $p>.05$).

To determine if the subjects' first day matching-to-sample performance was chance responding, where chance was defined as 50%

corect matching, a t-test (for a one sample case) was conducted. This

analysis indicated that the subjects' responding on the first day of

matching-to-sample was significantly below chance responding

($\underline{t}$[30]=-4.41,$\underline{p}$<.001).

DISCUSSION

Single Stimulus Food Training

The results from the single stimulus food training sessions indicate that all groups were equivalent prior to beginning group specific training. This is important because most subjects had been used as controls in a previous study (Pounds, 1982).

The procedure of single stimulus food training is more commonly referred to as autoshaping (see Schwartz & Gamzu, 1977, for a review of this area) and the present data can be compared with published data on autoshaping. The single stimulus food training data are in accord with previous autoshaping data. Similar average trials to first peck were found by Lubeck (1982) using two stimuli in a similar autoshaping sequence (i.e., 3-sec exposure to the stimulus, 90-sec ITI) and by Terrace, Gibbon, Farrell, and Baldock (1975) using a 10-second stimulus exposure with a mean ITI of 100 seconds.

Average trials to reliable autoshaping were also similar among the present results and those of Lubeck (1982) and Terrace et al. (1975). A wider range of responding for both the first key peck and reliable autoshaping measures was found in the present study than in either Lubeck or Terrace et al. The wider range obtained here may be a function of using three stimuli as opposed to two in the other studies, or to the present subjects' prior experimental history.

Regardless of the factors accounting for this difference, the effect was equally distributed among groups.

Group Specific Training

The results from group specific training can be summarized in three statements: 1) For both IEP groups responding occurred almost exclusively to the ST, suggesting that the matching stimulus on the CO was not a salient stimulus for the identity discrimination and did not acquire control over the pigeons' keypecking. 2) For both groups receiving NEU training neither the ST nor the CO controlled the pigeons' responding. 3) For the IEPNEU group, receiving IEP and NEU trials combined, the pigeons' did not learn to discriminate between types of training trials as no differential patterns of responding occurred.

Studies by Browne (1976) and Parisi and Matthews (1975) present data suggesting the feasibility of using the IEP training procedure as it was intended in this study. Browne and Parisi and Matthews conducted similar studies demonstrating that the explicit pairing of keylight stimuli and food hopper, while restraining the pigeon from responding, led to significantly quicker rates of autoshaping than control groups that received random or negative pairing of keylight stimuli and food hopper while restrained from pecking. In addition, Looney, Cohen, Brady, and Cohen (1977) in a conditional, differential

autoshaping procedure, utilized hues and line tilts as stimuli and established a conditional discrimination within 20 sessions. Looney et al. presented stimuli on a single key during training.

Where the IEP procedure in the present study differs from the Browne (1976), Looney et al. (1977), and Parisi and Matthews (1975) studies is in the utilization of two keys during training. By using two keys the IEP procedure becomes similar to procedures used in second-order autoshaping (see Rashotte, 1981, for a review). In second-order autoshaping a first order conditioned stimulus (CS, a stimulus such as hue or wavelength) which derives its associative strength from pairings with an unconditional stimulus (US, a stimulus such as food or drink) serves as a reinforcer for conditioning another, secondary CS (Rashotte, 1981). Rashotte (1981) indicated that second-order autoshaping to a visual stimulus can be demonstrated in pigeons, but that it occurs only in regard to certain procedural conditions. Second-order autoshaping will occur if the stimuli are presented sequentially or with overlap (Collins, 1976, cited in Rashotte, 1981; Gokey & Collins, 1980; Rashotte, 1981). Gokey and Collins (1980) stated that second-order autoshaping may be possible with the simultaneous presentation of stimuli but that it would take significantly more trials to acquire differential responding than if the stimuli were presented sequentially. Second-order autoshaping with simultaneous presentation of stimuli has not been established. Egger and Miller (1962), studying secondary reinforcement strength,

came to a similar conclusion. They noted that redundant stimuli, which a simultaneous presentation involves, did not acquire secondary reinforcement strength.

From the second-order autoshaping literature and the redundancy finding of Egger and Miller (1962) the results of the IEP training procedure appear logical. It may have been possible to establish differential responding to the ST and COs but a greater number of training trials or a procedure presenting the ST and CO stimuli sequentially would be necessary. Lubeck (1982), for example, obtained differential ST and CO responding using a similar IEP procedure except that the ST terminated upon CO onset, thus effecting a sequential order of presentation.

