DISCRIMINATION LEARNING BETWEEN AND WITHIN COMPLEX DISPLAYS

by

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ABSTRACT

The present experiment was designed to investigate discrimination learning between and within complex displays in a concept formation task. The displays were characterized by the presence or absence of a distinctive feature (human form) which was constantly varied from trial to trial. Subjects (pigeons) were able to acquire a discrimination between feature-present and feature-absent displays when such displays were assigned to positive and negative trials. Such differential training also caused responding within displays to converge on that distinctive feature in preference to other features which were common to reinforced and nonreinforced trials. The discriminations developed by the training procedure remained throughout extinction tests with "new" displays. In general, the development of stimulus control between and within these displays paralleled such development in simple displays as reported by Jenkins and Sainsbury (1969).

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This thesis is dedicated to the Vietnamese people in their struggle against the villains of the following pages. Together we pray that someday the American Eagle will learn the true meaning of the concept "mankind".

CHAPTER I

INTRODUCTION

The behavior of organisms is rich with many examples of animals learning to discriminate one situation from another and learning to use features of complex stimuli or situations as cues for action. The parent Herring Gull learns to distinguish its young within a few days and restricts all its activities to them, becoming indifferent and even hostile to other Herring Gull chicks (Tinbergen, 1953). This learning is often surprisingly acute. For example, the parent Gull will recognize its young despite an experimentally induced alteration of their color or location. Such learning based on varying aspects or features of the same instance (i.e., the same chicks) is termed discrimination learning (cf. Riley, 1968).

Animals can also learn to code complex stimuli or situations into categories and thus simplify the environment to some degree. For example, certain song birds such as the chaffinches can learn to distinguish the song dialect of its own community from those of other members of the species despite individual vocal differences (Nottebohm, 1970). Many psychologists think of such learning as concept formation (cf. Bourne, 1966). Concept formation allows the animal to code features into categories and to respond to all instances of the features in the same way; otherwise learning would be overwhelmingly complex as the song bird would be forced to deal with each individual song as an unique event. Thus, learning of categories to respond to restricts the number of response alternatives for the animal and facilitates his action. The animal is said to "abstract" or to "generalize".

Equally remarkable performances have been demonstrated in operant behavior laboratories where discrimination training procedures control the learning of abstractions and generalizations. For example, Verhave (1959) trained pigeons to discriminate between "good" and "bad" pills in a pharmaceutical manufacturing plant. The regular women inspectors could select pills reliably, but they were unable to verbalize their bases for selection. Using their accepted pills as positive instances and the pills they rejected as negative instances, the pigeons rapidly acquired the concept of "good" and "bad" pills. Similar results have been obtained by Cumming (1966) in training pigeons to inspect "good" and "bad" diodes on an assembly line. Pigeons have also been trained on such diverse concept-like discriminations as "ships" vs. no ships

(Skinner, 1960), "people" vs. no people (Herrnstein and Loveland, 1964), "man-made objects" vs. natural objects (Lubow, Siebert, and Carr-Harris, 1966), "forms" vs. "colors" (Siegel, 1969), and "apparent movement" vs. no movement (Siegel, in press). Thus, the laboratory animal, like his counterpart in nature, can learn to "abstract" or to "generalize".

Recently, there has been much concern with the mechanism for such concept formation in subhuman species and with the conditions that are necessary for such learning to take place (Goldiamond, 1966). Less attention has been given to the analysis of the resultant concept itself. In so far as concept formation involves a discrimination between positive and negative instances, the instances themselves may be considered as "features". In this sense, a feature is being defined as an abstracted characteristic common to a number of instances. What is the development of the discrimination between and within these features? How does this discrimination in "complex" instances compare with discrimination in more "discrete" displays (e.g., Jenkins and Sainsbury, 1969)?

The research reported in this thesis represents an attempt to answer these questions with respect to concept formation in the pigeon. The research is based in part on the studies in which the concept of "human being" has been investigated (Herrnstein and Loveland, 1964; Brown, 1966; Siegel, 1968; Siegel and Honig, 1970). In all these studies, pigeons were differentially trained to respond to displays containing people. The people differed in color, number, size, dress, orientation, etc. The pigeons learned to discriminate between the presence and absence of humans. Although the performance of pigeons in such artificial situations is somewhat surprising, Herrnstein and Loveland (1964) have indicated that the pigeon "rapidly forms a broad and complex concept when placed in a situation that demands one" (p. 551).

Since the initial Herrnstein and Loveland study raises a variety of empirical questions, it seems appropriate to define the limits of the present investigation. The ease and rapidity with which the discrimination was acquired has suggested to Herrnstein and Loveland that the pigeons either already had the concept at the beginning of the experiment or learned quickly during initial trials. While the present thesis does not attempt to comment on this directly, the rapid acquisition of such "unfamiliar" concepts as "good" and "bad" diodes and pills suggests that rapid and accurate learning of complex concepts is neither necessary nor sufficient proof that the animal was previously endowed with the concept, either innately or otherwise. Nonetheless, even if the animals learned how and when to respond only in the experimental situation (cf. Goldiamond, 1966), this process is of interest in revealing how perceptual-learning systems work and how they can be modified.

It should also be noted that the present thesis does not address itself to a consideration of the general cognitive abilities of avians. Interestingly, Thorpe (1961, 1963) has reviewed numerous ethological studies involving the identification of specific human beings by various species of birds despite "adverse" conditions of change in clothes, etc. He cites these as evidence for "ideation and manipulation of abstract ideas". This argument has recently been expanded (Thorpe, 1966) to indicate a complex avian consciousness including anticipation, expectancy, self-awareness, aesthetic, and ethical values. This thesis does not attempt to comment on such cognitive processes. However, the possibility of such complex behaviors existing in the avian's natural milieu can temper an initial excitement and perplexity about performance in the laboratory.

Successive and Simultaneous Concept Formation

Operationally, experimenters have chosen either successive or simultaneous methods of stimulus presentations in the study of concept formation.

In successive discrimination learning only one display (or stimulus complex or "instance") is present on any given trial. The displays differ from trial to trial and the subject must make one response in the presence of one stimulus and another response in the presence of the other. Usually, responses in the presence of positive stimuli can be rewarded while negative stimuli are presented while extinction is in effect. This type of successive discrimination is often referred to as a go/no-go discrimination. However, in a conditional successive discrimination it is possible to make a correct response and obtain reward on each trial. Conversely, in simultaneous discrimination, positive and negative displays are presented together, but usually in a random spatial arrangement from trial to trial. In the latter case, the subject must choose between the two displays which are present for comparison and such comparison has sometimes been regarded as easier to make than when both displays are not physically present (cf. Riley, 1968, pp.91ff). However, the relative ease or difficulty of simultaneous and successive discriminations can depend on a variety of experimental conditions. For example, under conditions where the stimuli to be discriminated are physically isolated the simultaneous problem is easier than the conditional successive (Bitterman and Wodinsky, 1953; Wodinsky, Varley, and Bitterman, 1954). Conversely, under conditions where the stimuli are closely juxtaposed, the successive discrimination is easier than the simultaneous (Bitterman, Tyler, and Elam, 1955; Wodinsky, Varley, and Bitterman, 1954). In addition, the relative difficulty of the conditional successive discrimination increases as the similarity of the two members of each pair of stimuli increases (Macaslin, 1954). Still other experimenters have observed no differences between go/no-go successive and simultaneous conditions (e.g., Grice, 1949).

A notation for the application of some of these procedures to concept formation may be helpful. Consider the general concept formation paradigm where B represents a distinctive feature such as "human being"; then A represents all those other features which are common to both "humans-present" and "humans-absent" displays. These common A features might include houses, cars, landscapes, and even subhuman animals. Since both A and B features change from trial to trial a suitable notation becomes $A_{1...n}$ and $B_{1...n}$. In effect, the animal never encounters a constant or invariant A or B and must learn to abstract or to generalize in order to select correctly from among composite displays. The actual training procedure becomes $A_{1...n}B_{1...n}(+)$, $A_{1...n}(-)$. Here the animal is rewarded for responses to displays containing some instance of B along with some instance of A but is never rewarded for responses to instances of A alone. This procedure can be administered both successively and simultaneously. Let B* represent the resultant feature which is abstracted or generated from $B_{1...n}$. Then, A* becomes the resultant common feature which is generated from $A_{1...n}$. But because $A_{1...n}$ features are always present as background to $B_{1...n}$, A* is also generated from the general background of $B_{1...n}$.

In the actual discrimination of concepts like human being it is not always easy to define B*. Since the animal in the above example never encounters a constant and unchanging B, it is a question of philosophy rather than empiricism how one would define B* when only $B_{1...n}$ are available as examples.

The discrimination of B* can be remarkably strong. For example, Siegel and Honig (1970) trained one group of pigeons on the problem $A_{1...n}B_{1...n}(+)$, $A_{1...n}(-)$ with successively presented slides similar to those used by Herrnstein and Loveland (1964). Another group was trained on the same problem using simultaneous presentations of the positive and negative displays. Both groups acquired the discrimination, although the simultaneously trained birds were consistently inferior to the successively trained animals. Good discrimination performance was maintained when new slides were successively presented in extinction sessions and even when slides were rotated 180°. A series of "matched-pairs tests" was employed in which pairs of displays were simultaneously shown. Each pair consisted of two photographs of the same scene which differed only in that one or more human forms ($B_{1...n}$) were present in one picture and absent in the other. Rather good discrimination performance was maintained throughout the "matched-pairs tests". Since the $A_{1...n}$ features used in the matched-pairs were identical, differences in stimulus control between displays would appear to be associated with the presence or absence of $B_{1...n}$. However, since the human feature in one member of a matched-pair was replaced by additional $A_{1...n}$ features, it remains possible (although highly unlikely) that stimulus control was based on "amount" of $A_{1...n}$ features present.

Taken together, the Herrnstein and Loveland (1964) and Siegel and Honig (1970) studies demonstrate unequivocally that responding of the pigeon may come under control of some complex feature or integrated compound. Siegel and Honig have noted that this control was imperfect and discrimination ratios did not reach the high levels normally obtained with pigeons on simple visual discriminations. Since most animals showed 60-70% responding to the positive (human-present) displays, the discrimination reflects imperfect extinction to the negative displays. One possible explanation is to postulate that one or more of the common features acquired control over responding. In other words, the failure of a strong discrimination between positive and negative displays may reflect a strong tendency to respond to a common feature regardless of the presence or absence of humans on the same display. Other experimenters have noted that in training subjects to respond differentially to complex stimuli, stimulus control is often acquired by multiple elements (e.g., Johnson and Cumming, 1968; Born and Peterson, 1969). Nonetheless, it is rarely observed that these elements or features are the occasion for similar levels of responding when they appear separately. While this observation prompts many experimenters to employ explanatory devices such as "attention" and "acquired distinctiveness of cues", Terrace (1966) has cautioned that such terms add little to our understanding. What is needed, therefore, is a specification of the conditions under which stimulus control does and does not develop to separate features of a complex display or an integrated compound of such features.

While the pigeon is capable of utilizing integrated compound features of positive instances (Williams, 1967), Reynolds (1961) has noted that a pigeon may be responding to only one of several aspects of a discriminative stimulus. In other words, every part of the positive instance that is present when a reinforced response occurs may not subsequently be an occasion for the emission of that response. Indeed, Jenkins and Sainsbury (1969, 1970), recording the locus of the peck-response, suggest a schema for the development of such stimulus control to separate features of simple displays.

The Jenkins and Sainsbury Experiments

The Jenkins and Sainsbury experiments (Jenkins, 1967; Jenkins, 1969; Jenkins and Sainsbury, 1969, 1970; Sainsbury, 1969; Sainsbury and Jenkins, 1967) were concerned with relatively simple visual discriminations and did not, in effect, utilize concept formation. In one experiment they examined the learning of a pair of displays: one member of the pair contained a circle as the distinctive feature (B) and two stars as the common features (A); the other member of the pair contained a star as the distinctive feature (B) and two circles as common features (A). One group of pigeons was trained on the discrimination AB(+), A(-) and this was referred to as the feature-positive condition.

Another group was trained A(+), AB(-) and termed the feature-negative condition. The displays appeared as bright objects on a dark ground and were rear-projected onto a translucent response key consisting of four independently operable sections. The location of the features (stars and circles) was randomly changed from trial to trial. Responses on each quadrant of the key were recorded along with the location of the features. It was found that the pattern of key pecks converged on the distinctive feature when it appeared in positive displays. Jenkins and Sainsbury (1969) report that the learning of the discrimination was facilitated when the distinctive feature appeared on positive trials. This has been termed the feature - positive effect and is marked by response convergence on the positive feature. When the feature appeared on negative trials the discrimination did not develop. Recently, Jenkins and Sainsbury (1969) have expanded these results into a theory of feature selection:

> The central idea is that successive discrimination training in the arrangement AB(+); A(-) leads to a simultaneous discrimination within the compound, AB, display. The animal comes to choose B because the response to B is always reinforced while the response to A is only sometimes reinforced. The choice of B within the AB display prevents A from gaining strength on AB(+) trials. Since A is still

> occurring on A(-) trials, the response to A extinguishes.
>
> In the feature-negative case, where training is under the arrangement A(+); AB(-), a simultaneous discrimination between A and B also forms, but the shift is away from B toward A; that is, in a direction opposite to that of the shift when the distinguishing feature is on the positive display. The shift occurs because the probability of reinforcement for a B-response is fixed at zero, while for an A-response, reinforcement-probability remains relatively high. In the present experiment, the probability of reinforcement for an A-response can hardly fall below .5, since positive and negative displays are presented equally often. Since a reinforcement probability of .5 is more than adequate to maintain responding to A, the no-go side of the discrimination is not achieved.
>
> Jenkins and Sainsbury, 1969, p.140

This explanation stems directly from data obtained on response location for spatially separate stimuli. This schema assumes that the displays consist of (i) single distinct features and (ii) physically separate features. Assumption (i) is fulfilled by the use of bright stars or circles projected against a dark ground. Each feature occuppied an area of 6.35mm in diameter and they were shown on response keys 36.49mm on a side. Assumption (ii) was fulfilled by dividing the display surface of the response key into four equal sections, each section 17.47mm on a side and limiting one feature to one section. The sections were further separated by a 1.59mm wide metal strip which presumably served to "prevent the activation of more than one sector by a single peck" (Jenkins and Sainsbury, 1970, p.47). With these two conditions fulfilled, Jenkins and Sainsbury further assumed that A and B do not interact perceptually. That is, A maintains its identity when it appears with B and the learning on any given trial can be assigned exclusively to one feature. In other words, as long as the features are spatially separate they can also be functionally separate. In support of this notion of non-perceptual interaction, the authors report that when features (red and green dots) are displayed together in compound clusters (1.5mm separation between features) discrimination learning was still facilitated when the features appeared on positive trials (although some learning of the successive discrimination was observed in the feature-negative case). In addition, the distinctive feature is still responded to when presented singly--a fact which indicates functional separation. While one could argue along Gestalt lines (cf. Koffka, 1935) that AB and A displays are unique perceptual configurations, there would be no need therefore for their assignment to positive and negative trials to affect the outcome of the discrimination (Jenkins and

Sainsbury, 1969, p.157). It is reasonable to conclude that functional separation is possible even when physical separation is minimal.

Thus, a critical requirement of this schema is the use of distinct functionally separable features as the stimuli. Presumably these features do not interact perceptually and to connote this Jenkins and Sainsbury refer to "punctate" displays. However, some degree of perceptual interaction is inevitable. For example, "although one can speak of a dot as a distinguishing feature and the lighted background as a common feature, the distinguishing feature cannot be entirely separate from the common feature" (Jenkins and Sainsbury, 1969, p.157). Since functional separation was nonetheless achieved in their experiments, it remains plausible that features are defined as functionally separate as long as responses can be made directly to them.

Application of Jenkins and Sainsbury's Schema to Concept Formation in the Present Experiment

The plan of the present experiment was to assess the application of the Jenkins and Sainsbury schema to the study of stimulus control in a concept formation paradigm.

