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OF PIGEONS.

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THE EFFECTS OF CONTEXT ON THE
CHOICE ACCURACY OF PIGEONS

by

ANNA MARIE VALERIO

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

This manuscript has been read and accepted for the Graduate Faculty in Psychology in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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Abstract

The Effects of Context on the Choice Accuracy of Pigeons

by

Anna Marie Valerio

Advisor: Professor Sheila Chase

The purposes of the investigation were (1) to examine the learning and performance of pigeons in a five-choice absolute identification task; (2) to determine if the range over which the luminance of stimuli was varied affected discriminability in a manner similar to the range effect found in humans; and (3) to see whether the relationship between stimulus magnitude and response location present during training could be transposed when new stimuli and new response possibilities were provided.

Since the 1950's it has been known that when humans are required to assign numbers to different stimulus intensities, i.e., making absolute identifications of these stimuli, increasing the distance between stimuli does not necessarily lead to better performance. According to statistical decision theory, increasing the separation between sensory effect distributions should improve the accuracy of discrimination. However, when the range of stimuli is sufficiently large, the expected improvements in discriminability, due to greater interstimulus differences, do not occur. This phenomenon has been termed the <u>range effect</u>.

In these experiments, pigeons were required to peck one of a row of five choice keys when the correct key choice was cued by the luminance of a centrally located display key. Different groups of pigeons were trained with three ranges of stimuli: narrow, moderate and wide. In the narrow range the luminances to be identified were 63, 124, 197, 313, 494 cd/m^2. In the moderate range, the luminances were 16, 63, 197, 494, 988 cd/m^2, and in the wide range, the stimuli were 2, 31, 197, 786, and 1955 cd/m^2. Within each range were two different conditions of stimulus-response relationship: ordered and unordered. Under the ordered condition, there was a monotonic relationship between stimulus magnitude and response location (i. e. referring to the keys as 1 to 5 from left to right, a peck at Key 1 was correct in the presence of the lowest luminance (S1), a peck at Key 2 was correct in the presence of the next highest luminance (S2), etc.). Under the unordered condition, there was an irregular order between luminance and key position (i. e. Key 4 was correct in the the presence of S1, Key 1 was correct in the presence of S2, Key 3 in the presence of S3, Key 5 in the presence of S4, and Key 2 in the presence of S5). Three White Carneaux pigeons were trained under each of the six conditions of the study. Training proceeded for 100 sessions. During each session, the five stimuli were presented in random order until each had been correctly identified 16 times. Following the last training session, all eighteen birds were given a transposition test during which two new luminances were presented as well as the five training luminances. The two novel luminances were .2 cd/m^2 (S0) and 2349 cd/m^2 (S6) which were dimmer and brighter, respectively, than any experienced by the birds during training. Two new keys, one at each end of the row of pecking keys, were made available during this session.

The results were analyzed using concepts derived from statistical decision theory. No evidence for a range effect was found but, in general, the performance of the ordered groups was superior to that of the unordered groups. The difference between the ordered and unordered groups was attributed in part to differences arising from occasional pecks on a key adjacent to that "intended". The superiority of the groups trained with luminance and response position monotonically related may also be due to learning by the pigeons trained under this condition that brighter lights require pecks on keys further to the right, and that dimmer lights require pecks on keys further to the left. Evidence for this was provided by the transposition test. The birds in the ordered condition pecked the new keys in the presence of the new stimuli more often than the birds in the unordered condition.

The results were discussed in relation to the range effect in humans and in relation to previous experiments concerned with the establishment of continuous repertoires in pigeons.

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I would like to thank my advisor, Dr. Sheila Chase for her guidance throughout this endeavor, and particularly for the long hours she spent with me in the laboratory at the beginning of this project.

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And finally I would like to thank two individuals whose contributions to this dissertation were so vast as to be inestimable. A special thanks, therefore, to Kathy Landry for her laboratory expertise, sense of humor, and culinary surprises during the long and arduous hours spent in the laboratory. I also thank my mother, Fernanda Valerio, whose patience, precision, and attention to detail in typing each of the various stages of the manuscript accelerated the completion of the project.

Table of Contents

List of Tables

List of Illustrations

At present, little is known concerning how pigeons accurately identify a set of several stimuli. Wildemann and Holland (1972) showed that pigeons were capable of responding differentially along a response surface in the presence of three different tones. Richter (Note 1) showed that pigeons can acquire a four choice discrimination and Chase (Note 2) found that pigeons can acquire a five choice discrimination when additional choices are introduced successively. In the present study, a five-choice luminance discrimination was present from the onset of training. In addition to providing evidence as to whether such a discrimination can be acquired, the present study was designed to answer questions concerned with the discrimination of luminances by pigeons. Particular attention was paid to two factors which may have an effect upon the accuracy with which luminances can be identified: (1) the range of values on a stimulus continuum which must be identified, (2) the relationship between the stimulus dimension and the spatial distribution of the response dimension.

The effects of range will be considered first. Despite large increases in the physical difference between adjacent stimuli, only minimal increases may be obtained in the accuracy of judgments between them. This phenomenon has been termed the range effect. The effects of range on discrimination may be demonstrated in two different experimental paradigms. In one paradigm, the size of the stimulus range is varied by increasing the distance between adjacent stimuli. In the other method, the discrimination between two stimuli separated by a fixed amount is observed when these stimuli are placed in wide and narrow ranges.

The present study employed the first method mentioned above. Using the second paradigm, Richter (Note 1) showed that the accuracy with which pigeons discriminated between two adjacent luminances was affected by the entire set of stimuli to which the subject was exposed. There were four luminance levels, S1, S2, S3, and S4 any one of which might be presented on the display key, and four separate response keys arranged in a horizontal row. A peck on the first key on the left was correct in the presence of S1, the second in the presence of S2, the third in the presence of S3, and the fourth in the presence of S4. A trial was signaled by the illumination of a rectangular pecking key located above the row of four circular pecking keys. A correct choice was defined by the luminance of the rectangular key on the particular trial and was followed by reinforcement and a 10-second intertrial interval. A correct response was required before the next programmed stimulus was presented.

In all of Richter's experiments, S2 and S3 were separated by .2 log units in luminance. Under one of her conditions (the .6 log unit range) all four stimuli were equally spaced (each separated by .2 of a log unit). Under a second condition (the 3.0 log unit range) S1 was separated from S2 by 1.4 log units and S4 was separated from S3 by 1.4 log units. This made it possible for her to compare accuracy in discriminating between S2 and S3 when the range was narrow and when the range was large, since the difference between S2 and S3 was 0.2 log units in both conditions.

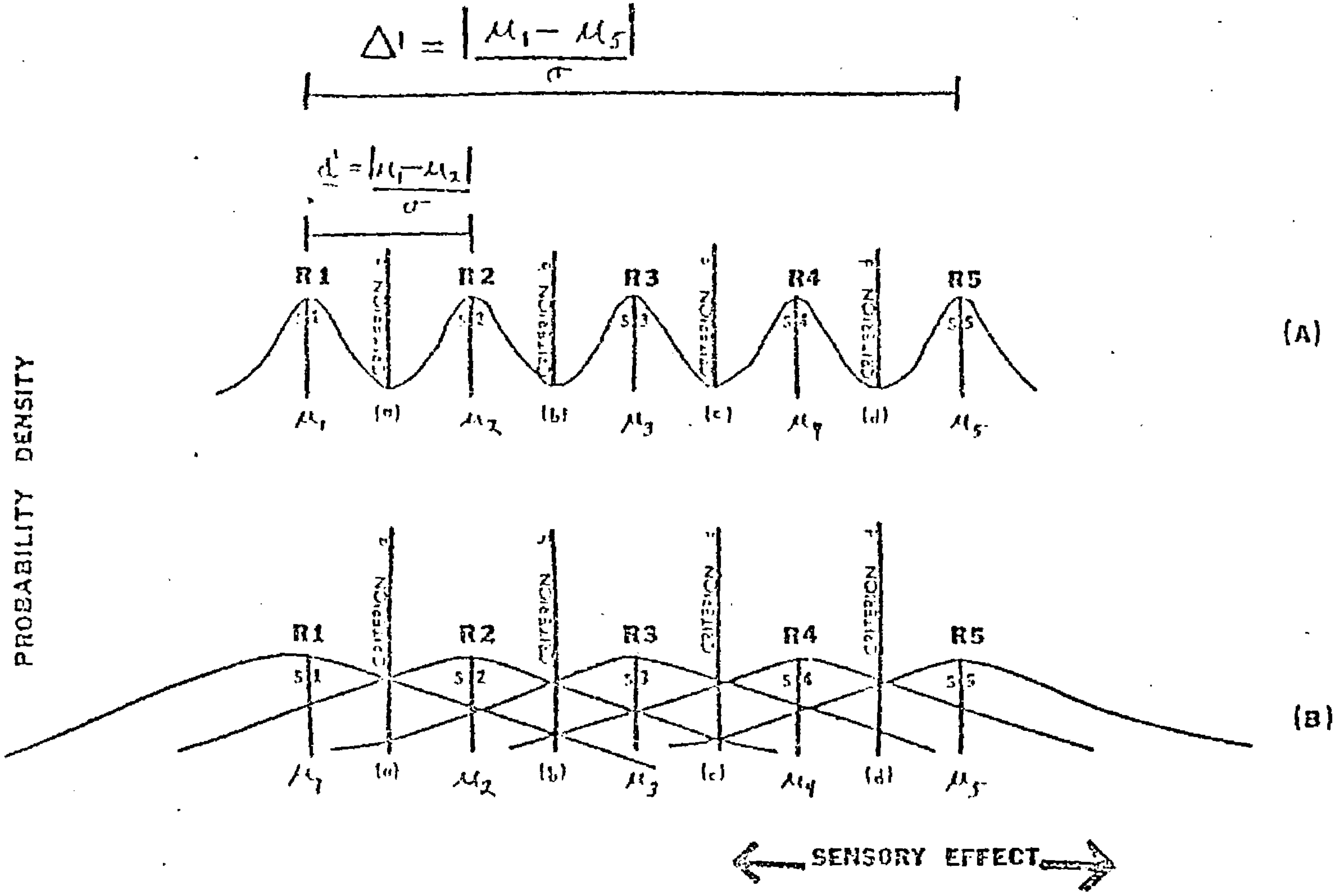
To further ascertain whether the discriminability of the two central stimuli was affected by a change in the stimulus range, a crossover design was employed. The birds that were originally trained on the narrow range condition were then switched to a wide range, and the birds originally trained on the wide range were switched to a narrow range. Every bird that was changed to the narrow range condition showed an increase in d' between S2 and S3 and every bird changed to the wide range condition showed a decrease in d'. While these data appeared to show that range affected accuracy of discrimination, Richter pointed out that it may not be range per se that was responsible. It is possible that the unequal spacing of the stimuli in the wide range was responsible. Richter suggested that subjects may have regarded the two stimuli which were closest together, S2 and S3, as identical on many trials. That the spacing of the stimuli in studies of discrimination may have an effect on sensitivity is also suggested by other data. Conneally (Note 3) studied pigeons' identification of luminance with different spacings between adjacent stimuli. In a procedure similar to Richter's (Note 1), pigeons were trained on a four-choice discrimination problem. The two extreme stimuli of the set were the same for all birds: S1 was a luminance of .7 log ft. L and S4 a luminance of -.7 log ft. L. The spacing of the two central stimuli in relation to the end stimuli was varied, however. Under Condition 1, S2 was a luminance of .5 log ft. L and S3 a luminance of -.5 log ft. L. Under Condition 2, S2 was a luminance of .1 log ft. L and S3, a luminance of -.1 log ft. L. In each condition, discriminability was obtained for the pairs of stimuli separated by .2 log units. The results showed that a .2 log unit difference between the end stimuli of the set appeared to be less discriminable than a similar luminance difference in the center of the range. Although the range (1.4 log ft. L) was the same under both conditions, fewer confusions between the extreme stimuli occurred under the condition in which the two central stimuli were more closely spaced (Condition 2). Stimulus spacing, therefore, is an important variable to be considered in studies of the range effect.

In their analyses of data, Richter (Note 1) and Conneally (Note 3) used concepts derived from signal detection theory. This approach to performance by a pigeon in a discrimination situation has also been used by Heinemann and Chase (1975) and Boneau and Cole (1965) among others.

Signal detection theory assumes that decisions concerned with stimulus events in the environment are based upon the sensory effects produced by these stimuli. The model as applied to a five-choice discrimination, is described below.

Panels (A) and (B) in Figure 1 show a situation in which the observer is required to make a different response (R1, R2, R3, R4 R5) in the presence of each of five stimuli (S1, S2, S3, S4, S5). It is assumed that the sensory effects produced by each of the five stimuli

Figure 1. Schematic diagram of signal detection problem for a five-choice discrimination.


$\Delta' = \frac{|\mu_1 - \mu_5|}{\sigma}$
$d' = \frac{|\mu_1 - \mu_2|}{\sigma}$
R1
R2
R3
R4
R5
CRITERION
S1
S2
S3
S4
S5
μ_1
(a)
μ_2
(b)
μ_3
(c)
μ_4
(d)
μ_5
(A)
(B)
PROBABILITY DENSITY
SENSORY EFFECT

are normally distributed and of equal variance. Near perfect discrimination among the five stimuli is possible if the sensory effect continuum is divided into five segments shown by the boundaries (criteria) at points (a), (b), (c) and (d) in Panel (A). For any sensory effect to the left of point (a), response 1 (R1) is made; for any sensory effect between criteria (a) and (b), response 2 (R2) is made; and so forth. In Panel (B) the situation illustrated is one in which errors are inevitable. For example, a subject with a category boundary at criterion (a) will make R2 incorrectly when the sensory effect produced by S1 falls within the region for R2, with a category boundary at criterion (b) will make R3 incorrectly when the sensory effect produced by S2 falls within the region for R3, and so on.

The discriminability of pairs of stimuli may be expressed in terms of d' which is the difference between the means (μ) of two hypothetical sensory effect distributions expressed in terms of their common standard deviation. For any two intensities I_i and I_{i-1}:

$$d'(I_i; I_i - 1) = \frac{[\mu(I_i) - \mu(I_i - 1)]}{\sigma}$$

The greater the value of d', the higher the sensitivity. In Figure 1, Panel (A), d' between S1 and S2 is shown diagrammatically.

Another index of discriminability among a set of stimuli is total sensitivity, (Δ'). The total sensitivity measure was developed by Durlach and Braida (1969) to make possible a comparison of performance under a variety of conditions (e.g. for different ranges and number of stimuli). It is simply d' between the two outermost stimuli

$I_{max}; I_{min}$) and is obtained by cumulating adjacent d' values for the entire set of stimuli. As given by Durlach and Braida (1969) the equation for total sensitivity is as follows:

$$\Delta' = \underline{d'} \; (I_{max} \; ; \; I_{min}) = \sum_{i=2}^{N} \underline{d'} \; (I_i \; ; \; I_{i-1})$$

The decision model described above suggests that Richter (1977) should not have obtained a change in d' between S2 and S3. However, results such as hers can be accounted for if we assume that increasing the range increases the variance of the distributions of sensory effect. Panels (A) and (B) in Figure 1 illustrate this. The means of the stimulus distributions in (A) and (B) are the same but the variance of the distributions is different. In this illustration, d' between the adjacent stimuli in Panel (A) is greater than d' between adjacent stimuli in Panel (B) because the variance is smaller in Panel (A), thus increasing the value of d'.

A range effect similar to that found by Richter (Note 1) was found earlier in the absolute identification of sound intensities in humans. Both Gravetter and Lockhead (1973) suggested that criterion variability increases with range. Like Richter (Note 1), Gravetter and Lockhead (1973) increased the stimulus range by increasing the distance between the extreme ends of the stimulus continuum while leaving the spacing between the central stimuli unchanged. They suggested that as the "criterial range" increased, criterion variability increased (p. 203). They defined criterial range as the distance between the two outermost criteria, points which are midway between the two most extreme stimuli that must be identified. Increasing the range over which stimuli vary increases the distance between the outer criteria.

According to the model proposed by Durlach and Braida (1969), there are two types of noise that contribute to the variability in absolute judgments: sensation noise and memory noise. Sensation noise arises from variation within the sensory system itself as well as the sensory effects produced by the stimulus. There are two types of memory noise. Noise arises when the sensory-trace mode is used. Here the S attempts to maintain a trace of the sensation. In the context-coding mode it is assumed that noise arises when the subject attempts to compare the sensation with the general context of stimuli in the experiment. The amount of context-coding noise depends on the width of the context. Increasing the range of stimuli, therefore, increases the context-coding noise. For sound intensities equally spaced in decibels Durlach and Braida (1969) assumed that the width of the context was determined by the total range of intensities in the stimulus set. For Durlach and Braida (1969), therefore, the effective range of stimuli was given by the objective stimulus range. This assumption differed from that of Gravetter and Lockhead (1973) who maintained that the effective range was the criterial range.

The present investigation was designed to resolve several questions which remained unanswered concerning the range effect in the pigeon. Richter (Note 1) showed that sensitivity varied inversely with range but in doing so, she, like Gravetter and Lockhead (1973) introduced unequal spacing within the set of stimuli. The reduced sensitivity with increased range that these investigators observed may be due to the increased range, the unequal spacing, or to both. Different mechanisms may be responsible for the range effect observed for equally spaced stimuli by Durlach and Braida (1969) with humans as subjects. It is of interest to determine whether pigeons show similar changes in sensitivity when range is increased in this manner.

As stated earlier, the second purpose of the investigation was to examine the effects of the relationship between the stimulus and response dimensions on the accuracy of identification of luminances in pigeons. The stimulus dimension with which this research deals is the luminance of white light and the response dimension is the position of the key which must be pecked in the presence of different values on this stimulus continuum. Is learning facilitated when points along the stimulus dimension and the response dimension are monotonically related, that is, for example, when the first key on the left must be pecked in the presence of the lowest luminance, the second key from the left in the presence of the next highest luminance, etc. ? If pigeons are capable of learning about such a relationship between stimulus and response dimensions, one would expect a monotonic ordering to facilitate performance. If, on the other hand, pigeons learn only to associate specific key choices with specific luminances, it should make no difference which key is designated as correct in the presence of any particular luminance.

Skinner pointed out that much of discrimination behavior can best be described as "the coherent, continuous activity of an integral organism" (Skinner, 1953, p. 116). He stated that the organism acquires a "coherent repertoire" (Skinner, 1953, p. 117) and suggested that such a coherent repertoire may be acquired as a result of training on limited points of correspondence between a stimulus dimension and a response dimension. An attempt at examining such a repertoire was made by Cumming and Eckerman (1965) who trained pigeons to peck at one end of a 10-inch horizontal key strip when it was dimly illuminated (.1 log ft. L) and at the other end when it was brightly illuminated (1.1 log ft. L). Following this training, the pigeons were given one-minute periods during which the illumination of the key strip assumed values equal to or intermediate between those present during training (.1, .6, .8, and 1.1 log ft. L). No reinforcers were delivered during this part of the experiment. The pigeons did not show any appreciable increase in pecks on the central areas of the strip when the new stimuli were presented. An increase in responding in the intermediate region of the key strip in the presence of the intermediate stimuli would have been an indication that the pigeons learned the relationship between luminance and location of pecks. Possibly Cumming and Eckerman failed to find evidence of a coherent repertoire because they trained using only two points of correspondence on the stimulus-response dimension. In one of their experiments, Wildemann and Holland (1972) trained pigeons to respond to three points of correspondence between the stimulus and response dimensions. The response dimension was similar to that used by Cumming and Eckerman (1965), key position along a horizontal response panel, and the stimulus dimension was frequency of a tone. Pecks on the left end of the panel were reinforced in the presence of a tone of 1250 Hz, pecks on the right end of the panel were reinforced in the presence of a 2500 Hz tone, and pecks on the panel's center region, in the presence of a 1668 Hz tone. Pigeons were then tested with two intermediate tones: 1470 Hz and 2222 Hz. Pecks at the region between left and center in the presence of the 1470 Hz tone and pecks at the region between right and center in the presence of the 2222 Hz tone would have provided evidence that the relationship between tonal frequency and response location had been learned. However, few responses were emitted to the intermediate areas when the intermediate tones were presented; responses were distributed around training positions. Thus, no evidence of a "coherent repertoire" was found. Wildemann and Holland (1972) discuss the possibility that responses to the intermediate areas were extinguished because reinforcement was never available following pecks on these regions. Even if the relationship between tonal frequency and response position were learned it may not have appeared during the test. However, this cannot be completely responsible for the results since Chase, Geller, and Hendry (1974) have shown, following a similar training procedure, that pigeons will peck keys in new positions provided that the stimulus and response dimensions are topographically related. Chase, Geller and Hendry (1974) presented pigeons with a row of five choice keys (Key 1 through 5, from left to right). On each trial, a circular spot of light appeared above one of the keys. Reinforcement occurred when a peck was made on the key below the spot. During training, the spot only appeared above Keys 1, 3, and 5. The birds were then tested with the spot above Key 2 or Key 4. When the spot was above Key 2 the birds pecked Key 2 and when the spot was above Key 4, the birds pecked Key 4 on some but not all of the trials. In a subsequent study, Hendry (Note 4) showed that pigeons will peck a novel key when trained to peck the key to the left of the spot, to the right of the spot, as well as below the spot. Pigeons were trained with the spot in two positions, above Key 2 and Key 4, and the test for a coherent repertoire was made by presenting the spot above the middle key, Key 3. The coherent repertoire was acquired under all three spot-key correspondences and furthermore, two points of correspondence during training were sufficient for the establishment of such coherent repertoire. Hendry (Note 4) also found that the particular type of response surface did not affect the establishment of a coherent repertoire: pigeons trained with five discrete keys performed as well as pigeons trained to peck on different positions on a continuous horizontal surface. Chase, et al. (1974) pointed out that the differences between these studies in which a coherent repertoire was acquired and those of Wildemann and

Holland (1972) and Cumming and Eckerman (1965) which failed to demonstrate such behavior may be due to the differences in the stimulus continua studied:

> After they were well trained, each pigeon typically moved his head horizontally until it was lined up with a point just above the spot, and then lowered it to peck the key. This sort of interaction between the discriminative stimuli and the topography of the response does not exist when the discriminative stimuli are diffuse sounds . . . .
> Such interactions may well play a critical role in the development of continuous repertoires of behavior.
> (Chase, et al., 1974, p. 16)

It well may be, as Chase, et al. (1974) suggest, that a coherent repertoire is not acquired unless a topographical relationship exists between stimulus and response continua. When points along the stimulus continuum are tonal frequencies or intensities of a light, it may prove a difficult task to locate the corresponding point along the response dimension. It is also possible that had Cumming and Eckerman (1965) used a larger number of points of correspondence they would have obtained evidence of a coherent repertoire, even with luminance as a stimulus dimension. In the present study, the training of one of the groups is very similar to that of Cumming and Eckerman (1965) except that discrete keys are used and training was given on five points of correspondence between the monotonically ordered stimulus and response dimensions. The performance of this group was compared to the performance of another group in which the relationship between stimulus magnitude and response location was arbitrary.