Little can be said at this point regarding groups that received NEU training. From their group specific training the only clear result is that these subjects learned not to respond to either the ST or CO. Further discussion regarding what may have been learned during this training will be covered under the examination of these birds' matching-to-sample training.

The performance of pigeons that received both IEP and NEU trials combined (IEPNEU training) can also be understood in light of the literature on second-order autoshaping. These pigeons did not differentially respond to the two types of trials. Responding during both types of trials was similar to that observed for the groups

receiving IEP training trials only. Pigeons responded almost exclusively to the ST. This may indicate that pigeons were only attending to the ST. Possibly, the procedure had the effect of exposing the pigeons to a differential autoshaping sequence with reinforcement being available at a probability of 50%. Gamzu and Williams (1973) have demonstrated that differential autoshaping with a 25% probability of reinforcement resulted in the acquisition and maintenance of high rates of responding by pigeons, a result similar to that which occurred in the present study.

The second-order autoshaping literature reviewed above can reliably explain the failure of this procedure to result in differential responding. The pattern of responding demonstrated by the IEP groups and the IEPNEU group indicates that the pigeons were responding only to a simple autoshaping precedure and not to a second-order autoshaping procedure. Both IEP and IEPNEU groups were exposed to simultaneously presented or redundant stimuli. As Egger and Miller (1962), Gokey and Collins (1980), and Rashotte (1981) have indicated this type of training would not be expected to result in the establishment of differential responding.

In the studies by Looney et al. (1977) and Lubeck (1982) the establishment of differential responding in conditions similar to the IEPNEU group were demonstrated. Lubeck's study is of greater interest here in that his procedures, in one group, were the same as those for the IEPNEU group except that the ST terminated upon CO onset. Half of

Lubeck's subjects (2 pigeons) demonstrated some degree of differential responding before they were transferred to the matching-to-sample task. Perhaps if Lubeck had continued IEPNEU training to a behavioral criterion all subjects would have acquired the discrimination. In the present study neither sequential presentation of stimuli nor extended training sessions were present.

Responses During The ITI

Responses during the first and last 45 seconds of the ITI were examined for the IEP and NEU groups. No differences were found between groups in terms of trials where one or more responses occurred for either the first or last 45-second period of the ITI. This result demonstrates that no inadvertent contingency was developed as a result of the training procedure.

Matching-To-Sample

Group specific training resulted in no differential performance on matching-to-sample training among groups. Subjects in all groups, including the control group, acquired the matching-to-sample discrimination at statistically equal rates. No differences were found among the groups either to acquisition of matching-to-sample prior to transfer tests for rules or at the point at which the first schedule change occurred (i.e., CRF to RR2).

To examine other possible facilitative effects of group specific training on matching-to-sample performance each group's first session of matching-to-sample was analyzed. Again no difference among groups was found. Initial matching performance for all groups was below chance levels. Below chance responding during the first session of matching-to-sample training has been observed frequently in this literature. Cumming and Berryman (1961) proposed a now generally accepted explanation for this phenomenon. According to this explanation subjects' initial responses to the ST never receive reinforcement. This causes an extinction effect toward the ST. Since in identity matching-to-sample the correct choice is the CO which is the same as the ST and since responding to the ST has been temporarily extinguished, the more probable response for the pigeon is to the nonmatching, incorrect CO. This temporary extinction effect desists as the pigeon comes under control of the contingencies.

The result of no difference in matching-to-sample acquisition was not surprising based on the results of group specific training. Both of the IEP groups and the IEPNEU group performed similarly during group specific training. Their group specific training data indicate that their performance was like that of pigeons receiving simple autoshaping training. The only difference was that the IEPNEU contingency would be more similar to differential autoshaping. This procedural difference would not result in a behavioral difference (Gamzu & Wiliams, 1973). Therefore, no difference in

matching-to-sample performance would be expected among these groups.

For the NEU groups two possibilities exist. It is possible that the NEU group specific training procedure resulted in the stimuli becoming conditioned inhibitors according to Rescorla's (1969) definition of a conditioned inhibitor. That is, these NEU stimuli resulted in a tendency opposite to that of a conditioned exciter, the IEP training procedure or autoshaping, in that no responding occurred to the NEU stimuli. The other possibility is that the NEU training procedure resulted in the stimuli becoming neutral, conveying no information about the NEU stimuli and reinforcement. Gamzu and Williams (1973) have shown in an autoshaping study that no reinforcement and the differential absence of food do not generate consistent key pecking.

