DURATION DISCRIMINATION IN PIGEONS

DISCRIMINATION OF TWO AUDITORY DURATIONS BY PIGEONS

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SCOPE AND CONTENTS:

Auditory duration discrimination in pigeons was investigated using a procedure designed to provide a direct analogue to the conventional "yes-no" signal detection task with humans. Two experiments are reported and discussed, the scope of which include development and maintenance of the discrimination using highly confusable durations, manipulation of the values of the auditory durations, achievement of stochastic stationarity, manipulation of the probability of reinforcement and extinction of the discrimination.

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ABSTRACT

This was an investigation of auditory duration discrimination in pigeons using a discrete-trial procedure designed to provide a direct analogue to the conventional "yes-no" signal-detection tasks with humans. On each trial only one of two durations, T_1 and T_2, was presented and the pigeon was required to peck one of two keys on T_1 trials, and the other key on T_2 trials. Experiment one was concerned with developing a shaping procedure and evaluating behavior at different values of T_1 and T_2. It provided evidence that birds could develop and maintain a partial discrimination and showed that, as the separation between the two stimuli was reduced, d' was systematically decreased. In Experiment two pigeons were run for an extended period of time with T_1 and T_2 fixed and then the probability of reinforcement was reduced. Reduction of reinforcement probability produced changes in performance similar to those exhibited by humans when pay-off functions are altered. Sequential analysis indicated the only sequential effect of any size was a tendency to repeat responses in some birds. Considerable individual differences were noted.

TABLE OF CONTENTS

INTRODUCTION

The purpose of the present investigation was to develop a discrete-trial procedure for examining duration discrimination in animals, a procedure that would provide data amenable to analysis in terms of a decision-theoretic model of the type exemplified by the psychophysical theory of signal detection (this theory is developed in detail in Green and Swets, 1966). The experimental procedure presented here represents an alternative to other methods used to study duration discrimination (or the related phenomenon of temporal discrimination) in animals. In order to indicate the possible advantages of the procedure developed here, it seems best to begin by considering these other methods and the interpretational difficulties associated with them.

One procedure frequently used to investigate timing behavior in animals is referred to as the differential reinforcement of low rate (DRL). Here the organism is required to space responses (e.g. on a pigeon key, or bar) t seconds apart. If he waits t seconds then responds, he is reinforced; if he responds before t seconds elapse he must wait another t seconds. The periods between responses, the inter-response times (IRTs) generally have a unimodal or bimodal distribution with one of the modes equal to t.[1] The mode at t is usually interpreted as evidence that the animal is exhibiting timing behavior or making a temporal discrimination. In other words, it is assumed that the temporal requirement of the schedule has acquired control over the animal's behavior in the same way that an external stimulus, such as a light, acquires control in other discrimination situations.

However, it is very difficult to determine whether the discrimination is purely temporal, since many other stimulus variables are confounded with time in this schedule. For example, one factor which appears to affect the organism's IRT is the occurrence or non-occurrence of reinforcement following the preceding response. Several studies which reveal the existence of certain sequential dependencies in DRL experiments seem to provide empirical evidence of this. (Ferraro, Schoenfield and Snapper, 1965, and Weiss et al., 1966).

Another difficulty in establishing the purely temporal basis of the discrimination is the fact that the organism's own responses determine the "stimulus value" (the IRT), thus the organism controls the stimulus variable of which his behavior is said to be a function. This makes

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[1] The other mode corresponds to very small IRT's produced by occasional bursts of responses.

it difficult to interpret sequential dependencies, since there is no way independently to assess the stimulus and response events preceding a given IRT, or evaluate their separate contributions.

Reynolds (1966) employed a different experimental procedure to examine temporal discrimination. A single response key was transilluminated by either a red or blue light. While the animal was never reinforced for responses made to the red key, he could change the color to blue as soon as he made two responses during red. The blue light came on for a fixed duration before changing back to red. The critical "timing" aspect of the schedule was that the animal could only obtain reinforcement during the blue period if he had waited at least t seconds between his first and second responses in the preceding red period. If the IRT in red was t or more seconds reinforcement could be obtained during the subsequent 30 second blue period on the basis of a 1 minute variable interval schedule (VI 1).[2] If the IRT during the red was less than t seconds no reinforcement was given during the subsequent 30 second blue period.

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[2] A variable interval schedule is one in which the first response following some variable interval of time is reinforced; the one minute refers to the typical value of this interval (Ferster and Skinner, 1958).

His analysis can be interpreted as evaluating whether the organism's response probabilities were constant over time. Specifically, he considered subsets of the observed IRT values during the red period consisting of all those IRTs greater than x for values of x ranging from 0 to 21 seconds. He then calculated the proportion of IRTs in each subset which exceeded x by an amount less than y (the so-called "IRT per opportunities"). If the response generating process were similar to a Poisson process (i.e., the response probabilities were constant over time), it can be shown that these proportions should all be equal (McGill, 1963). This, in fact, seemed to be the case, indicating there was no response differentiation in the red period. However, the rate of responding in the blue period, relative to its maximum, was found to be directly related to the delay between responses during the preceding red period, increasing with increasing duration of the IRT in red. This led Reynolds to conclude, "the birds discriminated the duration of the IRTs. The duration of IRT successfully controlled the rate of pecking during the succeeding blue-key periods...." (p.67).

An alternative interpretation would be that these results simply demonstrate a response-response correlation, that is, the response rate in blue was negatively correlated with response rate in red. The presence of this correlation does not necessarily provide evidence for a causal relation between the two behaviors. It would be possible for both behaviors to be a function of a third variable.

In this case, for instance, there is a possibility of schedule interaction. The type of schedule with which a given schedule is paired is known to affect response rate; pairing a VI with other schedules has produced contrast effects on the rate in VI (Catania, 1961, and Reynolds, 1961, a, b). Specifically, Bloomfield (1967) has reported contrast effects on response rate in VI when paired with a DRL on a multiple schedule, i.e. response rate in VI increased linearly with increasing DRL requirement. This finding would support an argument that schedule interaction partly accounted for the response rate increase in blue found in the Reynolds 1966 study.

Finally, one might question whether any interaction was present between the reinforcement and response rate. While it is not made explicit, it can be deduced from the results that reinforcement was a rare event for the animals in this study. Being so, it might well produce its own effects on response rate, independent of the preceding IRT in red. The author reports that "observation showed that occurrence of the reinforcing stimulus was not a confounding discriminative stimulus." (p.66). Causal observations of this sort do not seem to provide an adequate analysis of such effects or of the more complicated sequential confounding which may be involved. Since the appropriate data were not reported by Reynolds, it seems impossible to resolve the issue in this case.

The preceding discussion illustrates the basic problem of evaluating DRL or similar types of temporal schedules. A correlation between one variable and the animal's behavior is insufficient evidence for temporal discrimination unless other variables which might furnish a basis for the differential responding are adequately controlled.

An alternative method for studying discrimination behavior has been developed and has seen extensive application in psychological experiments with humans. This method has several distinguishing features, i.e., it is a discrete-trial, non-correction, choice procedure. It allows the presentation of two or more stimulus values, one of which occurs on every trial. The experimenter, not the subject, controls the stimulus enabling its presentation on a predetermined schedule with known statistical properties independent of the observer's behavior. The subject must make a choice response after each presentation and is not allowed to correct. The importance of these methodological features to the analysis of discrimination behavior can be more clearly seen in the context of a brief discussion of detection theory. (For a more detailed account see Green and Swets, 1966).

In the typical human signal detection experiment a subject is required to identify which of two possible stimulus events occurs in each of a series of trials. The particular stimulus value presented on each trial is usually determined by an independent trials binomial process. Thus, if the two stimulus values are denoted by S_1 and S_2, the stimulus schedule can be defined by the parameter γ denoting the fixed probability of an S_1 stimulus on each trial (the probability of an S_2 stimulus simply equals $1 - \gamma$).

If the subject's report that an S_1 or S_2 stimulus was presented is denoted by A_1 or A_2 respectively his performance can then be summarized by two proportions: the proportion of A_1 responses on S_1 trials, denoted by $\hat{P}(A_1|S_1)$, and the proportion of A_1 responses on S_2 trials, denoted by $\hat{P}(A_1|S_2)$. This notation is employed since these two proportions are normally interpreted as estimates of two corresponding theoretical probabilities: $P(A_1|S_1)$ and $P(A_1|S_2)$. These probabilities are often called "hits" and "false alarms", respectively (e.g., Green and Swets, 1966). Perfect discrimination is represented by a performance in which $P(A_1|S_1)$ equals one while $P(A_1|S_2)$ equals zero, i.e. the subject always responded A_1 on S_1 trials and A_2 on S_2 trials. No discrimination is evidenced when $P(A_1|S_1)$ equals $P(A_1|S_2)$, regardless of their particular value.

The central assumption of signal detection theory is similar to that of Thurstone (1927): each presentation of a particular stimulus value (S_i) evokes a value of a hypothetical sensory variable which can be represented as a Gaussian random variable. Thus the distribution of sensory values evoked by an S_i stimulus event can be characterized by the expected value, denoted μ_i, and standard deviation, denoted σ_i, of the sensory variable associated with that stimulus. If the distributions of sensory states evoked by two stimulus values are similar the subject will have difficulty discriminating the stimuli. He will be uncertain whether the sensory value evoked on a particular trial was produced by stimulus S_1 or S_2. It is assumed that he determines his response on the basis of a decision criterion c, reporting that stimulus value with the higher expected sensory value only if the sensory value on that trial is greater than c. Specifically, if μ_1 is greater than μ_2, the subject makes an A_1 response if the sensory value is greater than c. Thus there are two separate aspects of the discrimination process: the similarity of the distribution of sensory values evoked by S_1 and S_2, and the response criterion adopted by the subject. It is usually assumed that the distributions of sensory values are a function of the physical stimulus values and the subject's "sensitivity", which is a fixed feature of his perceptual system. In contrast, the response criterion c is viewed as a relatively arbitrary feature of the perceptual process, easily modified by such things as the subject's a priori expectation that a particular stimulus value will be presented and the costs or gains ("pay-offs") associated with the possible stimulus-response combinations. The similarity of the two sensory distributions is usually characterized by two measures, d' and k, where

$$d' = \frac{\mu_1 - \mu_2}{\sigma_2} \qquad (1)$$

and

$$k = \frac{\sigma_2}{\sigma_1} \qquad (2)$$

(assuming, as was done previously, that μ_1 is greater than μ_2). Note that d' is the difference between the larger expected value, μ_1 and the smaller value, μ_2, expressed in units of the standard deviation of sensory values on S_2 trials, σ_2. The measure k is a ratio of the standard deviation of sensory values on S_2 and S_1 trials.

It can be shown that the probabilities $P(A_1|S_1)$ and $P(A_1|S_2)$ are completely determined by the values of d', k and c. However, in many applications of the model it has been found that σ_1 was approximately the same as σ_2 (i.e. k equalled 1). Thus the model simplifies to a form having only two parameters d' and c (with k equal to one by assumption). In this two-parameter form of the model, which will be employed in this paper, the value of $P(A_1|S_2)$ and $P(A_1|S_1)$ are given by the following expressions:

$$P(A_1 \Big| S_2) = \int_{c'}^{\infty} g(x')dx' \tag{3}$$

and

$$P(A_1 \Big| S_1) = \int_{c'-d'}^{\infty} g(x')dx' \tag{4}$$

where

$$x = \frac{x - \mu_2}{\sigma_2} \tag{5}$$

$$c' = \frac{c}{\sigma_2} \tag{6}$$

and g(x') is a Gaussian normal distribution. Thus the response probabilities, $P(A_1|S_1)$ are completely specified by the parameters d' and c'.

The most important feature of the model is that it is possible to obtain separate estimates of d' and c' from the observed proportions $P(A_1|S_1)$ and $P(A_1|S_2)$. Specifically, if $Z(A_1|S_i)$ denotes that value of a normal deviate which is exceeded with probability $P(A_1|S_i)$ it follows from Eqs. 3 and 4 that

$$d' = Z(A_1|S_2) - Z(A_1|S_1) \tag{7}$$

and

$$c' = Z(A_1|S_2) \tag{8}$$

To obtain estimates of $Z(A_1|S_i)$ denoted $\hat{Z}(A_1|S_i)$, one finds that value of a normal deviate exceeded with a probability equal to $\hat{P}(A_1|S_1)$. Estimates of d' and c' can then be obtained by appropriate substitution in Eqs. 7 and 8.

$$\hat{d}' = \hat{Z}(A_1|S_2) - \hat{Z}(A_1|S_1) \qquad (9)$$

$$\hat{c}' = \hat{Z}(A_1|S_2) \qquad (10)$$

These equations follow from the definition of $Z(A_1|S_1)$ as equal to c' minus d' and $Z(A_1|S_2)$ as equal to c'.