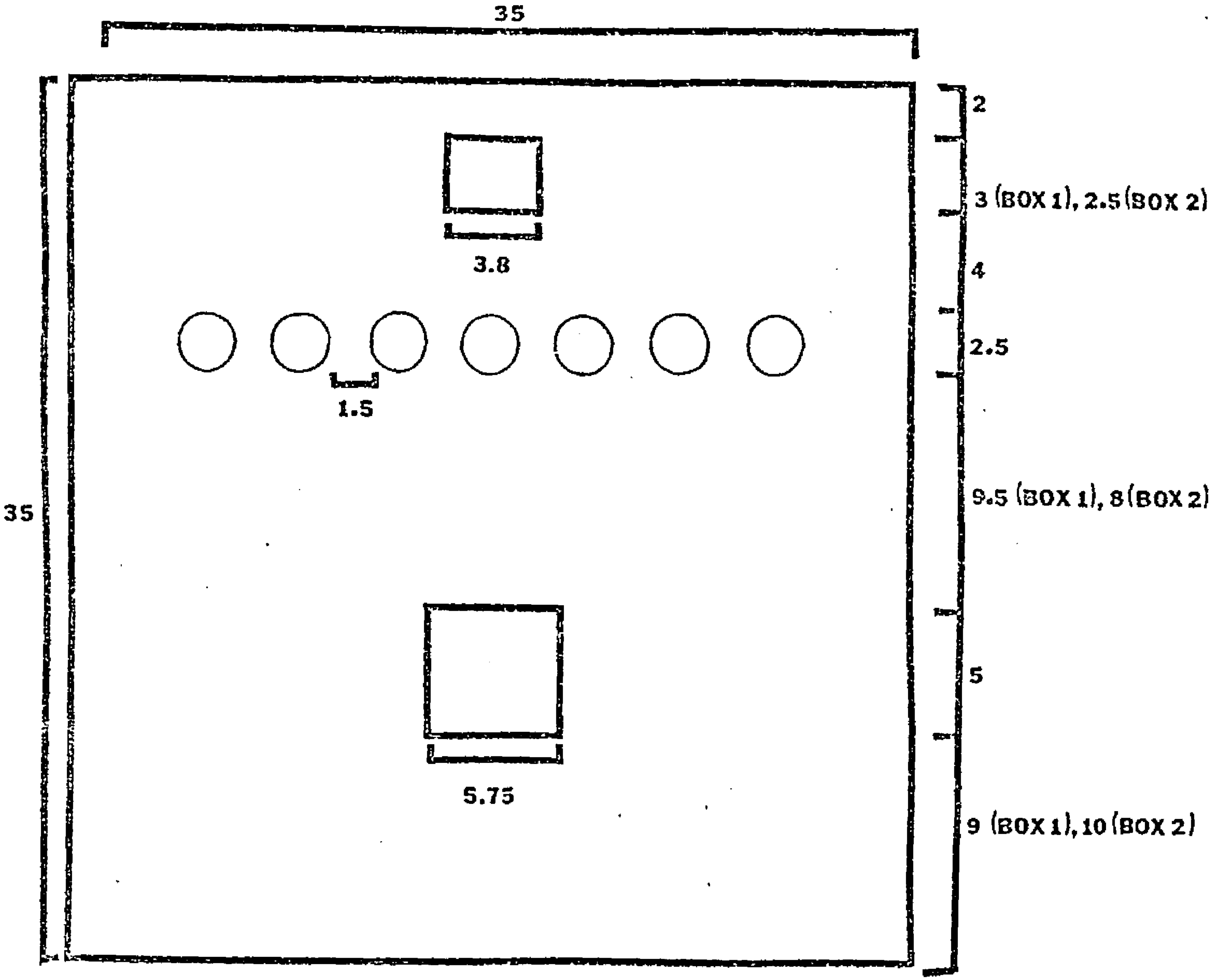
Method

Subjects. The subjects were 18 White Carneaux pigeons purchased from the Palmetto Pigeon Plant, Sumter, South Carolina. At the start of the experiment, all of the birds were under two years old. The birds were maintained between 80% to 85% of their free-feeding weights[1]. Water and grit were always available in their home cages.

Apparatus. Two BRS/LVE (Beltsville, Md.) pigeon chambers (Model No. 132-02) were used. The dimensions of the modified intelligence panels (Model No. 141-13) are given in Figure 2. The surfaces of the two intelligence panels were covered with black contact paper.

White light could be projected upon a translucent rectangular pecking key, the display key. The discriminative stimuli were different intensities of this light. The luminance of the display key was varied by placing various Kodak Wratten Gelatin Neutral Density Filters (#96) in the beam of a Kodak Carousel projector. The filters were inserted in Ektamount 35 mm cardboard slides. Each slide was coded by means of a specific combination of three holes, .6 cm in diameter, punched in the sides of the slide mounts. Light passing through these holes could illuminate any one of, or a combination of, three photoresistive cells (Archer, Electronic Parts #276-116). Various combinations of lit photoresistive cells were used to indicate which stimulus was presented. For Box 1 and Box 2, Kodak Carousel Slide Projectors (Model No. 800H and 750H, respectively) were used with quartz iodide projector bulbs (Sylvania Tungsten Halogen ELH Quartz

Figure 2. Front panel of pigeon chambers. Dimensions are in cm.


35
35
3.8
1.5
5.75
2
3 (BOX 1), 2.5 (BOX 2)
4
2.5
9.5 (BOX 1), 8 (BOX 2)
5
9 (BOX 1), 10 (BOX 2)

Trubeam, 300W, 120V). The low setting on the projectors was used.

Seven circular pecking keys were located below the display key in each box. These will be referred to as choice keys. One key at each end of the row was covered during Experiment 1 and uncovered during the Transposition Test. Each choice key could be illuminated at about 1.2 ft. L^{2} from behind by lighting a green, 6 volt pilot light. The chambers were continuously illuminated by a 28 volt pilot light (G.E. 1829) recessed into the center of the chamber ceiling. This was covered by one thickness of translucent tape to further decrease the level at which the chamber was illuminated. Ventilation and masking noise in the chamber were provided by a fan. Luminance was measured using a Spectra Pritchard Photometer, Photo Research Corporation, Hollywood, California, Code #1970-PR.

All experimental contingencies were controlled by standard relay equipment located in an adjacent room.

Pretraining. The birds in all conditions were trained in the same manner. Each bird was first trained to eat from the food hopper and next trained by the method of successive approximation to peck the middle key in the row of five choice keys. In all subsequent discussion, the keys will be referred to as Keys 1 through 5 beginning with the first key on the left and proceeding in order to the last key on the right. A peck at Key 3, during the first phase of pretraining was reinforced by 2-second access to the feeder filled with mixed grain. This phase of pretraining was continued until the bird had earned 20 grain presentations.

During the second phase of pretraining, the birds were trained to peck all of the choice keys. During this phase only one choice key was illuminated on each trial. A peck at the illuminated choice key was reinforced by 2-second access to the feeder during which time all choice keys were darkened. After the two-second feeder presentation, a choice key was again illuminated. The order in which each choice key was illuminated and the number of reinforcements received for correct choices on each key was as follows: Key 3, 20 reinforcements; Key 2, 10 reinforcements; Key 4, 10 reinforcements; Key 1, 10 reinforcements; Key 5, 10 reinforcements.

The third stage of pretraining was then begun. In this final stage, the display key was illuminated at 570 ft. L. A peck on the display key illuminated all of the five choice keys; a peck on any one of the five choice keys was reinforced and all keys were darkened for a 6-second intertrial interval. During the intertrial interval (ITI) the luminance level of the display key was .0044 ft. L. Pretraining was completed when the pigeon had received 40 reinforcements under this condition.

Procedure. The onset of a trial was indicated by the illumination of the display key at one of five levels of luminance. There were three such sets of luminances. The set referred to as the narrow range covered .9 log units, the moderate range, 1.8 log units, and the wide range, 3.0 log units. Within each range, an attempt was made to space the stimuli so as to divide the range into five steps, each equal in terms of discriminability, with the center stimulus the same for all sets. The five luminance levels for each of the three ranges are shown in Table 1 along with the particular key choice required for reinforcement in the presence of each of the stimuli.[3] The method by which the spacing between adjacent stimuli was determined is described in Appendix A. Two different key-luminance assignments were made within each range. These will be referred to as ordered and unordered. Under the condition referred to as ordered, there was a monotonic relationship between luminance and the position of the key choice required, that is, Key 1 was correct in the presence of S1, Key 2 was correct in the presence of S2, and so on. Under the condition referred to as unordered, there was an irregular order between luminance and key position. Referring to the keys as 1 to 5 from left to right, Key 4 was correct in the presence of S1, Key 1 was correct in the presence of S2, Key 3 in the presence of S3, Key 5 in the presence of S4 and Key 2 in the presence of S5. There were three birds in each of the six groups.

The order of presentation of the stimuli was random with the restriction that each stimulus appear an equal number of times within 40 trials. A session consisted of two repetitions of this 40-trial program.

A peck on the display key illuminated the five choice keys; the display key remained lit. A peck at any choice key was followed by a 10-second intertrial interval during which the choice and display

Table 1

General design of experiment

Range	Narrow	Moderate	Wide
	.9 log units	1.8 log units	3.0 log units
Stimuli* 1 through 5	18.2, 36.3, 57.5, 91.2, 144.	4.57, 18.2, 57.5, 144, 288	.57, 9.12, 57.5, 229, 570
Reinforced Key Choice	Ordered 1-2-3-4-5	Ordered 1-2-3-4-5	Ordered 1-2-3-4-5
	Unordered 4-1-3-5-2	Unordered 4-1-3-5-2	Unordered 4-1-3-5-2

*in ft. L

keys were darkened and inoperative. A correct choice was followed by reinforcement which consisted of access to a hopper filled with mixed grain for 2 seconds. An incorrect choice was followed by the ITI after which the stimulus in the presence of which the error occurred was presented again. A peck on the display key on the trial following an error illuminated only the keys not previously pecked in error. This procedure continued until the bird made the correct response, received reinforcement, and the projector stepped forward to the next programmed stimulus and a new trial was in effect. All data were analyzed in terms of first choices, that is, the first presentation of the stimulus according to the predetermined program.[4] Repeated presentations of the stimulus following an error were excluded from the data treatment. A session ended after 80 new trials. Training was continued for 100 sessions. There were six sessions per week with the exception of the period when data for Blocks 11 and 17 were collected during which there were five sessions.

Transposition Test

Method

Subjects. The 18 White Carneaux pigeons who served as subjects in the first experiment were given the transposition test.

Apparatus. The apparatus was identical to that used and described in the first experiment with the exception that two extra choice keys were added in each experimental chamber, one to the left of key 1 (key 0) and one to the right of key 5 (key 6). The two new keys were identical to the other choice keys.

Stimuli. The stimuli for the transposition test were identical to those used in the first experiment except for the addition of two new stimuli. For Stimulus 0, a piece of black oaktag was inserted in the slide mount. The luminance level of the display key when this slide was in the projector was .05 ft. L, which is an increase from the level of .004 ft. L present during the ITI. For Stimulus 6, nothing was inserted in the slide mount and the intensity of light was increased by using the high setting on the projector. The luminance level of the display key for Stimulus 6 was 685 ft. L.

Procedure. The procedure was the same as that used for an ordinary session with the exception that Stimuli 1 through 5 were presented a total of 12 times each instead of 16, and Stimuli 0 and 6 were each presented a total of 10 times. Reinforcement was available following a correct response to any one of the training stimuli but not following a response to either novel stimulus. Following an incorrect response to one of the training stimuli, the same stimulus in the presence of which an error occurred was presented again. A peck on the display key following an error illuminated only the keys not previously pecked in error. This procedure continued until the bird made the correct response, received reinforcement, and the projector stepped forward to the next programmed stimulus. On trials in which one of the novel stimuli was presented, the correction procedure just described was not in effect, so that the projector stepped forward following any response made by the bird. A session consisted, therefore, of 80 trials, on 60 of which reinforcement occurred. The order of presentation of the stimuli was random with the exception of the first five stimuli which were presented in order, 1 through 5. Each bird received a single test session.

Data Analysis

Total Sensitivity (Δ')

Total sensitivity is a measure of discriminability developed by Durlach and Braida (1969). It is based upon concepts derived from signal detection theory and is simply *d'* for the two outermost stimuli of the set. Figure 1 illustrates the sensory effects produced by five stimuli. As Panel (A) in Figure 1 shows, *d'* is the difference between the means of two sensory effect distributions expressed in terms of their common standard deviation. To obtain total sensitivity, (cumulative *d'*) all of the *d'* values between adjacent stimuli are summed.

Table 2 illustrates the rating scale method of obtaining *d'* using a hypothetical confusion matrix (Panel A). In Panel (A), a 5 x 5 matrix, showing the proportion of times each response was made as a first choice in the presence of each of the five stimuli. For example, in the presence of S1, R1 was made 69% of the time, R2 was made 24% of the time, and so on. In Panel (B) the proportions of first responses shown in Panel (A) are cumulated for each stimulus, as for example, P(R1 + 2 + 3|S1) is .99.

In this method of calculating *d'* and total sensitivity, up to four estimates of *d'* are calculated for each of the discriminations between adjacent stimuli. These four estimates for the mean of discrimination between S1 + 2, S2 + 3, S3 + 4, S4 + 5 are given in Panel C. These four estimates are used as *d'* for that stimulus pair.

Table 2

Procedure for obtaining *d*' and Δ'.

Proportion

	S1	S2	S3	S4	S5
R1	.69	.31	.07	.01	0
R2	.24	.38	.24	.06	.01
R3	.06	.24	.38	.24	.06
R4	.01	.06	.24	.38	.24
R5	0	.01	.07	.31	.69

(A)

Cumulative Proportion

	S1	S2	S3	S4	S5
R1	.69	.31	.07	.01	0
R1+2	.93	.69	.31	.07	.01
R1+2+3	.99	.93	.69	.31	.07
R1+2+3+4	1.00	.99	.93	.69	.31
R1+2+3+4+5	1.00	1.00	1.00	1.00	1.00

(B)

d' for the discrimination between:

	S1+2	S2+3	S3+4	S4+5
R1	1.01	.96	.85	-
R1+2	.96	1.01	.96	.85
R1+2+3	.85	.96	1.01	.96
R1+2+3+4	-	.85	.96	1.01
$\bar{x}$	.94	.94	.94	.94

(C)

Δ' = 3.76

For example, to obtain the four estimates of d' for the discrimination between S1 and S2, the proportion of R1 responses in the presence of S1, P(R1|S1) is treated as the hit rate, and the proportion of R1 responses in the presence of S2, P(R1|S2) is treated as the false alarm rate. Based on the proportion of R1 responses, one estimate of d' may then be obtained for the discrimination between S1 and S2, from tables published in Swets (1964). The second estimate of d' between S1 and S2 is obtained by treating P(R1 + R2|S1) as the hit rate, and P(R1 + R2|S2) as the false alarm rate, and obtaining the corresponding d' value from the d' table. The third and fourth estimates of d' are obtained in similar fashion: P(R1 + R2 + R3|S1) is treated as the hit rate, and P(R1 + R2 + R3|S2) as the false alarm rate, and finally, P(R1 + R2 + R3 + R4|S1) is treated as the hit rate, and P(R1 + R2 + R3 + R4|S2) as the false alarm rate. Their corresponding d' values are also obtained from the d' table. If a hit or false alarm rate should be less than .01 or greater than .99, for either the hit or the false alarm rate, the pair is not used in the analysis. The mean of each of the four estimates of d' is now obtained for the discrimination between S1 + 2, S2 + 3, S3 + 4, and S4 + 5 (Panel C). Finally, total sensitivity is obtained by summing all four estimates of d'.[5]

Results

Acquisition of the five-choice discrimination

One purpose of the present investigation was to examine the choice behavior of pigeons in a five-choice luminance discrimination task. The birds were given 100 sessions of training. As evidence that responding was under stimulus control and, thus, that a five-choice discrimination can be acquired by pigeons, choice curves were drawn, showing the proportion of times each response was made in the presence of each stimulus. Figures 3 through 5 illustrate the choice curves for the last 25 sessions of training for each bird. Figure 3 shows the choice curves for the wide-range birds. Note that the choice curve for each of the five responses is highest in the presence of the stimulus for which the response was correct. The curves for the moderate-range birds are similar (see Figure 4). Figure 5 shows the choice curves for the narrow range birds. While control over each of the five responses is not as clear here, the maximum for each response in most cases (18 out of 30) occurs in the presence of the appropriate stimulus.[6] In summary, these curves are similar to those expected if the birds follow the decision strategy described in the introduction (see Figure 1).

Choice curves similar to those shown in Figures 3 to 5 were obtained early in training. The birds approached asymptote early in training as can be seen both in percent correct (Figure 6) and total sensitivity (Figure 7). The confusion matrices for each bird from

Figure 3. Five-response choice curves for the wide-range birds for the last twenty-five days of training. In the wide-range condition, S1, S2, S3, S4, and S5 were luminances of .57, 9.12, 57.5, 229, 570 ft. L respectively. For the ordered group, Key 1 was correct in the presence of S1, Key 2 in the presence of S2, Key 3 in the presence of S3, Key 4 in the presence of S4, and Key 5 in the presence of S5. For the unordered group, Key 4 was correct in the presence of S1, Key 1 in the presence of S2, Key 3 in the presence of S3, Key 5 in the presence of S4, and Key 2 in the presence of S5. This is shown in the insert at the top of each column.

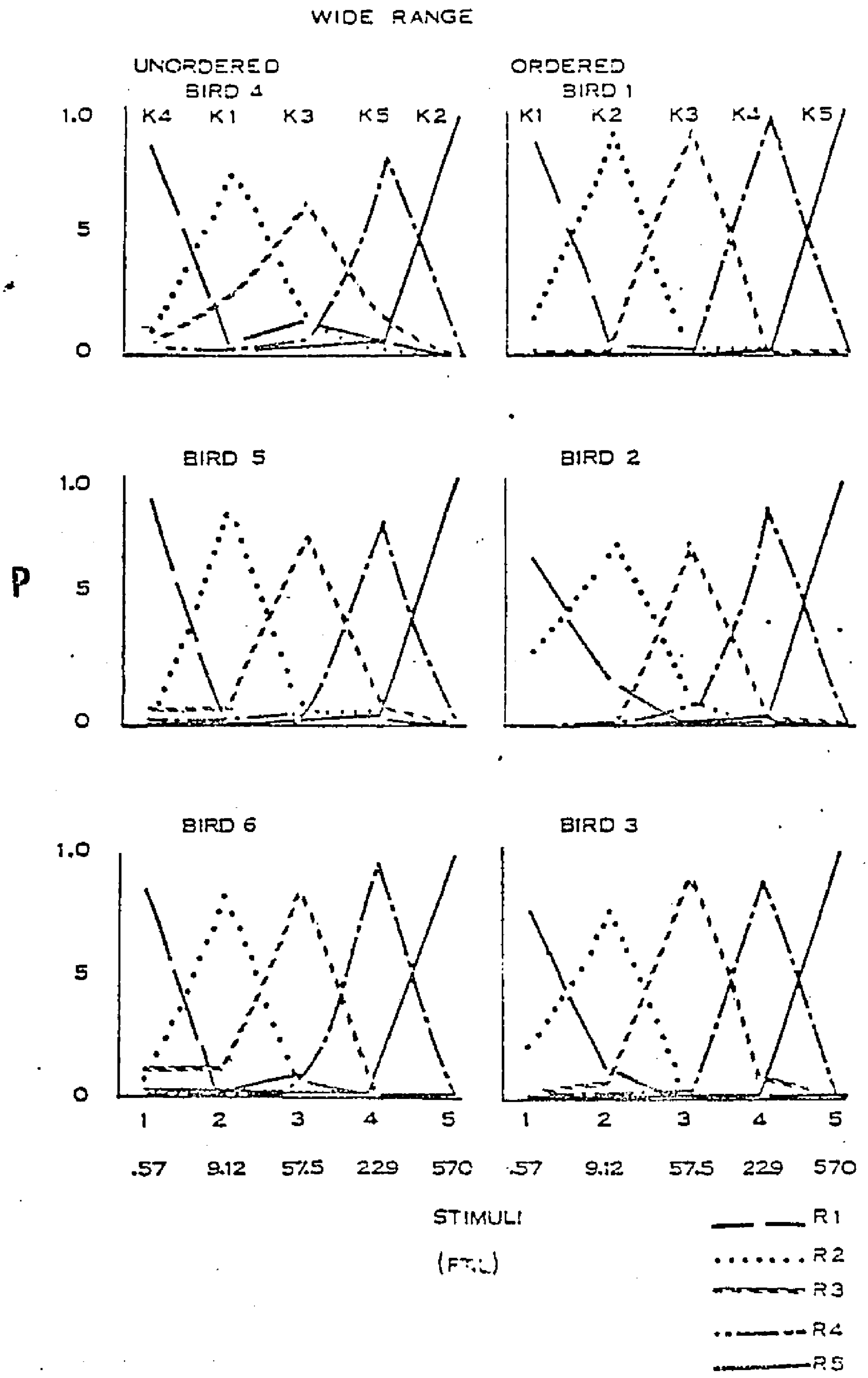

WIDE RANGE
UNORDERED
BIRD 4
K4 K1 K3 K5 K2
ORDERED
BIRD 1
K1 K2 K3 K4 K5
BIRD 5
BIRD 2
BIRD 6
BIRD 3
P
1.0
5
0
1 2 3 4 5
.57 9.12 57.5 229 570
STIMULI
(FT.L)
R1
R2
R3
R4
R5

Figure 4. Five-response choice curves for the moderate range birds for the last twenty-five days of training. In the moderate range, S1, S2, S3, S4, and S5 were luminances of 4.57, 18.2, 57.5, 144, 288 ft. L respectively. For the ordered group, Key 1 was correct in the presence of S1, Key 2 in the presence of S2, Key 3 in the presence of S3, Key 4 in the presence of S4, and Key 5 in the presence of S5. For the unordered group, Key 4 was correct in the presence of S1, Key 1 in the presence of S2, Key 3 in the presence of S3, Key 5 in the presence of S4, and Key 2 in the presence of S5. This is shown in the insert at the top of each column.