Jenkins and Sainsbury note that simple discriminations between AB and A displays appear to develop in accordance with the development of discriminations within AB displays. The importance of the requirement of functionally separable features is twofold. Firstly, in order to assess the application of this schema to discriminations involving features of the $A_{1...n}$ and $B_{1...n}$ variety, it only becomes necessary to allow responding to the features themselves. Secondly, since features can be defined as functionally separate as long as responses are made directly to them, spatial distributions can be varied. Thus, $B_{1...n}$ features can be arranged so that they are never completely separate from $A_{1...n}$ which can serve as nonspatially separate <u>background</u> features as well as spatially separate <u>common</u> features. In this way we gain the opportunity to use response location data to assess the application of the schema to a situation in which features are both spatially separate (common) and yet part of a nonspatially separate display (background). In other words, common and background features, while different from each other in Jenkins and Sainsbury's experiments, are the same in the present study.

Jenkins and Sainsbury (1969, 1970) have attempted to explain the development of stimulus control through differential reinforcement for a continuum of displays ranging from spatially separate features to nonspatial cases. While their experiments anchor one end of the continuum with spatially separate features, the authors are forced to approach the application to the nonspatial case through theoretical implications (Jenkins and Sainsbury, 1969, p.159ff.). By arranging $A_{1...n}$ features as nonspatially separate background features and spatially separate common features, another point of application of the schema may be tested along this continuum.

The previous discussion on concept formation has stressed the parallel between these concept paradigms ($A_{1...n}B_{1...n}$, $A_{1...n}$) and that of Jenkins and Sainsbury (AB; A). Recalling Jenkins and Sainsbury's use of the same circles and stars as A and B features, the use of complex and constantly varied features ($A_{1...n}$ and $B_{1...n}$) in the present experiment invites elaboration. When all instances of a feature (either A or B) are identical or even similar to each other the tendency to make the same response to each is great and learning of a discrimination between displays characterized by their presence or absence is relatively easy. But if there is much variability among positive (and/or negative) instances of a feature (as in $B_{1...n}$) learning is relatively difficult. Thus, the present experiment presents a dramatically different problem to the animal, the difficulty of which is largely a function of the degree of generalization among the features. To solve such a problem the animal comes to learn a concept since all negative instances of a given concept are paired with extinction and all positive instances are paired with reinforcement and come to govern responses. Thus, a discrimination <u>between</u> displays develops. By providing for the functional separation of $A_{1...n}$ and $B_{1...n}$ features, it can be determined whether such discrimination is marked by the development of a discrimination <u>within</u> the positive display itself (cf. Jenkins and Sainsbury, 1969). As noted earlier, such a within-display discrimination can develop for spatially separate features. Indeed, Jenkins and Sainsbury have stressed the spatial selection of B within displays as necessary to the achievement of discrimination between displays. To assess this in the present experiment, $B_{1...n}$ distinctive features will be spatially separate from $A_{1...n}$ common features. The plan was to employ displays in which the feature $B_{1...n}$ was located in a separate quadrant and responses could be made directly to it. As such, $B_{1...n}$ fulfills the requirement of functional separation. While common features were present in quadrants adjacent to $B_{1...n}$, they also tended to be present as nonspatial background features to $B_{1...n}$ itself. Such a spatial arrangement of $B_{1...n}$ and $A_{1...n}$ insured that they were also part of an integrated compound.

While the basic experimental paradigm is similar to that used by Siegel and Honig and the physical arrangement for recording peck-location is similar to Jenkins and Sainsbury's method, several differences between those studies and the present one seem potentially important:

1. Displays in the Siegel and Honig study were projected onto screens located above circular response keys. Catania (1964) has suggested that such a location may not be optimal for the visual acuity of the pigeon. This could partially account for failure to achieve high levels of discrimination. While the pigeon is near-sighted and presumably the displays above the response key are clearly seen, a peck at the display itself "involves, at least to some extent, a simple kind of stimulus clarification, in that the peck guarantees that the stimulus is in focus for the pigeon"(Catania, 1964, p.365). Thus, while in the present experiment the pigeon is required to respond to the displays themselves in order to provide feature-tracking location data, this technique presumably insures optimal visual acuity as well. Indeed, it has been more simply stated that pigeons look where they peck and this functions as an "overt

orienting response" (Mackintosh, 1969) providing "facilitative feedback" (Estes, 1969).

2. Jenkins and Sainsbury projected their displays directly onto the response keys (screens). When the pigeon pecked at the display it moved a small distance necessary to operate a micro-switch and this movement produced a small amount of visual distortion. While the importance of such response-produced distortion in simple star and circle displays is dubious, Siegel and Honig found a deterioration of discrimination when slides were projected out of focus and suggest that this variable should be maximally controlled with complex displays. Therefore, displays in the present experiment were projected onto "polacoat" screens located behind clear plexiglas response keys. Responses to these keys did not affect the displayed image.

3. Jenkins and Sainsbury used response keys which consisted of four individually operable sections. The sections or quadrants were further separated by a 1.59mm wide metal strip. While this design prevented activation of two quadrants by a single peck and insured functional separation of the features, it virtually provided four separate keys for responding. Although the varability of response location for the pigeon appears to be more a function of the schedule of reinforcement than anything else (cf. Eckerman and Lanson, 1969), it is reasonable to suspect that the actual physical separations of the quadrants could

inhibit a certain amount of alternation of responding between quadrants. More importantly, a crucial characteristic of the common features $A_{1...n}$ is that they are continuous between all quadrants. And since we have already noted that functional separation is possible even when physical separation is minimal, the quadrants in the present experiment were positioned adjacent to each other without a dividing metal strip. Separation was a maximum of .794mm. This construction allowed one peck to activate two quadrants thus increasing reinforcement probability. However, such a response would require double the normal force requirement and there are already a number of studies suggesting that the rate of responding to the higher force would decrease while the response rate to the lower requirement on the four individual quadrants would remain unaffected (e.g., Elsmore and Brownstein, 1968; Notterman and Mintz, 1965). Nonetheless, as an additional control for two-quadrant pecks, a delay circuit was arranged which required at least a 50msec. interval between pecks in order for them to be recorded.

For purposes of clarity, the subscripts $_{1...n}$ will be eliminated in the chapters which follow.

CHAPTER II

METHOD

Subjects

Subjects were 32 loft-reared homing pigeons (Columba livia). The majority of the birds were of the Blue Barred Rock breed and all were experimentally naive. Subjects had been reared locally and had contact principally with only two human caretakers prior to the experiment. At the start of the experiment all subjects were approximately 12 months old and weighed between 285-430g. All subjects were maintained at 70% of their free-feeding weights and housed in separate home cages with free access to water and grit.

Apparatus

All subjects were trained in an operant discrimination unit equipped with two 7.62cm x 7.62cm "polacoat" screens, one on each side of a centrally positioned food magazine. Four individually operable response keys, constructed from clear plexiglas and 3.81cm x 3.81cm x 1.588mm, were placed over each section. A string-gauge was employed to adjust and equalize the force requirements on all response keys and this procedure was repeated weekly.

Displays were rear-projected onto the screens by means of a Kodak Carousel 800 projector (modified by Lehigh Valley Electronics, no. 1649) equipped with a 1.0 neutral density filter. Two experimental units of identical design were equipped in this way.

Programming and recording equipment was located in an adjacent room. A continuous white masking noise was fed into loudspeakers located both inside and outside of the experimental units. Responses were recorded for separate quadrants during both training and testing.

Stimuli

All stimuli consisted of 35mm Kodachrome II or Ektachrome color transparencies (slides) which had been photographed with a single lens reflex camera equipped with an automatic exposure meter. The four types of stimuli used and a notation for them are shown in Figure 1. The displays containing B features included people of various races, ages, sizes, and dress. They were displayed in various attitudes and occupied various positions in and portions of the quadrant in which they appeared. The amount of a person displayed varied. For example, in some displays only an arm or a head would be visible, while others displayed an entire body or several people in a group. The A features also included a wide variety such as landscapes, houses, cars, various objects, and subhuman species. Several representative displays are reproduced in Figure 2. There were

FIG. 2

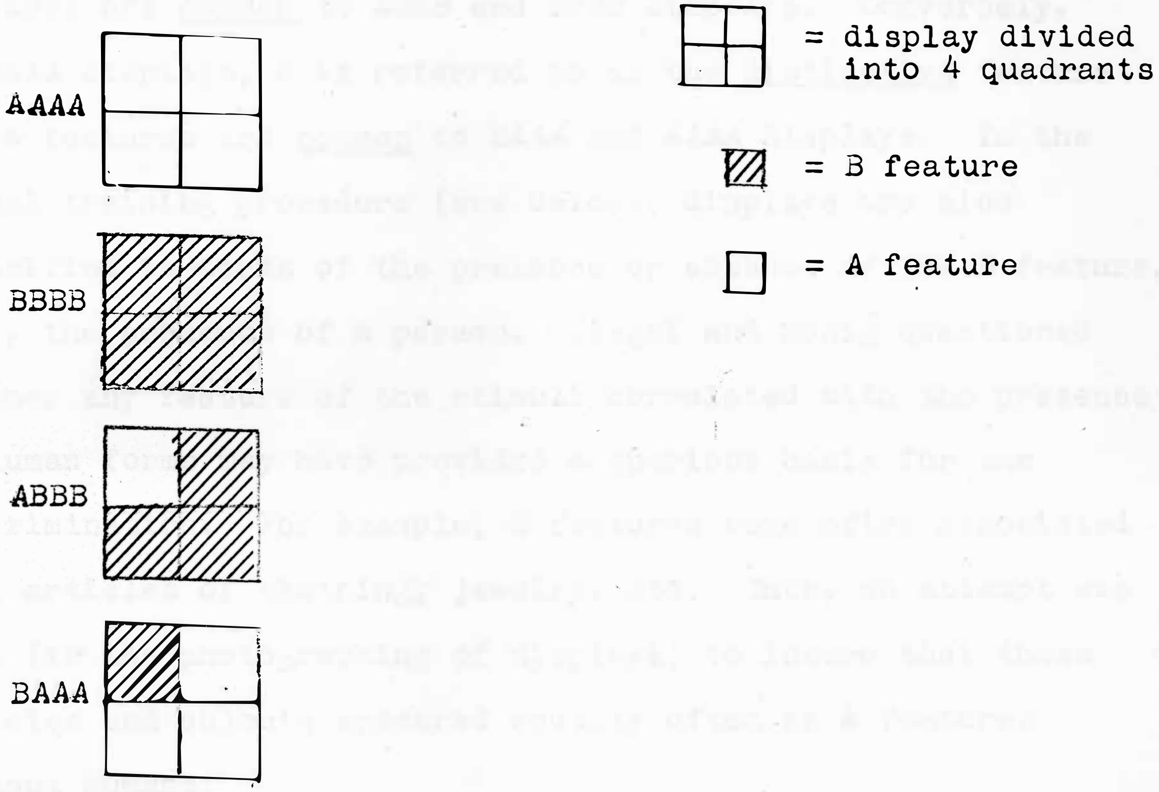
BBBB

AAAA

ABBB

BAAA

Figure 1. Schematic representation of the four types of displays used in the experiment.



approximately 2000 different displays utilized in this experiment: 500 AAAA, 500 BBBB, 500 ABBB, and 500 BAAA. In ABBB displays, A is referred to as the <u>distinctive</u> feature while B features are <u>common</u> to ABBB and BBBB displays. Conversely, in BAAA displays, B is referred to as the <u>distinctive</u> feature and A features are <u>common</u> to BAAA and AAAA displays. In the actual training procedure (see below), displays are also classified in terms of the presence or absence of the B feature, i.e., the presence of a person. Siegel and Honig questioned whether any feature of the stimuli correlated with the presence of human forms may have provided a spurious basis for the discrimination. For example, B features were often associated with articles of clothing, jewelry, etc. Thus, an attempt was made (in the photographing of displays) to insure that these articles and objects appeared equally often as A features without humans.

Because of the difficulty in constructing matched-pairs (See Testing Procedure below) of the ABBB variety, mannequins (Barbi-dolls) were frequently used in place of real people. The use of mannequins permitted greater flexibility in the design of these displays. Approximately 50% of the Test 2 slides of the ABBB/BBBB variety were mannequins and this was the only occassion in which mannequin slides were used in the experiment.

General Procedure

Subjects were randomly divided into eight groups of four subjects each.[1] All subjects were given conventional magazine training and shaping of the key-peck response during the first session. During this procedure only one screen was illuminated with white light and responses could be made to any quadrant. Following this, subjects were given four sessions of training on a variable interval one minute (VI 1) food reinforcement schedule. Reinforcement consisted of a 3-sec. access to mixed grain. These initial sessions were terminated when fifty reinforcements were received. In the fifth session, all subjects received 40 trials in which white light was displayed. Each trial was 90-sec. long followed by a 10-sec. inter-trial interval (ITI) during which time the screen was dark and reinforcement was not available. During the ITI an automatic shutter located in the projector was closed thus darkening the screen.

Following this preliminary training, subjects received either 25 or 60 daily sessions of discrimination training, depending on which group they were assigned to. Each session consisted of 40 successively presented slides (one screen

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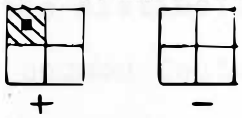
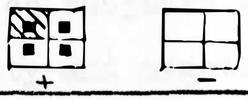
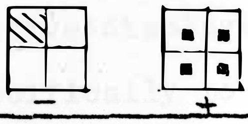
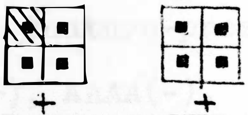
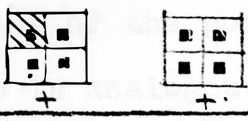
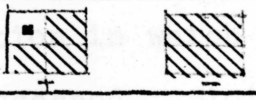
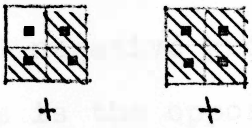
[1] The eight groups were all treated with similar procedures, save for reinforcement contingencies. While reported together, Groups FPG, FPS, and FPP2 were run first and at the same time, followed by the rest of the groups.

illuminated). Each session included 20 positive (+) and 20 negative (-) trials of 90-sec. each, randomly alternated in Gellermann series (Hilgard, 1951). The location of features within the displays was randomly changed from trial to trial. Thus, in 20 trials the distinctive feature (B of BAAA and A of ABBB) was presented five times in each quadrant. Each trial was followed by a 10-sec. ITI. The slides presented during a session all differed from each other, and different sets of slides were presented in each session. Slides were randomly selected for presentation during specific sessions. The slide library was sufficient to program about 25 sessions (1000 slides) for a given group without repetition. Only one screen was illuminated within a given session, but screens were randomly alternated between sessions (cf. Gellermann series).

Design

Table I presents the eight treatment groups, their positive and negative displays, and the specific response and reinforcement contingencies. Treatment groups are always classified in terms of the presence or absence of a B feature (human) on reinforced displays. The eight groups in Table I are defined in the following manner:

TABLE I. Notation and description of the eight experimental groups.