Data in these experiments are often reported in the form of ROC curves. To derive these, response frequencies are entered in a matrix, in which rows are possible stimulus events, and columns possible response types, in this case a 2 x 2 matrix. When cell entries in each row are normalized, i.e. divided by row totals, it is only necessary to have one entry for each row in order to know the whole matrix, i.e. the two conditional probabilities $P(A_1|S_1)$ and $P(A_1|S_2)$. If these two values are plotted in a 2-dimensional graph, it is possible to represent all the information in the matrix with a single point. Note that a point falling in the extreme upper left of the graph indicates perfect discrimination, while points falling on the positive diagonal reflect no discrimination, and intermediate points indicate intermediate levels of partial discrimination.

As the subject's criterion is systematically varied, the curve that results is called an ROC curve, the receiveroperating characteristic which, according to detection theory, should be symmetric about the negative diagonal (under the "equal variance" assumption), and pass through the points 0, 0 and 1, 1. The area lying under the curve can be used as an index of the discrimination. (Green and Swets, 1966).

If the normal deviates $\hat{Z}(A_1|S_1)$ and $\hat{Z}(A_1|S_2)$ are used instead of $\hat{P}(A_1|S_1)$ and $\hat{P}(A_1|S_2)$, the resulting normalized ROC curve should be a straight line with a slope of one.

Several recent studies have demonstrated the fruitfulness of a decision-theoretic approach in discrimination studies with animals. Experiments have been reported in which light intensity (Nevin, 1964; Morrison, 1967, and Keuchler, 1968), tone (Hack, 1963), and gustatory substances (Morrison and Norrison, 1966) have been used as stimuli. All experiments involved a "yes-no" procedure (see Green and Swets, 1966, for a discussion of yes-no and forced-choice tasks). In the Nevin experiment, which used rats, a response to one lever produced either a brief increment in illumination of the chamber or no increment. A press to a second lever was rewarded only if an increment had occurred. Responses in the absence of an increment were not reinforced. (This type of procedure shall be here referred to as a respond/no-respond task.) Probability of reinforcement for a press during the increasing illumination was 1, .5 or .2. Results showed a tendency for hits and false-alarms to vary together and to be positively correlated with reinforcement probability.

In Morrison's experiment (1967) a glass plate mounted on one wall was either illuminated or remained dark whenever the subjects (rats) pressed a lever mounted below it. Following the stimulus a choice response was made to one of two levers mounted on the opposite wall. If the left lever were pressed when the key stayed dark, or the right lever pressed when the key was illuminated, a reinforcement was given. Incorrect responses were not reinforced and simply produced an inter-trial-interval. Stimulus intensity and probability of reinforcement were both manipulated. When reinforcement probability was varied, response tendencies were found to change in an orderly fashion. When normalized hit and false alarm probabilities at particular intensities were plotted on an ROC graph the points for different pay-off (reinforcement) values were reasonably well-fit by straight lines, although the slopes tended to be less than one.

Keuchler's (1968) experiment was conducted with pigeons and involved an examination of three major independent variables: signal intensity, a-priori probability of signal presentation, and amount of reinforcement. On some trials a center key of three keys was incremented a small amount in brightness; the pigeon indicated by a choice response whether or not an increment had occurred, a peck to the right or left, respectively. Five pigeons were given 9 different schedules of a-priori probability of presentation. Hits and false alarms plotted separately for each bird traced out a straight line with a slope not differing from unity for four of the five birds. Two birds were then given five different conditions of pay-off values for correct responses. Again the hits and false alarms generated by the five conditions tended to fall along a straight line with a slope of one. Raising signal intensity seemed to displace the performances to a different ROC curve consistent with better discrimination.

Hack (1963) required rats to detect the presence of a tone which appeared or did not appear according to an a-priori probability which varied from .14 to .75 in a respond/no respond task. For a given intensity hits and false alarms varied along a straight line. As sound pressure level was increased the points were displaced toward the upper left of the ROC space, however they were not always fit by a line with a slope of unity.

Morrison and Norrison (1966) explored taste discrimination in rats using a choice procedure in which subjects were required to discriminate between different strength solutions of either sodium chloride, sucrose, tartaric acid or quinine and water. In general, the authors found that, as solution intensity was reduced, hits decreased, while false alarms increased, and d' systematically decreased.

Taken together these experiments are consistent with signal detection theory as a model of discrimination in animals for a variety of stimuli. Changes in signal intensity raised or lowered the ROC curve, or estimates of d', in conformity with the model. (Morrison, 1967; Keuchler, 1968; Hack, 1963; Morrison and Norrison, 1966). Operations defined by the theory as having non-sensory effects, such as manipulating signal presentation (Keuchler, 1968; Hack, 1963) or the probability of reinforcement (Nevin, 1964; Morrison, 1967; Keuchler, 1968) were shown to generate performance points that could be reasonably well fit by straight lines, although the slopes did not always conform to unity (i.e. the "equal variance" assumption did not always seem appropriate).

The first investigation to apply a decision-theoretic approach to duration discrimination was a study by Creelman (1962) with human observers. Creelman's model was based on a counting mechanism and was used to account for performance in a two-interval, forced-choice procedure in which brief (around one second) auditory durations were presented. It provided a good fit to the data over a wide range of conditions.

The only attempts to analyze duration discrimination in animals in a form amenable to analysis by this model (or the signal detection model to which it is related) is that represented in this paper and in another paper by Stubbs (1968). Stubbs used a discrete trial procedure in which a piegeon was presented with one of ten possible durations on each trial and required to make a choice response, i.e. respond to one key color when a short duration tone occurred, and another key color given a long duration tone, a method similar to the traditional psychophysical method of single stimuli (Guilford, 1954). The cut-off between short and long durations was always at the midpoint of the series presented. Of relevance here is the phase of the experiment in which pay-off values for both correct and incorrect responses were varied. Response frequencies were observed to vary in a fashion consistent with the pay-off structure. The investigation was not carried out as a test of the signal-detection model, neverthless, estimates of d' were recovered from the data after a method suggested by Triesman (1966) and found to remain constant for at least some of the conditions in which the bias changed. This would seem to provide evidence that duration discrimination in animals does behave in a fashion similar to that predicted by a decision-theory model. However, Stubbs employed more than two stimuli in his discrimination task which distinguishes it from the more conventional 2-stimulus detection problem. The experiments we shall now consider did employ just 2 stimuli and were designed to provide a direct analogue to the conventional detection task.

EXPERIMENTS

We shall consider some experiments in which pigeons were required to discriminate between two durations of a clearly audible tone stimulus on each of a series of trials. Each trial began with the illumination of a "set-up" key which the pigeon must peck to initiate the presentation of the tone stimulus. The tone remained on with equal probability for either T_1 or T_2 seconds, following which, two other keys, one on each side of the set-up key, were illuminated. In order to obtain food reinforcements the pigeon had to peck one of these keys on T_1 trials and the other on T_2 trials. We shall refer to the response which is reinforced on T_1 trials as an R_1 response, and that on T_2 trials as an R_2 response. The animal's performance on this task will be summarized by the proportion of R_2 responses on T_1 trials and the proportion of R_2 responses on T_2 trials, denoted by $\hat{p}_1$ and $\hat{p}_2$, respectively. (This notation is employed since these properties will be interpreted as estimates of corresponding theoretical probabilities denoted by p_1 and p_2). Thus $\hat{p}_2$ and $\hat{p}_1$ correspond to the type of "hit" and "false alarm" measures derived in signal detection analysis and discussed earlier in this paper. Two other estimates shall also be used to characterize performance, $\hat{p}_c$ and $\hat{p}_L$,

where $\hat{p}_c = P(\text{correct}) = (1 - \gamma)P(R_1|T_1) + \gamma P(R_2|T_2)$

and $\hat{p}_L = P(R_2) = (1 - \gamma)P(R_2|T_1) + \gamma P(R_2|T_2)$.

The experimental work consisted of two main experiments. Experiment one was concerned primarily with the problem of shaping the discrimination, particularly when the two temporal durations were so similar that the discrimination was less than perfect. Values of T_1 and T_2 were determined which would produce a terminal level of performance where the animal was correct on about 65 per cent of the trials. Experiment two was designed to evaluate the stability of the animals' performance during extended training at this level of partial discrimination and, secondly, to evaluate the effects of altering the probability of reinforcement following a correct response. The latter manipulation could be considered as being analogous to altering the pay-off function in signal detection experiments and thereby altering the observer's criterion.

Experiment One

This experiment involved the gradual shaping of 8 pigeons to perform the type of temporal discrimination which was just described. Since this experiment was designed primarily to lead to the more extensive second experiment, only its most important features will be discussed here.[3]

Apparatus

The animals were tested in a standard, two-key testing chamber (Lehigh Valley Electronics, Model 1519) modified by the addition of a third key, center-mounted 3.5 inches above the food hopper. Each key could be illuminated from behind by a white bulb. The sequence of stimulus events in the test chambers was controlled from a room next to that containing the test chambers. White noise and a 1000 Hz tone were produced by a Grason-Stadler noise generator and Hewlett-Packard audio-oscillator. These audio stimuli were presented in the experimental chamber by a speaker located on the lower left hand corner of the chamber wall which con-

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[3] A more detailed discussion of Experiment 1 is presented in Appendix A.

tained the keys and food hopper. The intensity of the tone and noise stimuli measured in a closed chamber by a General Radio Type 1551-C sound level meter placed directly in front of the center key was 80 db ± 10 db.

Accuracy of the temporal durations used in the study were limited by the relay control equipment but were accurate to ± .5 percent (i.e., to ± 25 ms of the final T_1 and T_2 values used in Experiment 1).

Trial data were recorded on Sodeco print-out counters and digital counters. They were then punched into IBM cards and analyzed by a Control Data Corporation 6400 computer.

Subjects

Subjects were eight white Carneaux pigeons, approximately five years of age and experimentally naive. All were originally thought to be male, but subsequent to the experiment one bird, subject No. 3, was found to be female. Only the results for the seven male birds will be discussed here.[4]

Procedure

The shaping process whereby the animals were trained to operate the set-up key to produce the tone stimulus, and

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[4] Results of the female are included in Appendix A.

then to peck one of the two side keys, consisted of five steps.

Step one - terminal link of the chain. Magazine training was followed by first shaping a key approach to a lighted key, then a key peck to the lighted key. On each trial either the right or left key could be transilluminated with a white light according to a random schedule in which each key had an *a priori* probability of .5 of being selected. A peck to the lighted key darkened the key and produced food for 4 seconds. A peck to an unlighted key had no effect. The inter-trial interval (ITI) was 5 seconds.

Step two - link two of the chain. After termination of the ITI the trial began with a one second tone followed by either right or left key light. A single peck to the lighted key darkened it and produced reinforcement. A peck to an unlighted key, including key pecks while the tone was on, had no effect. Reinforcement was decreased to 3 sec. access to grain and the ITI was increased to 15 seconds (in Experiment 2 it was increased to an interval which varied randomly in half-second intervals from 10 to 20 seconds). A response during the ITI delayed the start of the next trial for 15 seconds.

Step three - link one of the chain. The center key was transilluminated with a white light at the beginning of the trial. A single peck was required to turn the light off and produce link 2, the tone, for 1 second, at the termination of which either right or left key light came on. The same key peck contingencies as before were in effect in links 2 and 3. Pecks to the unlighted side keys in link 1 had no effect.

Step four - differentiating T_1 and T_2. The time during which the tone was on in the 2nd link was differentiated into two durations, a short duration, T_1, equal to 1 sec., and a long duration, T_2, which was gradually increased to 5 sec. over the session. Presentation of T_1 and T_2 was according to a random schedule in which each had an *a priori* probability of occurrence of .5.

During this phase of the experiment T_1 was always followed by the left key light, T_2 was followed by the right key light. (In Experiment 2, the above contingency was in effect for a random half of the subjects; for the other half it was reversed.) Pecks to the appropriate key following a T_1 and T_2 were designated R_1 a d R_2 respectively. Only an R_1 following a T_1, or an R_2 following a T_2, were reinforced. An R_1 given a T_2, or an R_2 given a T_1, had no effect.

Step five - brightness fading. At the termination of the tone, i.e., T_1 or T_2, both right and left key lights were transilluminated. However, brightness on the incorrect key was initially very dim. It was gradually increased to full brightness over five sessions. This technique was adapted following results obtained in the studies by Terrace (1966) on the formation of errorless discrimination.

Incorrect responses, i.e., R_2 T_1 or R_1 T_2, now had the effect of terminating the trial and producing the ITI. Correct responses were reinforced as before.