MODERATE RANGE

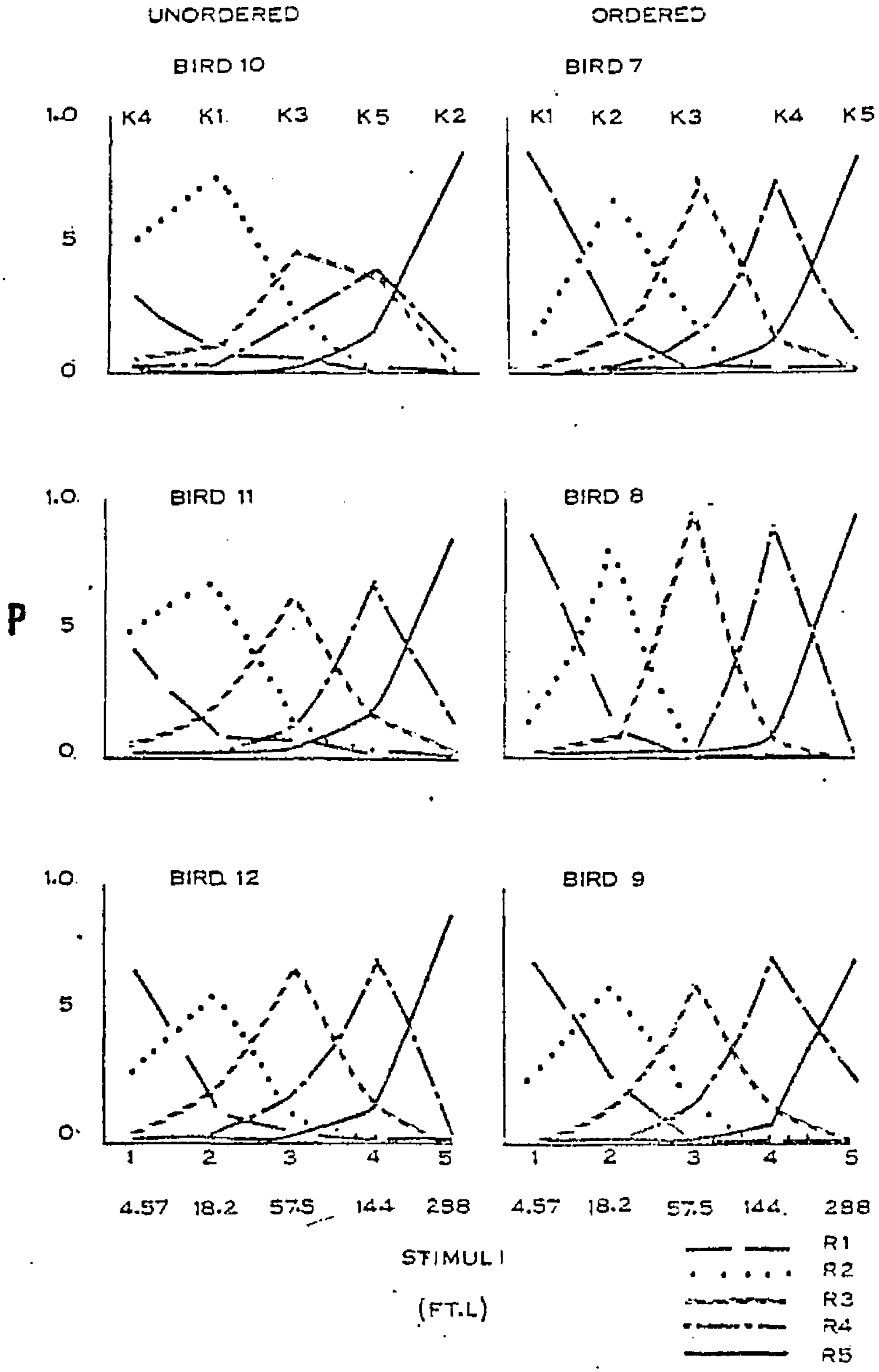


Figure 5. Five-response choice curves for the narrow range birds for the last twenty-five days of training. In the narrow range, S1, S2, S3, S4 and S5 were luminances of 18. 2, 36. 3, 57. 5, 91. 2, 144 ft. L, respectively. For the ordered group, Key 1 was correct in the presence of S1, Key 2 in the presence of S2, Key 3 in the presence of S3, Key 4 in the presence of S4, and Key 5 in the presence of S5. For the unordered group, Key 4 was correct in the presence of S1, Key 1 in the presence of S2, Key 3 in the presence of S3, Key 5 in the presence of S4, and Key 2 in the presence of S5. This is shown in the insert at the top of each column.

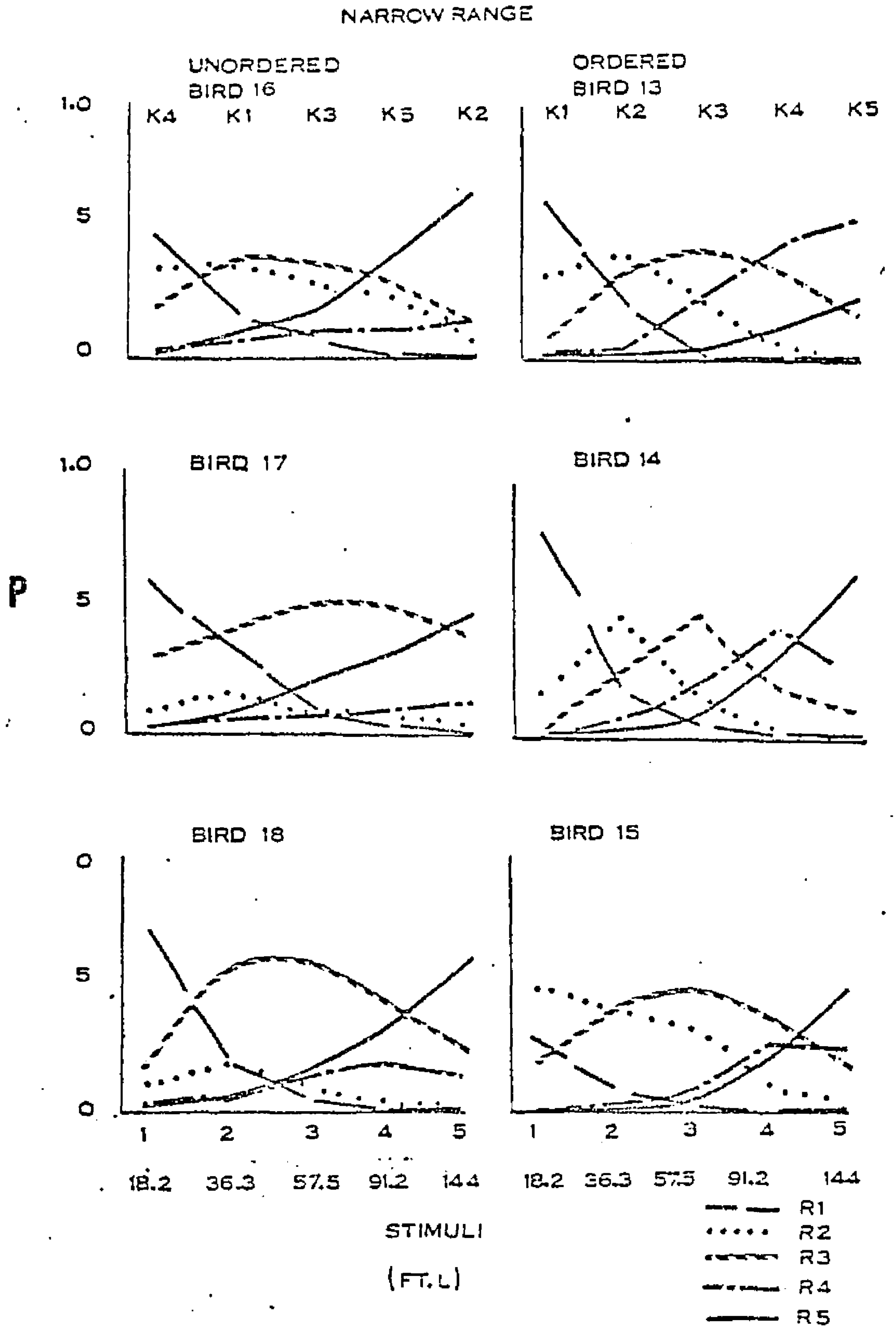

NARROW RANGE
UNORDERED
BIRD 16
ORDERED
BIRD 13
1.0
K4
K1
K3
K5
K2
K1
K2
K3
K4
K5
5
0
1.0
BIRD 17
BIRD 14
P
5
0
BIRD 18
BIRD 15
0
5
0
1
2
3
4
5
1
2
3
4
5
18.2
36.3
57.5
91.2
144
18.2
36.3
57.5
91.2
144
STIMULI
(FT. L)
R1
R2
R3
R4
R5

Figure 6. Percent correct as a function of training. Each point is based upon data obtained from three birds.

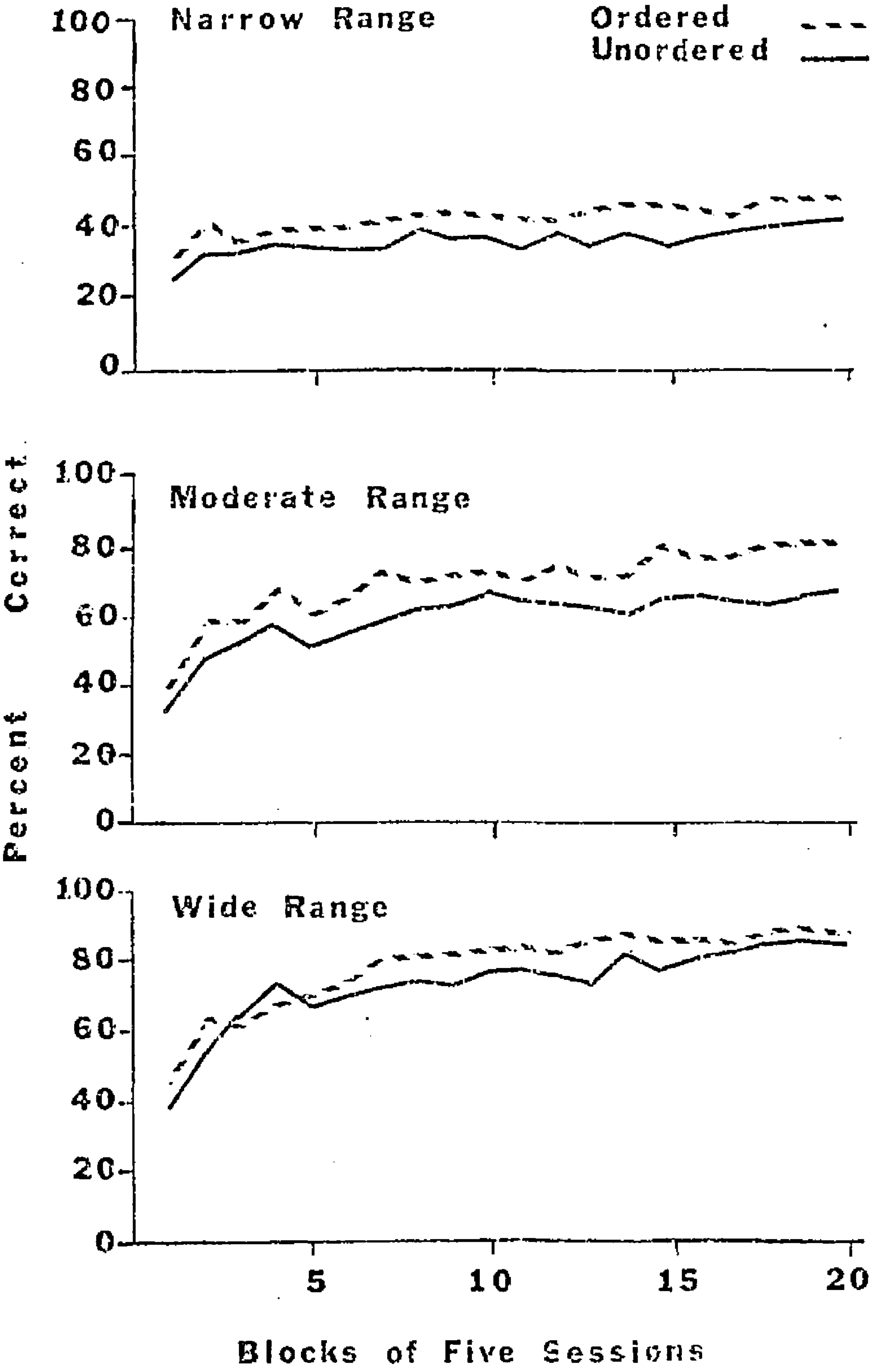
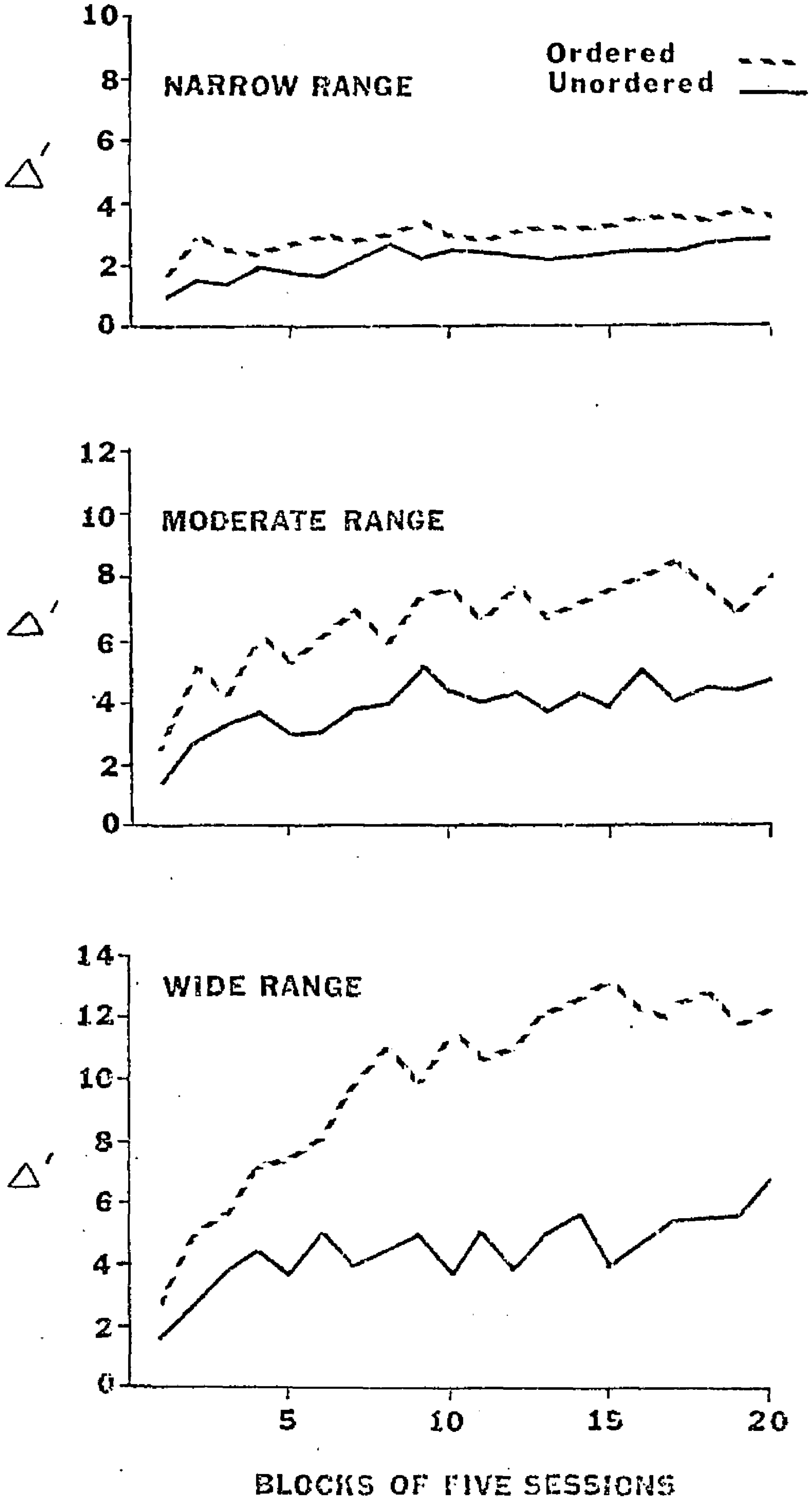

Narrow Range
Ordered
Unordered
Moderate Range
Wide Range
Percent Correct
100
80
60
40
20
0
5
10
15
20
Blocks of Five Sessions

Figure 7. Total sensitivity (Δ') as a function of training. Each point is based upon data obtained from three birds.


Ordered
Unordered
NARROW RANGE
MODERATE RANGE
WIDE RANGE
Δ′
Δ′
Δ′
0
2
4
6
8
10
0
2
4
6
8
10
12
0
2
4
6
8
10
12
14
5
10
15
20
BLOCKS OF FIVE SESSIONS

which these data were obtained appear in Appendix B. The 100 sessions of training are divided into 20 blocks of 5 successive sessions each. Only first responses, defined as the first key pecked for each of the 80 stimulus presentations within a session, were tabulated.

From Figure 6 it can be seen that birds trained on the ordered relation between stimulus magnitude and response location were more accurate than those trained on the unordered relationship and that the wider the separation between adjacent stimuli the greater the accuracy. Most gains in percent correct occurred during the first five blocks of training.

Figure 7 shows total sensitivity for the six different conditions throughout the entire experiment. Total sensitivity is higher for the ordered groups under all three ranges and, especially for the ordered groups, is greater as the spacing between adjacent stimuli (the range) increases.

A first consideration of this study was that the performance was stable sometime before training was discontinued; therefore, the data for the last 25 sessions of training were combined for further analyses. An analysis of variance was done on the total sensitivity obtained for each of the last five blocks of training (25 sessions) to determine whether the assumption that performance was stable was justified. The results of these six analyses of variance appear in Table 3. The data of the last five blocks of sessions (total 25 sessions) were stable for each experimental condition since the results of all of the analyses

Table 3

Results of six single-factor repeated-measure analyses of variance performed on total sensitivity values obtained furing the last five blocks of training for birds under each of six conditions.

Condition	F	df	Significance
Narrow-ordered	.56	4, 8	not significant
Narrow-unordered	2.03	4, 8	not significant
Moderate-ordered	.02	4, 8	not significant
Moderate-unordered	.63	4, 8	not significant
Wide-ordered	1.48	4, 8	not significant
Wide-unordered	.26	4, 8	not significant

of variance were insignificant.

The Effects of Range on Performance

In Table 4 the percent correct for the final 25 sessions is given for each bird. The mean percent correct for each of the six conditions is also shown. As range increases, percent correct increases. A two-way analysis of variance performed on the data yielded significant main effects for range and order (F (order) = 5.30, df = 2, 12, $p < .001$). The interaction between range and order was not significant ($F = .096$, df = 2, 12, $p > .05$). This relationship between range and percent correct is illustrated in Figure 8 for both ordered and unordered groups. There is no evidence that the rate of increase in percent correct levels off as range increases as would be expected if the range effect were demonstrated. Another way of determining whether a range effect exists is to plot total sensitivity against range. This is done in Figure 9. Figure 9 shows total sensitivity as a function of range for the last 25 sessions of training. The data for individual birds are given in Table 5 along with the means for each condition. In general, for both ordered and unordered groups, sensitivity increases. If a range effect were present, there would be diminishing gains in total sensitivity as range is increased. Clearly, an examination of Figure 9 does not provide evidence for a range effect in the present study.

In summary, both an ordered relationship between stimulus magnitude and response location and an increase in the spacing between

Table 4

Percent correct responses for each bird. Data based on last 25 sessions of training.

Condition	Bird	Percent Correct
Wide-Ordered	1	92.6
	2	80.8
	3	86.6
		$\bar{x}$ = 86.7
Wide-Unordered	4	78.4
	5	87.0
	6	87.2
		$\bar{x}$ = 84.2
Moderate-Ordered	7	76.6
	8	89.0
	9	67.8
		$\bar{x}$ = 77.8
Moderate-Unordered	10	56.2
	11	64.4
	12	70.6
		$\bar{x}$ = 63.7
Narrow-Ordered	13	43.6
	14	56.4
	15	40.4
		$\bar{x}$ = 46.8
Narrow-Unordered	16	38.0
	17	36.0
	18	44.8
		$\bar{x}$ = 39.6

Figure 8. Percent correct for the three ranges of stimuli for the last 25 sessions of training. Data are for first responses. The spacing on the abscissa is according to the power law scale used in these experiments. See Appendix A.

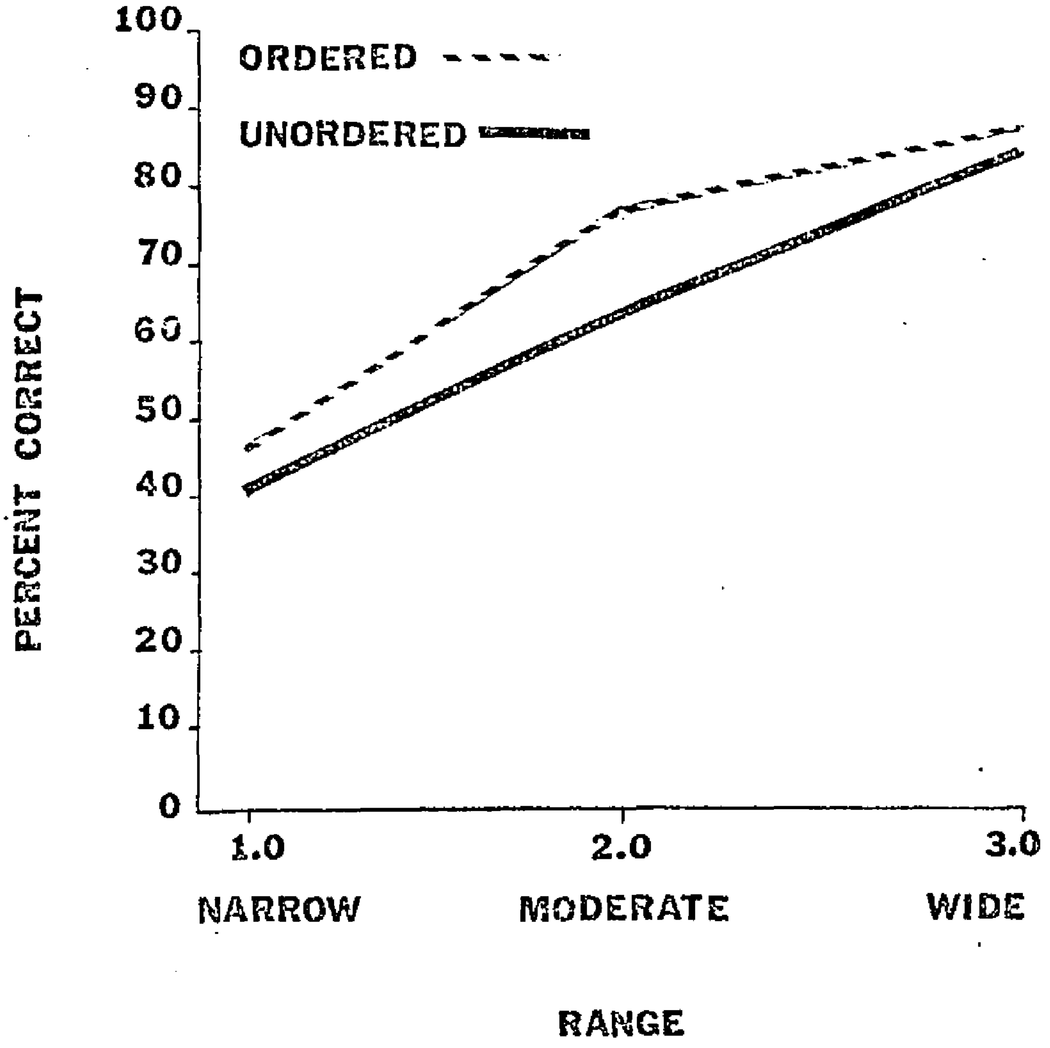

100
90
80
70
60
50
40
30
20
10
0
PERCENT CORRECT
ORDERED
UNORDERED
1.0
NARROW
2.0
MODERATE
3.0
WIDE
RANGE

Figure 9. Total sensitivity (Δ') for the three ranges of stimuli for the last 25 sessions of training. The spacing on the abscissa is according to the power law scale used in these experiments. See Appendix A.