GROUP	NOTATION		DESCRIPTION
Feature-present specific	FPS		Only responses to quadrant with B feature can be rewarded
Feature-present general	FPG		Responses to any quadrant of display with B feature can be rewarded
Feature-present general negative	FPGN		Responses to any quadrant of display with B feature absent can be rewarded
Feature-present pseudo VI 1	FPP1		Responses to any quadrant of any display can be rewarded 50% of the time on VI 1
Feature-present pseudo VI 2	FPP2		Responses to any quadrant of any display can be rewarded 100% of time on VI 2
Feature-absent specific	FAS		Only responses to quadrant with B feature absent can be rewarded. Complement of FPS
Feature-absent general	FAG		Responses to any quadrant of display with B feature absent in one quadrant can be rewarded. Complement of FPG
Feature-absent pseudo VI 1	FAP1		Responses to any quadrant of any display can be rewarded 50% of the time on VI 1. Complement of FPP1

+ = marks displays which are positive and can be rewarded

− = marks displays which are negative and cannot be rewarded

■ = marks quadrants on which responses can be rewarded

Feature-present refers to displays characterized by the presence of human feature (B) in one quadrant. In other words, the human features are the distinctive features while landscapes and related objects are common features. Feature-present specific (FPS) designates subjects who received positive displays of the BAAA variety and negative displays of the AAAA variety. In these positive displays, the subjects were required to respond specifically to the quadrant in which the B feature was present. Feature-present general (FPG) designates subjects trained BAAA(+), AAAA(-), Here, responses made generally to any quadrant of the positive display could be rewarded and this group is analogous to Jenkins and Sainsbury's feature-positive condition in which spontaneous tracking of the B feature can be assessed. Similarly, the Feature-present specific group enables us to determine if tracking of the B feature can be forced if it does not emerge spontaneously. The Feature-present general negative group (FPGN) were trained BAAA(-), AAAA(+). This is the opposite reinforcement condition from FPG and comparable to Jenkins and Sainsbury's feature-negative training condition. Here, responding is allowed to shift away from the human feature which appears on nonreinforced trials. Both feature-present pseudo groups (FPP1 and FPP2) received non-differential training on BAAA and AAAA displays in order to assess baseline performance and any natural response preferences which might develop between and/or within displays.

Feature-absent refers to displays characterized by the absence of a human feature (B) from one quadrant. In other words, the human features are now common features while the landscapes and other related features appear as the distinctive feature in one quadrant. Feature-absent specific (FAS) designates subjects trained ABBB(+), BBBB(-). Here, subjects were required to respond specifically to the single quadrant in which the human was absent (A). This group can be considered the complement of feature-present specific. Similarly, Feature-absent general (FAG) refers to subjects trained ABBB(+), BBBB(-) and responses to any part of the display with human feature absent from one quadrant could be rewarded. This group is the complement of feature-present general. Feature-absent pseudo subjects (FAP1) received non-differential training on ABBB and BBBB displays.as complementary procedure for feature-present pseudo groups. In general, Feature-absent groups were designed to assess the interchangeability of A and B features in the present concept experiment. Jenkins and Sainsbury ran groups in which they observed that the designation of A or B as the distinctive feature made little difference in the development of between or within-display discrimination. Their groups were symmetrical with respect to the use of discrete stimuli (circles and stars) as common or distinctive features. Superficially, the Feature-absent and Feature-present groups represent a similar symmetry, at least in terms of notation. However, while $A_{1...n}$ and $B_{1...n}$ are interchanged in these groups, the background features ($A_{1...n}$) are not. Thus, the interchange of A and B in the present design results in a type of asymmetry. The consequence of this asymmetry may be assessed by comparing Feature-absent and Feature-present groups.

When reinforcements were available they were obtainable on a variable interval one minute schedule (VI1). The single exception to this was Group FPP2 where reinforcements were available during all trials on a variable interval two-minute schedule (VI 2). Reinforcements consisted of a 3-sec. access to mixed grain during which time the displays remained on the screen but the magazine was illuminated with white light.

Testing Procedure

At the completion of training all subjects were given two tests in extinction sessions. Five regular training sessions intervened between the two tests.

Test 1 consisted of 40 "new" slides (not previously shown) successively presented in 30-sec. trials with a 10-sec. ITI. Of these 40 slides, 20 were positive displays and 20 were negative displays all randomly alternated.

Test 2 consisted of 20 matched-pairs of slides simultaneously presented in 30-sec. trials with a 10-sec. ITI between trials. Each matched-pair consisted of two slides of the same scene which differed only in one quadrant. For subjects trained on displays of the BAAA/AAAA variety, the AAAA display of the pair was identical to the BAAA display with the exception that one or more human forms or parts thereof were contained in the quadrant designated B. Thus, the exact notation of these matched-pairs becomes, for example:

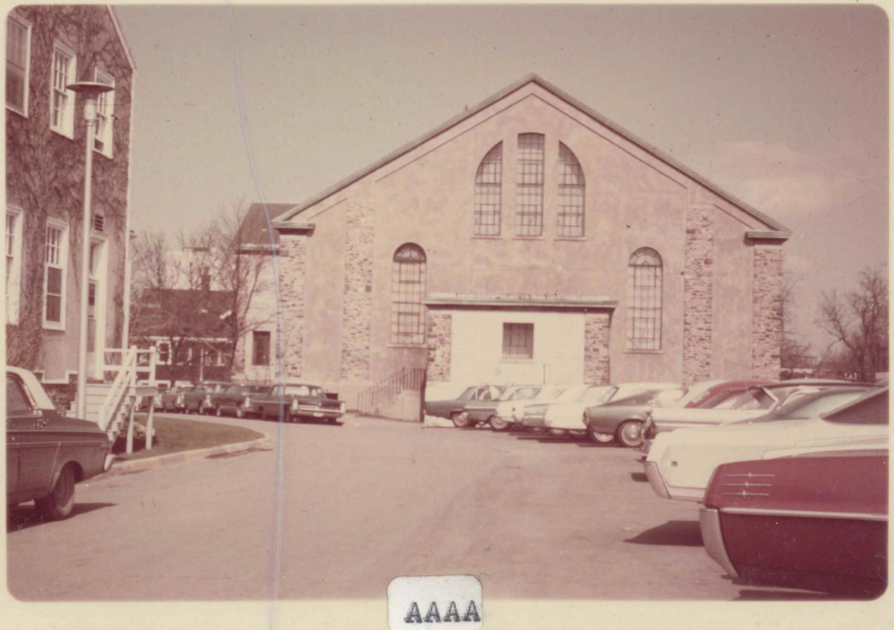
$$B_1A_2A_3A_4 \ / \ A_1A_2A_3A_4$$

The quadrant B_1 actually contained A_1 with the addition of the human feature which usually obscured much of A_1. For subjects trained on the displays of the ABBB/BBBB variety, the ABBB display of the pair was identical to the BBBB display with the exception that the B feature was removed from one quadrant leaving only the remaining A feature. Thus, the exact notation of these matched-pairs becomes, for example:

$$A_1B_2B_3B_4 \ / \ B_1B_2B_3B_4$$

Examples of both types of matched-pairs are shown in Figure 3.


BAAA


AAAA


BBBB


ABBB

FIG. 3

Reversal Training

As a supplementary procedure, Groups FPS and FPG were given FPGN training for 60 additional sessions and again tested with a new Test 1 and a new Test 2.

CHAPTER III

RESULTS

Measures

Trial-by-trial responses to each display were recorded throughout training and testing sessions. Trial-by-trial responses to each quadrant were also recorded for each subject. The discrimination ratio (DR) was used to describe the percentage of the total responses in a session made to positive displays. Algebraically, the DR equals $100P/(P+N)$ where P is the number of responses made to displays containing the distinctive feature and N the number made to displays not containing the distinctive feature. Similarly, a convergence ratio (CR) was used (i) in the case of the feature-present groups to describe the percentage of responses to the distinctive feature quadrant (B) against the total of responses to all quadrants of the feature-present display (BAAA). Algebraically, this CR (i) equals $100B/(B+A+A+A)$. The CR was also used (ii) in the case of feature-absent groups to describe the percentage of responses to the distinctive feature-absent quadrant (A) against total responses to all quadrants of the feature-absent display (ABBB). Algebraically, this CR (ii) equals $100A/(A+B+B+B)$. In other words, the DR was a measure of discrimination performance

<u>between</u> positive and negative displays while the CR was a measure of performance <u>within</u> the distinctive feature displays.

With no difference between response rates to positive and negative displays, the DR is 50. If a subject responds exclusively to displays containing the distinctive feature the ratio is 100. DR's less than 50 indicate an avoidance of the displays containing the distinctive feature. Similarly, if there is no difference between response rates to the feature-present quadrant (B of BAAA) or the feature-absent quadrant (A of ABBB) and the responses to the other quadrants of that display, the CR is 25. Early in training one would predict that all subjects would have a CR close to 25. If responses during training converged on the feature-present or feature-absent quadrant, the CR would be expected to increase gradually and approach 100. If, however, a subject tended to avoid this quadrant, the CR would decrease to values less than 25.

<u>Training Results</u>

The mean CR's and DR's in blocks of five sessions throughout training are presented for each group separately in Figures 4-11. Mean DR's and CR's for each of the first five training sessions are also included in these figures. DR's and CR's achieved in the last block of training for each bird (Pre-Test 1) are also presented in Tables II and III along with testing results which will be discussed later.

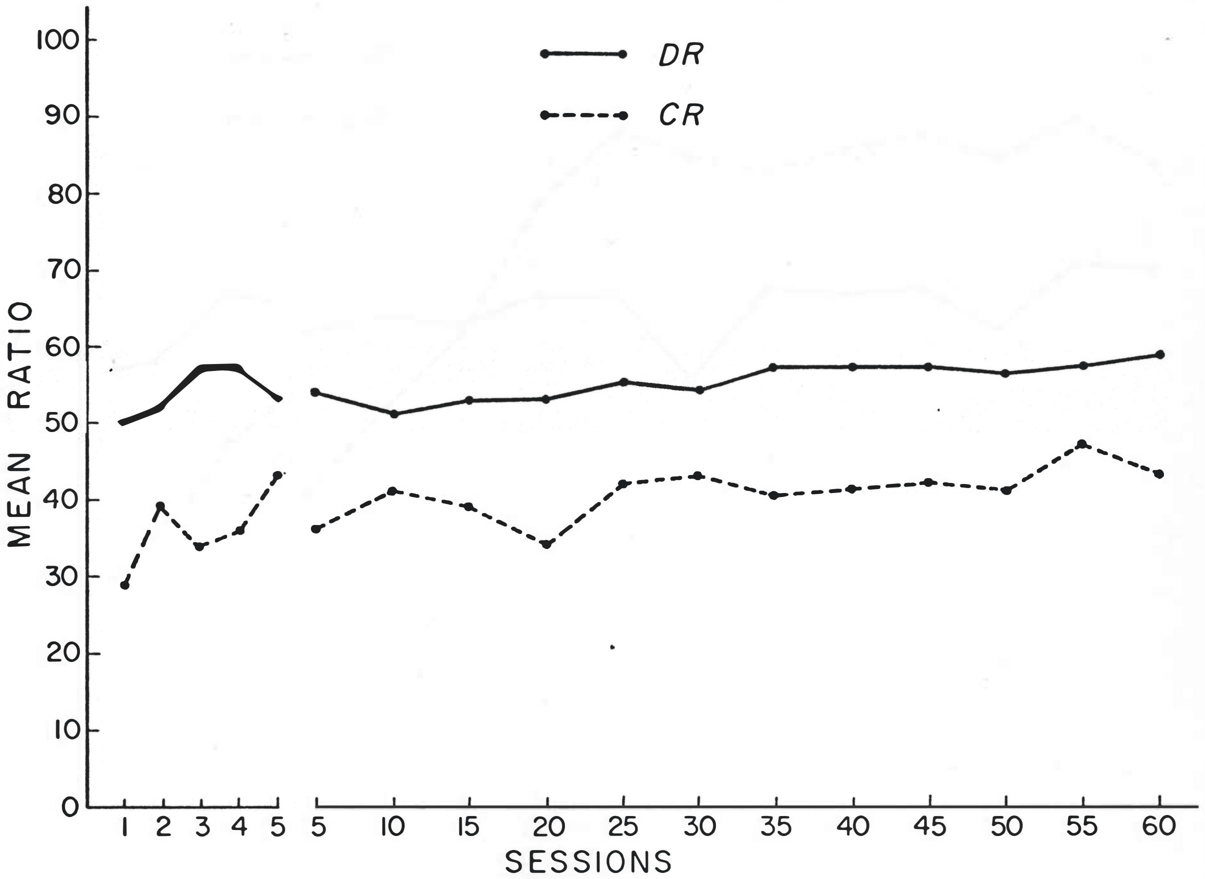


FIG. 4 MEAN RATIOS FOR GROUP FPG DURING TRAINING SESSIONS (n = 4).

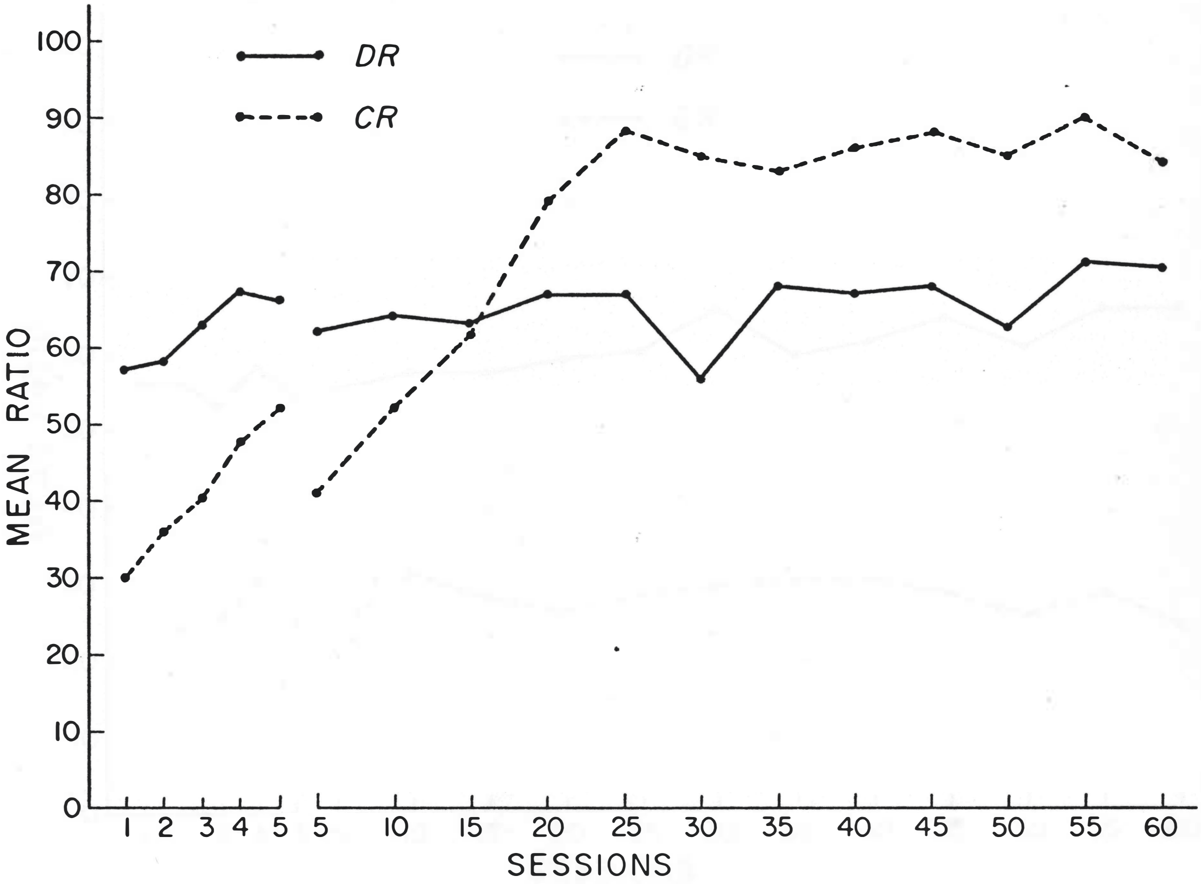


FIG. 5 MEAN RATIOS FOR GROUP FPS DURING TRAINING SESSIONS (n=4).