Based on the NEU groups' matching-to-sample performance data the explanation that the NEU stimuli were neutral receives more consistent support. If the NEU stimuli had become conditioned inhibitors then pigeons' acquisition of matching-to-sample in these groups would be quicker than any of the other groups, assuming they are equivalent to autoshaping. Also, if conditioned inhibition were present, first session responding should have been above chance. In both cases the pigeons would avoid responding to the conditioned inhibitor and would learn the matching-to-sample relations. The data are more consistent with the interpretation of the NEU training procedure being neutral.

The result of no difference among groups on all of the measures used to demonstrate transfer effects to the matching-to-sample discrimination indicates that the types of group specific training provided had no more differential effect than no training at all (the control group) in facilitating the acquisition of a matching-to-sample discrimination.

Transfer Tests

The final area in which any group differences could exist was on transfer test performance. Transfer tests were designed to assess whether the subjects' behavior was more in accord with an explanation based on S+ rules, S- rules, or a concept rule.

All subjects demonstrated performance predicted by S+ rules. All subjects responded at high accuracy rates when presented with a familiar ST and matching CO in a display where the incorrect choice was a novel CO. That pigeons behave according to S+ rules is a well-established finding in the matching-to-sample literature (Carter & Werner, 1978; Farthing & Opuda, 1974).

Of greater experimental interest in the present study was whether any of the groups would evidence behavior predicted by an S- rule. In the case where subjects were presented with a familiar ST and two incorrect COs, one familiar and one novel, a response that occurred to the novel stimulus, since it had never been paired with that ST as an

incorrect choice, would be evidence for an S- rule. No subjects'
performance on these transfer tests indicated the utilization of an S-
rule.

The third transfer test involved an assessment for concept-like
behavior. On these tests subjects presented with a novel ST and
matching CO, paired with a familiar, incorrect CO, should respond to
the novel CO if a concept rule is present. A concept rule was not
evidenced by any subject.

Subjects' responding during both the S- rule and concept rule
transfer tests was primarily to the familiar, incorrect CO. It is
possible that the pigeons may have developed an S- rule or concept
rule but that these were overridden by previous associations between
the familiar CO and reinforcement. Prior research may help answer
this question. Zentall and Hogan (1978) controlled for this by
presenting novel stimuli, singularly and with a 50% probability of
reinforcement, to provide an experimental history with novel stimuli.
They obtained some evidence of concept learning, but their training
procedure was complex and the causal aspects of this one factor cannot
be ascertained. Farthing and Opuda (1974) in transfer tests similar
to the concept rule and S+ rule tests utilized here controlled for
novelty and obtained results similar to those found here. These data
would not support a hypothesis based on familiarity overriding S- rule
or concept rule presence. Combining these findings with the present
results from group specific training and matching-to-sample training,

support is lent to the statement that developed rules were not overridden by a novelty factor.

That these transfer tests fail to assess what they assume to assess or that whatever rules group specific training may have developed are lost by learning a matching-to-sample discrimination are other possible explanations for not finding evidence of S- rules or a concept rule. Though these explanations should be considered, the failure to find group differences during group specific training and matching-to-sample training make them less than plausible. Future research should focus on studying these alternate explanations, but present results exclude an analysis of these. In light of other data presented these alternate explanations appear unwarranted at this time.

GENERAL DISCUSSION

From the results of the present study it can be stated that group specific training, using simultaneously presented visual stimuli in an autoshaping procedure, while varying the presentation of the food hopper between groups, had no facilitative effect on pigeons learning a matching-to-sample discrimination. Furthermore, group specific training produced no effects on the pigeons' behavior on transfer tests that assessed rule-governed performance. All subjects demonstrated behavior aligned with S+ rules but no evidence of behavior conforming to either S- rules or a concept rule was demonstrated.

It appears that the procedure utilized to present stimuli in group specific training did not have the effect expected on each group's pre-matching-to-sample history. The intent of group specific training was to establish an association between the stimuli presented, where each group would acquire an association differentially predictive of food presentation. Contrary to this intent, the results suggest that IEP and IEPNEU group specific training had effects similar to simple autoshaping and that NEU group specific training had a neutral effect in regard to forming associations between stimuli. The results from matching-to-sample and transfer tests further support such a conclusion.