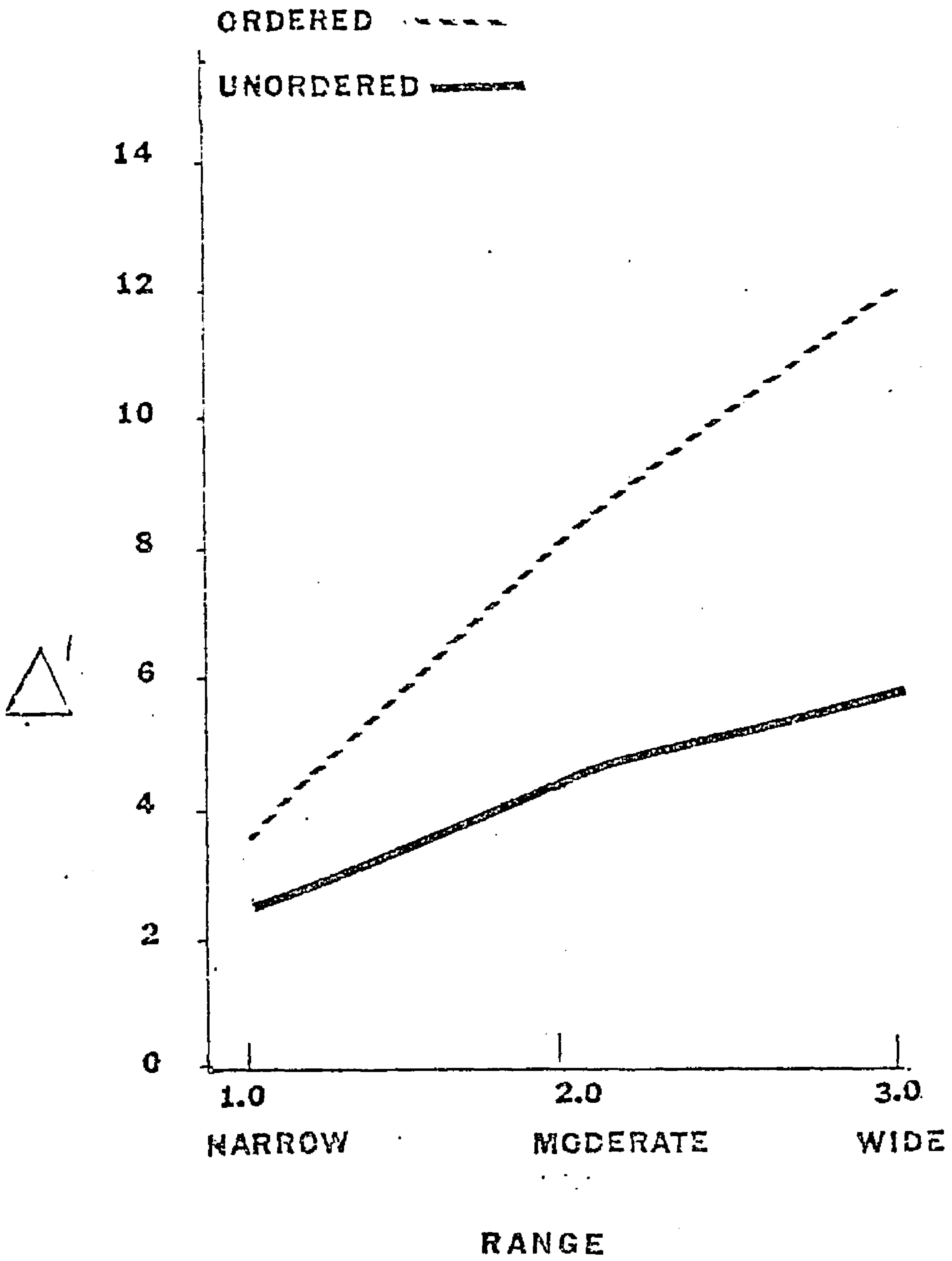

ORDERED
UNORDERED
14
12
10
8
6
4
2
0
Δ'
1.0
NARROW
2.0
MODERATE
3.0
WIDE
RANGE

Table 5

Total sensitivity for each bird. Data based on last 25 sessions of training.

Condition	Bird	Sensitivity
Wide-Ordered	1	14.51
	2	10.56
	3	12.24
		$\bar{x}$ = 12.44
Wide-Unordered	4	4.94
	5	6.68
	6	5.42
		$\bar{x}$ = 5.68
Moderate-Ordered	7	7.93
	8	11.10
	9	5.60
		$\bar{x}$ = 8.21
Moderate-Unordered	10	3.88
	11	4.35
	12	4.89
		$\bar{x}$ = 4.37
Narrow-Ordered	13	3.43
	14	4.36
	15	3.00
		$\bar{x}$ = 3.60
Narrow-Unordered	16	2.67
	17	2.07
	18	2.93
		$\bar{x}$ = 2.56

adjacent stimuli enhance the acquisition of a five-choice discrimination in pigeons. Although a range effect was not demonstrated, the superior performance of the ordered groups suggests that pigeons learned how the stimulus and response dimensions were related, that is, they acquired a coherent repertoire, and this relational learning aided them in the discrimination task. An explanation for the differences between the ordered and unordered groups will be considered in the following section.

The Effects of the Relationship between Stimulus-Response Dimensions on Performance

An examination of the types of errors made by pigeons suggests that the difference between the ordered and unordered groups obtained in the present study may be accounted for simply by assuming that the birds occasionally peck a key adjacent to the appropriate key. That some of the errors observed were due to such key confusion seems particularly likely here, since, to study the five-choice discrimination, additional keys were placed between those already present in the three-key box. The keys were therefore closer than they normally are in multiple-key experiments.

When an error is made, that is, when the incorrect key is pecked, the mistake may be due either to stimulus confusion, key confusion, or both. Stimulus confusion has already been considered. Errors arising from this source occur when sensory effects overlap (see Figure 1). Errors due to key confusion occur when the subject correctly identifies the stimulus, e.g. the sensory effects produced by Stimulus 3 fall within the region for R3, and a peck at the key designated as correct for R3 is "intended" but instead the pigeon pecks one of the adjacent keys. For purposes of the following analyses, it was assumed that such pecks were made only on adjacent keys. For Key 1 and Key 5, the end keys, such pecks were assumed to be made only on the closest inner key, and for Keys 2, 3, and 4, the inner keys, such pecks were assumed to be made on either adjacent key and with equal frequency.

Exactly what effect key confusion has on the observed behavior depends on the particular key choice required for each response. For the ordered groups, adjacent keys are correct for adjacent stimuli. Of the possible non-monotonic relationships between luminance and assigned key choice to be used for the unordered condition, one was chosen for which adjacent keys were never correct for adjacent stimuli. Choice of a key adjacent to the correct one would, therefore, be correct for a stimulus at least one removed from that for which the response was intended. In these experiments, for the unordered groups, R1 (the correct response given S1) was defined as a peck on Key 4, R2 as a peck on Key 1, R3 as a peck on Key 3, R4 as a peck on Key 5 and R5 as a peck on Key 2.

If key confusion occurs, the confusion matrices for the ordered and unordered groups would differ. This is illustrated in Table 6 for a situation in which there is key confusion with no stimulus confusion. In this illustration key confusion is assumed to occur on 4% of the trials. This would reduce the percent correct from 100 to 96. On the 4% of the trials on which key confusion occurs, it is assumed that pecks are made on keys adjacent to the correct one. The cells into which such responses would fall are circled in Table 6.

In Table 7 the confusion matrices for the last 25 sessions for birds trained under the wide condition are shown for the ordered and unordered condition. Matrices for individual birds appear in Appendix C. As in Table 6 the cells which are circled are those into which responses

Table 6

Proportions of responses without key confusion and with 4% confusion.

Without Key Confusion

	S1	S2	S3	S4	S5	
R1	1.0					
R2		1.0				
R3			1.0			(A)
R4				1.0		
R5					1.0	

Ordered Group with 4% Key Confusion

	S1	S2	S3	S4	S5	
Key 1 R1	.96	.02				
Key 2 R2	.04	.96	.02			(B)
Key 3 R3		.02	.96	.02		
Key 4 R4			.02	.96	.04	
Key 5 R5				.02	.96	

Unordered Group with 4% Key Confusion

	S1	S2	S3	S4	S5	
Key 4 R1	.96		.02	.04		
Key 1 R2		.96			.02	(C)
Key 3 R3	.02		.96		.02	
Key 5 R4	.02			.96		
Key 2 R5		.04	.02		.96	

Table 7

Proportions of responses for last 25 sessions of training for wide-ordered birds and wide-unordered birds.

Wide-ordered

	S1	S2	S3	S4	S5
R1	.77	.14	0	0	0
R2	.23	.81	.07	0	0
R3	0	.05	.87	.06	0
R4	0	0	.05	.90	.02
R5	0	0	0	.03	.98

Wide-unordered

	S1	S2	S3	S4	S5
R1	.86	.03	.08	.03	0
R2	.07	.81	.11	0	0
R3	.05	.14	.73	.10	.01
R4	0	.01	.06	.83	.01
R5	0	.01	.02	.03	.97

would fall if a key is pecked adjacent to the key correct for the particular response. A comparison of the confusion matrix for the unordered condition when no stimulus confusion errors occur (see Table 6) with that for the wide unordered group suggests that even within the wide range, the stimuli were not perfectly discriminable. Nonetheless, if one assumes that only adjacent stimuli are confused, the data for the unordered condition can be used as a rough estimate of the proportion of trials on which key confusion occurred. Key confusion in the presence of each stimulus may be estimated from the proportions in the circled cells: .05 for S1, .01 for S2, .10 for S3, .03 for S4, and, .01 for S5. From these considerations, it appears that key confusion occurs on about 4% of the trials.

In the next section the effects of key confusion on percent correct and total sensitivity will be considered in an effort to determine whether key confusion is sufficient to account for the differences between the ordered and unordered groups.

In order to determine how key confusion may have affected percent correct and total sensitivity obtained in these experiments, confusion matrices for the ordered and unordered groups were generated with different degrees of key confusion.[7]

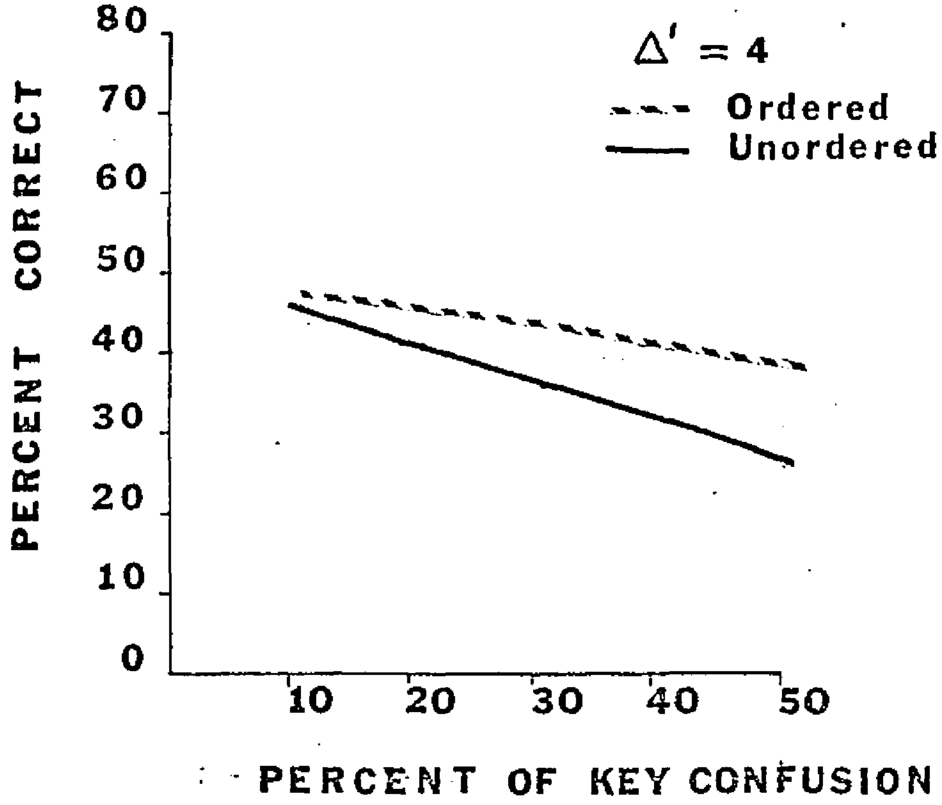
In generating these matrices it was assumed that (1) the decision as to which stimulus was presented and hence which response should be made is as described by the statistical decision theory model for stimuli equally spaced and with criteria placed midway between the means of adjacent sensory effect distributions (see pages 4 to 7); (2) on some trials the key choice made is that intended, for example, the outcome of the decision process required a peck on the R2 key and the R2 key is pecked; (3) on other trials, a key adjacent to the key intended is pecked (trials on which key confusion occurs). As shown in Tables 6 and 7, because of the difference in keys assigned for each response for the ordered and unordered groups, unintended choices have different effects on the confusion matrices for the ordered and unordered groups.

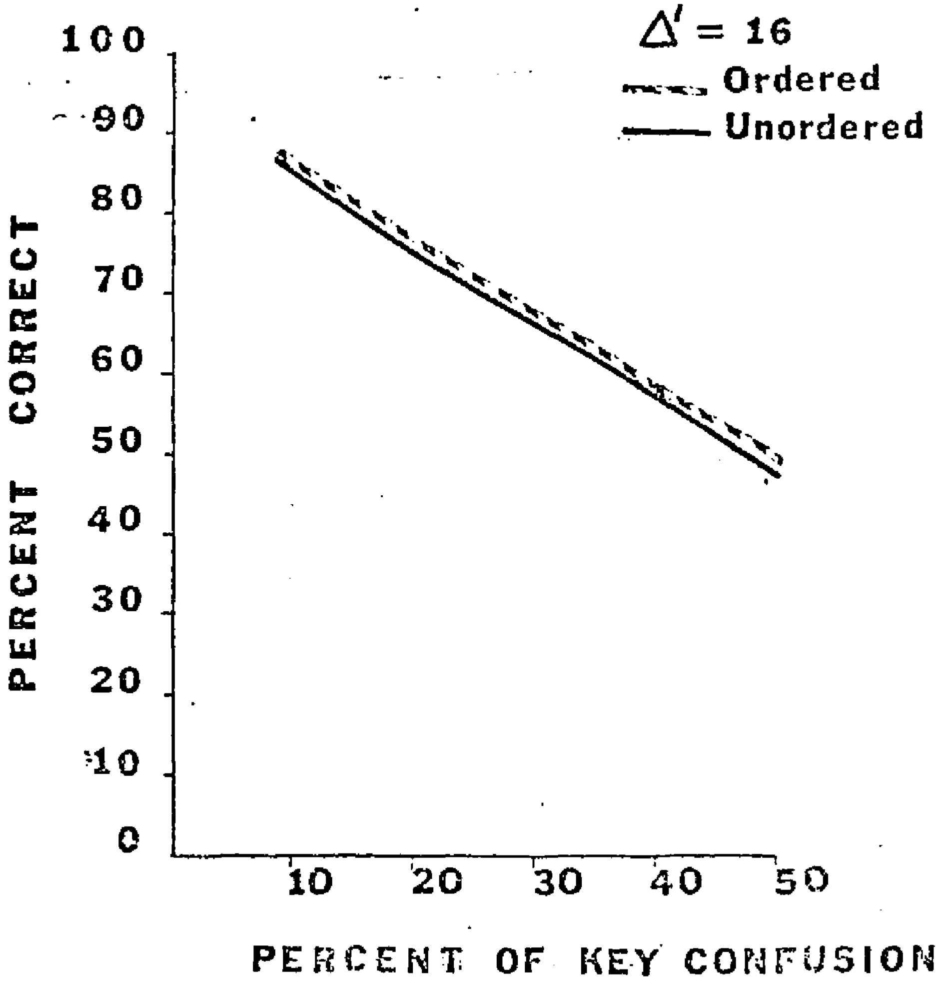
In these experiments it was observed that the percent correct for the ordered groups was higher than the unordered groups (see Figures 6 and 8).

As reported earlier the difference between the ordered and unordered groups in percent correct was significant. In Figure 10 the theoretical percent correct is shown for different degrees of key confusion for total sensitivities of 4 and 16. The occurrence of errors results in a difference in percent correct under the ordered and unordered conditions especially when the sensitivity is low. The percent correct is higher under the ordered condition as a result of accidental correct choices.

In general, the birds in the ordered groups were correct on 7.9% more trials than those in the unordered groups. As can be seen from Figure 10 for a total sensitivity of 4 a difference this large would be obtained if key confusion occurred on 30 percent of the trials. For a

Figure 10. Percent correct for different amounts of key confusion when total sensitivity is 4 and 16. See text for assumptions made in generating these curves.


Δ' = 4
Ordered
Unordered
PERCENT CORRECT
80
70
60
50
40
30
20
10
0
10
20
30
40
50
PERCENT OF KEY CONFUSION


Δ' = 16
Ordered
Unordered
PERCENT CORRECT
100
90
80
70
60
50
40
30
20
10
0
10
20
30
40
50
PERCENT OF KEY CONFUSION

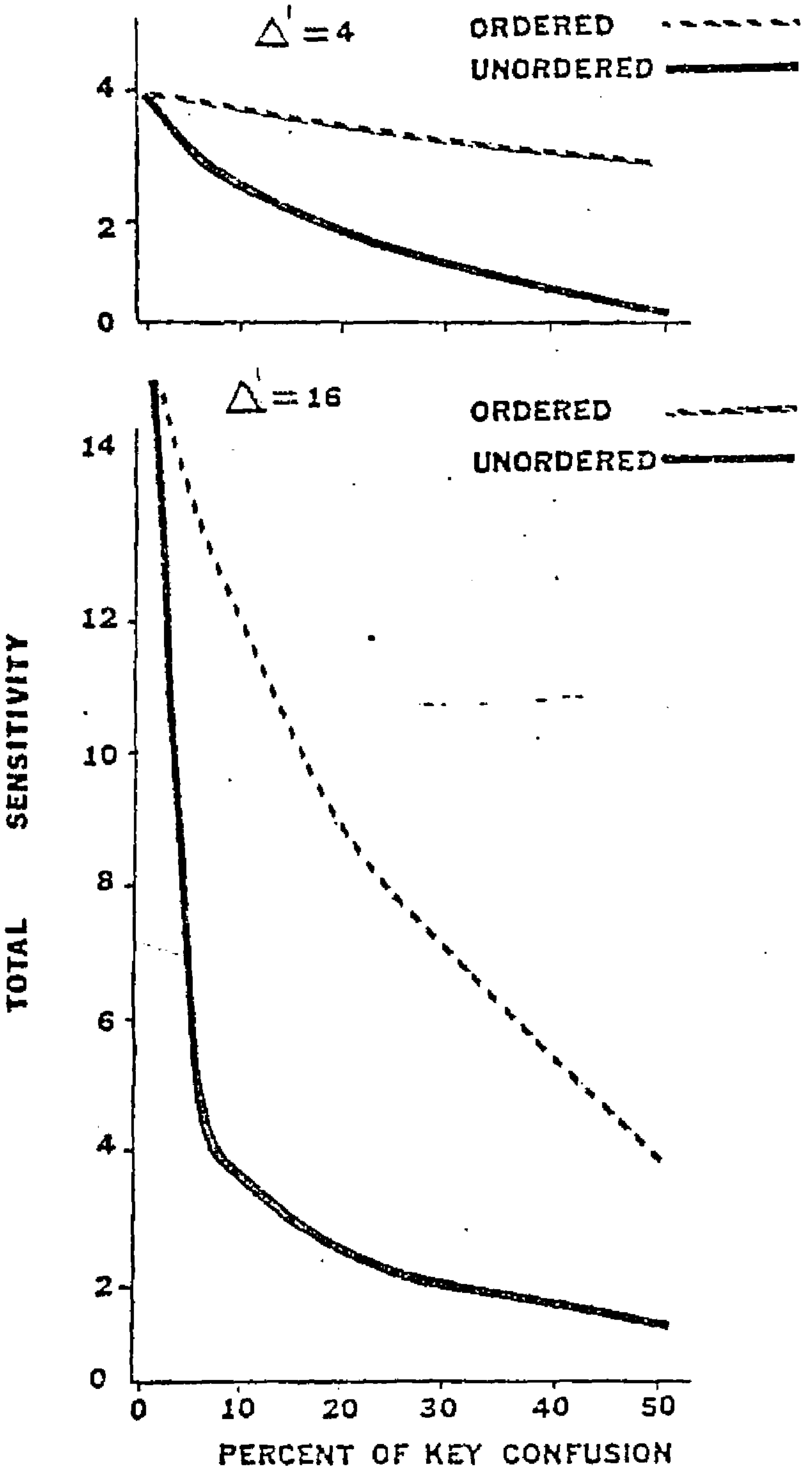
total sensitivity of 16, key confusion must occur on an even greater percentage of trials to produce this large a difference. From inspection of the confusion matrices for the wide-unordered group (Table 7) discussed earlier, it appears that key confusion occurs on only 4% of the trials. With this degree of key confusion there would be virtually no difference in percent correct between the ordered and unordered groups even at low levels of total sensitivity. Although this estimate is based on the performance of only three birds the higher percent correct shown by the ordered groups probably is not entirely due to the smaller effects of key confusion.

In the following section the effects of key confusion on total sensitivity will be considered.

In Figure 11, the effects of key confusion on the obtained total sensitivity are shown for different degrees of key confusion. Note that even small amounts of key confusion drastically reduce total sensitivity for the unordered groups.

Earlier it was observed that the effects of range on total sensitivity were quite different for the ordered and unordered group. Gains in total sensitivity with increased range leveled off slightly for the ordered birds and sharply for the unordered birds (see Figure 9). These results may reflect the effects of key confusion, since, as shown in Figure 11, the reduction in total sensitivity as a result of key confusion is greatest under the unordered condition. However, key confusion alone cannot completely account for the observed leveling off of

Figure 11. Total sensitivity for different amounts of key confusion when total sensitivity is 4 and 16. See text for assumptions made in generating these curves.


$\Delta' = 4$
ORDERED
UNORDERED
4
2
0
$\Delta' = 16$
ORDERED
UNORDERED
14
12
10
8
6
4
2
0
TOTAL SENSITIVITY
0
10
20
30
40
50
PERCENT OF KEY CONFUSION

total sensitivity with increased range. Total sensitivity for the wide-unordered group is 5.7 (Table 5). With only 4% key confusion, total sensitivity for the unordered group would not reach this level even for wider stimulus spacing than used in the present study (e.g. for total sensitivity without key confusion of 18, 4% key confusion will reduce total sensitivity to 4.2).

Therefore, although key confusion appears to be responsible for some of the differences between groups it does not appear to provide a complete explanation for these differences. The differences between the ordered and unordered groups are much larger than would be expected if key confusion occurred on only 4% of the trials. It is possible that the pigeons in the ordered groups learned that "as the brightness of the display key increases, pecks further to the right are necessary to obtain food" and that this rule aided them in choosing among the keys. More direct evidence that the relationship between stimulus magnitude and response location was learned may be obtained by exposing the pigeons to new luminances in a situation in which it is possible for them to make responses that show the same relationship to these new stimuli as that experienced during training. The results of such a transposition test will be reported below.