After this step key light brightness no longer functioned as a cue for the correct response and shaping was completed. The only stimulus correlated with a reinforced outcome was the auditory duration. A choice response was now required in the terminal link.

Following this shaping procedure the animals were presented with the following sequence of events during each discrimination trial: (1) the trial began with the center of the three response keys being lighted and the other two dark; (2) a single peck on the center key turned it off and turned on a 1000 Hz tone which stayed on for either T_1 or T_2 seconds; (3) when the tone went off both of the two side response keys were lighted simultaneously; (4) a single peck on either key turned the key lights off; (5) if the animal had pecked the R_i key and the tone duration was T_i ($i = 1, 2$) it received a food reinforcement followed by an inter trial interval (ITI), otherwise only the ITI occurred.

The R_1 and R_2 response keys were always the left and right keys, respectively, in this experiment (although this was varied in Experiment Two). Reinforcement was 3 seconds access to grain with the food hopper light on during that time. White noise was on continuously except during the tone period. The ITI was 20 seconds during which the chamber was illuminated by a "house light". If the animal pecked the key during the ITI it delayed the onset of the next trial by 20 seconds.

The sequence of T values was determined in blocks of 20 trials to approximate an independent trials Bernoulli process with T_1 and T_2 occurring with equal probability on each trial (both T values occurred equally often in each block of 20 trials but in a randomly determined sequence).

Experimental sessions were given daily, with each session lasting until 90 reinforcements had been obtained. Animals were kept at 80 percent normal (*ad libidum* feeding) body weight. If an animal was overweight prior to an experimental session he was not run that day, and if he was underweight he was fed upon return to his cage.

Following the shaping process the animals were given several sessions in which they were required to discriminate a T_1 equal 2 second and T_2 equal 5 second pair of tone durations. They were then required to make a more difficult discrimination by successively increasing the value of T_1 from 2 to 4 seconds in gradual stages while T_2 was fixed at 5 seconds. The number of sessions spent at each particular pair of T values is summarized in Table 1. Note that one

TABLE 1

Procedure for Experiment One.

TABLE 1

EXPERIMENT ONE

PROCEDURE	GROUP 1 SESSIONS	GROUP 1 TOTAL NO. SESSIONS	GROUP 2 SESSIONS	GROUP 2 TOTAL NO. SESSIONS
1. Shaping	1 - 15	15	1 - 15	15
2. T_1 = 2 Sec.	16 - 30	15	16 - 30	15
3. Transition to T_1 = 3 Sec.	31 - 33	3	31 - 33	3
4. T_1 = 3 Sec.	34 - 53	20	34 - 38	5
5. Fading	54 - 56	3		
6. T_1 = 3 Sec.	57 - 66	10		
7. Transition and Fading	67 - 69	3	39 - 41	3
8. T_1 = 4 Sec.	70 - 79	10	42 - 51	10

group of animals, Group 1, was run for 79 sessions, while another group, Group 2, was only run for 51. The basic difference between these two groups was the extended training of Group 1 with T_1 equal to 3 seconds (30 sessions) before moving to the T_1 equal to 4 seconds condition, as compared to the few sessions (5) with T_1 equal to 3 seconds for Group 2.

The periods of training identified as "fading" in Table 1 involved "brightness fading", that is, lighting only the correct response key, or "temporal fading", that is, producing gradual increments in T_1; These fading techniques were used to facilitate adjustment to the shifts in T values and were administered in random fashion to the birds in each group. Since the two types of fading procedure produced essentially equivalent behavior they will not be further dealt with in this section.[5]

Results

The observed values of $\hat{p}_1$ and $\hat{p}_2$ for each animal at each value of T_1 (2, 3 and 4 sec) are presented graphically in Fig. 1. Figure 1A presents these pairs of proportions for the T_1 equal 2 second condition with each animal's

---

[5] The reader is referred to Appendix A for further details of this "fading" procedure.

FIGURE 1

Estimates of p_1 and p_2 based on five sessions with T_2 equal to 5 seconds and T_1 equal to: A, 2 sec.; B, 3 sec.; and C, 4 sec.

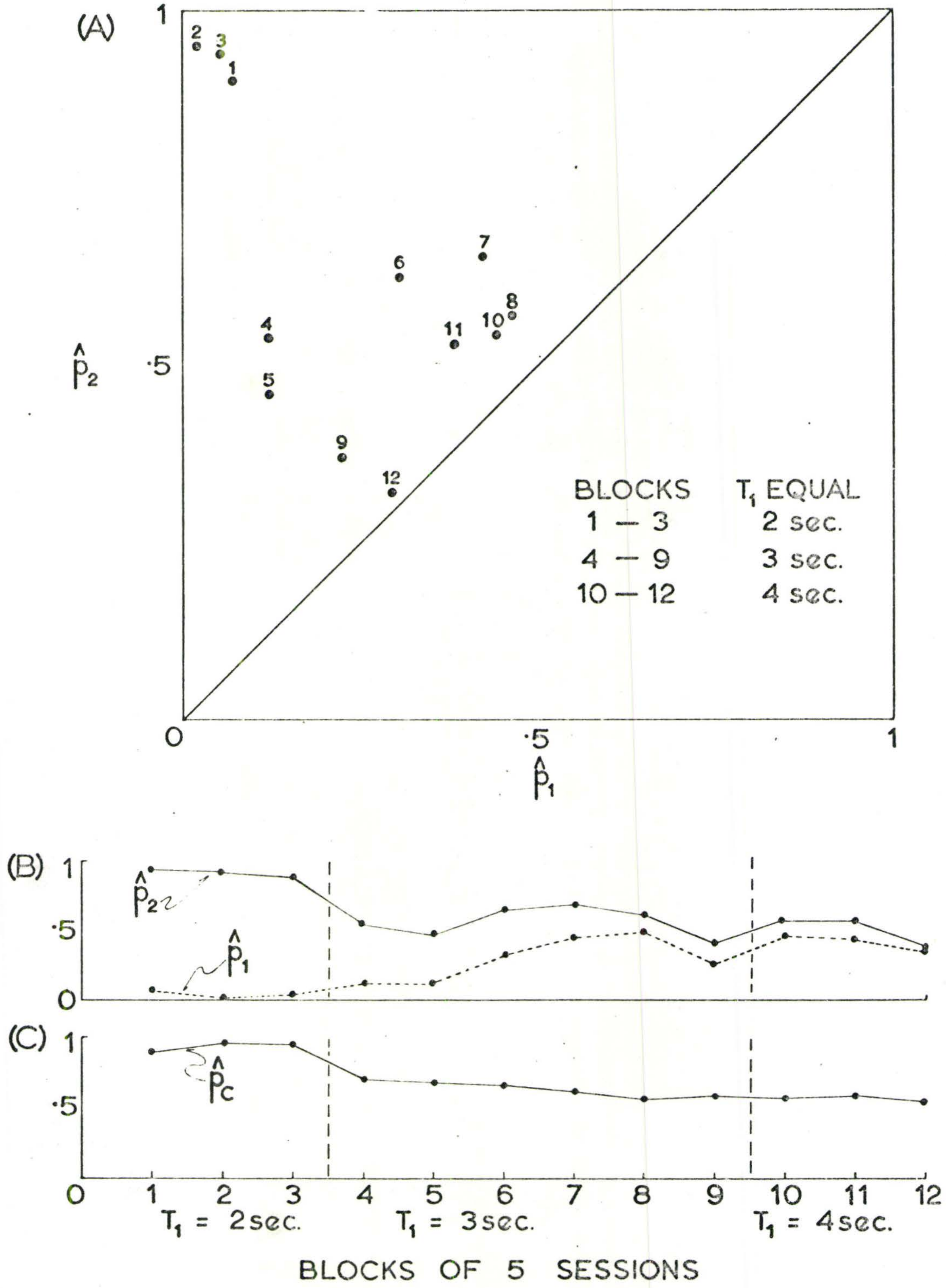
(A)
1
·5
0
·5
1
$\hat{p}_2$
$\hat{p}_1$
2
3
1
4
5
6
7
8
9
10
11
12
BLOCKS
1 — 3
4 — 9
10 — 12
T_1 EQUAL
2 sec.
3 sec.
4 sec.
(B)
1
·5
0
$\hat{p}_2$
$\hat{p}_1$
(C)
1
·5
$\hat{p}_c$
0
1
2
3
4
5
6
7
8
9
10
11
12
T_1 = 2sec.
T_1 = 3sec.
T_1 = 4sec.
BLOCKS OF 5 SESSIONS

FIGURE 1

performance defining a point ($\hat{p}_2$, $\hat{p}_1$) in a two-dimensional coordinate system. Similar graphs of the data for the T_1 equal 3 and 4 second conditions are presented in Figures 1B and 1C, respectively. Each point represents the pooled data from 5 sessions at each T_1 value, which corresponds to more than 450 trials for each data point. Data for the last 5 sessions are shown except for the T_1 equal 3 sec. condition, where data from the first 5 sessions of each group are shown. It is clear from simple visual inspection that the performance points were successively displaced away from the upper left hand corner of the graph toward the line $\hat{p}_1$ equal $\hat{p}_2$ as T_1 was made more similar to T_2, i.e., discrimination became poorer. This successive drop in proportion of correct responses was consistent for all 7 animals and is thus statistically significant, $p < .01$ (see Table 1 in Appendix A).

Another representation of these data is presented in Fig. 2 where $\hat{p}_1$ and $\hat{p}_2$, based on consecutive blocks of 5 sessions for each animal, are plotted for the entire experiment. The points where T_1 was reduced are indicated by vertical dashed lines. Again it is clear that the difference between $\hat{p}_2$ and $\hat{p}_1$ was progressively diminished as T_1 was increased.

To some extent the convergence of these two functions immediately after a change in T_1 was temporary and further sessions tended to improve performance, e.g., the data for

T_1 equal to 2 sec. and for Group 1, T_1 equal to 3 sec.

When T_1 was increased to its final value of 4 sec. there was only a difference of 1 second between T_1 and T_2. A group difference appears in this part of Fig. 2, as well as in Fig. 1C. Group 1 appeared to be discriminating better than Group 2. The mean $\hat{p}_C$ for the 2nd block of sessions was .644 for Group 1 and .562 for Group 2.

Discussion

The results in Fig. 1A, B and C suggest that the pigeons behaved in a fashion similar to humans in analogous psychophysical tasks. The shift in performance points toward the positive diagonal in Fig. 1 is consistent with an experimental manipulation decreasing the stimulus difference (making discrimination more difficult) in a conventional signal detection task. Furthermore, the substantial individual differences that existed among the birds within a group, make the use of group data highly questionable.

It is of special interest to note that the birds were able to maintain a partial discrimination over an extended series of trials instead of fixating on one response and accepting a simple random ratio reinforcement schedule of .5. For example, the overall mean $\hat{p}_C$ at T_1 equal to 4 seconds and T_2 equal to 5 seconds was .599. Some of the birds were performing only slightly better than chance,

FIGURE 2

Estimates of p_1 and p_2 in consecutive blocks of five sessions throughout Experiment One for Group 1 and Group 2.