Based on the second-order autoshaping literature discussed earlier, procedural changes could be implemented which may provide information regarding rule development or enhancement as a result of associations formed prior to matching-to-sample training. Lubeck's (1982) study is relevant in regard to an attempt to discern such information. Lubeck followed an experimental procedure similar to the one in the present study. However, Lubeck presented his group specific training sequentially and he also tested a wider variety of types of pairings with the food hoppper. For example, he examined groups that received stimuli that were randomly paired with food, and groups in which stimuli were explicitly paired and explicitly not paired with food; the former were combined with identity and nonidentity stimulus sequences in a number of permutations. Lubeck did not perform any transfer tests for rule governed behavior. Only in one group, a group similar to the IEPNEU group, did any facilitative effects occur to matching-to-sample. This one group acquired matching-to-sample significantly quicker than any of his other groups. This result is interesting in that of his four subjects in this group only two demonstrated a discrimination between IEP and NEU trial types during group specific training. Yet, all subjects in this group demonstrated facilitated transfer effects to matching-to-sample. Lubeck postulated that these birds may have been "ready" to discriminate, on the IEPNEU training, but that the discrimination index used as a measure was not sensitive to this

"readiness."

Lubeck (1982) suggested as one possibility that the facilitative effect he obtained was due to the subjects' learning a relation between stimuli predictive of reinforcement as well as a relation between stimuli not predictive of reinforcement. In effect, learning to perform according to both S+ rules and S- rules. Lubeck supported this hypothesis with data from the results of his groups receiving only identity stimuli, explicitly paired with food and those birds that received only nonidentity simuli, explicitly not paired with food. If subjects in his IEPNEU condition learned only an S+ relationship then groups receiving only IEP training should also demonstrate facilitated transfer. Conversely, if IEPNEU subjects learned only an S- relationship then groups receiving only NEU training should also have demonstrated a facilitated transfer effect. Based on this reasoning he concluded that conditioning in the presence of both relations (S+ and S-) is critical for facilitated transfer to matching-to-sample. He was not able to unequivocally demonstrate this because no transfer test or probe trials for rule-governed behavior were conducted. However, as Lubeck went on to point out based on data from an IEP omission procedure (Williams & Williams, 1969), although autoshaping will facilitate transfer to an operant conditional discrimination, associative factors influencing the acquisition and maintenance of an operant conditional discrimination alone may be restricted to an S+ relation. This statement remains speculation as

no data have been obtained to prove or disprove it. Had Lubeck conducted transfer tests for rule-governed behavior during or after matching-to-sample training an answer might have been obtained.

Although the present research results have added little to an understanding of under what conditions pigeons' behavior can be influenced to perform in accordance with rules other than S+ rules, the research direction still appears valid. Lubeck's (1982) results clearly indicate that training both S+ and S- rules (relations) has a facilitative effect on matching-to-sample. The possibility that both types of rules are utilized during acquisition of a conditional discrimination cannot be ruled out without further data. A finding that pigeons can utilize S- rules as well as S+ rules would demonstrate that the basis on which generalized matching concepts in humans are formed (Dixon & Dixon, 1978: Stromer & Osborne, 1982) is also available to other species with certain training procedures. This could provide valuable information toward a clearer understanding of how concepts develop and may yield practical methods applicable to teaching humans, especially those with developmental disabilities.

REFERENCES

Ascione, F.R. Methods of direct behavioral observation. Logan, UT: Exceptional Child Center, Utah State University, 1977.

Bauer, F.J., & Lawrence, D.H. Influence of similarity of choice-point and goal cues on discrimination learning. Journal of Comparitive and Physiological Psychology, 1954, 46, 241-252.

Berryman, R., Cumming, W.W., & Nevin, J.A. Acquisition of delayed matching in the pigeon. Journal of the Experimental Analysis of Behavior, 1963, 6, 101-107.

Bourne, L.E. Jr., & Dominowski, R.L. Thinking. Annual Review of Psychology, 1972, 105-130.

Bourne, L.E. Jr., & Guy, D.E. Learning conceptual rules 11: The role of positive and negative instances. Journal of Experimental Psychology, 1968, 76, 423-429.

Brown, P.L., & Jenkins, H.M. Autoshaping of the pigeon's keypeck. Journal of the Experimental Analysis of Behavior, 1968, 11, 1-8.

Browne, M.P. The role of primary reinforcement and overt movements in autoshaping the pigeon. Animal Learning and Behavior, 1976, 4, 287-292.

Carter, D.E. Reply to Zentall and Hogan. Science, 1976, 191, 309.

Carter, D.E., & Werner, T.J. Conditional discrimination learning by pigeons. Journal of the Experimental Analysis of Behavior, 1978, 29, 565-201.

Cohen, L.R. Generalization during acquisition, extinction, and transfer of matching with an adjustable comparison. Journal of the Experimental Analysis of Behavior, 1969, 12, 463-474.