Results of the Transposition Test

Confusion matrices for the transposition test, showing the number of times each response was made in the presence of each of the seven stimuli appear in Appendix D. The addition of a new key at either end of the row of choice keys disrupted performance of the five-choice discrimination somewhat. In Table 8 the percent correct for each bird during the last 25 days of training is given along with the percent correct in the presence of the training stimuli (S1 to S5) during the test session. A *t*-test showed that percent correct responses in the presence of S1 through S5 did not decrease significantly during the transposition test for the ordered group (t (8) = 1.86, $p > .05$) but did decrease significantly for the unordered groups (t (8) = 3.24, $p < .02$). However, an examination of percent correct responses in Table 8 shows that percent correct was still substantially above that expected if the keys were chosen randomly (20% correct).

The transposition test differs from the usual generalization test in that an opportunity to make a new response in the presence of the new ("generalization test") stimulus is provided. Here the opportunity was to peck the keys added at the left (Key 0) and the right (Key 6) ends of the row of choice keys. Without this opportunity, at least in a two-choice situation, the novel stimuli are classified in the same way as the training stimuli. For example, if one key (R1) is to be chosen in the presence of a dim light and another key (R2) in the presence of a bright light, R1 is made when test stimuli dimmer than the dim

Table 8

Percent correct first responses to S1 through S5 during the last 25 days of training and during the transposition test.

Ordered Condition	Bird	Training	Test
Narrow	13	43.6	35
	14	56.4	63.2
	15	40.4	38.2
Moderate	7	76.6	70
	8	89.0	83.4
	9	67.8	51.6
Wide	1	92.6	85.2
	2	80.8	75
	3	86.6	93.4
	$\bar{X}$ =	70.5	66.1

Unordered Condition	Bird	Training	Test
Narrow	16	38.0	28.4
	17	36.0	34.8
	18	44.8	50.0
Moderate	10	56.2	48.2
	11	64.4	53.4
	12	70.6	66.8
Wide	4	78.4	73.4
	5	87.0	71.8
	6	87.2	71.6
	$\bar{X}$ =	62.4	55.3

training stimulus are presented and R2 is made when test stimuli brighter than the bright training stimulus is presented (Heinemann and Chase, 1975).

In the present study, however, the proportion of new responses (R0 and R6) made in the presence of the test stimuli (S0 and S6) and in the presence of the adjacent training stimuli (S1 and S5) was examined to see whether new responses were made in the presence of new stimuli. For birds in the unordered groups, Keys 0 and 6 show no special relationship to the training problem. These keys may be ignored completely. Even if pecked, there is no reason to expect that these keys will be pecked more often in the presence of the novel stimuli than any other. For the ordered groups, on the other hand, pecks on Keys 0 and 6 in the presence of S0 and S6 respectively, provide evidence that the relationship present during training was transposed to a new situation.

In Table 9 the proportion of trials on which R0 is made in the presence of S1 and of S0 and the proportion of trials on which R6 is made in the presence of S5 and S6 is shown for all birds.[8] For the ordered birds, R0 was made a significantly greater proportion of times in the presence of S0 than in the presence of S1 ($\underline{t}$ (8) = 2.46, $p < .05$), and R6 was made a significantly greater proportion of times in the presence of S6 than in the presence of S5 ($\underline{t}$ (8) = 2.71, $p < .05$). For the unordered groups, there were no significant differences in the proportion of times the novel responses were made in the presence of either

Table 9.

Proportion of Response 0 to Stimulus 1 and 0 and proportion of response 6 to Stimulus 5 and 6 for all birds during the transposition test. Proportions are based upon 12 presentations of each training stimulus and 10 presentations of each test stimulus.

		Response 0		Response 6	
Condition	Bird	Stimulus 1 (Training)	Stimulus 0 (Test)	Stimulus 5 (Training)	Stimulus 6 (Test)
Wide-ordered	1	0	.10	0	0
	2	.17	.20	0	.10
	3	0	.20	0	.20
	$\bar{x}$ =	.06	.17	0	.10
Moderate-ordered	7	.08	0	.08	.90
	8	.33	1.00	0	.10
	9	0	.10	0	.30
	$\bar{x}$ =	.13	.37	.03	.43
Narrow-ordered	13	.17	.40	0	.40
	14	0	.80	0	0
	15	.17	.30	0	.17
	$\bar{x}$ =	.11	.50	0	.19
Group	$\bar{x}$ =	.10	.35	.01	.24
Wide-unordered	4	.08	0	0	0
	5	0	0	0	0
	6	0	0	0	0
	$\bar{x}$ =	.03	0	0	0
Moderate-unordered	10	.10	.08	0	0
	11	0	0	0	0
	12	0	0	0	0
	$\bar{x}$ =	.03	.03	0	0
Narrow-unordered	16	.17	.50	0	.20
	17	.08	0	0	0
	18	0	0	0	0
	$\bar{x}$ =	.08	.17	0	.07
Group	$\bar{x}$ =	.05	.07	0	.02

the training stimuli or the test stimuli ($t(8) = .41$, $p > .05$; $t(8) = 1.00$, $p > .05$).

Table 10 shows the proportion of trials in which Response 1 was made in the presence of S1 and S0 and the proportion of trials in which Response 5 was made in the presence of S5 and S6. For the ordered groups, in the presence of the new stimuli, (S0 and S6, respectively), Response 1 and Response 5 were made less often than in the presence of S1 and S5, although these differences were not significant ($t(8) = .428$, $p > .05$; $t(8) = .684$, $p > .05$). For the unordered groups, R1 and R5 were made slightly more often in the presence of S0 and S6 respectively, although, again, these differences were not significant ($t(8) = .404$, $p > .05$; $t(8) = .304$, $p > .05$).

These results show that the monotonic relationship between stimulus and response dimensions which was present during training was at least partially transposed.

Table 10

Proportion of Response 1 to Stimulus 1 and 0 and proportion of Response 5 to Stimulus 5 and 6 for all birds during the transposition test. Proportions are based on 12 presentations of each training stimulus and 10 presentations of each test stimulus.

		Response 1		Response 5	
Condition	Bird	Stimulus 1 (Training)	Stimulus 0 (Test)	Stimulus 5 (Training)	Stimulus 6 (Test)
Wide-ordered	1	.67	.90	1.00	1.00
	2	.25	.50	1.00	.90
	3	.92	.70	1.00	.80
	x̄ =	.61	.70	1.00	.90
Moderate-ordered	7	.33	.30	.92	.10
	8	.50	0	.83	.90
	9	.17	.30	.58	.70
	x̄ =	.33	.20	.78	.57
Narrow-ordered	13	0	.30	.25	.50
	14	.92	.20	.75	1.00
	15	0	.10	.58	.33
	x̄ =	.31	.20	.53	.61
Group	x̄ =	.42	.37	.77	.69
Wide-unordered	4	.42	.30	1.00	.90
	5	.75	.90	.83	1.00
	6	.67	1.00	.83	.90
	x̄ =	.61	.73	.89	.93
Moderate-unordered	10	0	.50	1.00	1.00
	11	.25	.50	.92	.90
	12	.83	.90	.92	1.00
	x̄ =	.36	.63	.95	.97
Narrow-unordered	16	.17	0	.83	.10
	17	.58	.60	.58	1.00
	18	.83	.20	.58	1.00
	x̄ =	.53	.27	.66	.70
Group	x̄ =	.50	.54	.83	.87

Discussion

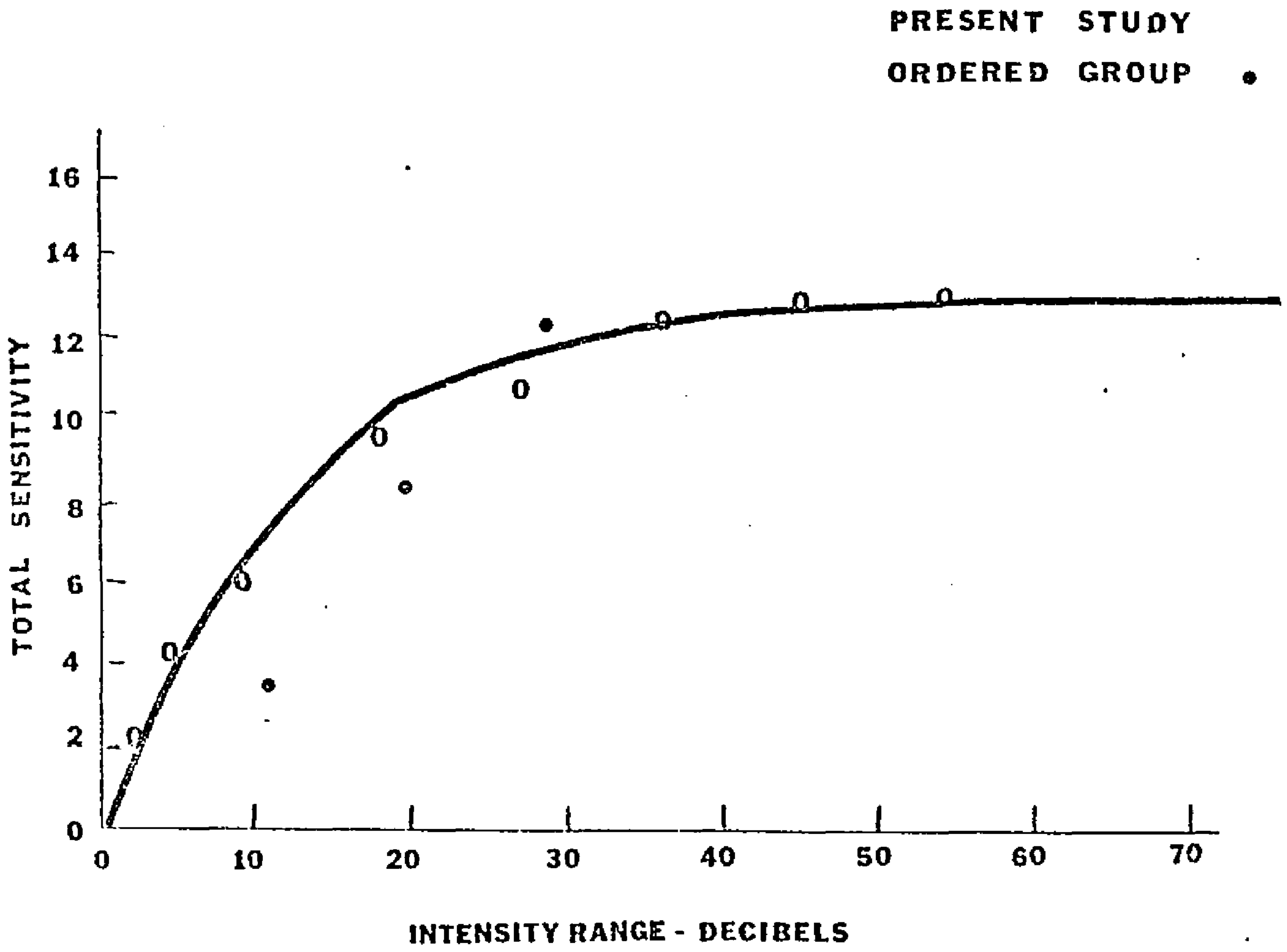
Acquisition of a five-choice discrimination

One of the purposes of the present investigation was to examine the choice behavior of pigeons when a five-choice discrimination was introduced. Previous studies have demonstrated differential responding in the presence of three and four stimuli, respectively (Wildemann and Holland, 1972; Richter, Note 1). The results of the present study showed that stimulus control of a five-choice discrimination is acquired relatively early, that is, within the first block. Moreover, the acquisition of a five-choice discrimination was not completely dependent upon the nature of the relationship between stimulus and response dimensions since both the ordered and unordered groups acquired the discrimination.

The Effects of Range on Performance

Another purpose of the present study was to examine the effects of range on discriminability when three ranges of stimuli were used. Braida and Durlach (1972), found that when humans identify tones differing in intensity equal increases in range (in dB) are not accompanied by equal increases in total sensitivity, especially for larger ranges. Figure 12 shows the relationship between range and total sensitivity. As Figure 12 illustrates, as range increases, there are diminishing gains in total sensitivity. No such relationship between range and total sensitivity was found in the present study. If the function relating total sensitivity to range is the same for pigeons as it is for humans,

Figure 12. Total sensitivity as a function of intensity range (from Braida and Durlach 1972, Figure 4d). The smooth curve drawn is derived from theoretical formulations. The data for the ordered groups in the present study are superimposed. Note that if it is reasonable to assume that the function relating total sensitivity to range is the same for pigeons as it is for humans, and light and sound logarithmic differences are comparable, then the data obtained in the present study correspond to the rising portion of the curve. See text for further discussion.


PRESENT STUDY
ORDERED GROUP •
TOTAL SENSITIVITY
0
2
4
6
8
10
12
14
16
0
10
20
30
40
50
60
70
INTENSITY RANGE - DECIBELS

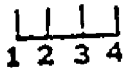
then it may be the case that the ranges used in the present experiment may correspond to the rising portion of the curve in Figure 12. It is possible, in the present study, that even the largest range was too small for a strong range effect to be observed.

An experiment recently completed in the laboratory in which the present research was conducted (Landry, Note 5) suggests that this hypothesis may be correct. The three birds trained on the moderate range ordered condition were trained on a seven-choice discrimination task similar to that in effect during the Transposition Test. For these birds, the dimmest stimulus was .47 ft. L and the brightest stimulus was 686 ft. L. This switch from 1.8 to 3.1 log units has been accompanied by an increase in total sensitivity of 4.8. The three birds trained on the wide range ordered condition were trained on a seven-choice discrimination task. For these birds, the dimmest stimulus was .06 ft. L and the brightest stimulus was 828 ft. L. This change from 3.0 to 4.1 log units had virtually no effect on total sensitivity. Further work is needed but these results suggest that pigeons do show a range effect similar to that found for humans.

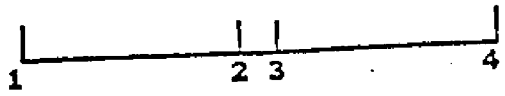
The accuracy of discrimination also appears to be affected by the spacing of stimuli within a given range. Figure 13 permits a comparison of the stimulus sets used by Richter (Note 1), Conneally (Note 3), and in the present study. A comparison between the results obtained in these studies is facilitated by the use of a concept employed by Durlach and Braida (1969), sensitivity per bel (δ').

Figure 13. Schematic illustration of design of experiments by Richter (Note 1), Conneally (Note 3) and present study. A 4 mm. distance in this diagram is equivalent to approximately .2 log units.

RICHTER

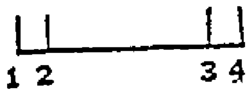


NARROW RANGE
$\delta' = 4.83$

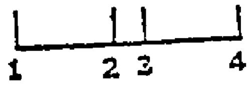


WIDE RANGE
$\delta' = 1.15$

CONNEALLY

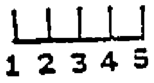


CONDITION 1
$\delta' = 1.70$



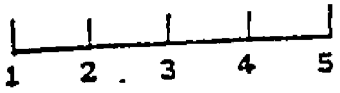
CONDITION 2
$\delta' = 2.25$

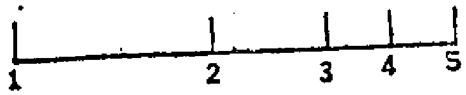
PRESENT STUDY



NARROW RANGE
$\delta' = 4.50$

MODERATE RANGE
$\delta' = 4.56$

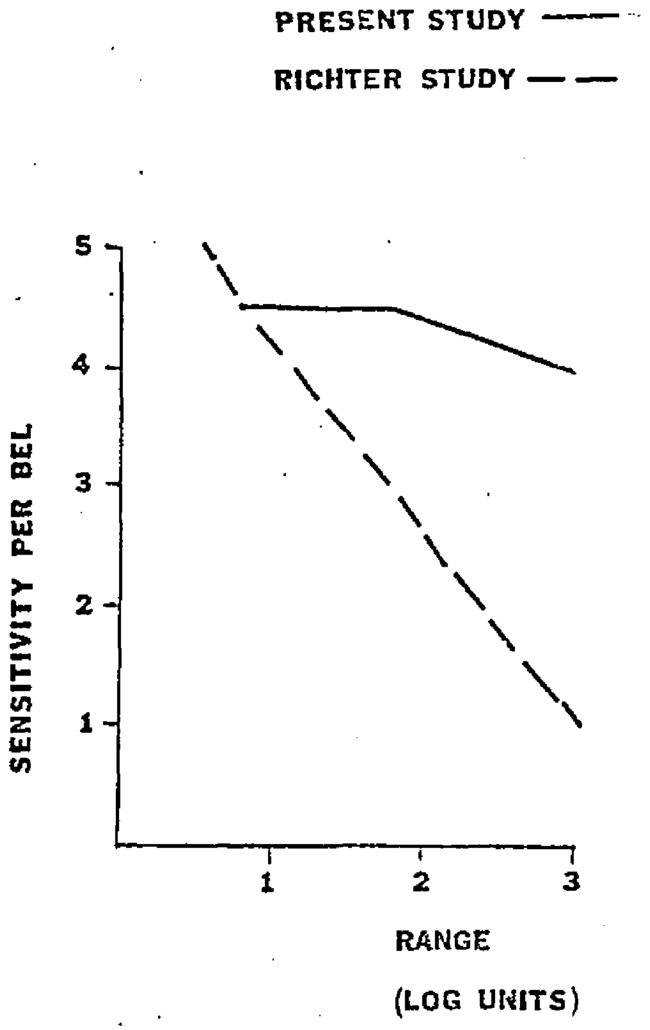




WIDE RANGE
$\delta' = 4.15$

Sensitivity per bel is d' for a stimulus difference of one log unit, and it permits a comparison of sensitivity when different ranges and stimulus spacings are used. Conneally found, for example, that sensitivity per bel is dependent on the stimulus spacing. Under both conditions the range was 1.4 log units. However, under Condition 1, sensitivity per bel was 1.70 and under Condition 2, sensitivity per bel was 2.25. In Figure 14, sensitivity per bel is shown as a function of range for the present study and that of Richter. This figure shows clearly the discrepancy between Richter's results and those reported in the present study. Note that in the narrow ranges, sensitivity per bel is approximately the same, whereas in the 3.0 log unit range, Richter found a substantial drop in sensitivity per bel. In the present study, sensitivity per bel was virtually unchanged. The two differences between Richter's study and the present study are the number of stimuli and the stimulus spacing. Chase (Note 2) found that sensitivity is not strongly affected by number of choices when the number was varied between two and five. It would therefore appear that the spacing of the stimuli is responsible for differences observed here.

Figure 14. Sensitivity per bel as a function of range for the present study and that of Richter (Note 1).


PRESENT STUDY
RICHTER STUDY
5
4
3
2
1
SENSITIVITY PER BEL
1
2
3
RANGE
(LOG UNITS)

Transposition Test

The results of the present study showed that a monotonic relationship between stimulus and response dimensions present during training could be transposed to novel stimuli and novel responses when pigeons were presented with two new points, one at each end of the stimulus-response continuum. In addition, it appears that a monotonic ordering of these dimensions facilitated performance of the discrimination. This suggests that not only are pigeons capable of learning a relationship between stimulus-response dimensions, but that they can apply this rule to new situations. Thus, Skinner's (1953) notion that coherent repertoires may be acquired following training on limited points of correspondence between stimulus-response dimensions has been supported by these results. Previously, work by Chase, Geller and Hendry (1974) showed that a coherent repertoire could be established when a topographical relationship (as described on page14) between stimulus and response continua exists. Other earlier attempts to demonstrate that a coherent repertoire could be established in this way were not successful (Cumming and Eckerman, 1965; Wildemann and Holland, 1972). However, although a topographical relationship between stimulus and response continua did not exist in the present study, the transposition test showed some evidence that a coherent repertoire was established. In spite of the absence of spatial cues between the stimulus-response dimensions, therefore, cues which were present in the study by Chase, Geller and Hendry (1974), a continuous repertoire was nevertheless demonstrated.

There may be several reasons why a continuous repertoire was found in the present study but not in the previous studies by Cumming and Eckerman, (1965) and Wildemann and Holland, (1972). In the present study, the response continuum was composed of a row of discrete choice keys, each separated by 1.5 cm, whereas in the two previous studies cited, the response continuum was not composed of discrete keys. It is possible that in the present study each key may have functioned as a highly discriminable stimulus since it was illuminated from behind by a green pilot light. The choice keys, therefore, contrasted highly with the surrounding intelligence panel which was black Thus, the fact that each key was separate from the next and contrasted with the background may serve to make the choice keys more discriminable from each other and facilitate the ability to locate each key's position along the response continuum. Although Hendry's (Note 4) data showed that the particular type of response surface did not significantly affect performance on the transposition test, the novel key was chosen more often by the pigeons trained with discrete keys (on 82% of the trials) than by birds trained on a continuous surface (72% of the trials).

In addition, it may well be that a continuous repertoire is facilitated when many responses along discrete areas of the response continuum are required. In the present study, the birds were trained on five points of correspondence between the stimulus and response continua, which represents a larger number of points of correspondence than any used previously. It is possible that having both many points of correspondence as well as a response continuum consisting of discrete areas for response facilitated the establishment of a continuous repertoire. A topographical relationship between stimulus and response dimensions is apparently not necessary for the establishment of a coherent repertoire, although the greater number of points of correspondence along the stimulus-response dimension may have provided advantages to the learning situation which offset any disadvantages due to the lack of a topographical relationship.

In the study by Chase, Geller, and Hendry (1974) as well as in the present one, it was observed that the new keys were pecked in the presence of the novel stimulus on some but not all of the trials. When presented with novel stimuli, subjects continue to make responses which were previously reinforced. In the present experiment, for example, when Stimulus 0 and Stimulus 6 were presented, some responses were made on Keys 1 and 5, respectively. It appears likely, therefore, that two types of learning are being observed, one in which the relationship between stimulus and response dimensions is transposed to a new situation, and one in which previously learned responses are maintained in the presence of a stimulus similar to the appropriate training stimulus.

Future studies might focus on (1) the number of points of correspondence necessary to produce a continuous repertoire of behavior and (2) the nature of the stimulus-response dimensions and the type of interactions which may occur between these dimensions.

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Footnotes

[1] Free-feeding weights were obtained for each bird by averaging the weights taken daily in a 2-week period prior to the experiment during which mixed grain was freely available in each home cage..

[2] 1 ft. L = 3.43 cd/m^2. Luminance was measured in ft. L in the present investigation to facilitate comparisons between the present study and those of Richter (Note 1) and others performed previously in the same laboratory.

[3] As a result of accumulation of dust on the optical system, particularly on the slides, there was a reduction of approximately .5 log units from the luminance levels measured at the onset of the experiment. The relative levels, however, remained approximately the same throughout the experiments.

[4] Data for an analysis of key preferences or response biases after an error had been made were not available.

[5] Another measure frequently used in determining the effects of range on performance has been information transmitted. However, due to the fact that a correlation exists between the measures of total sensitivity and information transmitted, the additional analysis of the data in terms of information transmitted was excluded from the present study.