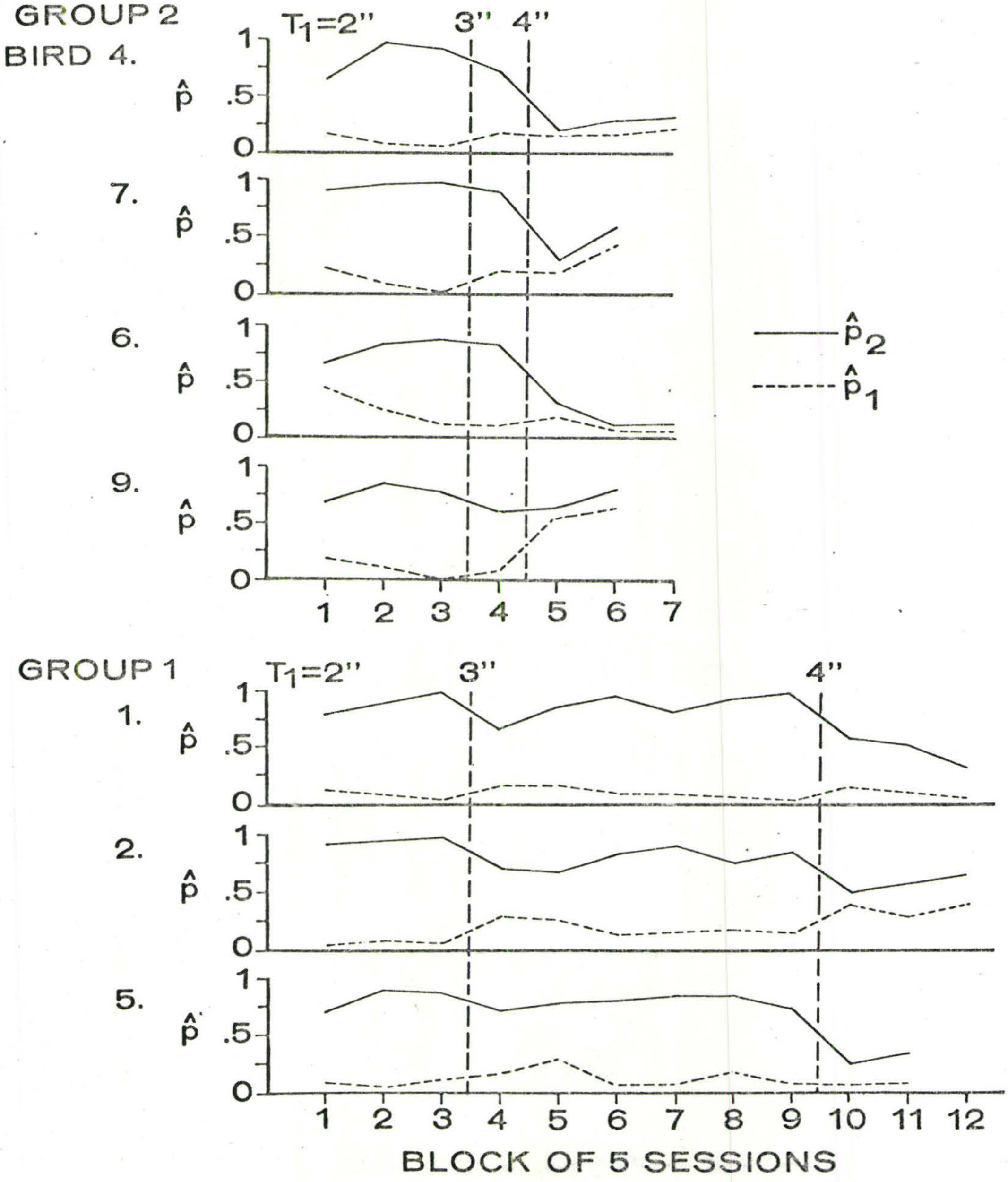
GROUP 2
BIRD 4.
7.
6.
9.
GROUP 1
1.
2.
5.
T_1=2"
3"
4"
$\hat{p}$
1
.5
0
1 2 3 4 5 6 7
1 2 3 4 5 6 7 8 9 10 11 12
BLOCK OF 5 SESSIONS
$\hat{p}_2$
$\hat{p}_1$

FIGURE 2

Experiment Two

On the basis of the results obtained in Experiment One, a second experiment was conducted to further explore the characteristics of the duration discrimination task. This experiment consisted of preliminary shaping of the temporal discrimination followed by four phases: phase one involved shaping and development of a partial discrimination; phase two involved extended training with fixed T values to determine whether the performance approximated a stationary stochastic process; phase three involved altering the reinforcement schedules (introducing a partial reinforcement schedule for some birds); and finally, phase four involved several sessions of extinction training.

Apparatus

The apparatus was the same as that employed in Experiment One except that two chambers and their associated control equipment were employed.

Subjects

The subjects were 16 males, white Carneaux pigeons, experimentally naive, ranging from 5 to 9 years of age at the start of the experiment, and varying in weight from 438 to 496 grams.

Procedure

The trial structure of this experiment was basically the same as in Experiment One except for a few minor modifications. The ITI varied randomly from trial to trial between the range of 10 to 20 seconds and was reset to 15 seconds whenever a response was made before it had elapsed. The birds were maintained at 80 per cent *ad libidum* weight throughout the experiment. All food was obtained in daily experimental sessions during 5 days of the week, providing body weight was 80 per cent ± 10 grams *ad lib* feeding weight. Subjects were fed in their home cages during the weekends.

Preliminary shaping. The same shaping procedure employed in Experiment One was again utilized to develop the original temporal discrimination. The five steps of shaping were in effect for the following periods: step one, 90 reinforcements after the first peck; step two, 45 reinforcements; step 4, 90 reinforcements; step 5, five sessions.[6]

Phase one. During this phase the difference between T_1 and T_2 was gradually reduced to a level where the animals

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[6] An auto shaping procedure was used for some of the subjects in Experiment 2 during step 1 of shaping. See Appendix B for details.

would maintain a steady partial discrimination with about 65 per cent correct responses. The results of Experiment One indicated that this type of performance could be expected if T_1 was 4 seconds and T_2 was 5 seconds. Accordingly, during Phase 1 of this experiment T_2 was fixed at 5 seconds while T_1 was successively increased from an initial value of 1 second to a final value of 4 seconds. While each animal went through precisely the same sequence of T_1 values, the number of sessions it spent at each value depended on how quickly discrimination stabilized following each change. This was determined subjectively by visual inspection of the bird's performance. The object of this procedure was to give the birds some opportunity to adjust to each new value of T_1 before further increasing the difficulty of the discrimination. The sequence of T_1 values for all birds was as follows: 1, 2, 2.5, 3, 3.25, 3.5 and 4 seconds. The specific number of sessions at each value for each animal beginning at T_1 equal to 2 sec. is indicated in Figure 3. After T_1 had assumed its final value of 4 sec. for 10 to 12 sessions the reinforcement was decreased to 2 seconds access to grain to prevent the weight gain which had begun to occur with 90 daily 3 second reinforcements.

Phase two. Sessions with T_1 equal to 4 sec. and with reinforcement equal to 2 sec. continued until behavior satisfied a criterion of stochastic stationarity. This was assessed for each bird by a Chi-Square test for stationarity over the last 12 sessions (Suppes and Atkinson, 1960, p.56). Under the null hypothesis, $P(R_2|T_1)$ for the first 6 sessions is assumed not to differ from $P(R_2|T_1)$ for the last 6 sessions; thus, the best predicted value of these probabilities is taken to be the mean $P(R_2|T_1)$ over all 12 sessions. A χ^2 with $P > .01$ was defined as indicating no difference and was considered to indicate stationarity between the first and last half. Since "stationarity" was behavior-dependent the number of sessions each subject was given during this phase varied, ranging between 18 and 41 sessions.

Phase three. In this phase the probability of reinforcement was altered. It will be convenient to designate the probability of reinforcement for correct response $R_i|T_i$ as π_i, where i can take two values, either 1 or 2. The probability of reinforcement for an incorrect response was always zero.

The 16 birds were randomly divided into four groups of four birds each, with the following values of π_i:

<u>Group 1</u>	π_1	π_2
1	.7	.7
2	.7	1.0
3	1.0	.7
4	1.0	1.0

Binomial sequences in which π was .7 determined the presentation schedule of reinforcement.

Note that the condition in Group 4 constituted no change from the prevailing condition in phase 2. For Group 1, the probability of reinforcement was equally reduced for both types of correct response. For both these groups the reinforcement probability was symmetrical over the possible correct responses. For Groups 2 and 3, however, π_1 was asymmetrically distributed over response outcomes.

The birds were given a minimum of 24 sessions; additional sessions were presented until response frequencies over the final 12 sessions satisfied the stationarity criterion used for phase 2. The number of sessions required for stationarity varied from 24 to 44.

Phase four. After achieving stationarity in phase 3, subjects were given 5 one-hour extinction sessions on consecutive days.

Results

Figure 3 shows the estimates p_1 and p_2 for single sessions throughout Experiment Two.[7] Solid vertical lines demarcate the separate phases and dotted vertical lines

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[7] These estimates of p_1 and p_2 are given in Appendix C along with estimates of p_C and p_L.

indicate the point at which T_1 increased for each bird.

The results are discussed separately for each phase of the experiment. Unless indicated all other statistics reported for phases 2 and 3 were obtained by pooling all trials of the final 12 sessions of each phase.

Phase one. The major feature of the phase one data in Fig. 3 is obvious by inspection: the accuracy of discrimination gradually diminished as T_1 was increased, with some evidence of improvement with practice following each change. Further comments on these data will be made later in the discussion section.

Phase two. After the stationarity criterion had been met, with T_1 equal to 4 sec. and T_2 equal to 5 sec. the probability estimates, p_1, p_2, p_C and p_L, were derived for each bird.[8] A general picture of the wide range in performance that was observed in this sample of birds can be obtained from Figure 4 which shows $\hat{p}_1$ and $\hat{p}_2$ of each of the birds in an ROC graph. The mean $\hat{p}_C$ over all birds was .659 and the mean $\hat{p}_L$ was .519, however, in view of the clear individual differences these means should be interpreted with caution.

Phase two: sequential analysis. A particular interest of the present experiment was to obtain detailed

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[8] Means for the final 12 sessions of phase 2 are shown for $\hat{p}_1$, p_2, $\hat{p}_C$ and $\hat{p}_L$ in Appendix D.

Figure 3

Estimates of p_1 and p_2 for single sessions throughout Experiment Two.

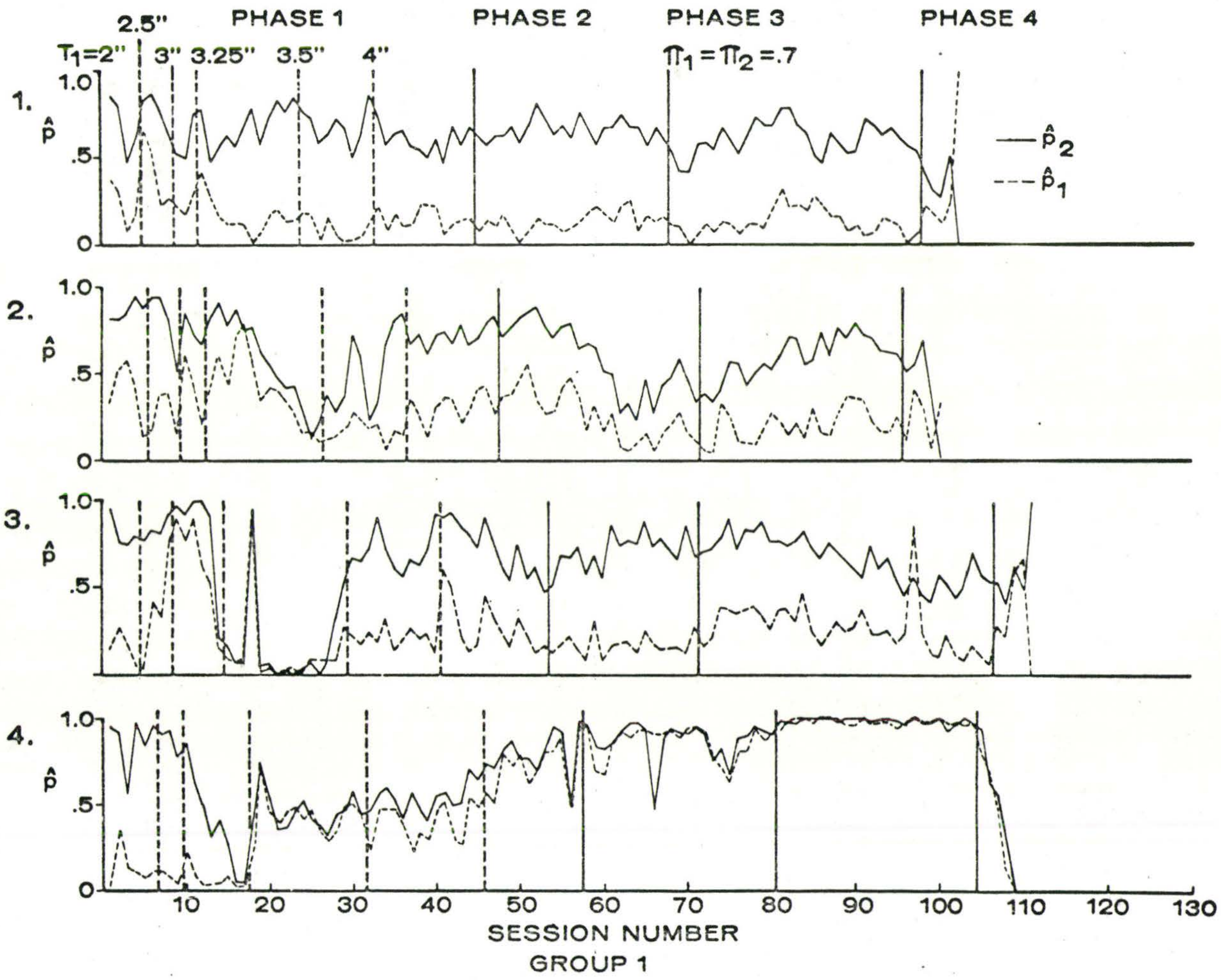
2.5"
PHASE 1
PHASE 2
PHASE 3
PHASE 4
T1=2"
3"
3.25"
3.5"
4"
Π1 = Π2 = .7
1.
2.
3.
4.
p̂
1.0
.5
0
p̂2
p̂1
10
20
30
40
50
60
70
80
90
100
110
120
130
SESSION NUMBER
GROUP 1