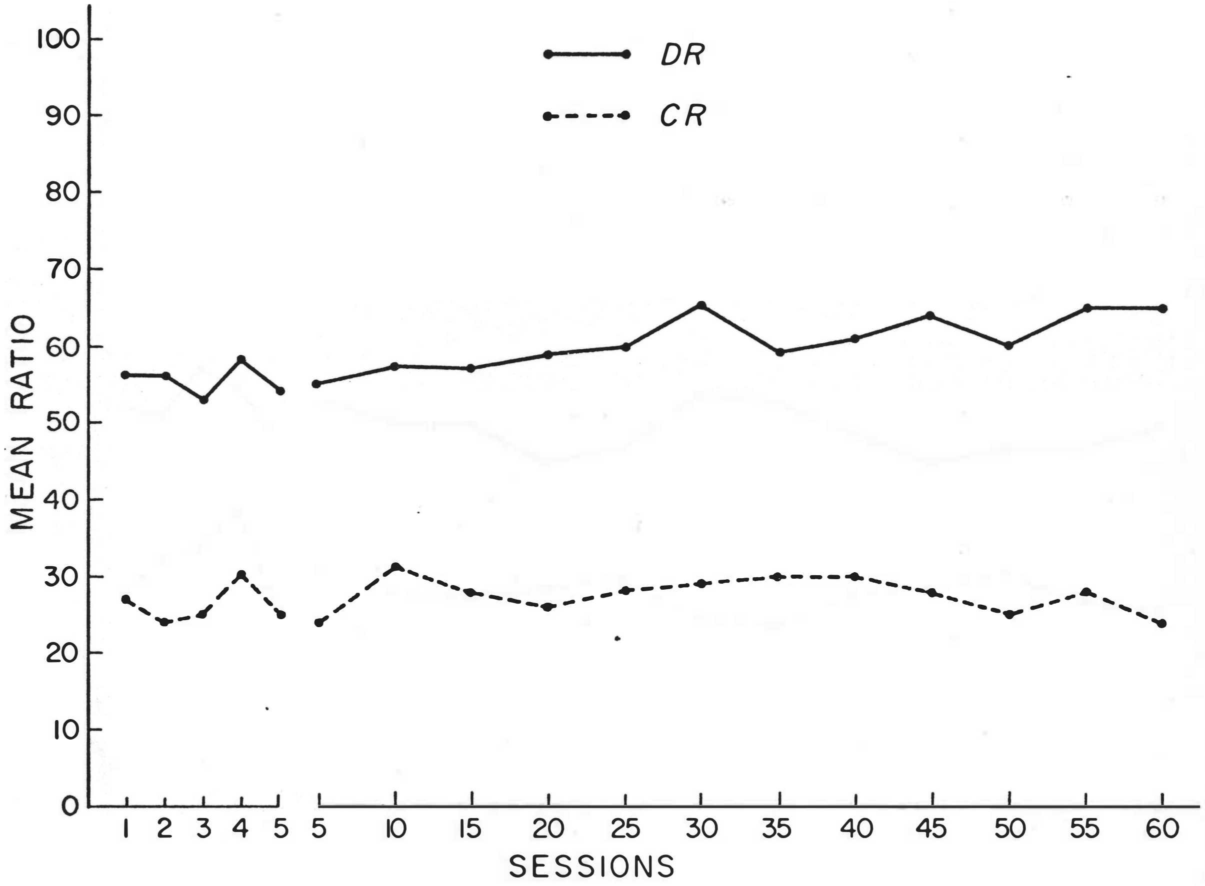


FIG. 6 MEAN RATIOS FOR GROUP FPGN DURING TRAINING SESSIONS (n=4).

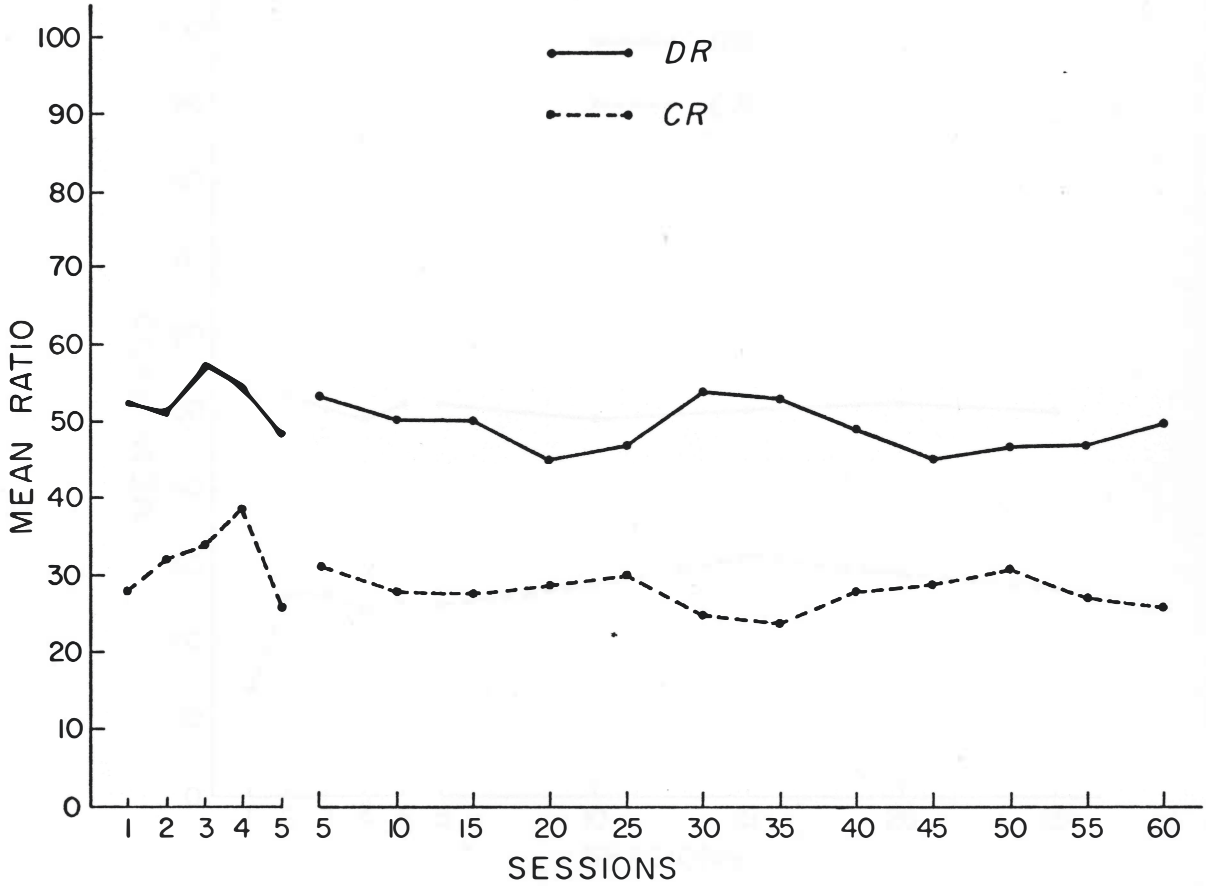


FIG. 7 MEAN RATIOS FOR GROUP FPP2 DURING TRAINING SESSIONS (n=4).

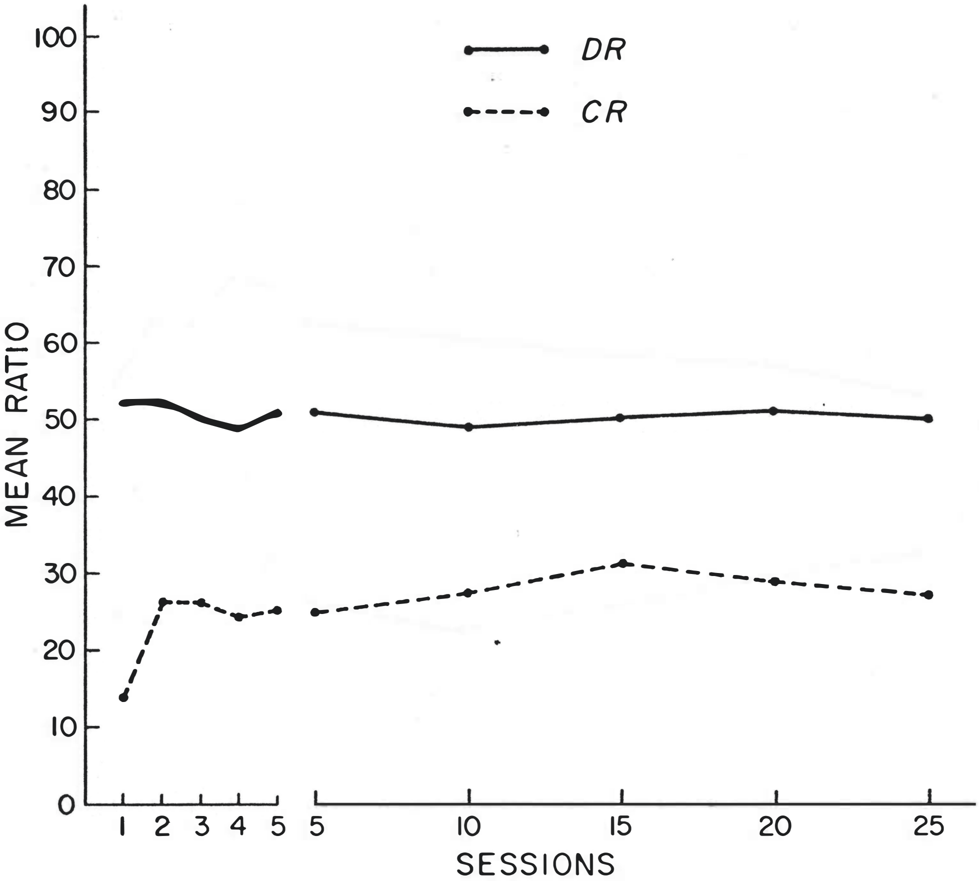


FIG. 8 MEAN RATIOS FOR GROUP FPP1 DURING TRAINING SESSIONS (n=4).

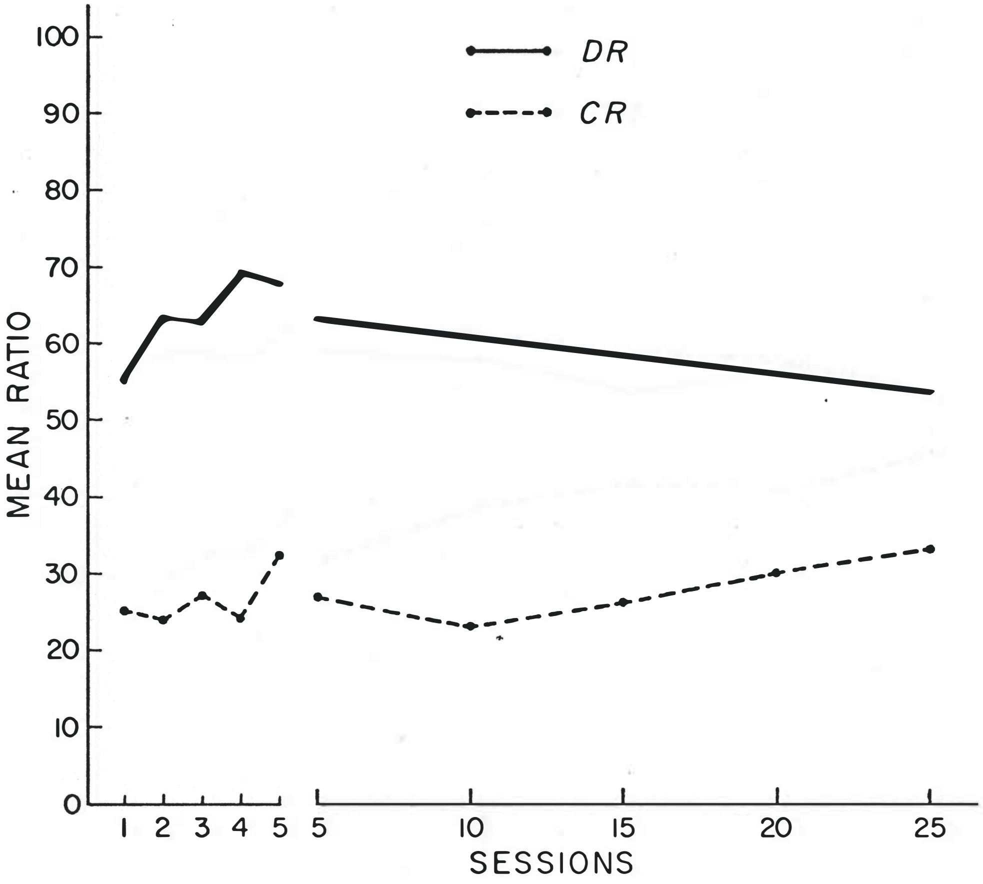


FIG. 9 MEAN RATIOS FOR GROUP FAG DURING TRAINING SESSIONS (n=4).

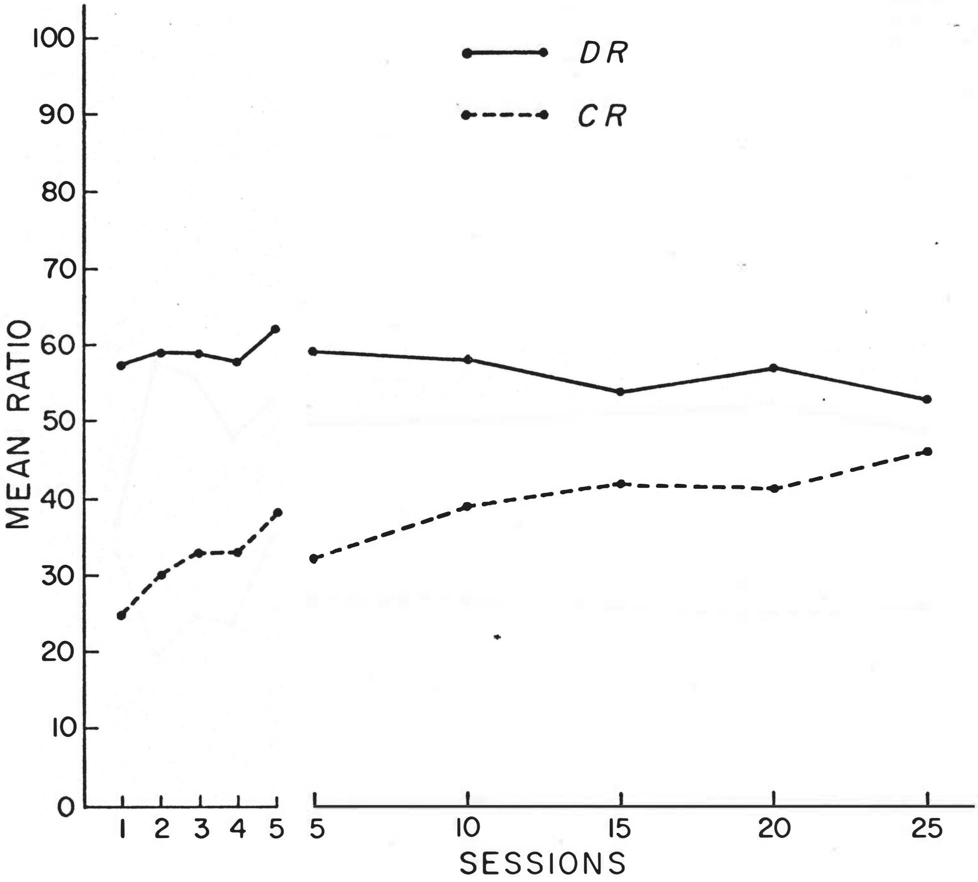


FIG. 10 MEAN RATIOS FOR GROUP FAS DURING TRAINING SESSIONS (n = 4).