[6] Hodos and Bonbright (1972) reported that the difference threshold for visual stimuli which varied in intensity was approximately 0.12

logarithmic units. Therefore, a greater number of errors would be expected for the narrow range groups since the spacing between adjacent stimuli approximates this difference threshold more closely than the spacing between stimuli in the moderate and wide ranges.

[7] These were done by hand as well as on a PDP-8 computer located in the Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, Massachusetts. I would like to thank Louis D. Braida and Nathaniel I. Durlach for the use of their computer.

[8] Bird 16 was accidentally given a session of training appropriate for the wide-ordered group on the third day preceding the transposition test. This experience with a large range and with stimulus and response dimensions monotonically ordered may be responsible for this bird's performance on the transposition test.

Appendix A. Method for obtaining stimuli spaced on an equal discriminability scale.

Appendix A

Earlier work by Chase (Note 2) has shown that luminances equally spaced on a logarithmic scale are not equally discriminable. When pigeons were presented with 13 luminance levels of white light ranging from .5 to 2.9 log ft. L in .2 log unit steps and reinforcement was contingent upon discrimination of the luminances, it was apparent that the higher intensity stimuli were more discriminable than the lower intensity stimuli. A scale based upon equal logarithmic steps between adjacent stimuli is not, therefore, an equal discriminability scale. Since Boakes (1969) found that a power law scale with an exponent of .2 is a better approximation of an equal discriminability scale for the pigeon, this scale was used.

The following procedure was used to decide upon the luminance levels of the five stimuli for each of the three ranges. Since a three log unit range was to be used for the wide range group and the smallest spacing possible was .1 log units, the scale was constructed by finding the antilog of values ranging from 0 to 3.0 log units in .1 log unit steps. These antilogs were then raised to a power of .2 as shown in Table A. The appropriate values for the equal discriminability scale were selected by dividing this power scale into equal steps within each of three ranges: narrow, moderate, and wide. The constraints were that the center stimulus be the same for all ranges, that the three ranges be as close to 1, 2, and 3 log units as possible (corresponding to the narrow, moderate and wide ranges, respectively, and that reso-

Table A

Scale of log values ranging from 0 to 3.0 log units and corresponding antilogs raised to a power of .2.

Log	Antilog	$L^{.2}$
0	1.00	1.00
.1	1.26	1.05
.2	1.58	1.10
.3	2.00	1.15
.4	2.51	1.20
.5	3.16	1.26
.6	3.98	1.32
.7	5.01	1.38
.8	6.31	1.45
.9	7.94	1.51
1.0	10.00	1.58
1.1	12.59	1.66
1.2	15.85	1.74
1.3	19.95	1.82
1.4	25.12	1.91
1.5	31.62	2.00
1.6	39.81	2.09
1.7	50.12	2.19
1.8	63.10	2.29
1.9	79.43	2.40
2.0	100.00	2.51
2.1	125.89	2.63
2.2	158.49	2.75
2.3	199.53	2.88
2.4	251.19	3.02
2.5	316.23	3.16
2.6	398.11	3.31
2.7	501.19	3.47
2.8	630.96	3.63
2.9	794.33	3.80
3.0	1000.00	3.98

lution was limited to .1 log units.

It was decided to use a filter of 1 log unit for Stimulus 3, the center luminance for all three ranges. Therefore, after the spacing in log units was found, the actual filters to be used which preserved the spacing were determined. Table B shows the luminance values obtained from the antilog scale of Table A and their corresponding logarithmic values and neutral density filters for each of the three ranges.

Table B

Luminances for three ranges of stimuli

		Luminance$^{.2}$	closest value from Table 11	Log value	ND Filter
Narrow Range	S1	2.00	2.00	1.5	1.5
	S2	2.25	2.29	1.8	1.2
	S3	2.50	2.51	2.0	1.0
	S4	2.75	2.75	2.2	.8
	S5	3.00	3.02	2.4	.6
Range on Luminance$^{.2}$ Scale = 1.02					
Moderate Range	S1	1.5	1.51	.9	2.1
	S2	2.0	2.00	1.5	1.5
	S3	2.5	2.51	2.0	1.0
	S4	3.0	3.02	2.4	.6
	S5	3.5	3.47	2.7	.3
Range on Luminance$^{.2}$ Scale = 1.96					
Wide Range	S1	1.0	1.00	0	3.0
	S2	1.75	1.74	1.2	1.8
	S3	2.50	2.51	2.0	1.0
	S4	3.25	3.31	2.6	.4
	S5	4.00	3.98	3.0	0
Range on Luminance$^{.2}$ Scale = 2.98					

Appendix B. Confusion matrices for all birds for 100 sessions of training. Shown are the percent of trials on which each response (R1 to R5) was made in the presence of each stimulus (S1 to S5). These values are based upon 80 presentations of each stimulus.

Wide-ordered Birds - confusion matrices

	Bird 1					Bird 2					Bird 3					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	53	19	03	0	0	33	13	01	0	0	41	46	06	0	0	1-5
R2	32	46	35	03	11	38	41	33	01	01	41	28	25	02	01	
R3	11	23	48	27	08	21	37	41	26	01	14	15	32	10	11	
R4	01	09	09	49	44	01	07	15	53	33	01	08	26	56	31	
R5	03	03	06	22	38	07	02	10	19	64	02	04	10	31	57	
R1	64	24	04	0	0	67	34	07	01	0	43	53	01	01	0	6-10
R2	26	45	13	02	0	30	40	21	03	0	48	41	26	01	0	
R3	0	31	68	02	0	03	22	52	22	0	06	06	54	04	0	
R4	0	0	13	66	23	0	03	18	64	30	0	0	18	64	11	
R5	11	0	03	31	77	0	0	01	10	70	04	0	01	30	89	
R1	72	58	32	0	01	59	29	02	0	01	72	37	03	0	01	11-15
R2	26	33	27	11	03	38	46	18	0	03	28	57	08	01	0	
R3	01	08	30	16	0	01	23	68	03	0	0	07	63	01	01	
R4	0	0	11	61	42	0	01	11	92	42	0	0	25	72	13	
R5	0	0	0	12	54	0	0	0	05	54	0	0	0	25	84	

Wide-ordered Birds - confusion matrices (cont.)

	Bird 1					Bird 2					Bird 3					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	73	22	01	0	0	75	49	12	04	0	74	25	01	0	0	16-20
R2	26	60	22	0	0	25	33	30	06	0	26	66	09	0	0	
R3	0	17	70	09	0	0	18	39	34	0	0	09	80	06	0	
R4	0	0	06	71	11	0	0	17	38	19	0	0	10	89	20	
R5	0	0	0	19	89	0	0	01	19	81	0	0	0	05	80	
R1	93	11	0	0	0	55	24	04	0	0	81	27	01	0	0	21-25
R2	06	61	02	0	0	38	60	40	02	0	18	70	07	0	0	
R3	0	27	07	12	0	06	13	48	25	0	0	02	85	07	02	
R4	0	0	01	75	22	01	02	06	54	37	0	0	06	88	17	
R5	0	0	0	12	77	0	0	01	18	63	0	0	0	04	80	
R1	90	11	0	0	0	50	30	05	0	0	91	39	05	0	0	26-30
R2	09	64	17	0	0	49	47	20	05	0	11	59	11	0	0	
R3	01	25	79	08	0	01	17	53	08	03	0	02	80	09	0	
R4	0	0	04	90	21	0	06	13	69	31	0	0	04	85	02	
R5	0	0	0	02	79	0	0	02	19	66	0	0	0	06	98	

Wide-ordered Birds - confusion matrices (cont.)

	Bird 1					Bird 2					Bird 3					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	89	02	0	0	0	71	29	06	0	0	84	35	0	0	0	31-35
R2	11	77	08	0	0	26	65	38	06	01	16	64	09	0	0	
R3	0	19	86	04	0	02	05	50	23	0	0	01	88	01	0	
R4	0	01	06	95	04	0	01	04	59	14	0	0	04	94	02	
R5	0	0	0	01	96	0	0	02	12	85	0	0	0	05	98	
R1	94	09	0	0	0	62	16	0	0	0	88	55	0	0	0	36-40
R2	06	76	06	0	0	34	64	11	05	01	12	42	01	0	0	
R3	0	15	90	08	0	03	20	81	19	0	0	02	92	01	0	
R4	0	0	04	92	05	0	0	08	61	11	0	0	06	98	02	
R5	0	0	0	0	95	0	0	0	16	87	0	0	0	01	98	
R1	85	12	0	0	0	68	31	0	0	0	75	34	0	0	0	41-45
R2	10	77	02	0	0	32	59	11	05	04	25	61	04	0	0	
R3	05	10	96	02	0	0	10	77	22	0	0	05	92	06	0	
R4	0	0	01	91	10	0	0	11	61	04	0	0	04	91	04	
R5	0	0	0	06	90	0	0	0	11	92	0	0	0	02	94	

Wide-ordered Birds - confusion matrices (cont.)

	Bird 1					Bird 2					Bird 3					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	95	04	0	0	0	66	26	01	0	0	66	16	0	0	0	46-50
R2	05	94	08	0	0	31	68	28	01	0	34	80	01	0	0	
R3	0	02	90	08	0	02	06	64	17	0	0	04	95	04	0	
R4	0	0	02	92	05	0	0	08	77	14	0	0	04	96	02	
R5	0	0	0	0	95	0	0	0	04	86	0	0	0	0	98	
R1	86	06	0	0	0	59	21	02	0	0	71	10	0	0	0	51-55
R2	13	81	05	02	0	29	71	14	0	0	29	85	05	0	0	
R3	0	12	90	04	0	12	08	76	12	0	0	05	92	12	0	
R4	0	0	05	92	01	0	0	08	80	04	0	0	02	85	05	
R5	0	0	0	01	99	0	0	0	08	96	0	0	0	02	95	
R1	88	09	0	0	0	60	17	0	0	0	64	12	0	0	0	56-60
R2	12	86	04	0	0	39	66	30	01	0	35	84	08	0	0	
R3	0	05	89	10	0	01	16	59	08	0	01	04	91	05	0	
R4	0	0	01	89	05	0	0	11	85	12	0	0	01	95	04	
R5	0	0	0	01	95	0	0	0	06	88	0	0	0	0	96	

Wide-ordered Birds - confusion matrices (cont.)

	Bird 1					Bird 2					Bird 3					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	86	04	0	0	0	68	16	0	0	0	75	16	0	0	0	61-65
R2	14	92	05	0	0	32	69	17	0	0	24	81	02	0	0	
R3	0	04	90	04	0	0	15	71	04	0	01	01	98	04	0	
R4	0	0	05	95	01	0	0	11	92	04	0	0	0	95	06	
R5	0	0	0	01	99	0	0	0	04	96	0	0	0	01	94	
R1	85	11	0	0	0	81	19	0	0	0	71	29	0	0	0	66-70
R2	15	86	04	0	0	19	72	16	0	0	28	69	04	0	0	
R3	0	02	94	08	0	0	09	80	10	0	01	02	92	04	0	
R4	0	0	02	91	0	0	0	04	86	02	0	0	04	94	02	
R5	0	0	0	01	100	0	0	0	04	98	0	0	0	02	98	
R1	84	12	0	0	0	75	29	02	0	0	62	21	0	0	0	71-75
R2	16	84	01	0	0	25	65	14	0	0	36	75	06	0	0	
R3	0	04	92	06	0	0	06	80	06	0	01	04	92	06	0	
R4	0	0	06	94	0	0	0	04	89	05	0	0	01	94	0	
R5	0	0	0	0	100	0	0	0	05	95	0	0	0	0	100	

Wide-ordered Birds - confusion matrices (cont.)

	Bird 1					Bird 2					Bird 3					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	86	11	0	0	0	79	24	0	0	0	84	21	0	0	0	76-80
R2	14	85	01	0	0	21	66	19	0	0	16	75	02	0	0	
R3	0	04	90	05	0	0	09	72	05	0	0	04	88	04	0	
R4	0	0	0	09	95	0	01	09	91	08	0	0	10	94	01	
R5	0	0	0	0	100	0	0	0	0	92	0	0	0	02	99	
R1	91	08	0	0	0	51	25	0	0	0	68	14	0	0	0	81-85
R2	09	89	0	0	0	49	70	16	0	0	31	81	0	0	0	
R3	0	03	98	05	0	0	05	75	05	0	01	05	95	08	0	
R4	0	0	01	94	03	0	0	09	92	05	0	0	05	90	01	
R5	0	0	0	01	97	0	0	0	02	95	0	0	0	02	99	
R1	90	04	0	0	0	70	31	0	0	0	65	04	0	0	0	86-90
R2	10	92	0	0	0	30	69	20	01	0	35	89	02	0	0	
R3	0	04	98	04	0	0	0	76	06	0	0	07	95	04	0	
R4	0	0	02	97	0	0	0	04	88	0	0	0	02	91	04	
R5	0	0	0	0	100	0	0	0	05	100	0	0	0	05	96	

Wide-ordered Birds confusion matrices (cont.)

	Bird 1					Bird 2					Bird 3					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	90	05	0	0	0	79	16	01	0	0	86	16	0	0	0	91-95
R2	10	92	05	0	0	21	83	11	01	0	12	74	11	0	0	
R3	0	02	92	02	0	0	0	77	06	0	01	10	89	12	0	
R4	0	0	02	95	02	0	0	10	88	05	0	0	0	88	0	
R5	0	0	0	02	98	0	0	0	05	95	0	0	0	0	100	
R1	73	04	0	0	0	62	11	0	0	0	76	15	0	0	0	96-100
R2	26	81	01	0	0	38	88	11	01	0	24	79	06	0	0	
R3	0	11	95	01	0	0	01	86	08	0	0	06	91	19	0	
R4	0	0	02	95	0	0	0	02	82	0	0	0	02	80	01	
R5	0	0	0	02	01	0	0	0	09	100	0	0	0	01	99	

Wide-unordered Birds - confusion matrices

	Bird 4					Bird 5					Bird 6					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	40	27	28	32	13	46	36	28	13	05	30	30	30	09	05	1-5
R2	08	35	10	0	01	22	26	08	0	0	28	38	10	0	09	
R3	38	22	19	05	09	21	11	26	13	16	25	18	28	20	14	
R4	02	06	19	36	20	09	19	20	30	10	04	09	23	26	09	
R5	13	10	23	27	57	03	08	18	45	69	14	05	09	45	64	
R1	54	09	25	19	01	55	23	11	05	0	37	16	08	08	05	6-10
R2	15	60	10	0	04	41	70	24	04	04	35	45	14	0	0	
R3	20	21	51	14	01	03	05	49	17	04	16	31	56	06	08	
R4	10	04	04	40	11	0	03	11	64	26	01	01	15	79	17	
R5	0	06	10	26	82	01	0	04	11	66	10	07	07	08	70	
R1	70	04	20	02	0	46	26	10	04	01	82	36	11	07	02	11-15
R2	05	75	04	0	0	26	50	10	01	0	11	30	04	0	0	
R3	07	19	69	07	0	21	14	38	13	06	06	31	76	11	06	
R4	18	20	05	80	26	11	01	18	62	31	01	02	09	80	18	
R5	0	04	02	11	74	04	07	22	19	61	0	0	0	03	74	

Wide-unordered Birds — confusion matrices (cont.)

	Bird 4					Bird 5					Bird 6					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	79	14	16	0	0	66	29	04	0	02	83	27	04	04	0	16-20
R2	09	75	04	0	0	19	60	25	0	0	10	55	05	0	02	
R3	06	10	74	02	02	14	10	51	14	0	01	17	82	04	01	
R4	06	0	04	90	07	01	01	17	84	29	06	01	08	91	11	
R5	0	01	02	08	90	0	0	02	02	69	0	0	01	01	85	
R1	68	12	15	02	0	81	29	20	02	02	90	25	08	05	0	21-25
R2	16	73	09	0	03	05	49	31	02	02	01	70	13	0	0	
R3	08	10	64	16	02	09	18	39	20	02	08	05	70	12	04	
R4	05	03	10	76	39	05	02	08	66	46	0	0	04	80	08	
R5	02	01	02	05	56	0	01	01	08	48	0	0	05	02	88	
R1	82	19	19	04	01	65	22	06	04	0	86	06	15	04	0	26-30
R2	05	59	16	0	04	15	52	38	09	04	11	90	12	0	0	
R3	10	18	49	19	08	17	25	32	06	05	0	04	69	02	0	
R4	02	04	16	64	15	01	0	19	70	21	02	0	04	94	0	
R5	0	0	0	13	72	01	01	05	11	70	0	0	0	0	10	

Wide-unordered Birds - confusion matrices (cont.)

	Bird 4					Bird 5					Bird 6					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	64	08	10	02	06	64	05	02	0	02	76	12	11	01	0	31-35
R2	15	79	17	0	01	31	86	40	02	02	18	76	08	0	0	
R3	12	14	62	25	10	05	06	51	22	04	04	11	65	05	01	
R4	06	0	06	66	09	0	02	04	71	08	03	0	11	94	05	
R5	02	0	05	06	74	0	0	02	05	84	0	0	05	0	94	
R1	70	16	11	06	01	81	08	0	01	0	81	08	09	01	01	36-40
R2	11	60	14	02	05	11	82	34	0	01	13	74	08	0	0	
R3	16	24	49	16	02	06	10	55	20	01	05	17	74	08	02	
R4	02	0	22	69	01	01	0	06	69	06	01	01	09	89	02	
R5	0	0	04	06	90	0	0	05	10	91	0	0	01	02	94	
R1	69	02	12	09	02	80	10	01	0	0	91	04	10	04	0	41-45
R2	15	77	26	01	01	11	79	08	01	0	05	83	10	0	0	
R3	15	17	41	11	02	07	11	69	12	0	04	07	74	12	02	
R4	01	0	15	69	08	01	0	19	82	05	0	02	02	84	01	
R5	0	02	05	10	86	0	0	04	04	95	0	0	04	0	96	

Wide-unordered Birds - confusion matrices (cont.)

	Bird 4					Bird 5					Bird 6					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	75	05	06	08	08	77	02	0	04	0	89	07	10	11	02	46-50
R2	11	72	24	01	0	19	74	08	01	02	05	70	09	01	0	
R3	10	20	69	10	01	04	22	81	06	06	04	20	73	10	02	
R4	02	01	0	75	15	0	0	06	84	01	02	0	06	74	07	
R5	01	01	01	06	76	0	0	05	05	90	0	02	02	04	88	
R1	76	11	20	09	01	91	05	05	04	0	75	04	19	06	0	51-55
R2	10	76	36	05	0	09	80	16	0	01	09	78	06	02	0	
R3	14	12	44	17	04	0	15	75	10	02	12	15	65	06	01	
R4	0	0	0	62	05	0	0	04	82	01	04	0	05	82	0	
R5	0	0	0	06	90	0	0	0	04	95	0	02	05	02	99	
R1	62	14	11	02	0	86	06	02	06	0	89	09	08	02	0	56-60
R2	11	66	30	01	02	09	79	11	0	02	04	77	13	01	01	
R3	25	16	52	16	0	04	14	81	15	05	04	11	59	19	01	
R4	0	0	04	72	02	0	0	04	77	08	04	0	11	75	04	
R5	01	04	02	08	95	01	01	01	01	85	0	02	09	02	94	

Wide-unordered Birds - confusion matrices (cont.)

	Bird 4					Bird 5					Bird 6					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	65	04	09	06	0	74	12	04	01	0	92	03	23	0	01	61-65
R2	10	77	39	0	02	24	70	05	01	01	04	89	27	0	0	
R3	20	19	48	38	01	02	17	70	11	04	02	03	45	06	01	
R4	04	0	01	54	05	0	0	21	85	16	01	04	06	90	12	
R5	01	0	04	02	91	0	0	0	01	79	0	01	0	04	86	
R1	84	06	08	11	0	92	11	04	04	0	87	04	13	04	01	66-70
R2	08	84	36	01	0	06	66	08	0	0	04	81	14	0	0	
R3	08	08	51	20	05	01	22	82	02	0	05	13	71	04	02	
R4	01	0	01	60	02	0	0	06	91	01	02	01	0	92	0	
R5	0	02	04	08	92	0	0	0	02	99	01	0	02	0	96	
R1	72	12	17	08	0	88	08	01	04	0	88	06	21	02	0	71-75
R2	12	64	41	02	0	08	75	08	0	01	04	79	15	0	0	
R3	13	19	38	30	06	02	15	84	06	02	06	09	57	02	02	
R4	01	01	01	36	05	02	0	06	84	0	02	0	06	95	01	
R5	01	04	02	24	89	0	02	01	06	96	0	05	0	0	96	

Wide-unordered Birds - confusion matrices (cont.)

	Bird 4					Bird 5					Bird 6					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	68	05	16	11	01	89	04	01	04	0	92	05	14	01	0	76-80
R2	17	65	15	0	0	04	89	10	0	0	01	71	11	0	0	
R3	12	29	58	21	02	06	08	77	06	01	05	22	64	09	02	
R4	01	0	08	62	01	0	0	09	88	0	01	0	05	90	0	
R5	01	01	04	05	95	01	0	02	02	99	0	01	06	0	0	
R1	76	06	19	08	0	89	02	04	08	0	94	05	14	01	02	81-85
R2	17	74	28	0	0	01	94	12	0	0	0	80	06	0	01	
R3	05	19	45	16	02	10	02	77	09	0	05	12	71	14	01	
R4	01	01	06	72	01	0	0	06	81	01	01	02	05	85	0	
R5	0	0	02	05	96	0	01	0	02	99	0	0	04	0	95	
R1	92	02	11	01	01	90	01	01	08	0	85	01	06	0	01	86-90
R2	04	76	12	0	0	04	88	12	0	0	02	82	04	0	0	
R3	01	21	62	06	01	05	09	76	06	01	12	14	82	01	0	
R4	02	0	05	91	04	01	0	08	84	01	0	01	05	95	0	
R5	0	0	09	01	94	0	02	02	02	98	0	01	02	04	99	

Wide-unordered Birds - confusion matrices (cont.)

	Bird 4					Bird 5					Bird 6					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	96	02	14	04	01	98	01	02	01	0	69	01	01	0	0	91-95
R2	0	68	08	0	0	01	84	09	01	01	18	84	02	0	0	
R3	01	24	75	11	0	01	14	84	15	0	13	13	81	02	01	
R4	02	01	04	85	04	0	0	05	77	0	0	0	11	96	01	
R5	0	05	0	0	95	0	01	0	05	99	0	01	04	01	98	
R1	89	04	09	06	0	89	09	01	0	0	67	0	05	01	0	96-100
R2	08	81	16	0	0	06	81	19	0	0	17	93	05	0	0	
R3	04	14	68	17	0	02	08	72	12	01	13	04	88	02	0	
R4	0	0	02	74	01	01	02	05	80	02	01	01	02	95	0	
R5	0	01	04	02	99	01	0	02	08	96	01	01	0	01	100	

Moderate-ordered Birds - confusion matrices

	Bird 7					Bird 8					Bird 9					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	21	18	07	0	0	54	24	03	0	01	47	49	20	01	0	1-5
R2	64	57	42	14	11	33	44	35	19	16	25	26	28	10	03	
R3	09	16	22	23	09	05	24	44	23	06	11	09	23	18	13	
R4	04	08	29	45	30	08	09	17	37	44	14	11	25	54	55	
R5	03	01	0	17	50	0	0	01	22	32	04	05	05	18	30	
R1	58	38	04	0	0	61	24	0	0	0	71	56	08	04	01	6-10
R2	36	58	24	03	0	38	53	13	0	0	21	25	21	05	0	
R3	06	04	39	11	0	0	23	82	16	0	08	14	36	26	11	
R4	0	0	31	58	28	0	0	05	77	51	0	04	28	46	36	
R5	0	0	01	28	72	01	0	0	06	49	0	01	07	19	51	
R1	74	38	01	0	0	70	19	05	12	07	80	45	14	03	03	11-15
R2	24	44	18	03	0	29	54	16	0	0	17	30	24	05	06	
R3	03	17	50	26	0	01	16	63	05	0	03	24	39	30	10	
R4	0	01	15	64	41	0	0	16	70	34	0	01	15	47	28	
R5	0	0	01	07	59	0	11	0	14	58	0	0	07	14	53	

Moderate-ordered Birds - confusion matrices (cont.)