Cumming, W.W., & Berryman, R. Some data on matching behavior in the pigeon. Journal of the Experimental Analysis of Behavior, 1961, 4, 281-284.

Cumming, W.W., & Berryman, R. The complex discriminated operant: Studies of matching-to-sample and related problems. In D.I. Mostofsky (Ed.), Stimulus generalization. Stanford, CA: Stanford University Press, 1965.

Dixon, M.H., & Dixon, L.S. The nature of standard control in children's matching-to-sample. Journal of the Experimental

Analysis of Behavior, 1978, 30, 205-212.

Eckerman, D.A., Lanson, R.N., & Cumming, W.W. Acquisition and maintenance of matching without a required observing response. Journal of the Experimental Analysis of Behavior, 1968, 11, 435-441.

Egger, M.D., & Miller, N.E. Secondary reinforcement in rats as a function of information value and reliability of the stimulus. Journal of Experimental Psychology, 1962, 64, 97-104.

Farthing, G.W., & Opuda, M.J. Transfer of matching to sample in pigeons. Journal of the Experimental Analysis of Behavior, 1974, 21, 199-213.

French, G.M. Associative problems. In A.M. Schrier, H.F. Harlow, & F. Stollnitz (Eds.), Behavior of nonhuman primates. New York: Academic Press, 1965.

Gamzu, E.R., & Williams, D.R. Associative factors underlying the pigeons key pecking in autoshaping procedures. Journal of the Experimental Analysis of Behavior, 1973, 19, 225-232.

Gokey, D.S., & Collins, R.L. Conditional inhibition in feature negative discrimination learning with pigeons. Animal

Learning and Behavior, 1980, 8, 321-236.

Harlow, H.F. The formation of learning sets. Psychological Review, 1949, 56, 51-65.

Harlow, H.F., & Hicks, L.H. Discrimination learning theory: Uniprocess vs. duoprocess. Psychological Review, 1957, 64, 104-109.

Herrnstein, R.J., & Loveland, D.H. Complex visual concept in the pigeon. Science, 1964, 146, 549-551.

Hinkle, D.E., Wiersma, W., & Jurs, S.G. Applied statistics for the behavioral sciences. Chicago: Rand McNally, 1979.

Holmes, P.W. Transfer of matching performance in pigeons. Journal of the Experimental Analysis of Behavior, 1979, 31, 103-114.

Honig, W.K. Discrimination, generalization, and transfer on the basis of stimulus differences. In D.I. Mostofsky (Ed.), Stimulus generalization. Stanford, CA: Stanford University Press, 1965.

Itard, J. The wild boy of Aveyron. New York: Century, 1932.

Lashley, K.S. Conditional reactions in the rat.
Journal of Psychology, 1938, 6, 311-324.

Levine, M. Hypothesis behavior. In A.M. Schrier, H.F. Harlow, & F.
Stollnitz (Eds.), Behavior of nonhuman primates. New York:
Academic Press, 1965.

Looney, T.A., Cohen, L.R., Brady, J.H., & Cohen, P.S. Conditional
discrimination performance by pigeons on a response independent
procedure. Journal of the Experimental Analysis of Behavior, 1977,
27, 363-370.

Lubeck, R.C. An analysis of the stimulus-reinforcer relation
in matching-to-sample. Unpublished doctoral dissertation, Utah
State University, 1982.

Mackintosh, N.J. The psychology of animal learning. New York:
Academic Press, 1974.

Malott, R.W., & Malott, M.K. Perception and stimulus generalization.
In W.C. Stebbins (Ed.), Animal psychophysics: The design and
conduct of sensory experiments. New York: Appleton-Century-Crofts,
1970.

Malott, R.W., Malott, K., Svinicki, F.K., & Ponicki, E. An analysis of matching and non-matching behavior using a single key, free operant procedure. Psychological Record, 1971, 21, 545-564.

Parisi, T., & Matthews, T.J. Pavolian determinants of the autoshaped keypeck response. Bulletin of the Psychonomic Society, 1975, 6, 527-529.

Poole, J., & Lander, E.G. The pigeons concept of pigeon. Psychonomic Science, 1971, 25, 157-158.

Pounds, D.L. Inter- and intra-sensory modality stimulus scaling: A method for the determination of the relative salience of stimuli in poison-based avoidance learning by pigeons. (Doctoral dissertation, Utah State University, 1981.) Dissertation Abstracts International, 1982, 42, 3866B. (University Microfilms No.DA8205317)

Rashotte, M.E. Second-order autoshaping: Contibutions to the research and theory of pavlovian reinforcement by conditioned stimuli. In R.M. Locurto, H.S. Terrace, J. Gibbon (Eds.), Autoshaping and conditioning theory. New York: Academic Press, 1981.