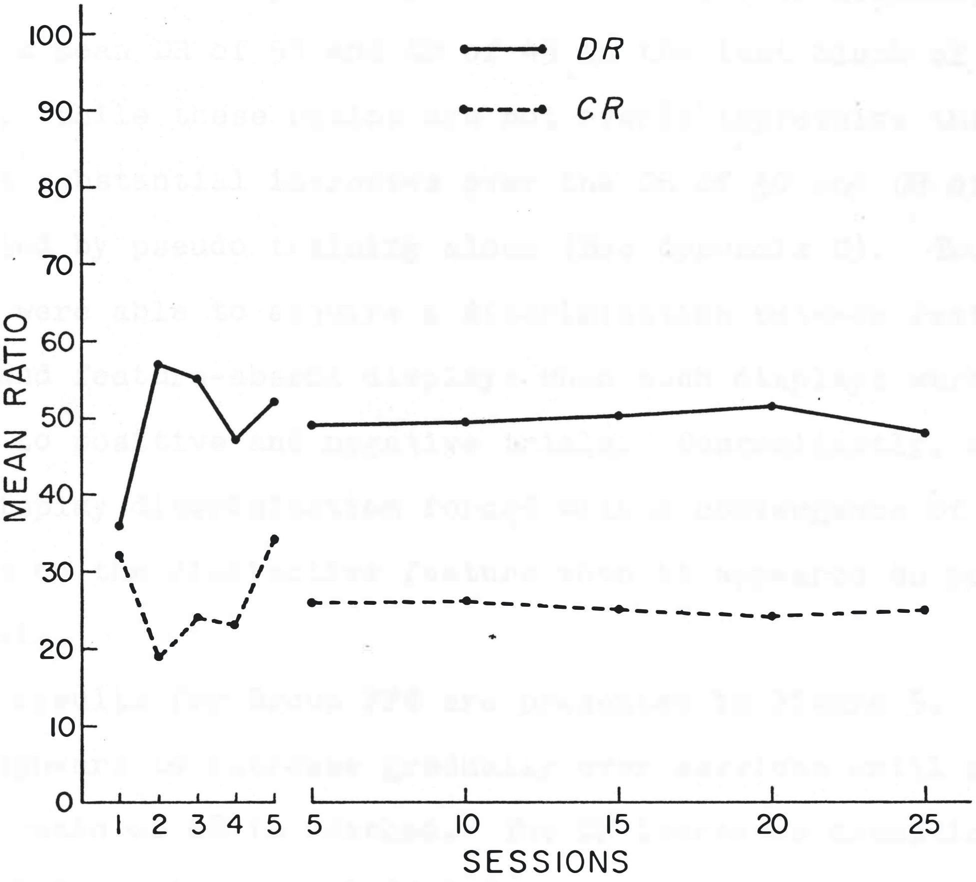


FIG. 11 MEAN RATIOS FOR GROUP FAP1 DURING TRAINING SESSIONS (n = 4).

The results for FPG are presented in Figure 4. Here both the DR and CR show only a very small increase over sessions reaching a mean DR of 58 and CR of 43 in the last block of training. While these ratios are not overly impressive they do represent substantial increases over the DR of 50 and CR of 25 expected by pseudo training alone (See Appendix C). Thus, subjects were able to acquire a discrimination between feature-present and feature-absent displays when such displays were assigned to positive and negative trials. Concomitantly, a within-display discrimination formed with a convergence of responses on the distinctive feature when it appeared on positive trials.

The results for Group FPS are presented in Figure 5. The DR here appears to increase gradually over sessions until a mean terminal ratio of 68 is reached. The CR increases dramatically over initial sessions until 80-90% of all responses to the positive displays are being given to the quadrant containing the B feature. Thus, when responding was demanded to the distinctive feature (B of BAAA) a dramatic within-display discrimination formed.

Groups receiving pseudo-discrimination training showed no noticeable development toward discriminating between- or within-displays reaching asymptotic DR's near 50 and CR's near 25 (Group FPP2, Figure 7; Group FPP1, Figure 8; Group FAP1, Figure 11).

Mean ratios for Group FPGN during training sessions are presented in Figure 6. Here the DR shows a gradual increase to a mean of 65. This indicates an avoidance of the feature-present displays because such displays appeared on negative trials for this group. However, within the feature-present displays themselves, the group as a whole did not avoid the feature (B) quadrant (mean CR in last block=23.8). But, three of the four subjects within this group did show avoidance of B with final block CR's of less than 25 (22, 18, and 17 respectively, Table II).

Mean ratios for Group FAG are presented in Figure 9. Here discrimination between-displays is surprisingly good during early sessions but gradually decreases to a mean of 54. Concomitantly, the CR shows a gradual increase to a terminal mean of 33 indicating a small preference in responding to the feature-absent quadrant. It should be noted that this group was trained for only 25 sessions. Usually groups trained for 60 sessions did not show discernible changes in either DR's or CR's after 25 sessions. However, Group FAG's ratios change noticeably throughout training and performance may not have been asymptotic.

Figure 10 presents the mean ratios for Group FAS during training sessions. The DR changes little over sessions and a terminal DR of 53 indicates little if any discrimination between positive and negative displays. However, the mean CR increases gradually to a terminal 45 indicating a marked preference in responding to the feature-absent quadrant. Group FAS was also trained for 25 sessions. While the performance of the complement group (FPS) did not change noticeably after 25 sessions, caution must be taken in interpreting these final block ratios as asymptotic.

To summarize the results thus far, subjects were able to acquire a discrimination between feature-present and feature-absent displays when such displays were assigned to positive and negative trials. When responding was demanded to the distinctive feature (B of BAAA or A of ABBB) a within-display discrimination formed with a convergence of responses on the distinctive feature when it appeared on positive trials. Three out of four subjects in one group (FPGN) avoided (to a slight degree) the feature when it appeared on negative trials. When responding was required only to the display containing the distinctive feature (FPG and FAG), a small but consistent preference for responding to the feature itself developed within-displays.

Testing Results (Within Groups)

Results for the last block of training (Pre-Test 1), Test 1, retraining (Pre-Test 2) and Test 2 sessions are presented in Tables

II and III in terms of DR's and CR's for each subject. All Pre-Test 1 ratios represent the means for the last five sessions prior to Test 1. All Pre-Test 2 ratios represent the means for the five retraining sessions given between Test 1 and Test 2. It should be noted that for groups in Table II, Pre-Test 1 refers to sessions 55-60, while for groups in Table III, Pre-Test 1 refers to sessions 20-25. Hence, ratios are presented under the column labelled "Session 25" (Table II) representing the means for sessions 20-25 and can be compared with Pre-Test 1 ratios in Table III.

Analyses of variance were carried out on the variates T_1-T_5 for Groups with 60 training sessions and T_1-T_4 for Groups with 25 training sessions (DR's only) and these are reported in Table IV. Parallel analyses of variance were carried out on the CR's only and these are presented in Table V. An r value is also listed for each analysis and this indicates the maximum number of mutually orthogonal contrasts rejectable among the group means (cf. Rodger, 1967a, 1967b).

Table II presents the results for Birds 1-16 all of which received 60 training sessions prior to Test 1. It is clear from a comparison of performance at session 25 (T_1) with session 60 (T_2) that there was generally little change during the last 35 sessions of training. Generally, birds in both Groups FPG and FPS

TABLE II. Pre-Test and Test results for birds receiving 60 training sesssions.

GROUP	BIRD	T_1 SESSION 25		T_2 PRE-TEST 1		T_3 TEST 1		T_4 PRE-TEST 2		T_5 TEST 2	
		DR	CR	DR	CR	DR	CR	DR	CR	DR	CR
FPG	1	53	44	65	51	69	56	68	55	74	97
	2	54	42	54	33	55	40	56	37	60	85
	3	58	41	59	42	62	60	63	49	81	60
	4	55	39	56	44	61	57	56	45	35	48
	mean	55.0	41.5	58.5	42.5	61.8	53.3	60.8	46.5	62.5	72.
FPS	5	63	88	65	81	66	89	48	99	77	94
	6	71	85	73	76	70	91	64	83	76	83
	7	65	95	75	92	71	95	71	90	93	95
	8	67	83	66	88	70	91	73	79	80	92
	mean	66.5	87.8	69.8	84.3	69.3	91.5	64.0	87.8	81.5	91.
FPGN	9	59	28	72	17	65	19	72	24	68	20
	10	61	27	65	22	72	25	59	25	47	14
	11	60	20	59	18	59	41	59	29	49	19
	12	58	38	64	38	68	33	64	41	58	25
	mean	59.5	28.3	65.0	23.8	66.0	29.5	63.5	29.8	55.5	19.
FPP2	13	46	29	51	27	47	35	51	26	45	14
	14	44	31	48	21	47	39	50	28	46	29
	15	49	34	50	28	49	29	48	28	52	23
	16	48	24	49	28	47	32	48	30	47	25
	mean	46.8	29.5	49.5	26.0	47.5	33.8	49.3	28.0	47.5	22.

TABLE III. Pre-Test and Test results for birds receiving 25 training sessions.

GROUP	BIRD	T_1 SESSION 25(Pre-Test 1)		T_2 TEST 1		T_3 PRE-TEST 2		T_4 TEST 2	
		DR	CR	DR	CR	DR	CR	DR	CR
FPP1	17	50	28	51	35	51	26	45	32
	18	49	31	54	28	50	28	44	32
	19	52	22	51	39	48	28	45	15
	20	48	27	48	24	48	30	79	35
	mean	49.8	27.0	51.0	31.5	49.3	28.0	53.3	28.5
FAG	21	53	33	75	29	60	31	34	40
	22	55	29	71	27	65	31	56	38
	23	49	43	61	47	68	38	52	27
	24	58	28	67	26	61	25	56	33
	mean	53.8	33.3	68.5	32.5	63.5	31.3	49.5	34.5
FAS	25	52	45	59	51	60	42	49	38
	26	52	42	60	47	53	47	46	37
	27	52	47	71	37	61	38	37	47
	28	55	50	67	42	58	46	53	43
	mean	52.8	46.0	64.3	44.3	58.0	43.3	46.3	41.3
FAP1	29	48	24	57	23	54	17	44	17
	30	49	33	52	25	56	25	42	20
	31	48	18	49	19	49	21	36	16
	32	48	24	50	24	50	21	46	14
	mean	48.3	24.8	52.0	22.8	52.3	21.0	42.0	16.8

TABLE IV. Summary tables of analyses of variance of discrimination ratios during training and testing conditions.

GROUP	SOURCE	SS	df	MS	F	r
FPG	Between Ss	634.2	3			
	Within Ss	1034.0	16			
	Between Treatment	146.7	4	36.6	.995	0
	Residual	887.3	12	73.9		
	Total	1668.2	19			
FPS	Between Ss	326.8	3			
	Within Ss	1092.4	16			
	Between Treatment	723.7	4	180.9	5.892	2
	Residual	368.7	12	30.7		
	Total	1419.2	19			
FPGN	Between Ss	258.2	3			
	Within Ss	615.6	16			
	Between Treatment	302.8	4	75.7	2.911	1
	Residual	312.8	12	26.0		
	Total	873.8	19			
FPP2	Between Ss	17.8	3			
	Within Ss	64.0	16			
	Between Treatment	23.3	4	5.8	1.716	0
	Residual	40.7	12	3.3		
	Total	81.8	19			
FPP1	Between Ss	130.1	3			
	Within Ss	826.3	12			
	Between Treatment	38.1	3	12.7	.145	0
	Residual	788.2	9	87.5		
	Total	956.4	15			
FAG	Between Ss	96.6	3			
	Within Ss	1337.8	12			
	Between Treatment	912.6	3	304.2	6.444	2
	Residual	425.2	9	47.2		
	Total	1434.4	15			
FAS	Between Ss	61.1	3			
	Within Ss	924.3	12			
	Between Treatment	703.1	3	234.3	9.563	3
	Residual	221.2	9	24.5		
	Total	985.4	15			
FAP1	Between Ss	62.3	3			
	Within Ss	339.5	12			
	Between Treatment	274.3	3	91.4	12.620	3
	Residual	65.2	9	7.2		
	Total	401.8	15			

TABLE V. Summary tables of analyses of variance of convergence ratios during training and testing conditions.

GROUP	SOURCE	SS	df	MS	F	r
FPG	Between Ss	622.9	3			
	Within Ss	4080.8	16			
	Between Treatment	2599.0	4	649.7	5.264	2
	Residual	1481.8	12	123.4		
	Total	4703.7	19			
FPS	Between Ss	272.5	3			
	Within Ss	440.4	16			
	Between Treatment	137.7	4	34.4	1.365	0
	Residual	302.7	12	25.2		
	Total	712.9	19			
FPGN	Between Ss	560.9	3			
	Within Ss	721.6	16			
	Between Treatment	314.3	4	78.5	2.315	1
	Residual	407.3	12	33.9		
	Total	1282.5	19			
FPP2	Between Ss	30.0	3			
	Within Ss	508.0	16			
	Between Treatment	267.5	4	66.8	3.336	1
	Residual	240.5	12	20.0		
	Total	538.0	19			
FPP1	Between Ss	38.1	3			
	Within Ss	430.3	12			
	Between Treatment	41.6	3	13.8	.320	0
	Residual	388.7	9	43.1		
	Total	468.4	15			
FAG	Between Ss	244.1	3			
	Within Ss	400.3	12			
	Between Treatment	23.1	3	7.7	.183	0
	Residual	377.2	9	41.9		
	Total	644.4	15			
FAS	Between Ss	19.1	3			
	Within Ss	288.3	12			
	Between Treatment	47.1	3	15.7	.585	0
	Residual	241.2	9	26.8		
	Total	307.4	15			
FAP1	Between Ss	116.1	3			
	Within Ss	209.3	12			
	Between Treatment	139.2	3	46.4	5.948	2
	Residual	70.1	9	7.8		
	Total	325.4	15			

showed an improvement in DR's and CR's from session 60 (Pre-Test 1) to Test 1 but these trends were not significant. During Pre-Test 2, there was a tendency toward improved performance for most subjects, but again this was not significant. However, in Test 2 Group FPG showed a significant improvement in CR's over Pre-Test 2 levels. Similarly, Group FPS showed a dramatic improvement in DR's from Pre-Test 2 to Test 2. While Group FPGN showed a significant avoidance of the distinctive feature within-displays in Test 2, discrimination between-displays was poorer on Test 2 then in previous conditions. Interestingly, Group FPP2 showed little change throughout all conditions with the exception of an increased avoidance of the distinctive feature during simultaneous Test 2 when compared with previous conditions.

Table III presents the results for Birds 17-32, all of which received 25 training sessions prior to Test 1. Groups FAG and FAS showed a dramatic and significant improvement in between-display discrimination from Session 25 to Test 1. While within-display performance changed little for FAG and FAS during any conditions, the DR's for both groups reflect a significant deterioration in the accuracy of between-display discrimination from Pre-Test 2 to Test 2.

Throughout all Pre-Test and Test conditions pseudo-trained groups did not differ significantly from the DR of 50 and the CR of 25 expected by chance responding. The single exception was Group FAP1 and FPP1 which showed avoidances of the distinctive features in Test 2.

In summary, the results of Test 1 seemed to support the findings observed during training with some additional improvement in discrimination performance. Ratios during Pre-Test 2 retraining sessions reflected a tendency toward a post-Test 1 improvement. However, a decrement in discrimination between simultaneously presented matched-pairs was observed for all birds except those in FPG and FPS which improved slightly.

<u>Results Between Groups: General Analyses of Response Rates</u>

In order to assess the significance of these observed treatment effects between groups, formal analyses of covariance were carried out. While acquisition and test data are presented in terms of the DR and CR, the formal analyses were applied to the differences between response rates to P and N, and to differences between response rates to the distinctive feature and the total display. Since it is generally agreed that the variance of a ratio (DR or CR) is likely to be larger, sometimes much larger, than the variance of a difference (cf. Yule and Kendall, 1953, p.329), the use of P-N rather than P/(P+N) is preferable for the formal analyses. Then, P-bN represents a weighted score (where b is the regression coefficient calculated from the data) and this is the basic notation of the analysis of covariance in which group means are adjusted for the variance not directly related to the treatment effects and are free of the linear effect of the covariate.

Analyses of covariance were carried out on both response rates <u>between</u> and <u>within</u> displays.[1] In the between-display analyses, response rates to the negative displays were designated the covariate X_1, X_2...., X_k and rates to the positive displays were designated the criterion Y_1, Y_2,...., Y_k. In the within-display analyses, response rates to B in BAAA displays or rates to A in ABBB displays were designated the criterion while rates to the remainder of the displays were designated the covariate.