	Bird 7					Bird 8					Bird 9					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	55	11	0	0	0	75	30	0	0	0	72	30	10	0	01	16-20
R2	38	67	23	0	0	25	59	31	01	0	25	49	16	0	01	
R3	08	20	64	17	0	0	11	62	20	0	03	17	51	29	01	
R4	0	01	12	75	11	0	0	06	62	21	0	01	10	60	13	
R5	0	0	0	08	89	0	0	0	11	77	0	01	12	11	81	
R1	85	33	05	0	0	74	20	01	0	0	77	37	08	02	01	21-25
R2	10	41	29	0	0	24	52	29	0	0	19	39	29	01	02	
R3	05	26	54	42	05	02	28	68	19	02	04	20	39	25	02	
R4	0	0	12	45	30	0	0	02	74	26	0	04	19	60	34	
R5	0	0	0	13	65	0	0	0	08	71	0	0	04	11	59	
R1	71	24	01	0	0	76	20	0	0	0	70	31	05	0	0	26 -30
R2	29	61	29	0	0	24	59	17	0	0	25	45	15	01	0	
R3	0	14	49	26	04	0	21	71	10	0	04	20	50	26	10	
R4	0	0	20	49	19	0	0	11	08	06	01	02	28	58	27	
R5	0	0	0	25	77	0	0	0	0	94	0	01	02	15	63	

Moderate-ordered Birds - confusion matrices (cont.)

	Bird 7					Bird 8					Bird 9					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	74	34	02	0	01	76	11	0	0	0	61	20	0	0	0	31-35
R2	21	54	25	01	0	24	75	04	0	0	26	60	21	04	0	
R3	02	08	56	16	04	0	14	95	09	0	10	19	55	16	02	
R4	01	01	15	69	11	0	0	01	88	11	02	01	24	66	25	
R5	01	0	01	14	83	0	0	0	04	89	0	0	0	14	72	
R1	70	30	0	0	0	79	08	0	0	0	73	31	05	01	0	36-40
R2	29	50	15	0	0	18	74	15	01	0	20	05	25	05	01	
R3	01	20	50	15	02	01	19	73	04	0	03	20	50	33	06	
R4	0	0	34	68	15	0	0	11	89	10	03	01	17	37	20	
R5	0	0	01	17	82	01	0	01	04	90	0	0	03	23	72	
R1	75	26	01	0	0	90	11	0	0	0	85	52	05	01	0	41-45
R2	21	56	16	01	0	09	84	11	0	0	12	38	24	08	0	
R3	04	17	60	19	0	01	05	88	10	0	02	10	48	29	04	
R4	0	0	22	65	19	0	0	01	84	08	0	0	24	38	17	
R5	0	0	0	15	81	0	0	0	06	92	0	0	0	25	79	

Moderate-ordered Birds - confusion matrices (cont.)

	Bird 7					Bird 8					Bird 9					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	70	15	0	0	0	80	19	0	0	0	75	36	04	0	0	46-50
R2	30	71	16	0	0	19	77	10	0	0	19	49	29	04	0	
R3	01	14	62	14	01	01	04	90	16	0	05	15	46	20	05	
R4	0	0	20	72	24	0	0	0	82	08	01	0	21	66	30	
R5	0	0	0	14	75	0	0	0	01	92	0	0	0	10	65	
R1	55	17	0	0	0	74	15	0	0	0	91	35	06	0	0	51-55
R2	39	65	25	0	0	26	71	28	01	0	06	44	21	04	01	
R3	05	17	69	26	01	0	14	70	15	0	02	17	48	22	04	
R4	0	0	06	70	20	0	0	02	76	10	0	02	25	58	38	
R5	0	0	0	04	79	0	0	0	08	90	0	01	0	16	58	
R1	76	17	0	0	0	90	11	0	0	0	86	30	01	0	0	56-60
R2	24	65	12	0	0	10	75	06	0	0	10	52	19	04	0	
R3	0	17	72	24	0	0	14	88	09	0	01	16	60	28	04	
R4	0	0	15	69	29	0	0	06	82	10	01	01	20	56	35	
R5	0	0	0	08	71	0	0	0	09	90	01	0	0	12	61	

Moderate-ordered Birds - confusion matrices (cont.)

	Bird 7					Bird 8					Bird 9					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	60	10	02	0	0	80	07	0	0	0	68	39	02	0	0	61-65
R2	32	70	22	08	0	19	81	02	0	0	24	38	22	08	0	
R3	06	19	48	16	02	01	11	09	06	0	05	20	48	16	02	
R4	01	01	25	52	24	0	0	0	90	09	01	01	25	52	24	
R5	0	0	02	24	74	0	0	0	04	91	02	02	02	24	74	
R1	80	09	0	0	0	90	21	0	0	0	72	42	02	01	0	66-70
R2	19	59	11	0	0	10	73	02	0	0	26	31	16	0	0	
R3	01	31	80	14	01	0	05	89	20	0	0	24	54	14	05	
R4	0	01	09	71	17	0	0	08	65	09	01	01	28	66	21	
R5	0	0	0	15	81	0	0	01	15	91	0	01	0	19	74	
R1	86	16	0	0	0	85	14	0	0	0	81	24	0	0	0	71-75
R2	14	55	04	0	0	15	73	01	0	0	17	62	19	05	0	
R3	0	29	44	06	0	0	11	95	10	01	0	10	68	15	02	
R4	0	0	17	74	10	0	01	04	84	08	01	04	14	69	20	
R5	0	0	01	20	90	0	0	0	06	91	0	0	0	11	77	

Moderate-ordered Birds - confusion matrices (cont.)

	Bird 7					Bird 8					Bird 9					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	90	29	0	0	0	76	14	0	0	0	76	36	02	0	0	76-80
R2	09	51	15	0	0	24	80	04	0	01	21	46	15	01	0	
R3	01	17	71	06	0	0	06	94	05	0	02	16	54	21	05	
R4	0	02	14	82	16	0	0	02	84	0	0	01	28	68	35	
R5	0	0	0	11	84	0	0	0	11	100	0	0	01	10	60	
R1	77	16	0	0	0	86	19	0	0	0	68	19	01	0	0	81-85
R2	22	64	14	0	0	14	74	02	0	0	32	62	14	04	01	
R3	0	19	72	19	0	0	08	96	05	0	0	17	60	15	01	
R4	0	01	14	69	20	0	0	01	94	08	0	01	25	74	21	
R5	0	0	0	12	80	0	0	0	01	92	0	0	0	08	76	
R1	80	14	0	0	0	91	06	0	0	0	60	14	0	0	0	86-90
R2	19	74	14	0	0	09	84	0	0	01	38	65	11	01	01	
R3	01	10	68	06	01	0	10	100	05	0	02	17	66	12	04	
R4	0	01	17	71	06	0	0	0	86	06	0	04	22	70	15	
R5	0	01	01	22	92	0	0	0	09	92	0	0	0	16	80	

Moderate-ordered Birds - confusion matrices (cont.)

	Bird 7					Bird 8					Bird 9					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	90	25	0	0	0	86	10	0	0	0	84	35	04	0	0	91-95
R2	10	64	16	02	0	14	85	05	0	01	16	61	21	04	01	
R3	0	10	72	22	01	0	05	95	05	01	0	04	61	14	04	
R4	0	01	10	70	11	0	0	0	92	06	0	0	14	79	24	
R5	0	0	01	04	88	0	0	0	02	91	0	0	0	04	71	
R1	82	08	0	0	0	91	15	0	01	0	72	24	02	0	0	96-100
R2	17	84	09	0	0	09	79	06	0	0	26	66	17	01	01	
R3	0	08	79	06	01	0	05	89	04	0	01	09	69	14	0	
R4	0	01	10	84	17	0	0	05	91	08	0	01	11	77	29	
R5	0	0	01	04	81	0	0	0	04	92	0	0	0	08	70	

Moderate-unordered Birds - confusion matrices

	Bird 10					Bird 11					Bird 12					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	08	10	08	06	01	55	47	31	18	06	23	22	24	16	06	1-5
R2	58	59	34	10	04	14	19	09	08	08	25	22	11	05	06	
R3	10	10	11	14	09	10	14	21	18	15	27	30	30	31	22	
R4	05	08	17	14	12	09	09	25	26	16	13	08	19	14	10	
R5	20	14	30	56	74	12	10	14	31	55	13	19	16	34	56	
R1	13	04	04	02	0	37	32	15	0	03	73	41	22	01	0	6-10
R2	77	76	24	05	04	34	48	24	25	0	06	23	23	0	01	
R3	10	12	42	10	0	15	15	29	03	08	13	32	28	03	06	
R4	0	02	22	17	01	12	05	24	30	15	04	0	04	15	05	
R5	0	05	08	65	95	01	0	09	42	74	04	04	24	81	87	
R1	39	19	09	01	0	52	33	13	11	0	52	27	08	01	02	11-15
R2	55	58	20	0	01	20	39	20	01	04	23	28	11	01	0	
R3	05	23	55	39	0	20	25	51	16	02	17	31	55	11	12	
R4	01	0	14	47	30	05	0	06	40	11	05	01	26	64	21	
R5	0	0	01	12	67	01	02	09	31	82	03	02	0	23	64	

Moderate-unordered Birds - confusion matrices (cont.)

	Bird 10					Bird 11					Bird 12					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	52	29	11	03	0	45	24	09	04	0	81	38	02	01	0	16-20
R2	41	56	24	04	0	36	52	33	0	0	11	35	17	04	0	
R3	05	14	55	28	04	14	22	35	21	04	04	24	60	20	05	
R4	01	0	05	42	18	05	01	13	50	32	04	01	17	56	22	
R5	01	0	04	23	78	0	0	10	25	64	0	01	02	19	72	
R1	40	35	15	14	01	36	26	10	04	01	70	19	01	05	0	21-25
R2	42	43	38	05	09	56	61	35	01	0	12	45	21	01	0	
R3	09	11	38	32	02	0	08	44	25	04	09	32	53	20	06	
R4	07	09	08	39	31	06	05	09	44	17	09	02	21	51	18	
R5	02	01	0	09	57	01	0	02	26	77	0	01	02	22	75	
R1	22	14	14	06	01	50	22	14	04	0	64	09	09	08	03	26-30
R2	75	79	59	16	0	39	68	30	0	0	16	50	14	05	01	
R3	01	01	11	06	06	08	10	46	23	05	09	33	53	27	09	
R4	01	05	15	50	22	04	0	08	42	17	08	05	19	48	21	
R5	0	01	01	21	70	0	0	02	32	78	03	03	05	13	65	

Moderate-unordered Birds - confusion matrices (cont.)

	Bird 10					Bird 11					Bird 12					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	40	17	05	01	0	70	26	10	01	01	60	29	0	02	0	31-35
R2	55	64	08	01	0	24	58	44	04	01	30	36	06	0	0	
R3	02	12	70	33	09	05	16	30	25	10	08	29	72	34	05	
R4	01	02	16	56	19	01	0	12	40	19	01	04	19	58	31	
R5	01	04	01	09	72	0	0	04	29	68	01	02	02	06	64	
R1	40	09	05	01	0	48	23	09	01	0	81	30	01	02	0	36-40
R2	55	54	08	04	0	38	60	19	01	0	10	39	12	01	0	
R3	02	38	70	29	09	11	14	69	24	0	02	26	66	41	05	
R4	01	02	16	55	19	04	01	02	56	25	06	04	12	41	17	
R5	01	0	01	11	72	0	01	01	18	75	0	01	08	14	77	
R1	31	10	01	0	0	65	16	05	02	01	76	34	0	01	0	41-45
R2	68	65	15	01	02	29	66	25	01	0	21	41	17	04	01	
R3	01	17	68	21	0	06	16	60	26	04	02	19	64	44	06	
R4	0	06	16	72	22	0	01	10	51	15	0	0	04	41	30	
R5	0	01	0	05	75	0	0	0	19	80	0	06	15	10	62	

Moderate-unordered Birds - confusion matrices (cont.)

	Bird 10					Bird 11					Bird 12					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	55	16	05	01	0	62	16	02	01	0	70	19	02	01	0	46-50
R2	41	72	15	02	0	29	57	14	04	0	24	57	20	01	02	
R3	02	08	60	23	06	04	25	68	32	01	02	19	49	28	05	
R4	01	02	20	68	12	04	01	14	52	12	02	01	20	54	09	
R5	0	01	0	05	81	01	0	02	10	86	01	02	09	16	84	
R1	50	15	06	02	0	48	12	04	05	0	63	21	01	02	0	51-55
R2	48	71	28	02	0	46	60	11	0	01	26	36	17	02	01	
R3	01	10	45	16	0	04	24	64	26	02	07	34	57	21	06	
R4	0	02	20	72	17	02	04	19	55	14	03	02	19	59	11	
R5	01	01	01	06	82	0	0	01	14	82	0	06	04	15	81	
R1	55	11	01	01	0	42	15	12	04	0	77	17	09	01	0	56-60
R2	44	81	24	04	0	48	65	05	0	0	14	60	17	04	01	
R3	0	05	48	19	01	06	19	62	28	02	05	20	51	28	11	
R4	0	02	26	61	21	04	0	19	61	20	04	0	19	48	12	
R5	0	0	01	14	77	0	01	01	05	77	0	02	04	18	75	

Moderate-unordered Birds - confusion matrices (cont.)

	Bird 10					Bird 11					Bird 12					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	39	05	09	02	0	59	30	08	05	01	74	24	08	05	0	61-65
R2	54	88	35	02	01	30	49	19	0	0	22	64	15	04	0	
R3	01	05	40	21	01	04	20	58	29	01	04	11	62	28	04	
R4	04	02	16	58	10	08	0	08	48	32	0	0	10	53	16	
R5	02	0	0	16	88	0	01	09	19	65	0	01	05	10	80	
R1	45	13	16	01	0	50	19	12	01	02	72	26	05	01	0	66-70
R2	51	76	17	02	0	49	65	36	05	0	17	51	17	01	0	
R3	04	09	34	24	0	0	15	38	34	08	08	19	65	21	0	
R4	0	0	32	57	0	01	01	14	49	39	0	0	11	69	21	
R5	0	01	0	15	0	0	0	0	11	51	02	04	01	08	79	
R1	32	12	11	04	01	70	22	05	01	0	70	09	04	02	01	71-75
R2	62	74	28	01	0	22	72	21	0	01	23	64	17	0	04	
R3	06	12	41	24	02	05	04	60	32	05	05	27	68	25	02	
R4	0	01	19	52	12	02	01	12	62	21	02	0	10	66	14	
R5	0	0	01	19	84	0	0	01	04	72	0	0	01	06	79	

Moderate-unordered Birds - confusion matrices (cont.)

	Bird 10					Bird 11					Bird 12					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	36	14	10	02	0	44	09	04	01	0	72	14	01	0	0	76-80
R2	59	68	12	01	0	46	65	09	0	0	27	66	17	0	0	
R3	02	15	42	31	02	06	17	65	14	01	01	14	70	14	04	
R4	01	04	34	42	09	02	09	22	69	20	0	01	11	74	04	
R5	01	0	01	22	89	02	0	0	16	79	0	04	0	12	92	
R1	25	08	09	01	0	31	05	06	02	01	72	16	04	02	0	81-85
R2	71	84	29	0	01	56	79	20	0	0	23	62	19	05	0	
R3	04	08	21	12	0	11	14	66	29	0	05	17	68	19	06	
R4	0	01	39	62	04	0	01	06	61	25	0	0	07	64	08	
R5	0	0	02	24	95	01	01	01	08	74	0	04	01	10	86	
R1	31	14	06	06	04	34	11	08	0	0	56	13	06	0	0	86-90
R2	59	66	15	01	0	52	61	10	0	0	33	43	0	0	0	
R3	10	17	60	36	04	13	28	60	09	0	10	37	60	08	02	
R4	0	02	17	45	11	0	0	17	65	08	01	0	32	68	02	
R5	0	0	01	11	81	01	0	05	26	92	0	06	01	25	95	

Moderate-unordered Birds - confusion matrices (cont.)

	Bird 10					Bird 11					Bird 12					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	22	09	08	04	0	49	09	10	02	0	52	08	04	02	01	91-95
R2	66	79	21	02	0	48	72	15	0	0	44	75	05	0	0	
R3	11	11	54	49	01	04	19	59	14	01	02	16	62	11	01	
R4	0	0	16	34	14	0	0	12	64	12	0	01	22	72	05	
R5	0	01	01	11	85	0	0	04	20	86	01	0	06	14	92	
R1	32	09	01	01	01	50	19	06	01	0	82	22	01	0	01	96-100
R2	58	79	29	02	0	48	61	21	01	0	16	47	10	01	0	
R3	09	11	62	52	09	01	20	61	14	04	01	27	77	12	01	
R4	0	01	06	29	08	01	0	10	75	10	0	0	11	79	14	
R5	01	0	01	15	82	0	0	01	09	86	0	04	0	08	84	

Narrow-ordered Birds - confusion matrices

	Bird 13					Bird 14					Bird 15					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	32	22	06	04	02	48	26	15	07	06	35	15	10	06	04	1-5
R2	35	41	42	29	21	21	31	30	17	14	31	32	32	24	10	
R3	19	22	22	25	16	15	22	25	21	26	25	39	32	25	20	
R4	11	09	21	32	52	11	10	19	41	36	09	10	17	29	45	
R5	02	06	08	10	08	05	10	11	13	17	0	04	08	15	21	
R1	48	27	05	0	0	42	12	01	0	0	57	22	12	02	0	6-10
R2	30	38	31	16	07	25	36	28	10	0	25	45	30	05	0	
R3	19	25	46	25	20	25	34	38	18	15	15	28	40	18	18	
R4	03	08	14	40	40	08	14	29	57	59	03	05	14	64	68	
R5	0	01	04	19	33	0	04	05	15	26	0	0	04	12	14	
R1	49	31	06	0	0	41	17	06	0	0	22	24	09	06	01	11-15
R2	26	33	23	08	08	35	29	22	12	0	47	50	30	22	06	
R3	22	22	30	17	06	24	53	56	25	12	26	25	32	16	24	
R4	01	13	30	51	48	0	0	12	46	61	05	01	22	51	54	
R5	01	01	11	24	37	0	0	02	17	26	0	0	06	06	15	

Narrow-ordered Birds - confusion matrices (cont.)

	Bird 13					Bird 14					Bird 15					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	35	15	01	0	0	29	23	06	0	0	29	13	08	0	0	16-20
R2	49	55	35	05	0	49	49	41	14	08	42	45	28	08	04	
R3	13	22	35	16	02	18	24	34	28	19	26	40	51	28	15	
R4	02	05	32	54	56	01	03	10	40	39	02	01	17	47	58	
R5	0	02	04	25	41	02	01	08	18	34	0	0	03	17	23	
R1	25	13	16	09	12	42	09	02	0	0	49	17	06	0	01	21-25
R2	42	32	19	09	03	32	58	24	06	01	45	62	38	10	06	
R3	08	19	19	23	11	25	25	52	30	21	06	19	45	36	20	
R4	02	14	29	36	47	0	08	16	49	46	0	01	09	29	39	
R5	23	21	15	21	27	0	01	05	15	44	0	0	02	25	34	
R1	37	32	13	04	02	48	14	06	0	0	31	14	04	0	02	26-30
R2	56	49	38	15	06	41	50	24	05	01	49	52	30	05	0	
R3	06	06	10	15	08	11	24	31	24	16	20	28	51	36	14	
R4	01	11	22	31	35	0	11	38	51	54	0	06	15	42	35	
R5	0	01	17	34	49	0	01	01	20	29	0	0	0	17	48	

Narrow-ordered Birds - confusion matrices (cont.)

	Bird 13					Bird 14					Bird 15					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	11	04	04	0	0	35	09	02	0	0	49	19	10	0	0	31-35
R2	59	49	24	10	01	48	69	35	17	10	44	66	34	09	04	
R3	27	32	31	14	15	12	21	35	35	21	06	15	43	39	16	
R4	02	15	36	59	58	02	01	21	30	45	0	0	13	42	40	
R5	0	0	05	17	25	02	0	06	17	24				10	40	
R1	16	02	04	0	0	44	15	04	0	0	54	28	12	01	01	36-40
R2	54	54	30	11	04	46	56	32	02	01	41	56	31	09	04	
R3	27	29	34	20	12	08	29	41	49	17	05	16	39	29	12	
R4	02	14	26	58	59	02	0	22	24	30	0	0	12	12	31	
R5	0	01	06	11	25	0	0	01	25	51	0	0	05	11	51	
R1	29	09	06	0	0	68	21	10	0	0	47	14	01	01	0	41-45
R2	54	66	24	10	0	28	38	17	05	01	51	64	49	12	08	
R3	13	17	39	21	17	05	39	45	36	10	02	22	41	50	15	
R4	02	08	28	52	49	0	02	17	31	38	0	0	09	25	41	
R5	01	0	04	16	34	0	0	10	28	51	0	0	0	11	36	

Narrow-ordered Birds confusion matrices (cont.)

	Bird 13					Bird 14					Bird 15					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	20	08	01	0	0	46	10	05	0	0	54	26	06	0	02	46-50
R2	61	55	27	09	05	48	55	16	01	01	46	55	25	06	05	
R3	15	30	44	39	22	06	34	45	40	04	0	17	42	41	24	
R4	02	06	21	36	51	0	0	31	41	50	0	01	22	43	39	
R5	01	01	06	16	21	0	01	04	17	45	0	0	04	10	29	
R1	32	11	02	0	02	64	17	04	0	0	48	21	05	01	02	51-55
R2	56	59	26	16	05	26	54	19	04	02	47	64	56	20	09	
R3	06	19	39	25	17	08	24	46	35	20	04	14	21	37	15	
R4	05	09	31	44	40	0	04	22	42	33	01	01	16	30	43	
R5	0	01	01	15	35	02	01	08	19	43	0	0	01	11	30	
R1	32	19	04	0	0	69	11	05	0	0	33	23	05	01	04	56-60
R2	60	59	31	20	05	28	56	29	02	01	24	56	40	17	05	
R3	04	12	36	32	21	02	28	35	52	19	08	18	30	42	22	
R4	04	10	27	35	38	0	05	28	54	50	0	02	24	30	35	
R5	0	0	02	12	35	01	0	04	10	29	0	0	01	10	34	

Narrow-ordered Birds - confusion matrices (cont.)