FIGURE 3

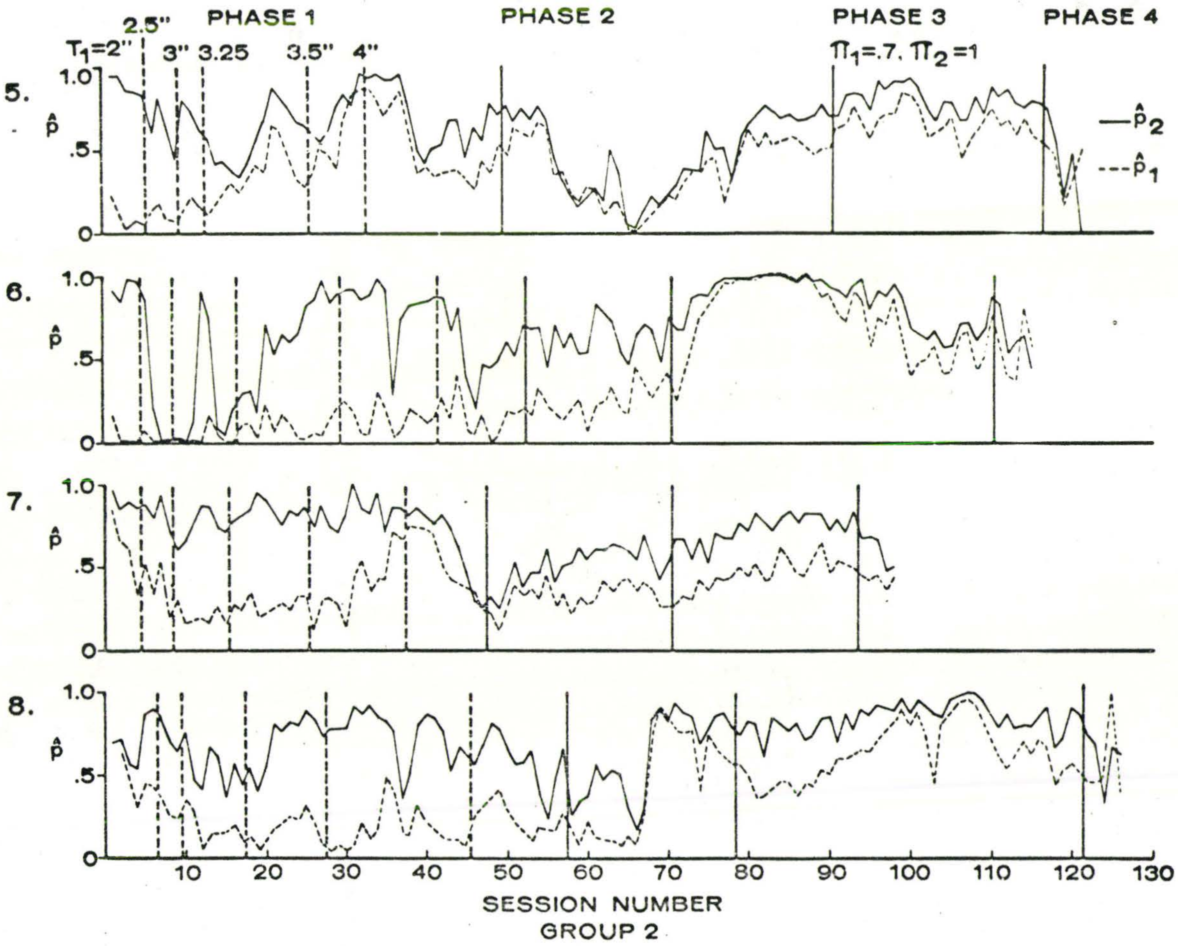
PHASE 1
PHASE 2
PHASE 3
PHASE 4
2.5"
T1=2"
3"
3.25
3.5"
4"
π1=.7, π2=1
5.
6.
7.
8.
p̂
1.0
.5
0
—p̂2
---p̂1
10
20
30
40
50
60
70
80
90
100
110
120
130
SESSION NUMBER
GROUP 2

FIGURE 3

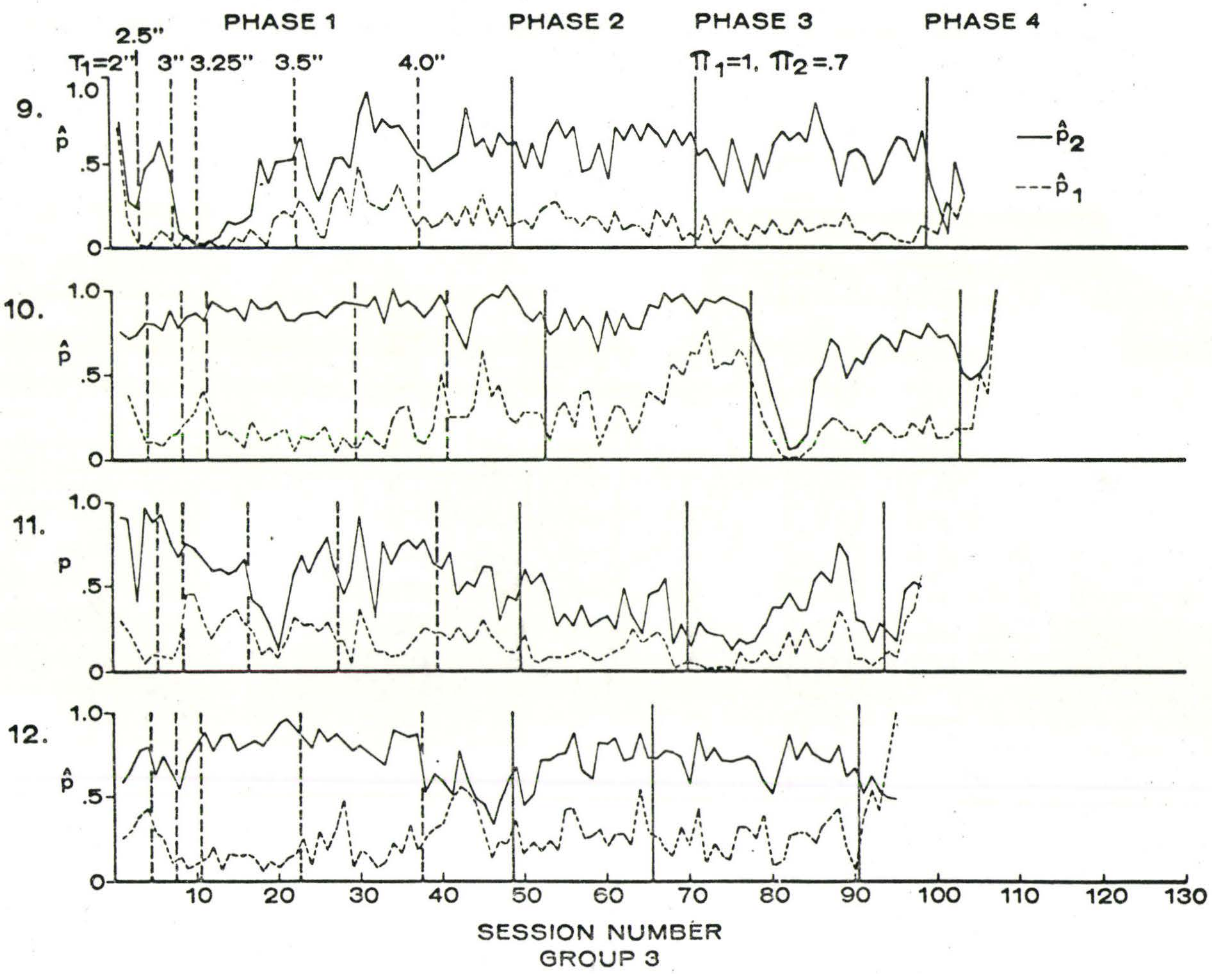
PHASE 1
PHASE 2
PHASE 3
PHASE 4
2.5"
T1=2"
3"
3.25"
3.5"
4.0"
π1=1, π2=.7
9.
10.
11.
12.
p̂
1.0
.5
0
—p̂2
---p̂1
10
20
30
40
50
60
70
80
90
100
110
120
130
SESSION NUMBER
GROUP 3

FIGURE 3

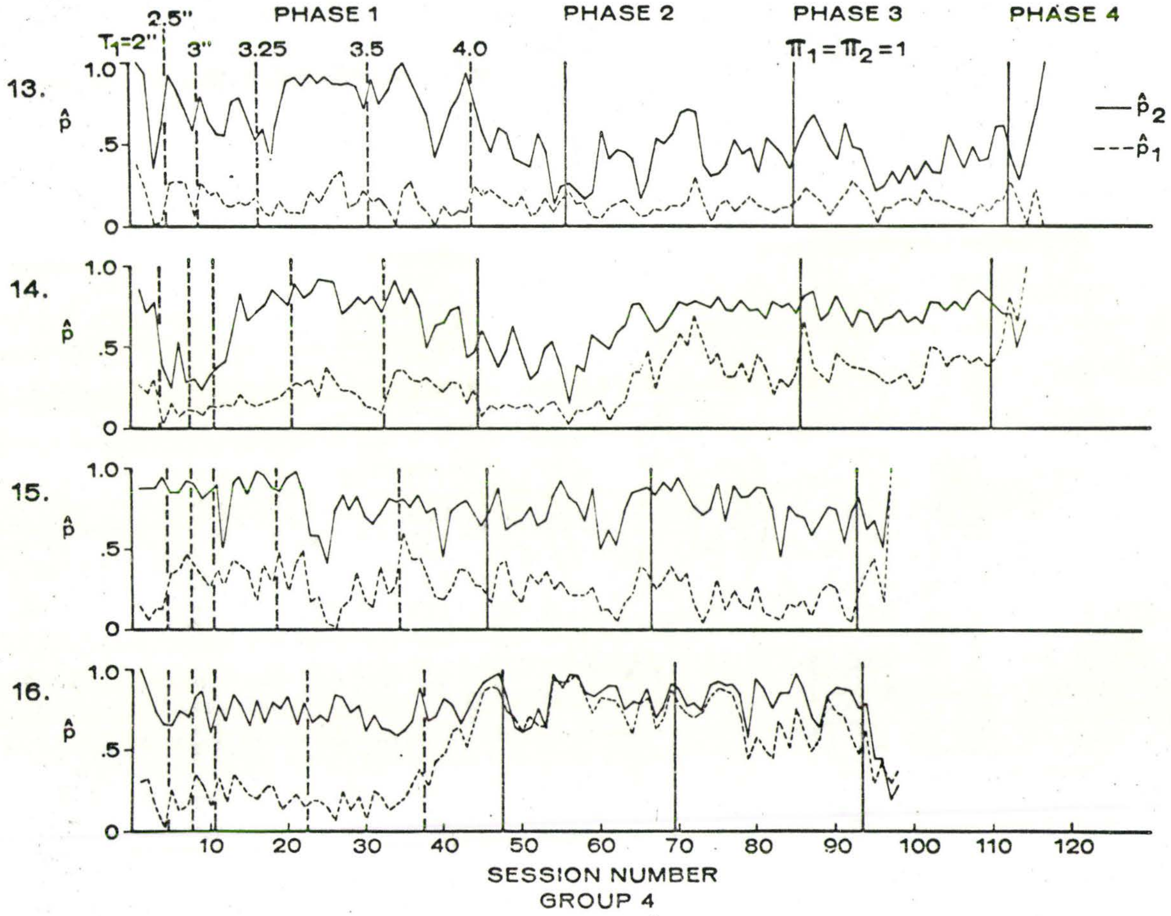
PHASE 1
PHASE 2
PHASE 3
PHASE 4
$T_1=2''$
2.5"
3"
3.25
3.5
4.0
$\pi_1=\pi_2=1$
13.
14.
15.
16.
$\hat{p}$
1.0
.5
0
$\hat{p}_2$
$\hat{p}_1$
10
20
30
40
50
60
70
80
90
100
110
120
SESSION NUMBER
GROUP 4

FIGURE 3

FIGURE 4

ROC graph showing estimates of p_1 and p_2 for all 16 birds in phase 2.