Between and within-display analyses were performed on four sets of data:

1. <u>Pre-Test 1 Data</u>--Mean rates for each bird in each group for the last five training sessions prior to Test 1.
2. <u>Test 1 Data</u>--Rates for each bird in each group for Test 1.

[1] All raw data for these analyses are presented in Appendix A.

3. Pre-Test 2 Data--Mean rates for each bird in each group for the five retraining sessions prior to Test 2.
4. Test 2 Data--Rates for each bird in each group for Test 2.

Thus, a total of eight analyses of covariance were carried out. Table VI presents the summary tables for each of those analyses. An r value is also listed in the summary tables. There were eight groups receiving different experimental treatments and treatment effects were significant in every analysis. This indicates significant treatment effects in response rates to the positive displays (between analyses) and to the distinctive features (within analyses). Differences between treatment means for each of the eight groups were then tested by use of a modification of the R method (Rodger, personal communication) and its companion F tables. It was decided to use a Type I error-rate at 5% for all statistical decisions to be made.

There are basically 10 contrasts (hypotheses) of interest that will be evaluated across treatment means ($\bar{u}_j$) and these are presented in Table VII. Of the 28 possible comparisons between groups and of the infinite number of multiple contrasts among these groups, ten were selected which were the most meaningful

TABLE VI. Summary tables for the anlayses of covariance of response rates.

DATA SET	SOURCE	SS	df	MS	F	r
BETWEEN						
Pre-Test 1	Total	7819.8	30			
	Error	1552.6	23	67.50		
	Treatment	6266.7	7	895.24	13.26	7
Test 1	Total	29866.1	30			
	Error	9767.4	23	424.66		
	Treatment	20098.7	7	2871.24	6.76	5
Pre-Test 2	Total	7897.5	30			
	Error	2494.9	23	108.47		
	Treatment	5402.6	7	771.80	7.11	5
Test 2	Total	6473.1	30			
	Error	2943.8	23	127.99		
	Treatment	3529.3	7	504.18	3.93	3
WITHIN						
Pre-Test 1	Total	9666.1	30			
	Error	1623.7	23	70.59		
	Treatment	8042.4	7	1148.91	16.27	7
Test 1	Total	17453.2	30			
	Error	2901.1	23	126.13		
	Treatment	14552.1	7	2078.87	16.48	7
Pre-Test 2	Total	6711.8	30			
	Error	553.6	23	24.06		
	Treatment	6158.2	7	879.74	36.56	7
Test 2	Total	5527.6	30			
	Error	1309.8	23	56.94		
	Treatment	4217.8	7	602.54	10.58	7

TABLE VII. Hypotheses of interest.

Let $\bar{u}_1$=mean of Group FPG
$\bar{u}_2$=mean of Group FPS
$\bar{u}_3$=mean of Group FPGN
$\bar{u}_4$=mean of Group FPP1
$\bar{u}_5$=mean of Group FPP2
$\bar{u}_6$=mean of Group FAG
$\bar{u}_7$=mean of Group FAS
$\bar{u}_8$=mean of Group FAP1

H_0	Statement of Contrast	Description
H1	$\bar{u}_4+\bar{u}_5-2\bar{u}_1 = 0$	The difference between FPG and both FPP1 and FPP2 is zero
H2	$\bar{u}_4+\bar{u}_5-2\bar{u}_2 = 0$	The difference between FPS and both FPP1 and FPP2 is zero
H3	$\bar{u}_4+\bar{u}_5-2\bar{u}_3 = 0$	The difference between FPGN and both FPP1 and FPP2 is zero
H4	$\bar{u}_6-\bar{u}_8 = 0$	The difference between FAG and FAP1 is zero
H5	$\bar{u}_7-\bar{u}_8 = 0$	The difference between FAS and FAP1 is zero
H6	$\bar{u}_1-\bar{u}_2 = 0$	The difference between FPG and FPS is zero
H7	$\bar{u}_1-\bar{u}_3 = 0$	The difference between FPG and FPGN is zero
H8	$\bar{u}_6-\bar{u}_7 = 0$	The difference between FAG and FAS is zero
H9	$\bar{u}_6-\bar{u}_1 = 0$	The difference between FPG and FAG is zero
H10	$\bar{u}_2-\bar{u}_7 = 0$	The difference between FPS and FAS is zero

with respect to the experimental design. Briefly, Hypotheses (H) 1-3 compare the feature-present treatments with their respective pseudo-trained controls (See Design). Similarly, H4 and H5 assess the differences between feature-absent treatments and their single pseudo-trained group. The differences between performance of Groups FPS and FPG is compared by H6 while H7 compares the feature-positive and feature-negative training conditions (FPG and FPGN respectively). Groups FAG and FAS are compared in H8, while H9 and H10 examine the difference between complement groups of feature-present and feature-absent treatments.

Results Between Groups : Between-Display Analyses

The evaluation of the hypotheses of interest for between data sets are presented in Tables C1-C4 (Appendix C). The decision set which was used in this evaluation is discussed in Appendix B.

Pre-Test 1 results (Table C1) demonstrate that Groups FPG, FPS, and FPGN are not equivalent in between-display responding with both pseudo Groups FPP1 and FPP2 (the values of the functions H1, H2, and H3 are each large enough to be "scientifically significant"). These findings are upheld in Test 1 (Table C2), Pre-Test 2 (Table C3), and Test 2 (Table C4). With the exception of Pre-Test 1, Groups FAG and FAS both differed from their pseudo Group FAP1 in all between-display data sets (H4 and H5 were both large enough for "scientific significance"). And, except in Pre-Test 1, Group FPGN differed little from FPG indicating that feature-positive and feature-negative conditions produced little difference in between-display discriminations (H7 too small for interpretation).

In all between-display data sets, Groups FAG and FAS responded similarly (H8 too small) as did Groups FPG and FPS (H6 too small). Complement treatments of feature-present and feature-absent training (FPG and its complement FAG; FPS and its complement FAS) produced similar between-display responding (H9 and H10 too small). The single exception to this was in Pre-Test 1 where FPS and FAS differed significantly(Table C1).

To state these results another way, subjects were able to discriminate between feature-present and feature-absent displays when these displays were assigned to positive and negative trials. Designation of A or B as the distinctive feature produced complementary between-display responding. Assignment of "specific" or "general" response contingencies within displays (e.g.,specific= FPS or FAS, general=FPG or FAG) did not significantly effect between-display discrimination, although "specific" groups had demonstrated higher DR's throughout training. When the distinctive feature appeared on the negative trials (FPGN) discrimination between-displays did not differ than when the feature appeared on positive trials (FPG). These results were demonstrated in the successive training and testing conditions as well as during simultaneous matched-pairs testing.

Results Between Groups: Within-Display Analyses

The results of the tests of hypotheses for within-display data sets are presented in Tables C5-C8 (Appendix C). Clearly, each of the treatments produced a non-zero effect. Once again, using the parameters of significance defined in Appendix B, those hypotheses within a standardized range are regarded as too small to warrant interpretation in this thesis.

Table C5 presents the tests of hypotheses for Pre-Test 1 data. Here, both Groups FPG and FPS showed a clear difference in responding to the feature quadrant (B) compared to their pseudo groups (H1 and H2 large). This finding was also demonstrated in Test 1 (Table C6), Pre-Test 2 (Table C7), and Test 2 (Table C8). However, Group FPGN showed no significant avoidance of the feature quadrant for any data set (H3 too small). Group FPS showed markedly more response convergence on the feature than Group FPG in all data sets (H6 large).

In all within data sets, Group FAS showed a higher rate of responding to the feature-absent quadrant than FAG (H8 large) or FAP1 (H5 large). However, Group FPS showed a noticeably higher rate of responding to the feature-present quadrant than FAS did to the feature-absent quadrant (H10 large). And, while FPG and FAG differed in Pre-Test 2 and Test 2 data (H9), this hypothesis is not rejectable for the other cases.

To summarize these results, subjects were able to discriminate between the presence and absence of the feature within-displays when such displays were assigned to positive and negative trials. In feature-present training, responses converged on the B feature when it appeared on positive trials, while feature-absent training produced a convergence on the A feature on positive trials. However, in general, designation of B as the distinctive feature resulted in better within-display discrimination than when A was distinctive. Group FPGN did not avoid the feature (B) when it appeared on negative trials but three subjects within this group showed consistent CR's of less than 25 throughout training and testing.

Reversal Training

As an additional procedure to assess the reliability of these treatment effects, Groups FPS and FPG were both given FPGN training for 60 additional sessions followed by a new Test 1, retraining for five sessions, and a new Test 2. Figures 12 and 13 present the mean ratios for FPS and FPG respectively during FPGN training. Here there is a dramatic decrease in both the DR and CR until mean terminal ratios similar to FPGN (Figure 6) are reached. Response rates for the original FPGN group were then compared with the rates for these two groups and eight analyses of covariance carried out on between- and within-display data sets. Table VIII presents the summary tables for these analyses. None of the treatment effects were significant indicating that both Groups FPG and FPS were successfully reversed to FPGN levels of performance through the retraining sessions.

Position Preferences

An examination of response location data for successive and simultaneous presentations revealed no specific preferences developing between groups. Ranking of the position preferences for all subjects across training and testing conditions revealed the following number of birds preferring each quadrant: Quadrant IV: 10 subjects, Quadrant III: 8 subjects, Quadrant II: 8 subjects, and Quadrant I: 6 subjects.[1] This preference was consistent

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[1] According to the following mathematical notation: Upper left= Quadrant I, upper right= Quadrant II, lower left= Quadrant III, and lower right= Quadrant IV.

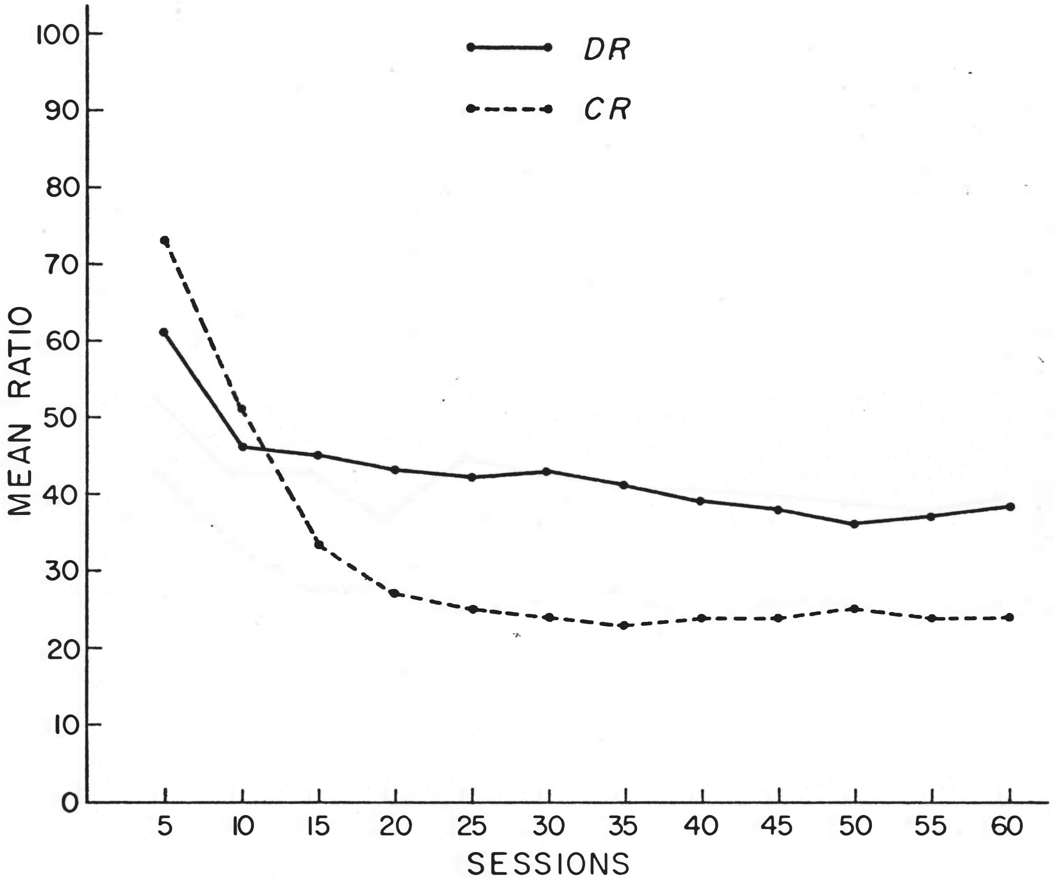

FIG. 12 MEAN RATIOS FOR GROUP FPS DURING FPGN TRAINING SESSIONS (n=4).

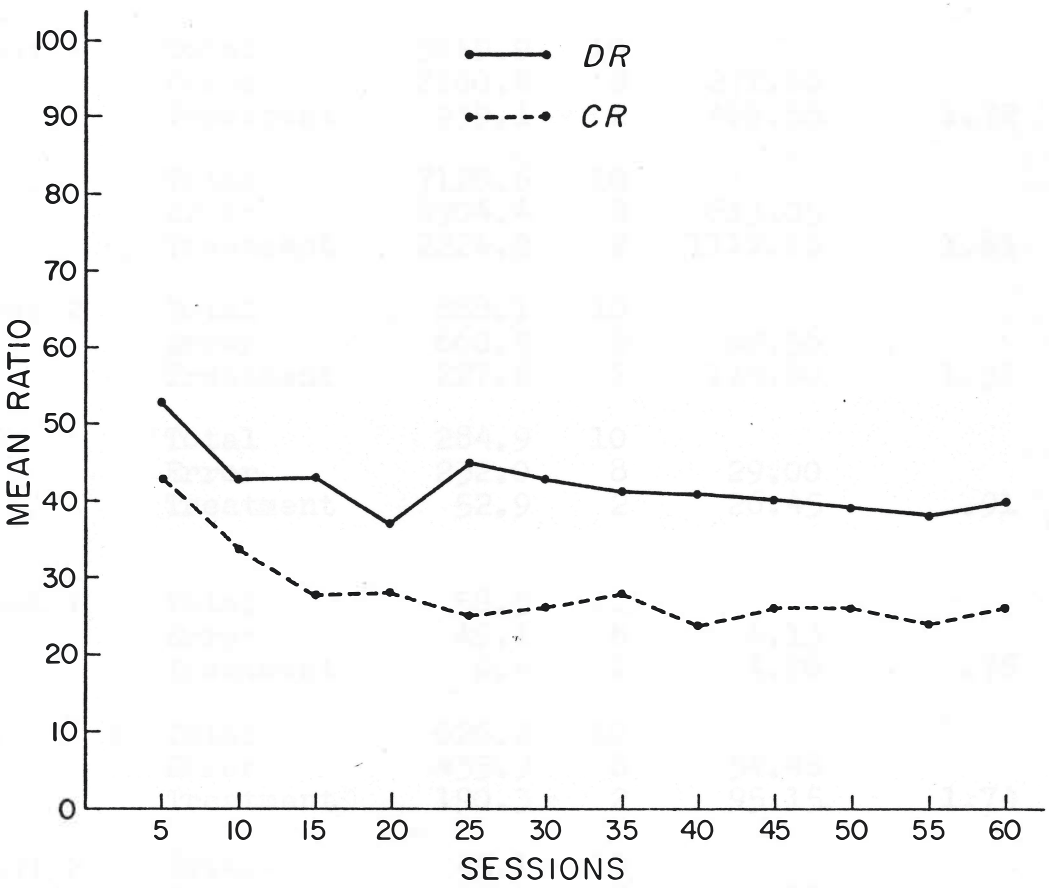

FIG. 13 MEAN RATIOS FOR GROUP FPG DURING FPGN TRAINING SESSIONS (n = 4).

TABLE VIII. Summary tables of analyses of covariance for reversal training.