	Bird 13					Bird 14					Bird 15					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	35	19	08	0	0	74	20	06	0	01	59	11	06	02	0	61-65
R2	56	59	28	20	04	24	55	25	06	02	24	55	45	13	04	
R3	08	12	34	32	20	01	21	39	19	08	17	30	40	02	19	
R4	01	10	29	35	31	0	04	22	48	46	0	04	09	37	40	
R5	0	0	02	12	45	01	0	08	26	42	0	0	0	18	37	
R1	41	09	08	0	01	85	21	06	0	0	50	10	06	01	0	66-70
R2	52	64	40	20	04	10	51	29	10	04	36	55	45	19	11	
R3	05	17	25	20	21	04	21	42	24	11	14	30	34	35	15	
R4	01	08	24	44	45	01	05	17	39	31	0	05	14	32	34	
R5	0	02	04	16	29	0	01	05	28	54	0	0	01	12	40	
R1	71	76	11	01	0	68	15	10	0	0	31	04	08	02	0	71-75
R2	25	44	34	08	05	29	49	20	0	04	51	66	41	20	10	
R3	02	20	39	31	16	04	30	42	36	09	17	29	42	45	22	
R4	01	09	14	40	41	0	06	22	44	34	0	01	09	21	26	
R5	0	01	02	20	38	0	0	05	20	54	0	0	0	11	41	

Narrow-ordered Birds confusion matrices (cont.)

	Bird 13					Bird 14					Bird 15					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	64	25	02	0	0	72	20	06	0	0	29	09	02	0	0	76-80
R2	26	48	31	08	05	28	51	21	02	0	50	45	49	19	06	
R3	09	20	24	31	16	0	24	36	21	10	21	42	35	25	16	
R4	01	08	40	51	58	0	05	26	44	32	0	04	11	29	30	
R5	0	0	02	10	21	0	0	10	32	58	0	0	02	28	48	
R1	61	25	02	0	0	84	28	06	01	0	25	11	04	01	01	81-85
R2	35	41	28	02	01	14	45	20	04	0	50	38	32	10	01	
R3	02	32	49	42	16	02	21	40	11	10	25	48	51	44	20	
R4	01	02	21	54	69	0	06	26	52	30	0	04	09	30	36	
R5	0	0	0	01	14	0	0	07	31	60	0	0	04	15	41	
R1	56	11	04	01	0	76	12	06	0	0	36	06	08	0	0	86-90
R2	32	36	15	09	04	20	49	18	05	0	46	41	22	06	04	
R3	11	48	45	34	11	04	38	55	26	14	16	50	52	28	12	
R4	0	04	31	46	51	0	01	11	33	22	01	02	10	36	25	
R5	0	01	05	10	34	0	0	09	35	64	0	0	08	30	59	

Narrow-ordered Birds confusion matrices (cont.)

	Bird 13					Bird 14					Bird 15					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	77	26	08	0	0	81	16	08	0	0	29	12	04	0	0	91-95
R2	19	36	17	04	0	15	54	21	04	02	59	46	36	09	05	
R3	04	34	55	42	25	04	28	56	32	15	12	38	51	52	24	
R4	0	04	19	42	51	0	02	11	34	21	0	04	05	25	20	
R5	0	0	01	11	24	0	0	04	30	61	0	0	04	14	51	
R1	49	21	0	0	0	90	22	05	0	0	37	12	01	0	0	96-100
R2	41	45	21	10	02	09	42	22	05	01	38	41	26	11	04	
R3	10	30	56	31	20	01	30	51	15	06	24	45	59	55	20	
R4	0	04	16	32	51	0	06	16	52	25	01	01	11	25	22	
R5	0	0	06	26	26	0	0	06	28	68	0	0	02	09	54	

Narrow-unordered Birds - confusion matrices

	Bird 16					Bird 17					Bird 18					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	18	18	13	07	06	12	10	06	11	06	33	30	14	13	03	1-5
R2	33	25	22	13	04	16	12	08	07	01	22	10	23	05	11	
R3	06	18	37	28	15	36	32	28	27	17	23	30	28	16	23	
R4	43	29	17	11	29	05	04	04	04	06	03	03	05	14	06	
R5	0	10	11	42	46	30	41	55	51	69	19	26	30	52	56	
R1	39	25	15	10	03	25	11	03	04	0	41	27	24	11	04	6-10
R2	25	19	22	09	03	15	13	14	09	09	33	27	25	34	25	
R3	14	46	51	34	20	56	68	76	72	68	14	34	40	14	31	
R4	23	10	10	16	11	0	05	0	03	0	10	04	04	13	01	
R5	0	0	01	31	64	04	04	08	13	24	02	09	08	29	39	
R1	54	36	25	10	07	29	16	09	05	02	54	26	18	05	03	11-15
R2	21	25	15	06	11	20	16	06	09	09	15	26	19	12	09	
R3	10	20	34	54	20	36	65	68	71	58	25	43	49	32	29	
R4	10	15	24	16	27	10	02	05	05	04	02	0	03	19	12	
R5	05	04	05	14	28	05	04	12	11	31	02	04	11	32	46	

Narrow-unordered Birds - confusion matrices (cont.)

	Bird 16					Bird 17					Bird 18					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	53	30	12	04	01	21	11	0	02	0	62	38	08	03	0	16-20
R2	20	28	20	21	04	09	12	12	12	13	05	14	18	11	03	
R3	20	29	36	30	16	60	66	76	56	47	26	37	47	42	22	
R4	07	12	28	31	30	10	05	06	14	15	03	04	10	14	18	
R5	0	01	04	14	49	0	05	05	15	24	03	07	17	30	58	
R1	54	36	15	02	02	15	13	06	02	0	80	35	11	06	04	21-25
R2	21	22	23	13	05	18	09	14	10	15	05	21	16	02	02	
R3	16	29	32	28	21	57	65	67	69	57	14	35	58	29	16	
R4	03	07	13	37	55	08	09	11	13	12	0	06	07	19	07	
R5	06	06	16	20	16	01	03	01	06	16	01	02	06	43	70	
R1	54	41	17	08	02	22	17	09	05	01	69	26	06	04	01	26-30
R2	10	12	08	06	02	06	20	15	10	10	14	22	17	06	03	
R3	27	24	26	36	21	49	45	54	62	51	15	42	60	54	19	
R4	08	15	34	30	32	20	15	17	15	20	01	06	11	15	09	
R5	01	08	15	20	41	02	02	05	08	17	01	02	05	21	67	

Narrow-unordered Birds - confusion matrices (cont.)

	Bird 16					Bird 17					Bird 18					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	49	27	04	02	0	32	14	11	04	01	52	21	05	0	0	31-35
R2	14	11	05	06	05	04	04	02	05	05	12	15	09	04	05	
R3	26	47	50	28	20	52	76	62	70	61	34	59	64	44	17	
R4	07	15	34	36	35	10	06	15	19	22	01	01	17	22	15	
R5	04	0	08	28	40	01	0	09	02	10	0	04	05	30	62	
R1	52	36	10	05	01	37	28	09	02	02	55	22	01	0	0	36-40
R2	14	14	08	04	02	06	05	05	06	06	24	29	12	04	0	
R3	28	44	52	31	17	55	58	59	55	39	21	49	53	41	12	
R4	06	06	21	46	35	0	07	19	21	19	0	0	28	31	17	
R5	0	0	09	14	44	01	01	09	15	34	0	0	07	24	70	
R1	54	26	05	0	0	33	21	08	0	01	62	25	05	02	0	41-45
R2	17	19	15	11	01	01	04	04	04	04	09	11	11	0	02	
R3	25	40	46	31	16	58	70	61	69	46	25	59	61	46	22	
R4	02	11	25	29	30	06	04	71	11	20	04	05	15	24	15	
R5	01	02	09	29	52	01	01	02	16	29	0	0	08	28	60	

Narrow-unordered Birds - confusion matrices (cont.)

	Bird 16					Bird 17					Bird 18					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	70	45	12	06	0	56	29	16	05	02	71	31	07	02	0	46-50
R2	19	15	09	10	04	01	01	05	08	05	11	08	11	02	0	
R3	05	30	46	41	34	38	55	54	62	45	14	54	66	57	27	
R4	05	10	29	22	30	05	10	14	17	14	04	01	07	11	11	
R5	01	0	04	20	32	0	05	11	08	34	0	05	08	26	63	
R1	65	29	15	0	0	31	20	08	08	02	61	26	06	01	0	51-55
R2	12	15	14	08	01	06	04	02	05	05	13	15	08	05	01	
R3	14	39	49	50	36	56	63	62	42	36	22	58	64	50	23	
R4	06	12	14	26	09	04	06	12	14	17	02	0	11	21	09	
R5	02	05	09	16	54	02	06	15	31	39	01	01	10	22	67	
R1	38	19	02	0	01	42	16	13	01	04	71	18	09	01	0	56-60
R2	23	15	05	09	06	05	05	02	04	0	16	26	12	04	02	
R3	34	58	65	51	35	50	69	68	62	52	12	49	64	61	28	
R4	01	04	08	16	11	0	02	07	15	08	0	05	10	16	16	
R5	02	04	20	24	46	02	08	08	17	36	0	02	05	17	54	

Narrow-unordered Birds - confusion matrices (cont.)

	Birds 16					Birds 17					Birds 18					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	51	11	08	0	0	28	22	10	04	0	63	17	09	0	01	61-65
R2	21	12	20	10	08	05	15	14	08	04	15	23	20	08	05	
R3	24	62	50	44	29	64	56	61	61	56	18	49	50	38	24	
R4	04	06	08	04	02	02	04	11	14	17	04	06	11	16	14	
R5	0	08	15	42	61	01	02	04	14	22	0	04	10	38	55	
R1	46	19	09	02	0	32	12	08	02	0	58	29	12	02	02	66-70
R2	21	32	20	09	05	10	11	11	06	05	25	25	11	05	02	
R3	30	38	42	35	0	52	66	66	65	48	14	34	52	38	30	
R4	0	02	10	11	08	04	04	10	14	11	02	05	10	11	07	
R5	02	09	19	42	69	01	06	05	12	36	01	06	14	44	57	
R1	47	26	05	0	0	35	17	10	04	0	78	30	11	02	02	71-75
R2	23	16	14	16	06	08	06	19	05	0	09	14	14	04	02	
R3	27	50	52	45	24	52	68	61	66	58	09	42	56	50	25	
R4	01	01	06	06	09	05	05	06	04	10	02	09	09	06	12	
R5	01	06	22	32	61	0	04	04	21	32	01	05	10	38	58	

Narrow-unordered Birds - confusion matrices (cont.)

	Bird 16					Bird 17					Bird 18					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	49	20	09	01	04	51	29	11	04	0	72	26	07	0	01	76-80
R2	31	20	28	14	04	12	14	06	11	02	08	21	14	08	02	
R3	17	51	40	38	16	35	46	52	40	39	14	43	52	45	30	
R4	01	04	09	09	11	01	05	06	12	15	06	05	13	15	12	
R5	01	05	15	39	65	0	06	24	32	44	0	04	14	32	54	
R1	49	15	11	02	0	48	25	09	02	01	76	23	05	01	01	81-85
R2	29	38	21	20	05	11	16	11	10	05	11	21	11	08	04	
R3	21	26	35	30	15	32	49	58	51	38	10	45	60	41	26	
R4	0	06	09	15	17	04	02	09	05	06	02	05	10	20	20	
R5	01	15	24	32	62	05	08	14	31	50	0	05	14	30	49	
R1	46	16	05	01	0	45	21	11	01	01	71	13	05	01	0	86-90
R2	30	41	28	29	08	16	20	09	06	02	10	17	09	04	0	
R3	22	34	40	24	14	34	46	50	48	31	19	64	51	36	22	
R4	0	04	11	08	11	01	02	08	06	04	0	02	09	11	06	
R5	01	05	16	39	68	04	10	22	39	61	0	04	26	48	71	

Narrow-unordered Birds - confusion matrices (cont.)

	Bird 16					Bird 17					Bird 18					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	52	16	02	0	0	77	46	15	02	01	62	24	09	0	0	91-95
R2	29	36	36	26	14	0	09	11	09	05	16	16	08	0	04	
R3	17	39	39	28	15	20	38	42	51	34	20	56	66	48	21	
R4	0	04	08	09	12	01	04	02	05	09	01	04	10	24	14	
R5	01	05	15	38	59	01	04	29	32	51	0	0	06	28	61	
R1	38	14	06	01	0	76	48	20	04	05	75	15	01	0	02	96-100
R2	45	36	35	22	08	04	15	09	06	05	06	09	09	02	0	
R3	16	44	32	31	15	19	34	55	60	49	16	75	73	48	25	
R4	01	0	04	09	09	0	0	06	12	06	02	01	06	26	24	
R5	0	06	22	37	69	01	04	10	17	35	0	0	10	23	49	

Appendix C. Confusion matrices based upon data obtained during the last 25 sessions of training for all birds. Shown are the percent of trials on which each response (R1 to R5) was made in the presence of each stimulus (S1 to S5). These values are based upon 400 presentations of each stimulus.

Wide-ordered birds -- confusion matrices -- last 25 sessions.

	Bird 1					Bird 2					Bird 3					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	86	06	0	0	0	68	21	0	0	0	76	14	0	0	0	76-100
R2	14	89	02	0	0	32	75	15	01	0	24	79	04	0	0	
R3	0	05	94	03	0	0	03	77	06	0	01	06	91	09	0	
R4	0	0	04	95	01	0	0	07	88	03	0	0	04	88	01	
R5	0	0	0	01	99	0	0	0	05	96	0	0	0	02	99	

Wide-unordered birds -- confusion matrices -- last 25 sessions.

	Bird 4					Bird 5					Bird 6					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	84	04	14	06	01	91	03	02	04	0	82	03	08	01	01	76-100
R2	09	73	16	0	0	03	87	12	0	0	08	82	06	0	0	
R3	05	21	62	14	01	05	08	77	10	01	10	13	82	06	01	
R4	01	0	05	77	02	0	0	06	82	01	01	01	06	92	0	
R5	0	01	04	03	96	0	01	01	04	98	0	01	03	01	98	

Moderate-ordered birds -- confusion matrices -- last 25 sessions.

	Bird 7					Bird 8					Bird 9					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	84	18	0	0	0	86	13	0	0	0	72	25	02	0	0	76-100
R2	15	67	13	01	0	14	80	03	0	01	27	60	16	02	01	
R3	01	13	72	12	01	0	07	95	05	0	01	13	62	15	03	
R4	0	01	13	75	14	0	0	02	90	05	0	01	20	73	25	
R5	0	0	01	12	85	0	0	0	05	94	0	0	0	05	94	

Moderate-unordered birds -- confusion matrices -- last 25 sessions.

	Bird 10					Bird 11					Bird 12					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	30	10	07	03	01	42	10	07	01	0	67	14	03	01	01	76-100
R2	62	75	21	01	0	50	68	15	0	0	29	57	10	01	0	
R3	07	12	48	36	03	07	19	62	16	01	04	22	68	13	03	
R4	0	02	22	42	09	01	02	14	67	15	0	01	17	71	06	
R5	01	0	01	17	86	01	0	02	16	83	0	03	02	14	90	

Narrow-ordered birds -- confusion matrices -- last 25 sessions.

	Bird 13					Bird 14					Bird 15					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	62	22	03	0	0	81	19	06	0	0	31	10	04	0	0	76-100
R2	31	41	22	06	02	17	48	20	04	0	49	42	33	11	04	
R3	07	33	46	36	18	02	28	48	21	11	20	44	50	41	18	
R4	01	04	25	45	56	0	04	18	43	26	0	03	09	29	27	
R5	0	0	03	12	24	0	0	07	31	62	0	0	04	19	50	

Narrow-unordered birds -- confusion matrices -- last 25 sessions.

	Bird 16					Bird 17					Bird 18					Sessions
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
R1	47	16	07	01	01	59	34	13	03	02	71	20	05	0	01	76-100
R2	33	34	29	22	07	09	15	09	08	04	10	17	10	04	02	
R3	19	39	37	30	15	28	42	51	50	38	16	57	60	44	25	
R4	0	03	08	08	12	01	03	06	08	08	02	03	10	19	15	
R5	01	07	18	37	64	02	06	20	30	48	0	02	14	32	57	

Appendix D. Confusion matrices for all birds for the Transposition Test. Shown are the percent of trials on which each response (R0 to R6) was made in the presence of each stimulus (S0 to S6). These values are based upon 12 presentations of S1 through S5 and 10 presentations each of S0 and S6.

Transposition Test -- confusion matrices -- wide-ordered birds

Bird 1

	S0	S1	S2	S3	S4	S5	S6
R0	10	0	0	0	0	0	0
R1	90	67	0	0	0	0	0
R2	0	33	67	0	0	0	0
R3	0	0	33	92	0	0	0
R4	0	0	0	08	100	0	0
R5	0	0	0	0	0	100	100
R6	0	0	0	0	0	0	0

Bird 2

	S0	S1	S2	S3	S4	S5	S6
R0	20	17	0	0	0	0	0
R1	50	25	08	0	0	0	0
R2	20	58	75	17	0	0	0
R3	10	0	17	83	0	0	0
R4	0	0	0	0	92	0	0
R5	0	0	0	0	08	100	90
R6	0	0	0	0	0	0	10

Bird 3

	S0	S1	S2	S3	S4	S5	S6
R0	20	0	0	0	0	0	0
R1	70	92	08	0	0	0	0
R2	10	08	83	0	0	0	0
R3	0	0	08	92	0	0	0
R4	0	0	0	08	100	0	0
R5	0	0	0	0	0	100	80
R6	0	0	0	0	0	0	20

Transposition Test -- confusion matrices -- wide-unordered birds

Bird 4

	S0	S1	S2	S3	S4	S5	S6
R0	0	08	0	0	0	0	10
R1	30	42	0	08	0	0	0
R2	50	50	100	08	0	0	0
R3	10	0	0	83	25	0	0
R4	10	0	0	0	42	0	0
R5	0	0	0	0	17	100	90
R6	0	0	0	0	17	0	0

Bird 5

	S0	S1	S2	S3	S4	S5	S6
R0	0	0	17	0	0	08	0
R1	90	75	0	0	0	0	0
R2	0	0	67	0	0	0	0
R3	0	17	17	92	50	08	0
R4	10	08	0	0	42	0	0
R5	0	0	0	0	0	83	100
R6	0	0	0	08	08	0	0

Bird 6

	S0	S1	S2	S3	S4	S5	S6
R0	0	0	08	0	0	0	0
R1	100	67	17	0	0	17	10
R2	0	08	33	0	0	0	0
R3	0	17	42	92	0	0	0
R4	0	0	0	08	83	0	0
R5	0	08	0	0	0	83	90
R6	0	0	0	0	17	0	0

Transposition Test -- confusion matrices - moderate-ordered birds

Bird 7

	S0	S1	S2	S3	S4	S5	S6
R0	0	08	0	0	0	0	0
R1	30	33	08	0	0	0	0
R2	20	50	50	0	0	0	0
R3	40	08	42	83	0	0	0
R4	10	0	0	17	92	0	0
R5	0	0	0	0	08	92	10
R6	0	0	0	0	0	08	90

Bird 8

	S0	S1	S2	S3	S4	S5	S6
R0	100	33	0	0	0	0	0
R1	0	50	08	0	0	0	0
R2	0	17	92	0	0	0	0
R3	0	0	0	100	08	0	0
R4	0	0	0	0	92	17	0
R5	0	0	0	0	0	83	90
R6	0	0	0	0	0	0	10

Bird 9

	S0	S1	S2	S3	S4	S5	S6
R0	10	0	0	0	0	0	0
R1	30	17	0	0	0	0	0
R2	50	67	58	0	0	0	0
R3	10	17	33	58	08	08	0
R4	0	0	08	42	67	33	0
R5	0	0	0	0	25	58	70
R6	0	0	0	0	0	0	30

Transposition Test -- confusion matrices -- moderate unordered birds

Bird 10

	S0	S1	S2	S3	S4	S5	S6
R0	10	08	08	0	0	0	0
R1	50	0	08	08	0	0	0
R2	20	33	58	08	0	0	0
R3	20	58	25	75	25	0	0
R4	0	0	0	0	08	0	0
R5	0	0	0	08	67	100	100
R6	0	0	0	0	0	0	0

Bird 11

	S0	S1	S2	S3	S4	S5	S6
R0	0	0	08	0	0	0	0
R1	50	25	08	08	0	0	0
R2	0	42	25	0	0	0	0
R3	40	33	50	58	0	0	10
R4	10	0	0	17	67	08	0
R5	0	0	08	17	33	92	90
R6	0	0	0	0	0	0	0

Bird 12

	S0	S1	S2	S3	S4	S5	S6
R0	0	0	0	0	0	0	0
R1	90	83	08	0	0	0	0
R2	0	08	17	0	0	0	0
R3	10	08	75	92	42	0	0
R4	0	0	0	08	50	08	0
R5	0	0	0	0	08	92	100
R6	0	0	0	0	0	0	0

Transposition Test -- confusion matrices -- narrow-ordered birds

Bird 13

	S0	S1	S2	S3	S4	S5	S6
R0	40	17	0	0	0	0	0
R1	30	0	0	0	0	0	0
R2	30	75	33	08	0	0	0
R3	0	08	42	67	50	08	0
R4	0	0	17	25	50	67	10
R5	0	0	08	0	0	25	50
R6	0	0	0	0	0	0	40

Bird 14

	S0	S1	S2	S3	S4	S5	S6
R0	80	0	0	0	0	0	0
R1	20	92	08	08	0	0	0
R2	0	08	58	33	08	0	0
R3	0	0	25	58	42	0	0
R4	0	0	08	0	33	25	0
R5	0	0	0	0	17	75	100
R6	0	0	0	0	0	0	0

Bird 15

	S0	S1	S2	S3	S4	S5	S6
R0	30	17	0	0	0	0	0
R1	10	0	0	0	0	0	0
R2	40	42	42	25	0	0	0
R3	20	42	58	58	50	25	33
R4	0	0	0	08	33	17	0
R5	0	0	0	08	08	58	33
R6	0	0	0	0	08	0	17

Transposition Test -- confusion matrices -- narrow-unordered birds

Bird 16

	S0	S1	S2	S3	S4	S5	S6
R0	50	17	08	0	0	0	0
R1	0	17	08	17	08	0	0
R2	40	42	0	08	0	0	0
R3	10	25	67	42	58	08	10
R4	0	0	0	0	0	08	60
R5	0	0	17	33	33	83	10
R6	0	0	0	0	0	0	20

Bird 17

	S0	S1	S2	S3	S4	S5	S6
R0	0	08	0	0	08	0	0
R1	60	58	42	08	08	0	0
R2	0	0	08	08	0	0	0
R3	40	33	25	50	42	42	0
R4	0	0	08	0	0	0	0
R5	0	0	08	33	42	58	100
R6	0	0	08	0	0	0	0

Bird 18

	S0	S1	S2	S3	S4	S5	S6
R0	0	0	0	0	0	0	0
R1	20	83	17	0	0	0	0
R2	30	0	17	0	08	0	0
R3	40	08	50	75	33	25	0
R4	10	0	0	08	17	17	0
R5	0	08	17	17	42	58	100
R6	0	0	0	0	0	0	0