Rescorla, R.A. Pavlovian conditioning and its proper control procedures. Psychological Review, 1967, 74, 71-80.

Rescorla, R.A. Pavlovian conditioned inhibition.
Psychological Bulletin, 1969, 72, 77-94.

Revesz, G. Experimental study of abstraction in monkeys.
Journal of Comparitive Psychology, 1925, 5, 293-341.

Rodewald, H.K. Symbolic matching-to-sample by pigeons.
Psychological Reports, 1974, 34, 987-990.

Schwartz, B., & Gamzu, E. Pavlovian control of operant behavior. In
W.K. Honig & J.E.R. Staddon (Eds.), Handbook of operant behavior.
Englewood Cliffs, N.J.: Prentice-Hall, 1977.

Siegel, R.K., & Honig, W.K. Pigeon concept formation: Successive and
simultaneous acquisition. Journal of the Experimental Analysis
of Behavior, 1970, 13, 385-390.

Smoke, K.L. Negative instances in concept learning.
Journal of Experimental Psychology, 1933, 16, 583-588.

Spence, L.W. The nature of discrimination learning in animals.
Psychological Review, 1936, 43, 427-449.

Stromer, R., & Osborne, J.G. Control of adolescents' arbitrary
matching-to-sample by positive and negative stimulus relations.
Journal of the Experimental Analysis of Behavior, 1982, 37,
329-348.

Terrace, H.S., Gibbon, J., Farrell, L., & Baldock, M.D. Temporal
factors influencing the acquisition of an autoshaped key peck.
Animal Learning and Behavior, 1975, 3, 53-62.

Thorndike, E.L. Animal intelligence. New York: Macmillan, 1911.

Urcuioli, P.J. Transfer of oddity-from-sample performance in pigeons.
Journal of the Experimental Analysis of Behavior, 1977, 28,
195-202.

Urcuioli, P.J., & Nevin, J.A. Transfer of hue matching in pigeons.
Journal of the Experimental Analysis of Behavior, 1975, 24,
149-155.

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

Yerkes, A.W. Experiments with an infant chimpanzee. *Journal of Genetic Psychology*, 1935, 46, 171-181.

Zentall, T.R., & Hogan, D.E. Abstract concept learning in the pigeon. *Journal of Experimental Psychology*, 1974, 102, 393-398.

Zentall, T.R., & Hogan, D.E. Pigeons can learn identity or difference, or both. *Science*, 1976, 191, 408-409.

Zentall, T.R., & Hogan, D.E. Same/different concept learning in the pigeon. *Journal of the Experimental Analysis of Behavior*, 1978, 30, 177-186.

APPENDIX

TABLE 7

The Trial with the First Response, the Number of Trials Prior to Reliable Autoshaping, and the Number of Single Stimulus Food Training Sessions.

Group	Trial # First Response	Trial # Reliable Response	Number of Sessions
IEP			
1	5	11	1
2	10	17	1
3	9	11	1
4	6	12	1
5	3	17	1
IEP600			
1	188	194	4
2	26	28	2
3	64	69	2
4	48	50	2
5	1	9	1
NEU			
1	45	55	2
2	37	43	2
3	65	133	3
4	3	29	1
5	64	82	2
NEU600			
1	8	10	1
2	23	31	1
3	12	26	1
4	3	13	1
5	7	9	1
6	124	126	3
IEPNEU			
1	1	5	1
2	302	307	6
3	10	27	1
4	80	82	3
5	3	5	1
CONTROL			
1	5	15	1
2	2	19	1
3	1	6	1
4	68	77	3
5	3	8	1

TABLE 8

Total Number of Trials with One or More Responses During Group
Specific Training Sessions for Groups IEP, IEP600, NEU, and NEU600.