DATA SET	SOURCE	SS	df	MS	F	r
BETWEEN						
Pre-Test 1	Total	3119.9	10			
	Error	2180.8	8	272.60		
	Treatment	939.1	2	469.55	1.72	0
Test 1	Total	7128.6	10			
	Error	4904.4	8	613.05		
	Treatment	2224.2	2	1112.10	1.81	0
Pre-Test 2	Total	888.1	10			
	Error	660.5	8	82.56		
	Treatment	227.6	2	113.80	1.37	0
Test 2	Total	284.9	10			
	Error	232.0	8	29.00		
	Treatment	52.9	2	26.45	.91	0
WITHIN						
Pre-Test 1	Total	58.5	10			
	Error	49.1	8	6.13		
	Treatment	9.4	2	4.70	.76	0
Test 1	Total	626.2	10			
	Error	435.9	8	54.48		
	Treatment	190.3	2	95.15	1.74	0
Pre-Test 2	Total	45.1	10			
	Error	33.3	8	4.16		
	Treatment	11.8	2	5.90	1.41	0
Test 2	Total	24.4	10			
	Error	18.7	8	2.33		
	Treatment	5.7	2	2.85	1.21	0

within subjects during all successive and simultaneous presentations, regardless of the side on which the food magazine was present. Within simultaneous tests, 15 subjects preferred the right screen and 17 subjects preferred the left. Since subjects tended to prefer the lower right portions of the displays, it is of interest to note that all subjects were given grain on the lower right side and water on the lower left side of their home cages.

CHAPTER IV

DISCUSSION

The most obvious aspects of these findings is that the development of stimulus control between and within complex displays parallels such development in simple displays as reported by Jenkins and Sainsbury (1969, 1970). Following a brief discussion of these findings, a detailed comparison of the main results of the present experiment with Jenkins and Sainsbury's theoretical schema and the concept literature will be made.

Feature-Present Training

The present results indicate that when $B_{1 \ldots n}$ (distinctive feature) is located on the reinforced trial, differential training (Group FPG) causes responding to converge on that feature in preference to $A_{1 \ldots n}$ features which are common to reinforced and non-reinforced trials. Such training also causes a reduction in the tendency to respond on negative trials, which contain only $A_{1 \ldots n}$, and this results in a between-display discrimination. These results are similar to those obtained by Jenkins and Sainsbury with discrete A and B features. However, these authors have noted that the discrimination within-displays always precedes the formation of the between-display discrimination. It is clear from Figure 4 that these discriminations in Group FPG did not develop at appreciably different times. Jenkins and Sainsbury also report that after only 12 sessions animals trained with B as the distinctive feature on positive trials showed DR's and CR's between 80-90.[1] By contrast, the animals in Group FPG reached a mean terminal DR of 58.5 and CR of 42.5 after 60 training sessions.

While such control over responding by $B_{1...n}$ falls far short of control exercised by the B feature in Jenkins and Sainsbury's displays, this control was facilitated by FPS training. Here (Figure 5), when convergence was demanded to $B_{1...n}$, such treatment resulted in a consistently better (although not significantly better) between-display discrimination and a significantly better within-display discrimination than when such control emerged spontaneously as in Group FPG. Jenkins and Sainsbury did not run a group comparable to FPS, but even the FPS requirement of responding to $B_{1...n}$ did not cause complete cessation of responding to $A_{1...n}$. Indeed, it is doubtful that Jenkins and Sainsbury would have observed any improvement in an "FPS"-type group since their feature-positive birds were already performing at near perfect levels of discrimination.

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[1] Jenkins and Sainsbury actually present their data in terms of an index from 0-1.0 representing, for example with between-display discriminations, the ratio of responses on the positive display to total responses. These ratios have been simply multiplied by 100 for comparison with the present data.

When the feature $B_{1...n}$ is located on the negative trial (Group FPGN), responses for three out of four subjects shift away from it but continue to occur to $A_{1...n}$ on negative trials resulting in a slight within-display discrimination. In addition, there is an over-all reduction in responses to displays containing $B_{1...n}$ and this results in the formation of a between-display discrimination. Comparison of Group FPGN with the "feature-negative case" used by Jenkins and Sainsbury reveals an important difference. In the latter studies, when B was located in the negative display, responses shifted away from B but continued to be made to the common feature on negative as well as on positive trials. Consequently, a between-display discrimination failed to develop in their studies. Although this particular point will be discussed in detail later, a few comments seem appropriate at this time.

In their initial efforts to explain the failure of the between-display discrimination in the feature-negative case and its success in the feature-positive case (an effect termed asymmetry), Jenkins and Sainsbury reasoned that "the fact of asymmetry tells us that the development of the go/no-go discrimination is not to be understood as the direct consequence of comparing entire displays" (Jenkins and Sainsbury, 1970, p.19).

The fact that this asymmetry did not occur in the present experiment is intriguing for several reasons. Firstly, if the bird were comparing entire displays and then adjusting his behavior appropriately there would be no reason to expect an asymmetry in the between-display discrimination. But since we know that the common and distinctive features were responded to selectively within-displays, the displays may not have been perceived exclusively in this way. Secondly, one could argue that simultaneous presentations of displays affords a greater opportunity for the comparison of the positive and negative stimuli than successive presentations. Accordingly, if the bird were comparing entire displays we might predict greater difficulty with successive than with simultaneous presentations. Indeed, Groups FPG and FPS show this "predicted" superiority in between-display discrimination on simultaneous Test 2 when compared with successive conditions (Table II). This improvement in between-display discrimination on Test 2 is paralleled by a similar improvement in within-display discrimination for the same groups. Conversely, Group FPGN shows an improvement in within-display discrimination from successive conditions to Test 2, but between-display discrimination is actually poorer here than in successive conditions. This latter result may be more a consequence of the use of matched-pairs in the simultaneous tests than a difficulty in comparing simultaneous displays *per se*. For example, Siegel and Honig note that "the slides presented in such tests may be confusing to the *S*, since so many elements in the two matched displays are identical. In any ordinary discrimination task one would expect poorer performance with very similar displays, and this is precisely what we obtained in the matched-pairs tests." Indeed, when their successively-trained animals were tested with simultaneous presentations of un-matched displays, between-display discrimination jumped from a pre-test mean level of 66 to a test mean of 95! However, the "confusing" nature of the matched-pairs should have disrupted between-display discrimination for Groups FPG and FPS instead of improving such discrimination. The essential difference may lie in the fact that the latter Groups discriminated concomitantly between and within-matched-pairs while Group FPGN did not.

Feature-Absent Training and Comparisons

When the $A_{1...n}$ feature is made distinctive and presented on the reinforced trial, FAG training does not cause responses to converge significantly on that feature in preference to $B_{1...n}$ features which are now common to reinforced and nonreinforced trials. Between-display discrimination does develop for Groups FAG and FAS, however, as responding decreases to the feature-absent displays. This is accompanied by convergence only when responding is reinforced specifically to $A_{1...n}$ (FAS). Such required responding results in a significantly better within-display discrimination for Group FAS than when such convergence is allowed to develop spontaneously.

In general, feature-present and feature-absent training conditions produced similar levels of between-display discrimination. This result agrees with Jenkins and Sainsbury's observations that A and B features can be interchanged and a strong between-display discrimination will still appear. They note, however, that the distinctive feature is still discriminated within-displays and this result does not seem to be dependent on a distinctive feature that is more "peckable" than common features. Since discrimination within-displays was more difficult when $A_{1...n}$ (Group FAS) rather than $B_{1...n}$ (Group FPS) was used as the distinctive feature, it remains possible that human features and landscape features were not as "interchangeable" as Jenkins and Sainsbury's circles and stars. Indeed, inspection of Table III indicates that Groups FAG and FAS show a decrement in between-display discrimination from Pre-Test 2 to simultaneous Test 2 itself. Thus, feature-absent groups do not manifest the superiority of performance in simultaneous conditions observed for the complement feature-present groups.

The discriminations developed by both feature-present and feature-absent training procedures remain throughout extinction tests with new displays. While performance tends to improve steadily on Test 1, and in Pre-Test 2 retraining, a decrement in discrimination between simultaneously presented matched-pairs (Test 2) was observed for all birds except those in Groups FPG and FPS which improved slightly.

Throughout training and testing conditions, Groups FPP1, FPP2, and FAP1 displayed a very slight but consistent preference for the human feature. Nonetheless, since these preferences were not significantly different from chance CR's of 25, any notion of the human feature being more "peckable" than other features must be viewed with caution. Indeed, both Groups FAP1 and FPP2 showed a significant avoidance of the distinctive feature in Test 2.

Comparison with Jenkins and Sainsbury's Theory of Feature Selection

These findings can be directly compared with those supporting Jenkins and Sainsbury's theory of feature selection. The first empirical observations to be compared are the feature-positive and feature-negative effects. Recalling the previous discussion of these effects, the pattern of key pecks converged on the distinctive feature when it appeared in positive displays but the feature was avoided when it appeared in negative displays. While Jenkins and Sainsbury report these exact same patterns, their feature-positive effect was marked by a facilitation of discrimination between-displays when the feature appeared on positive trials. The present experimental treatment of FPG resulted in clear evidence of feature convergence. FPGN training did not result in clear evidence of feature avoidance. In addition, discrimination between-displays was not facilitated for the feature-positive groups (H7 too small, between-data sets). Indeed, there was a surprisingly strong tendency for the feature-negative group (FPGN) to perform significantly better in Pre-Test 1 between-display discrimination than the feature-positive group (FPG).

Since the positions of the common and distinctive features change from trial to trial the animal must discriminate between them in order to respond selectively. The results of this within-display discrimination are in general agreement with what Jenkins and Sainsbury refer to as the "simultaneous" discrimination between distinctive and common features. Those authors note that "convergence on the distinctive feature within the positive display drives the probability of reinforcement for a response to common features toward zero and thus allows the successive (between-display) discrimination to form" (Jenkins and Sainsbury, 1970, p.68). Continuing with this reasoning, Jenkins and Sainsbury note that an avoidance of the distinctive feature within the negative display leaves the probability of reinforcement for a response to common features at .5. In their experiments the response continued to occur to both members of the pair of displays and the between-display discrimination did not develop. in their feature-negative group. By contrast, the birds in Group FPGN _did_ develop this discrimination. In other words, the birds were required to learn that the same common feature can predict reinforcement when not accompanied by the distinctive feature and can predict nonreinforcement when the distinctive feature is on the same display. The response to the common feature is said to be made conditional upon the presence or absence of the distinctive feature. The achievement of this discrimination in the present study is not nearly so remarkable as its failure in the Jenkins and Sainsbury experiments. As those authors point out, the spatial separation of the common and distinctive features was only about 3.18cm. Generally, discrimination learning is impaired when there is a separation between cue and response (cf. Stollnitz, 1965). Indeed,

> When there is a separation we may consider that the response is made directly to common features associated with the site of the response. In order to learn the discrimination, the response to these common features must be made conditional upon the spatially remote distinctive features. The effect of separating the cue from the locus of the response has generally been ascribed to a

> reduction in the probability of observing the cue. For example, it is said that monkeys look where they put their fingers (Stollnitz, 1965, p.250). Although the present results may be seen as another case in which spatial separation causes a deficit, they do not seem to be interpretable as a failure to observe. As previously noted, the distinctive and common features must both be observed and discriminated from one another in order for the response to occur selectively to either type of feature.
>
> Jenkins and Sainsbury, 1970, p.69

As spatial separation decreases, as observed in Jenkins and Sainsbury's (1970, p.157) compact cluster experiment, the between-display discrimination does develop to some degree in most subjects trained in the feature-negative case. When nonspatially separate features are used as in the present experiment the between-display discrimination appears to develop even more so. Indeed, Jenkins has recently commented on the possibility of learning in the feature-negative case:

> If the successive discrimination were to be learned in the feature-negative case, the presence of _B_ (distinctive feature) would have to inhibit the response to _A_ (common feature). The virtually complete failure of inhibitory control to develop is undoubtedly peculiar to the punctate visual stimuli of the present experiments. We know that when the _B_-feature is a diffuse auditory stimulus the response to a common, visual _A_-feature can be inhibited. It may already have been noticed that the feature-negative case is like the Pavlovian paradigm for establishing conditioned inhibition. Using that paradigm in the operant case, and choosing an auditory stimulus for

> the B-feature, Brown and Jenkins (1968) obtained a successive go/no-go discrimination in which B was shown to inhibit the response to A.
>
> Jenkins, 1969, p.29

Comparison with Concept Studies

In the concept literature, experimenters have attempted to correlate the amount of information transmitted by positive instances with the concomitant learning (Hovland, 1952; Hovland and Weiss, 1953; Hunt, 1962; Haygood and Devine, 1967; Haygood and Stevenson, 1967). The correct concept has usually been attained by a higher percentage of subjects when transmitted by all-positive instances than by all-negative instances.[1] This difference has been attributed to the difficulty of assimilating information concerning what the concept "is not" as compared with assimilating information concerning what it "is" (Hovland and Weiss, 1953). Apparently the discriminative cues present in the positive instances are more effective in the communication of information.

In discriminations such as Jenkins and Sainsbury's and the present one, "the assignment of the distinctive feature to positive or negative trials has no effect on information available to the animal about when reinforcement will follow" (Jenkins and Sainsbury, 1970, p.19). However, when the distinctive feature appears on

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[1] In these experiments, human subjects were first instructed as to how many different stimulus dimensions were relevant and the number of possible values for each dimension. Thus, in all-negative instances subjects would have to attain the correct concept, eg., of black square by examining instances of red square, black circle, and red circle.

positive trials, a response emitted in the presence of the feature could be considered equivalent to the verbal statement "is". In other words, the animals must learn what the distinctive feature "is" (i.e., when circle "is" present or when concept human "is" present reinforcement is available). Conversely, assignment of the distinctive feature to the negative trials is equivalent to the statement "is not" (i.e., the animal must learn that when circle or human "is not" present, or is absent, reinforcement is available).

The critical data of the present experiment which demonstrate concept learning are the extinction test responses to "new" displays. The results from Test 1 and Test 2 showed very clearly that animals were able to discriminate the presence ("is") and absence ("is not") of $A_{1...n}$ and $B_{1...n}$ features in complex displays. Animals in Group FPGN learned (Pre-Test 1) what the concept "is not" better than those required to learn what it "is" (Group FPG). Superficially, this result appears to stand in sharp contrast to traditional predictions derived from the concept literature (cf. Hovland and Weiss, 1953). However, the similarity of Groups FPG and FPGN in all other between-display data sets does not offer decisive evidence on this point. But, at the very least, birds did not form this particular "is" concept better than "is not" concepts as would be generally expected.

It is clear from Tables II and III that for all feature-present and feature-absent cases in which a between-display DR above 50 was recorded, there was a concomitant CR of 25 or above. Furthermore, when this between-display discrimination was significantly different from that obtained with pseudo-trained groups, there was always a significant within-display discrimination. However, many difficult and puzzling questions arise when we consider the special case of the feature-negative group (FPGN). While we have chosen to point out that three out of four birds in Group FPGN displayed slight avoidances of the $B_{1...n}$ feature throughout training and testing, this within-display discrimination was not significantly different for the group as a whole when contrasted with pseudo levels. Since the successive discrimination developed nevertheless, one is led to speculate that it is neither necessary nor sufficient for a within-display discrimination to precede or accompany a between-display discrimination in the feature-negative case. The essential difficulty may be that "is" and "is not" concepts require qualitatively different types of behavior.

Another way of conceptualizing the verbal statements "is" and "is not" involves the discriminations of matching and oddity. When an animal matches stimuli he chooses a response that in essence says what the stimulus (or distinctive feature) "is". On the other hand, oddity or "non-matching" involves choosing what the stimulus "is not". Cumming and Berryman (1965) had observed that simultaneous matching and oddity are differentially affected by pentobarbital. Oddity performance was far less sensitive to 5mg/kg-12.5mg/kg of pentobarbital than matching performance which was well below the normal range of accuracy at 10mg/kg. These results were later replicated by Nevin and Liebold (1966). In an informal experiment which is not reported here because of several procedural errors, Groups FPGN and FPG were retrained for five sessions and given a "new" Test 1 with 10mg/kg of pentobarbital. Three birds in Group FPG showed a significant reduction in both CR's and DR's. Performance of Group FPGN was not significantly different from its Pre-Test 1 or Test 1 performance. This "informal" observation would seem to lend support to Cumming and Berryman's suggestion that matching and oddity performance require qualitatively different types of behavior. Thus, "is" and "is not" concepts may reflect similar differences.