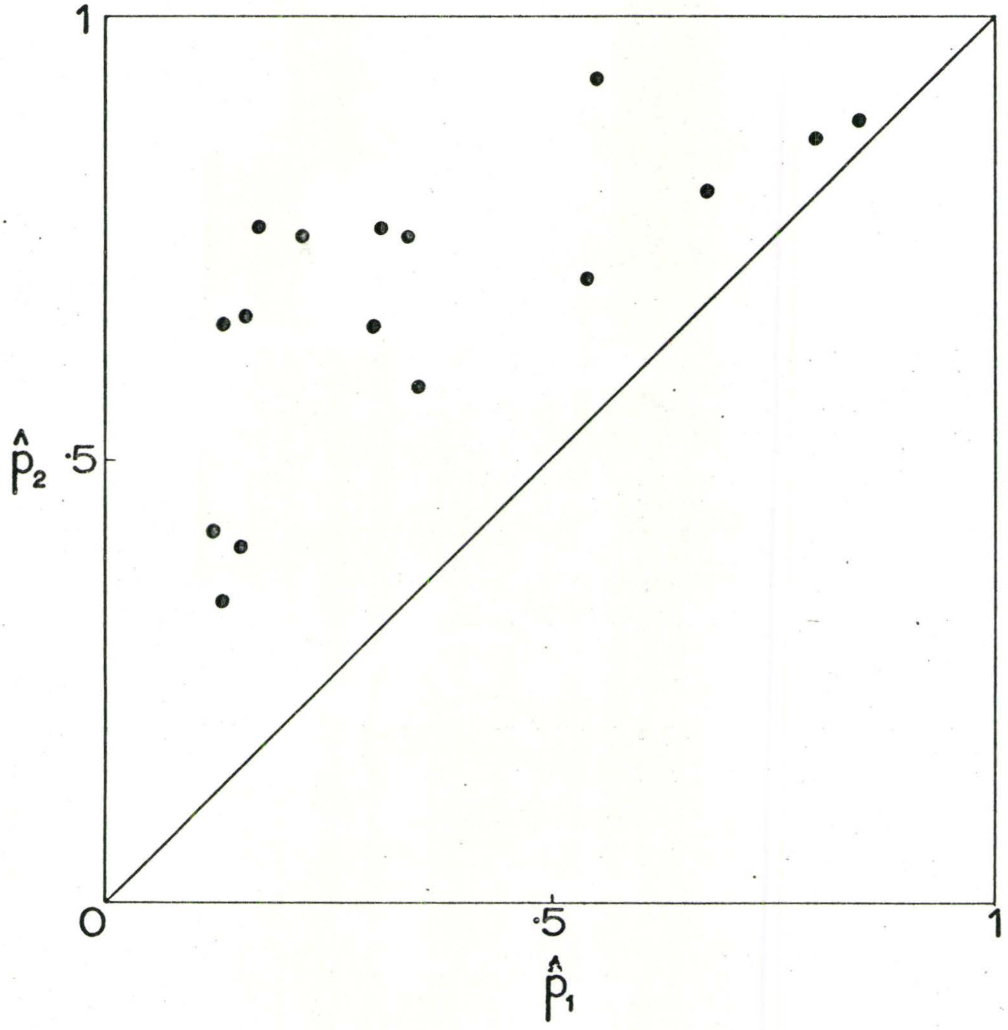

FIGURE 4

information of trial-by-trial changes in performance. One way of evaluating such fluctuations in performance as may occur is to derive estimates of the two probabilities:

$$P(R_{2,n} \mid T_{2,n} \; R_{j,n-1} \; T_{i,n-1} \; E_{k,n-1}) \tag{11}$$

and

$$P(R_{2,n} \mid T_{1,n} \; R_{j,n-1} \; T_{i,n-1} \; E_{k,n-1}) \tag{12}$$

where R designates the response variable, T the stimulus variable and E the reinforcement variable, as previously defined, for i, j equal to 1 or 2, and k equal to 1, 2 or 0. Estimates of these probabilities (since they are conditional on events occurring only one trial earlier) are denoted

$$\hat{P}(R_2 \mid T_2 \; R_j \; T_i \; E_k) \tag{13}$$

$$\hat{P}(R_2 \mid T_1 \; R_j \; T_i \; E_k).^{9} \tag{14}$$

Equations 13 and 14 indicate, respectively: the proportion p_2 on trial n given that response R_j, stimulus T_i, and reinforcement event E_k occurred on trial n-1; and the proportion p_1 on trial n given that response R_j, stimulus T_i and reinforcement event E_k occurred on trial n-1. Note that in phase 2 there were 4 possible $T_i \; R_j \; E_k$ sequences on trial

---

[9] Note that in eq. 13 and 14 trial subscripts are omitted, since the temporal sequence observed in this paper will always follow that indicated in eq. 11 and 12.

n-1. Thus there were four pairs of conditional p_2 and p_1 values. These 1st order conditional probabilities are plotted in Figure 5. Figure 5A gives a general idea of how points are ordered in the total performance space. Fig. 5B gives a much enlarged view of a subregion of the performance space to indicate how the performances were arrayed, although the reader should be careful to notice that the scale range is not the same for all graphs in Figure 5B.[10] In general the open triangle appears to be upper rightmost of the points in Fig. 5B. No clear indication of other sequential dependencies emerges in consistent fashion for all birds. An order test (Suppes and Atkinson) was carried out over all response frequencies for individual birds and was significant ($p < .01$) for six of the birds, those marked with an asterisk; the pooled Chi-square was also significant ($p < .01$). The mean associative strength as indicated by the ϕ coefficient was .078 (Hays, 1963).[11] Thus, there is an indication of a statistically significant, but very weak, relationship between the events on one trial and performance on the next trial.

---

[10] These 1st order conditional probability estimates are presented numerically in Appendix E.

[11] The Chi-Square values are given in Appendix F, along with the ϕ coefficients.

FIGURE 5

First-order conditional probabilities. A shows the general position of the points in a separate ROC graph for each bird; B shows a more detailed view of a subregion of each graph; C presents averages of the conditional probabilities over all birds.