Sessions	1	2	3	4	5	6	7	8	9	10
	Responses to the ST While Only the ST Was Illuminated									
IEP										
1	32	52	60	55	49					
2	57	57	60	60	60					
3	58	59	59	60	59					
4	60	60	60	60	60					
5	58	54	58	54	56					
IEP600										
1	60	60	60	60	60	60	60	60	60	60
2	40	60	44	59	60	55	60	56	58	60
3	57	60	59	60	60	60	60	59	60	60
4	58	60	60	60	60	60	60	60	59	57
5	60	60	60	59	60	60	60	60	60	60
NEU										
1	6	1	1	0	0					
2	12	1	2	0	2					
3	19	3	2	0	0					
4	29	1	1	1	1					
5	15	a	1	1	0					
NEU600										
1	38	2	1	1	2	0	0	0	0	1
2	13	0	0	1	0	0	1	0	0	1
3	16	1	0	1	0	0	0	2	0	1
4	13	1	1	0	0	0	0	0	0	1
5	8	2	1	0	0	0	0	1	a	1
6	11	1	0	0	1	2	5	1	0	0
	Responses to the ST While Both the ST and CO Were Illuminated									
IEP										
1	40	52	60	55	37					
2	59	57	60	60	60					
3	58	60	59	60	59					
4	60	60	60	60	59					
5	60	59	60	60	60					
IEP600										
1	60	60	59	60	59	60	60	60	60	59
2	53	60	50	58	56	56	60	60	60	60
3	60	60	59	60	59	60	60	60	60	60

Sessions	1	2	3	4	5	6	7	8	9	10
IEP600										
4	60	60	60	60	60	60	60	60	60	58
5	60	60	60	60	60	60	60	60	60	60
NEU										
1	5	0	1	1	1					
2	7	0	5	0	3					
3	15	2	1	0	0					
4	23	0	2	1	0					
5	12	a	0	1	1					
NEU600										
1	33	2	1	2	1	0	0	0	0	0
2	11	0	0	2	0	1	2	0	0	1
3	13	0	2	2	0	0	0	0	1	0
4	10	1	1	0	3	1	0	0	0	1
5	7	0	a	0	0	0	0	2	a	0
6	8	0	1	0	1	2	6	1	0	0

Responses to the Illuminated CO

	1	2	3	4	5	6	7	8	9	10
IEP										
1	17	11	13	12	5					
2	7	5	0	0	0					
3	28	17	15	4	5					
4	9	0	4	2	11					
5	13	4	3	1	0					
IEP600										
1	4	0	1	0	1	0	1	1	3	9
2	4	4	11	4	7	6	1	3	0	1
3	23	11	16	10	7	4	2	10	6	6
4	5	0	0	0	0	0	0	0	0	2
5	3	0	0	0	0	0	1	2	0	0
NEU										
1	5	0	2	0	1					
2	13	2	0	1	0					
3	19	3	4	3	3					
4	21	0	3	2	0					
5	13	a	0	0	0					
NEU600										
1	33	2	0	4	4	1	0	1	0	0
2	6	0	1	2	3	2	0	0	0	0
3	12	1	1	3	0	0	0	1	1	1
4	14	0	0	0	3	0	0	0	0	0
5	8	0	a	1	1	1	0	1	a	0
6	7	0	1	0	1	0	1	0	0	0

a=absent data points due to computer malfunction. These sessions
were conducted.

TABLE 9

Total Number of Trials with One or More Responses During Group Specific Training for the IEPNEU Group. Data from Identity, Explicitly Paired (IEP) Trials and Nonidentity, Explicitly Unpaired (NEU) Trials are Presented Separately.

Sessions	1	2	3	4	5	6	7	8	9	10
	Responses to the ST While Only the ST Was Illuminated IEP Trials									

Responses to the ST While Only the ST Was Illuminated
IEP Trials

Sessions	1	2	3	4	5	6	7	8	9	10
1	30	30	30	30	30	30	30	26	28	30
2	9	25	29	29	21	23	16	18	19	24
3	28	26	27	26	30	29	29	30	30	30
4	20	30	27	29	28	29	30	24	25	27
5	29	30	24	28	30	30	30	30	30	30

Responses to the ST While Only the ST Was Illuminated
NEU Trials

1	30	30	30	30	30	30	30	28	30	30
2	11	26	25	30	25	16	27	18	20	26
3	28	27	30	28	29	30	30	30	29	30
4	23	28	30	28	28	27	29	26	29	30
5	29	26	25	26	30	30	30	30	30	30

Responses to the ST While Both the ST and CO
Were Illuminated-IEP Trials

1	28	30	30	30	30	30	30	27	30	30
2	4	23	29	30	24	23	18	25	25	27
3	29	27	29	21	27	29	30	30	30	30
4	29	30	29	30	30	30	30	26	27	29
5	30	30	20	29	30	30	30	30	30	30

Responses to the ST While Both the ST and CO
Were Illuminated-NEU Trials

1	29	30	30	30	30	29	30	29	30	30
2	10	22	27	30	27	18	28	25	26	28
3	25	29	30	26	28	28	30	30	29	30
4	28	29	29	30	30	28	30	27	29	30
5	30	30	24	26	30	30	30	30	30	30