Some insight into the nature of these differences may be achieved if we consider feature-present and feature-absent training conditions as representing "is" and "is not" concepts.

Consider the simplest rule that would be sufficient to produce a between-display discrimination in each condition (cf. Jenkins, 1969). In FPG training a suitable rule is respond to $A_{1...n}$ or $B_{1...n}$ when $B_{1...n}$ _is_ present. In FPS training a suitable rule is respond to $B_{1...n}$ when it _is_ present. Both these feature-present conditions require responding when the human feature is present. In Group FAG, a suitable rule is respond to $A_{1...n}$ or $B_{1...n}$ when $B_{1...n}$ _is_ _not_ present in one quadrant. In FAS training, a suitable rule is respond to $A_{1...n}$ when $B_{1...n}$ _is_ _not_ present in the same quadrant. Both these feature-absent conditions require responding when the human feature is not present in one quadrant of the display. The latter rule could not be based efficiently on the presence of $A_{1...n}$ since $A_{1...n}$ is always present as background features in all parts of all displays. Nonetheless, feature-absent and feature-present training result in similar levels of between-display responding. The single exception is in simultaneous testing where feature-present groups are superior.

The rules may appear somewhat ambiguous for birds in Groups FPGN and FAS who are required to respond to one feature ($A_{1...n}$) on the basis of the absence of another feature ($B_{1...n}$). Similarly, the rule for Group FAG requires responding to either of two features ($A_{1...n}$ or $B_{1...n}$) on the basis of the absence of one feature ($B_{1...n}$). Group FAS, as required by training procedures, discriminated between these features within-displays. However, the inability of Groups FAG and FPGN to form reliable within-display discriminations leads us to speculate that the performance of these "is not" concepts may represent failures to "spontaneously" regulate a response to one part of the display on the basis of another part of the display. This suggestion minimizes failures to inhibit responding since significant between-display discriminations developed for both "is" and "is not" conditions. Such between-displays discrimination could not be achieved without animals inhibiting responding to negative displays. Futhermore, the suggestion that one part of the display failed to regulate responding to another part is not due to a physical inability to detect differences between these parts. Birds in Groups FPG, FPS, and FAS all learned to discriminate between these parts ($A_{1...n}$ and $B_{1...n}$) within-displays. However, it is possible that when such discrimination is not required by the reinforcement contingencies <u>and</u> when "is not" concepts are involved, animals perceive the displays as integrated compounds (i.e., perceptual wholes) and not as distinctive features. Further speculation at this time would overstep the restrictions placed by our present empirical knowledge.

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APPENDIX A. Raw data for analyses of covariance of response rates.

Pre-Test 1 Between: Response rates for individual birds in each group.

FPG		FPS		FPGN		FPP1		FPP2		FAG		FAS		FAP1	
X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
38.4	70.9	33.4	62.7	16.0	41.0	29.7	29.7	72.7	76.0	57.3	64.7	72.8	79.1	42.4	38.9
65.0	76.3	15.3	41.6	52.6	99.4	47.1	45.2	72.3	67.2	41.2	49.5	73.8	77.8	26.5	25.4
34.0	48.3	21.7	66.6	57.4	84.3	48.2	51.8	55.0	56.0	86.9	82.7	136.2	145.0	43.3	40.1
71.4	90.7	26.3	52.2	61.2	110.5	53.8	49.3	22.3	21.8	39.6	54.7	105.6	131.0	65.0	60.5

Pre-Test 1 Within: Response rates for individual birds in each group.

34.8	36.0	11.9	50.8	15.7	3.5	21.2	8.4	55.6	20.4	43.6	21.1	43.6	35.7	29.4	9.5
51.5	25.0	9.9	31.8	40.8	11.8	31.1	14.2	53.0	14.2	35.3	14.2	44.8	33.0	17.0	8.5
27.8	20.5	5.2	61.4	47.3	10.1	40.2	11.6	40.1	15.9	47.3	35.4	76.4	68.6	33.0	7.1
50.7	40.0	6.5	45.7	37.7	23.5	36.2	13.1	15.6	6.2	39.4	15.3	65.1	65.9	46.2	14.4

Test 1 Between: Response rates for individual birds in each group.

FPG		FPS		FPGN		FPP1		FPP2		FAG		FAS		FAP1	
X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
55.0	122.8	44.2	85.4	24.5	45.1	18.5	19.0	110.7	97.8	41.9	127.7	90.5	131.6	48.3	63.3
76.4	92.0	22.7	52.0	59.2	150.1	70.3	82.8	29.4	25.7	32.6	78.2	80.4	122.8	25.8	27.6
32.6	53.4	40.9	98.3	45.8	65.1	20.4	21.4	90.7	88.3	72.2	114.9	69.5	171.5	52.4	49.8
40.2	62.2	26.4	63.0	46.1	99.7	87.4	82.1	35.4	31.2	47.6	98.3	73.3	146.2	75.8	75.8

Test 1 Within: Response rates for individual birds in each group.

53.7	69.1	9.0	76.4	19.9	4.6	12.4	6.6	63.7	34.1	90.3	37.4	64.9	66.7	48.6	14.7
55.2	36.8	4.8	47.2	44.2	15.0	59.5	23.3	15.6	10.1	56.9	21.3	65.6	57.2	20.7	6.9
21.6	31.8	4.8	93.5	27.1	18.7	13.1	8.3	62.3	26.0	60.6	54.3	107.4	64.1	40.4	9.4
27.0	35.2	5.6	57.4	30.9	15.2	62.4	19.7	21.2	10.0	72.8	25.5	84.7	61.5	57.8	18.0

Pre-Test 2 Between: Response rates for individual birds in each group.

FPG		FPS		FPGN		FPP1		FPP2		FAG		FAS		FAP1	
X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
31.8	68.8	54.3	51.0	23.1	58.2	30.7	30.5	76.3	79.8	43.0	64.4	48.7	72.3	34.4	40.2
64.1	82.0	20.8	36.7	58.0	84.8	48.2	46.1	76.7	76.2	35.0	64.7	62.8	71.8	25.0	31.2
26.5	44.2	22.3	54.9	58.1	83.2	49.3	50.1	51.3	48.2	37.5	79.4	82.0	127.8	39.1	37.4
66.5	85.1	20.7	56.6	53.0	95.0	51.3	50.2	23.0	21.2	32.4	51.0	92.5	125.5	75.7	75.0

Pre-Test 2 Within: Response rates for individual birds in each group.

31.1	37.8	1.0	53.2	17.5	5.6	20.1	8.5	58.9	20.9	44.2	20.2	41.6	20.2	50.2	10.0
51.4	30.5	6.1	30.6	43.6	14.4	32.1	13.7	54.8	21.4	44.6	20.1	38.0	33.8	23.3	7.9
22.7	21.5	5.5	49.3	41.5	16.6	41.0	12.0	34.7	13.5	48.8	30.5	79.5	48.3	29.7	7.7
46.4	38.7	11.9	44.7	31.2	21.8	35.9	13.4	14.8	6.4	38.0	13.0	67.8	57.8	59.1	15.8

Test 2 Between: Response rates for individual birds in each group.

FPG		FPS		FPGN		FPP1		FPP2		FAG		FAS		FAP1	
X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
19.5	56.8	16.5	56.6	16.6	35.5	16.1	13.3	32.9	27.1	63.3	32.4	35.8	34.3	17.8	13.8
46.2	68.1	10.2	33.2	53.1	46.2	34.5	27.6	33.2	27.8	32.2	40.5	57.6	49.1	13.9	9.9
7.3	30.3	3.0	37.7	47.0	45.4	27.4	22.2	26.5	28.9	39.3	42.3	110.4	65.3	23.1	13.0
51.2	27.4	10.3	42.4	46.3	63.8	7.7	29.6	9.2	8.0	23.9	30.3	67.2	76.6	34.0	28.4

Test 2 Within: Response rates for individual birds in each group.

1.2	45.3	3.6	53.0	13.2	3.4	9.0	4.3	23.4	3.7	19.5	12.9	21.3	13.0	11.5	2.3
4.4	24.5	5.7	27.5	45.7	7.4	18.7	8.9	19.8	8.0	25.1	15.4	30.7	18.4	7.9	2.0
12.0	18.3	2.0	35.7	37.9	9.1	18.9	3.3	22.3	6.6	31.0	11.3	34.8	30.5	10.9	2.1
14.3	13.1	3.2	39.2	34.9	11.4	19.1	10.5	6.0	2.0	20.4	9.9	43.4	33.2	24.3	4.1

APPENDIX B. Statistical Methods.

The observed means of Y (m_{yj}) and X (m_{xj}) are first calculated from the raw data presented in Appendix A. For example, using the Test 2 Between data set we calculate:

Group=	FPG	FPS	FPGN	FPP1	FPP2	FAG	FAS	FAP1
m_{yj} =	45.6	42.4	47.7	23.1	22.9	36.3	56.3	16.2
m_{xj} =	31.0	10.0	40.7	21.4	25.4	39.6	67.7	22.2

Then, the grand mean of the m_{xj}'s ($m_{xj.}$) = 32.25

and,

$m_{xj}-m_{xj.}$ =-1.25 -22.5 8.45 -10.85 -6.85 7.35 35.45 -10.05

Then, from the analysis of covariance,

$$b = E_{xy}/E_{xx} = .330$$

and, the adjusted means of Y = $m_{yj}-b(m_{xj}-m_{xj.})$ =

46.01 49.74 44.91 26.68 25.16 33.88 44.60 19.52

From the analysis of covariance summary table (Table VI)

$$F_m = 3.93$$

and, from Rodger's companion F tables,

$$F_{[.95];7,23} = 1.286$$

Rodger tells us that the number of mutually orthogonal contrasts rejectable in any set of data = $\left[F_m/F_{[E\alpha];v_1 v_2}\right] = r$

Then, in these data,

$$\begin{aligned} r &= \left[F_m/F_{[.95];7,23}\right] \\ r &= \left[3.93/1.286\right] \\ r &= 3 \end{aligned}$$

The square brackets in the above equations indicate that the fractional part of the ratio is discarded.

There are a number of distinct ways of using the R technique. That which is used here finds $v_1=7$ mutually orthogonal contrasts of which $r=3$ are rejected and $v_1-r=4$ are retained. Those rejected will each have the value

$$\begin{aligned} F &= F_m/r \\ &= 3.93/3 \\ &= 1.31 > F_{[.95];7,23} \end{aligned}$$

and those retained will each have a value

$$F = 0$$

Any contrast which is accepted takes the form:

$$c_1u_1 + c_2u_2 \ldots + c_8u_8 = 0$$

Any contrast which is rejected takes the form:

$$c_1u_1 + c_2u_2 \ldots + c_8u_8 = g\sigma\sqrt{\sum_1 c_1^2}$$

Here, the expression under the square root simply makes allowance for the scale of the contrast and σ makes allowance for the scale of the individual observations. In the present experiment, a numerical value of g was not chosen, so the letter itself must be used.

Decisions about any set of contrasts imply values for the true means (u_j). Let the implied values be $\bar{u}_j$, then:

$$\bar{u}_j - u. = g\sigma(m_{yj} - b(m_{xj} - m_{x.}) - m_{y.})\ (rn/SSB)^{\frac{1}{2}}$$

When this equation is applied to the Test 2 Between data above, we calculate:

$.566g\sigma$ $.783g\sigma$ $.502g\sigma$ $.562g\sigma$ $-.650g\sigma$ $-.142g\sigma$ $.483g\sigma$ $-.979g\sigma$

Any contrasts across these $\bar{u}_j$ which are non-zero represent hypotheses which are false (when taken across u_j) either by direct test or by the implication of the set of decisions made earlier.

But values of $\sum_i c_i \bar{u}_i$ which are nearly zero will usually be difficult to interpret "scientifically". Rodger points out that it is true that any value

$$\sum_i c_i \bar{u}_i > g\sigma \sqrt{\sum_i c_i^2} \quad \sqrt{r F_{[E\alpha]; v_1, v_2} / F_m}$$

$$> g\sigma \sqrt{\sum_i c_i^2} \quad w$$

would be rejected if tested directly. In these data

$$w = \sqrt{3 \times 1.286/3.93}$$

$$= .990$$

Values of $\sum_i c_i \bar{u}_i / g\sigma \sqrt{\sum_i c_i^2}$ for the 10 contrasts of interest are shown below. Those outside the range 0 ± .990 are marked ** and considered to be "scientifically significant". Those values outside the range 0 ± .830 but inside the former range are marked * and also considered to be "scientifically significant".

Contrast	Values
H1	-2.343**
H2	-2.778**
H3	-2.215**
H4	- .837*
H5	1.462**
H6	.218
H7	- .064
H8	.625
H9	.707
H10	.300

The values which appear above are referred to as the Standardized Units and are the same values which appear in Table C4.

The values required to justify * and ** for each analysis and table are the following:

TABLE	ANALYSIS	** 0±	* 0±
C1	Pre-Test 1 data (between)	.907	
C2	Test 1 data (between)	.987	
C3	Pre-Test 2 data (between)	.975	
C4	Test 2 data (between)	.989	.830

C5	Pre-Test 1 data (within)	.862	.630
C6	Test 1 data (within)	.859	
C7	Pre-Test 2 data (within)	.704	.650
C8	Test 2 data (within)	.960	.600

APPENDIX C. Values of hypotheses.

TABLE C1. Values of hypotheses for Pre-Test 1 data (between).

H_0	Standardized Units
H1	-2.492**
H2	-4.040**
H3	-4.722**
H4	- .618
H5	.898*
H6	.774
H7	1.115**
H8	- .280
H9	.792
H10	1.090**

TABLE C2. Values of hypotheses for Test 1 data (between).

H_o	Standardized Units
H1	-2.106**
H2	-2.705**
H3	-3.021**
H4	1.659**
H5	1.925**
H6	.299
H7	.457
H8	.266
H9	.766
H10	.743

TABLE C3. Values of hypothese for Pre-Test 2 data (between).

H_o	Standardized Units
H1	-2.802**
H2	-2.309**
H3	-3.966**
H4	-1.516**
H5	1.684**
H6	.246
H7	.582
H8	.168
H9	.256
H10	.670

TABLE C4. Values of hypotheses for Test 2 data (between).

H_o	Standardized Units
H1	-2.343**
H2	-2.778**
H3	-2.215**
H4	- .837*
H5	1.462**
H6	.218
H7	- .064
H8	.625
H9	.707
H10	.300

TABLE C5. Values of hypotheses for Pre-Test 1 data (within).

H_o	Standardized Units
H1	.731*
H2	2.315**
H3	.004
H4	.290
H5	1.188**
H6	-1.372**
H7	.636*
H8	- .898**
H9	.368
H10	.841*

TABLE C6. Values of hypotheses for Test 1 data (within).

H_0	Standardized Units
H1	.927**
H2	2.201**
H3	- .053
H4	.424
H5	1.181**
H6	1.103**
H7	.849*
H8	.757*
H9	.566
H10	.912**

TABLE C7. Values of hypotheses for Pre-Test 2 data (within).

H_o	Standardized Units
H1	.980**
H2	2.441**
H3	.131
H4	.245
H5	1.188**
H6	1.266**
H7	.755**
H8	- .764**
H9	.665*
H10	1.167**

TABLE C8. Values of hypotheses for Test 2 data (within).

H_o	Standardized Units
H1	1.360**
H2	2.290**
H3	.012
H4	.552
H5	1.153**
H6	- .806*
H7	1.167**
H8	- .601*
H9	.849*
H10	1.054**