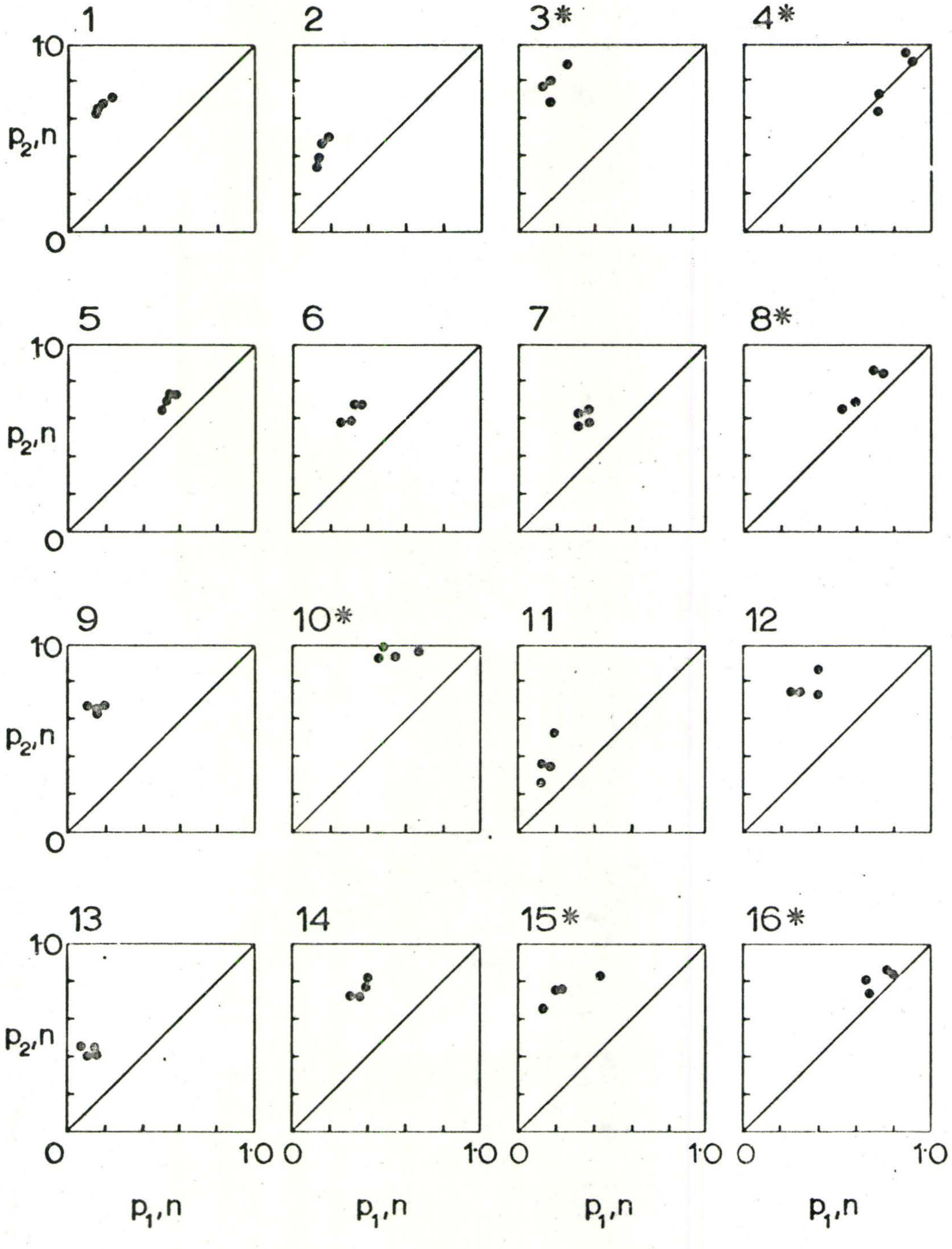

FIGURE 5A

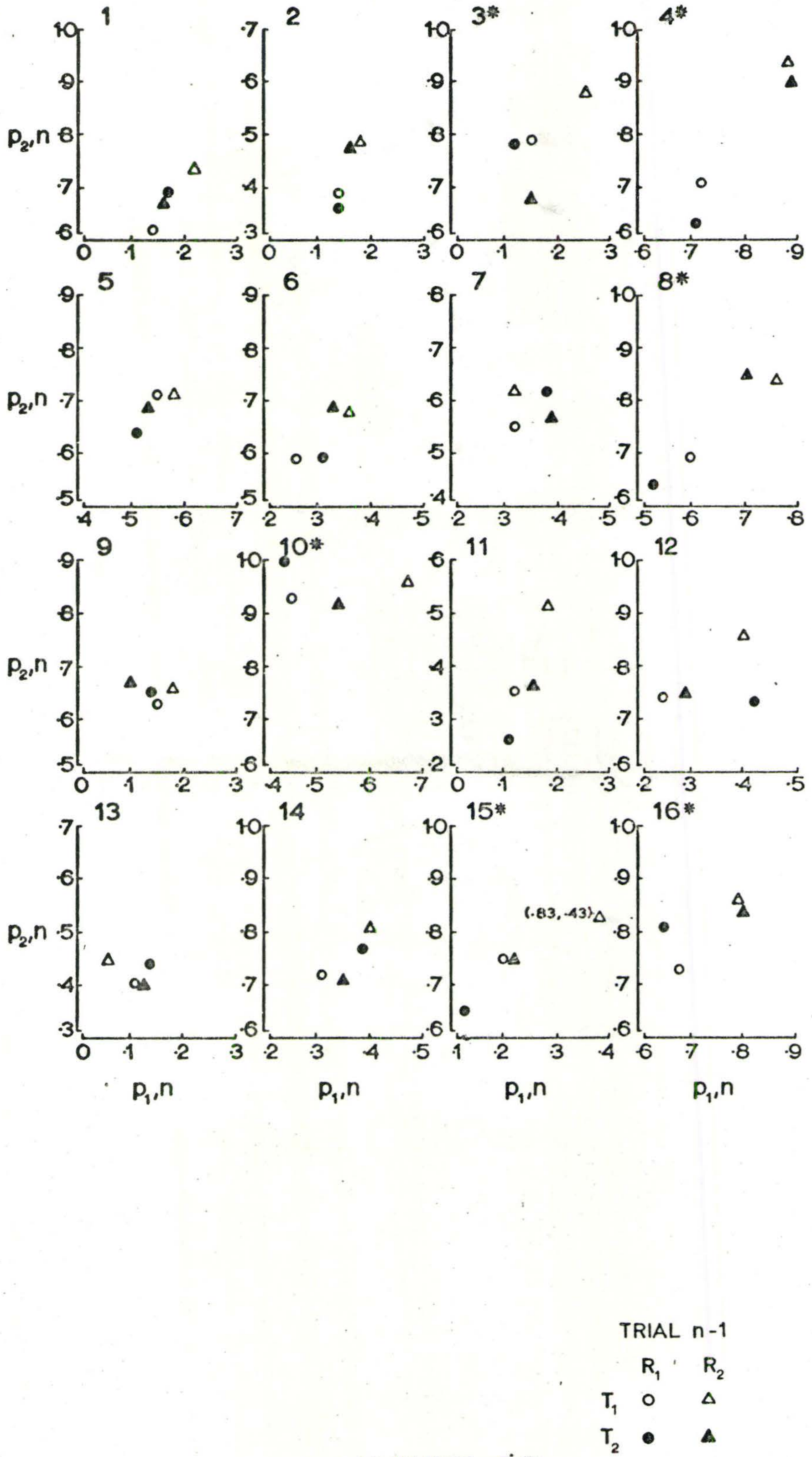

FIGURE 5B

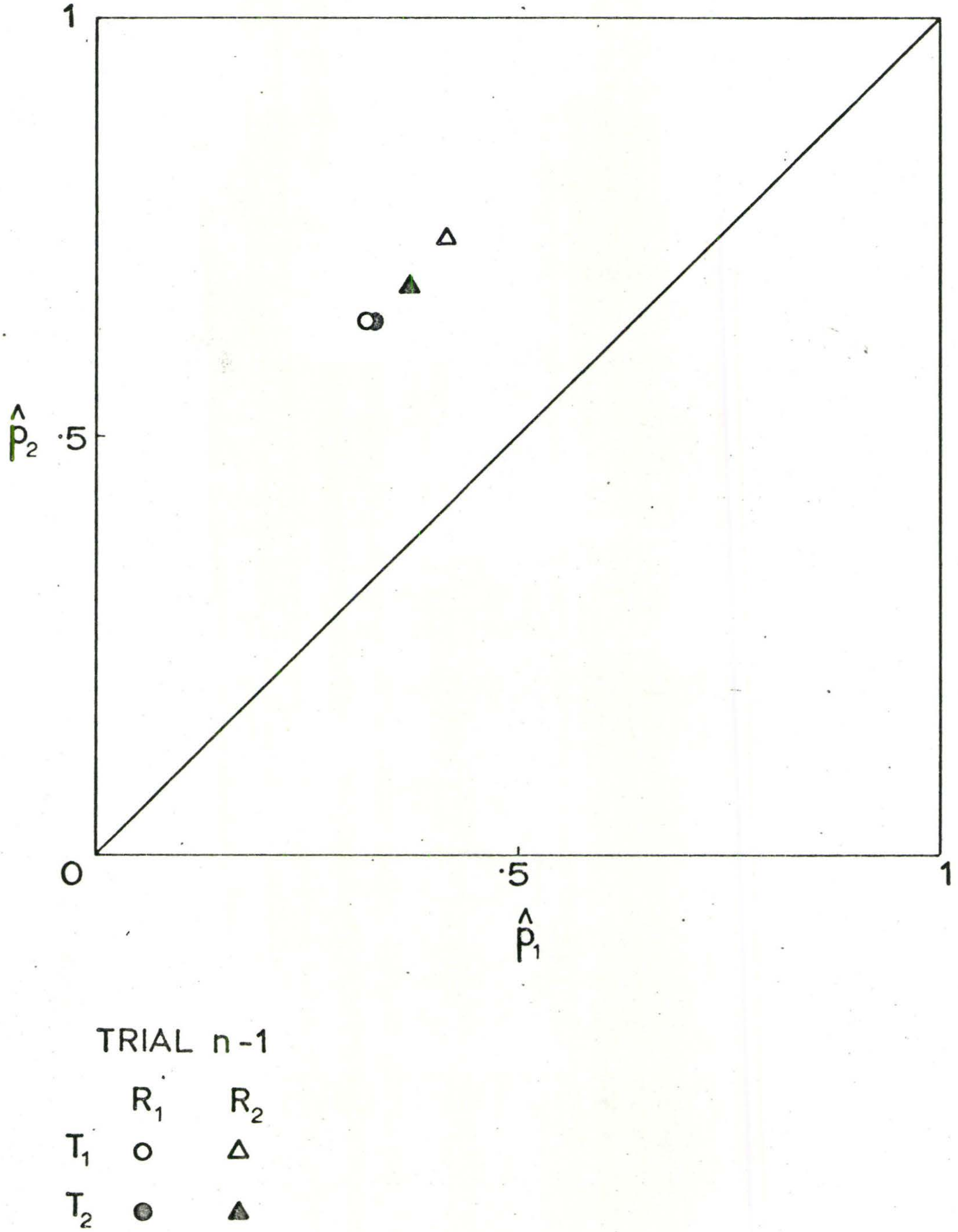

FIGURE 5C

Finally, in Figure 5C is shown the average of all the individual graphs shown in Fig. 5B. While the pattern of sequential effects in Fig. 5C is consistent with that reported for human observers, e.g. Tanner, Haller & Atkinson, 1967, in some psychophysical tasks, these average sequential effects are not representative of the effects observed for individual birds. Particularly since the birds are clearly idiosyncratic in terms of other aspects of their performance, such as probability correct and probability of an R_2.

It is of interest to consider to what extent the response tendency on trial n is conditioned on the stimulus of the preceding trial, which may be evaluated by suppressing the response and reinforcement outcomes on the previous trial. There are two possible stimulus events on trial n-1 (T_1 and T_2). In Table 2 the conditional proportions $P(R_{2,n}|T_{1,n-1})$ and $P(R_{2,n}|T_{2,n-1})$ are given for each bird. There do not appear to be first-order effects that were consistent across all birds.

Similarly, by suppressing stimulus and reinforcement information one may derive estimates of conditional probabilities $P(R_2|R_1)$ and $P(R_2|R_2)$. These are also shown in Table 2. For thirteen of the 16 birds $\hat{P}(R_2\ R_1) < \hat{P}(R_2|R_2)$. In a sign-test on the data of Figure 7, p equals .022. Probability estimates of $R_{2,n}$ conditional on the E_k event on trial n-1 were also derived and are presented in Table 2. Eleven of

TABLE 2

First-order conditional probability estimates, $P(R_2|T_i)$, $P(R_2|R_j)$, $P(R_2|E_k)$, and $P(C_l|C_m)$, for each bird in phase 2.

Table 2

BIRD	$\hat{P}(R_2 \mid T_2)$	$\hat{P}(R_2 \mid T_1)$	$\hat{P}(R_2 \mid R_2)$	$\hat{P}(R_2 \mid R_1)$
1.	.413	.395	.427	.388
2.	.275	.273	.320	.257
3.	.431	.486	.451	.465
4.	.867	.878	.898	.697
5.	.594	.641	.626	.604
6.	.491	.423	.515	.433
7.	.487	.446	.470	.463
8.	.733	.752	.784	.622
9.	.383	.394	.388	.388
10.	.731	.761	.762	.699
11.	.207	.250	.276	.213
12.	.534	.541	.554	.518
13.	.272	.258	.252	.269
14.	.535	.558	.556	.536
15.	.458	.507	.519	.449
16.	.804	.799	.823	.715
Overall $\bar{x}$	.513	.524	.539	.482

BIRD	$\hat{P}(R_2 \mid E_1)$	$\hat{P}(R_2 \mid E_2)$	$\hat{P}(R_2 \mid E_o)$	$\hat{P}(C \mid C_1)$	$\hat{P}(C \mid C_o)$
1.	.381	.417	.425	.747	.763
2.	.261	.313	.267	.633	.620
3.	.469	.525	.498	.790	.823
4.	.714	.892	.878	.513	.521
5.	.636	.609	.616	.585	.563
6.	.419	.508	.492	.676	.649
7.	.438	.476	.483	.602	.636
8.	.646	.774	.746	.571	.552
9.	.389	.381	.396	.761	.750
10.	.704	.736	.790	.711	.636
11.	.237	.248	.211	.609	.587
12.	.497	.521	.610	.737	.702
13.	.257	.250	.284	.646	.662
14.	.521	.521	.686	.691	.706
15.	.471	.484	.502	.773	.737
16.	.701	.819	.811	.551	.551
Overall $\bar{x}$	.484	.523	.538	.662	.654

the sixteen birds showed a tendency for $\hat{P}(R_2|E_1) < \hat{P}(R_2|E_2)$. There appeared to be an effect of non-reinforcement on the preceding trial for some of the birds as well. However, the results were not significant in a sign-test of the data.

Finally, estimates were obtained of the probability of a correct response on trial n, following a correct and following an incorrect response on the preceding trial. This can be denoted as $\hat{P}(C_1|C_m)$, where m equals 1 or 0. M equals 1 represents a correct response and m equal to 0 denotes an incorrect response. There were no statistically significant differences observable between these conditional probabilities presented in Table 2. The means over all birds for $P(C_1|C_1)$ and $P(C_1|C_0)$ were .662 and .654 respectively.[12]

In addition to the events of the directly preceding trial, events over a longer series of previous trials might influence the performance in this type of discrimination situation. There are a large number of ways to characterize events over a long series of trials. We shall only consider homogeneous runs of stimuli and responses on the m trials preceding trial n, where m could equal 1, 2, 3, 4 or 5. Specifically, estimates of the following conditional pro-

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[12] These conditional probability estimates, $P(R_2|T_i)$, $P(R_2|R_j)$, $P(R_2|E_k)$ and $P(C_1|C_m)$, are given in Appendix G, along with the number of trials, N, on which each estimate is based.

babilities were obtained:

$$P(R_{2,n} | T_{i,n} \quad T_{1,n-1} \quad T_{2,n-2})$$
$$P(R_{2,n} | T_{i,n} \quad T_{1,n-1} \quad T_{1,n-2} \quad T_{2,n-3})$$
$$\vdots$$
$$P(R_{2,n} | T_{i,n} \cdot T_{1,n-1} \cdots T_{1,n-m} \quad T_{2,n-m+1})$$

and

$$P(R_{2,n} | T_{i,n} \quad T_{2,n-1} \quad T_{1,n-2})$$
$$P(R_{2,n} | T_{i,n} \quad T_{2,n-1} \quad T_{2,n-2} \quad T_{1,n-3})$$
$$\vdots$$
$$P(R_{2,n} | T_{i,n-1} \cdots T_{2,n-m} \quad T_{1,n-m+1})$$

for $i = 1, 2$ and $m = 1, 2, 3, 4$ and 5.

For obvious reasons these are referred to in the present discussion as "higher order" conditional probabilities.

In Figure 6 these conditional probabilities are plotted as a function of the preceding <u>stimulus run</u>, up to run lengths of 5.[13] Observation of these probabilities does not reveal any consistent sequential effects. However, for several birds there did appear to be a tendency for the plotted lines to converge as run length increased; c.f., 2, 4, 5, 6, 7, 8, 14 and 16. The effect, if any, was small however. Furthermore, since the number observations for the longer stimulus runs was small, the probability estimates

---

[13] Numerical values of the "higher-order" sequential probabilities conditional on stimulus runs are given in Appendix H, along with the number of trials, N, on which each estimate is based.

FIGURE 6

Higher-order conditional probabilities as a function of the preceding stimulus run, for individual birds in phase 2.