Sessions	1	2	3	4	5	6	7	8	9	10

Responses to the Illuminated CO-IEP Trials

	1	2	3	4	5	6	7	8	9	10
1	4	0	0	0	0	0	0	2	2	0
2	5	7	1	1	1	4	10	4	4	3
3	7	11	2	13	12	7	2	1	0	2
4	2	0	1	0	0	0	0	0	0	0
5	5	0	8	0	1	1	0	1	0	0

Responses to the Illuminated CO-NEU Trials

	1	2	3	4	5	6	7	8	9	10
1	11	2	0	0	1	2	0	2	0	1
2	2	4	3	0	4	4	0	5	4	2
3	14	11	1	11	9	5	8	2	2	0
4	4	8	2	0	1	2	1	0	0	0
5	0	0	6	2	1	0	0	0	0	0

TABLE 10

Total Number of Trials with One or More Responses for the First and Last 45-Second Segments of the ITI. Data are Presented for the IEP, IEP600, NEU, and NEU600 Groups.

Sessions	1	2	3	4	5	6	7	8	9	10
First 45-Second Segment										
IEP										
1	8	6	9	3	7					
2	39	23	7	12	8					
3	19	30	21	0	1					
4	a	a	a	a	a					
5	a	a	a	a	a					
IEP600										
1	10	5	10	7	3	6	8	3	2	0
2	8	5	5	3	4	19	7	6	7	2
3	3	10	13	8	6	5	9	4	9	3
4	a	a	a	a	a	a	a	a	a	a
5	a	a	a	a	a	a	a	a	a	a
NEU										
1	4	0	0	0	0					
2	2	2	4	0	2					
3	54	56	60	60	60					
4	16	15	3	7	1					
5	9	a	2	1	1					
NEU600										
1	22	2	0	1	16	2	3	8	3	2
2	5	0	0	0	2	2	1	1	0	0
3	10	1	1	1	6	27	30	58	57	59
4	6	1	2	0	4	0	0	0	0	2
5	8	0	a	a	0	4	5	0	a	0
6	5	0	0	0	0	0	1	0	0	0
Second 45-Second Segment										
IEP										
1	7	3	0	1	0					
2	17	1	2	1	6					
3	8	8	11	1	0					
4	a	a	a	a	a					
5	a	a	a	a	a					
IEP600										
1	1	1	0	0	0	1	2	1	0	1
2	16	4	0	1	1	0	0	0	0	0

Sessions	1	2	3	4	5	6	7	8	9	10
IEP600										
3	3	1	5	1	0	1	3	1	1	1
4	a	a	a	a	a	a	a	a	a	a
5	a	a	a	a	a	a	a	a	a	a
NEU										
1	0	0	0	0	0					
2	0	0	4	1	2					
3	49	46	50	50	50					
4	4	11	2	3	3					
5	0	a	1	1	1					
NEU600										
1	5	3	0	4	19	2	4	6	3	2
2	0	0	0	1	1	0	1	0	1	1
3	1	0	0	0	3	21	10	38	44	36
4	1	1	2	2	3	2	1	1	0	3
5	0	0	a	a	2	1	4	0	a	0
6	0	0	0	0	0	1	0	0	2	1

a=absent data points. For the IEP and IEP600 groups this is due to a computer program error, making this data unavailable. For the NEU and NEU600 groups this is due to computer malfunction. These sessions were conducted.

TABLE 11

The Number of Correct Trials during Transfer Tests, in Percent, for Subjects in All Groups.

Group	S+ Rules	S- Rules	Concept Rule
IEP			
1	100	33.3	6.7
2	100	30.0	0
3	100	20.0	0
4	100	33.3	0
5	96.7	16.7	0
IEP600			
1	100	3.3	6.7
2	90.0	26.7	6.7
3	100	3.3	0
4	90.0	13.3	3.3
5	96.7	0	6.7
NEU			
1	100	3.3	6.7
2	100	10.0	0
3	100	20.0	0
4	93.3	13.3	3.3
5	100	33.3	33.3
NEU600			
1	96.7	3.3	0
2	100	40.0	23.3
3	100	20.0	10.0
4	93.3	23.3	3.3
5	96.7	0	13.3
6	100	13.3	36.7
IEPNEU			
1	100	0	0
2	100	20.0	30.0
3	100	11.1	0
4	100	17.7	3.3
5	80.0	13.3	10.0
CONTROL			
1	100	20.0	3.3
2	100	3.3	6.7
3	100	3.3	13.3
4	100	10.0	0
5	93.3	0	0