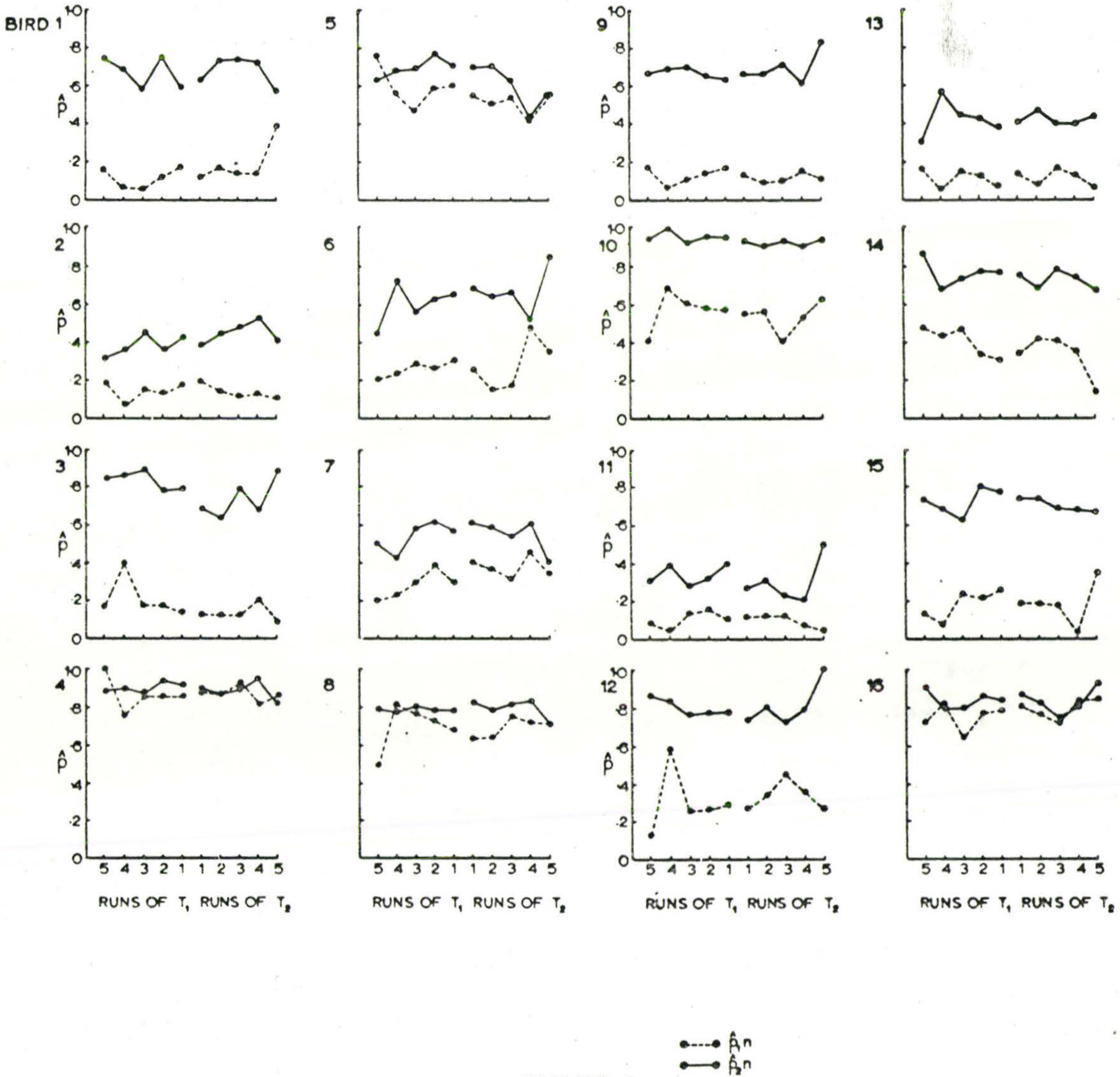
BIRD 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
1·0
·8
·6
·4
·2
0
$\hat{p}$
5 4 3 2 1 1 2 3 4 5
RUNS OF T_1 RUNS OF T_2
$\hat{p}_1 n$
$\hat{p}_2 n$

FIGURE 6

for these points are not reliable.

Finally, "higher-order" probability estimates conditional on preceding <u>response runs</u> were calculated; i.e., the following probabilities were estimated:

$$P(R_{2,n} | R_{2,n-1} \quad R_{1,n-2})$$

$$\vdots$$

$$P(R_{2,n} | R_{2,n-1} \cdots R_{2,n-m} \quad R_{1,n-m+1})$$

and

$$P(R_{2,n} | R_{1,n-1} \quad R_{2,n-2})$$

$$\vdots$$

$$P(R_{2,n} | R_{1,n-1} \cdots R_{1,n-m} \quad R_{2,n-m+1})$$

for m equal to 1, 2, 3, 4 and 5.

These are shown graphically in Figure 7.[14] For several birds the plots have a positive slope, indicating the conditional $P(R_2)$ decreases with preceding runs of R_1 and increases with preceding runs of R_2; c.f., birds 2, 4, 6, 8, 11, 13, 14, 15, 16. For no bird is a reverse slope indicated. Thus there does appear to be a sequential effect as a function of response run length for some of the birds.

Phase two: response time analysis. In many discrimination tasks the response time is a feature of the behavior

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[14] Numerical values of the "higher-order" sequential probabilities conditional on response runs are provided in Appendix I, along with the number of trials, N, on which each estimate is based.

FIGURE 7

Higher-order conditional probabilities as a function of the preceding response run, for individual birds in phase 2.

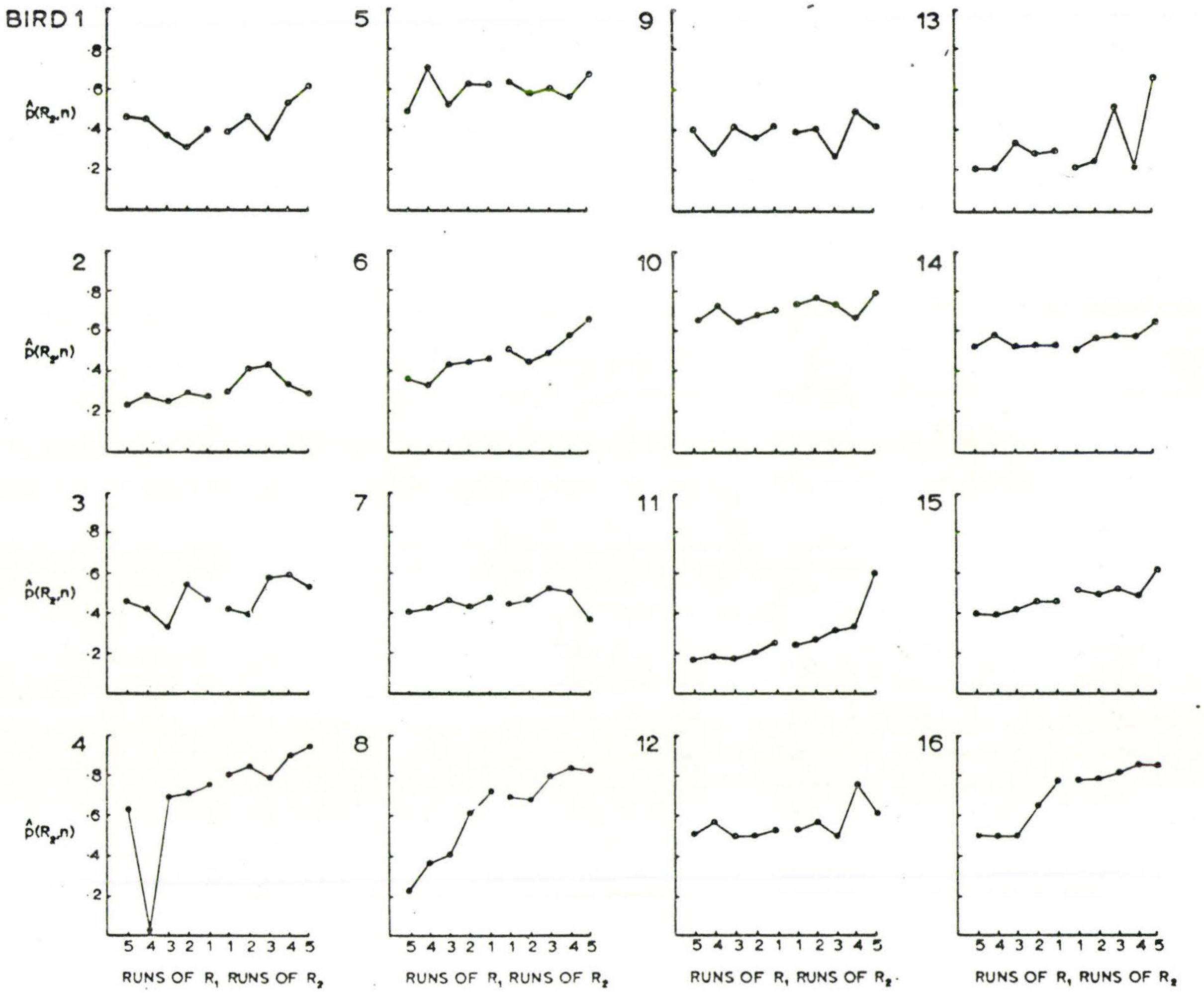
BIRD 1
5
9
13
2
6
10
14
3
7
11
15
4
8
12
16
·8
·6
·4
·2
$\hat{p}(R_2,n)$
5 4 3 2 1 1 2 3 4 5
RUNS OF R_1 RUNS OF R_2

FIGURE 7

that may bear an important relation to the performance. In this experiment the period elapsing from the offset of the stimulus to the point when the first response on a side-key occurred is the response time (RT). Response times were collected into .2 sec. categories and are plotted for each bird in normalized distributions in Figure 8. The figure provides a picture of the variability between subjects in making this type of choice response, i.e., some distributions are bimodal while others are unimodal; some display great variability, others very little. In general, however, the modal response time for most birds was no greater than 1 second.

In Table 3 the mean response times for each bird conditional on the stimulus and response, and on correct and incorrect trials as well, are given. The mean RT for all birds was 1.20 sec. with a range of .67 to 2.05. There was no significant difference in the RT's for correct and incorrect responses, which were 1.20 and 1.21 respectively.

There does, however, appear to be a response-dependent difference in RT. For 10 of the 16 birds mean RT was lower on both types of R_2 trials than on R_1 trials. Overall means were 1.40, 1.40, 1.21 and 1.15 for R_1T_1, R_1T_2, R_2T_1 and R_2T_2 trials respectively.

Thus there appears to be little information concerning

FIGURE 8

Frequency distributions of response times in phase 2 for individual birds.

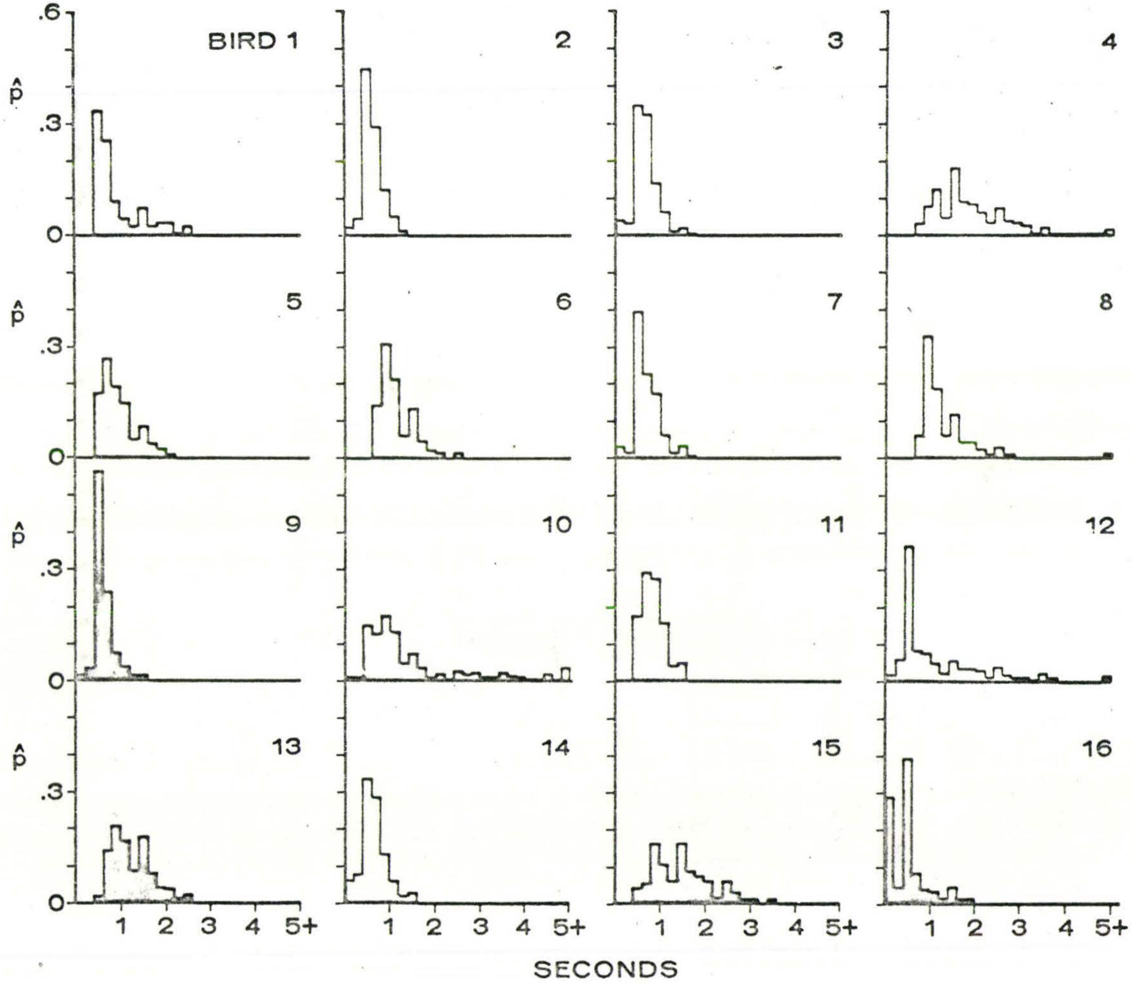

FIGURE 8

TABLE 3

Response times: A, phase 2, B, phase 3.

TABLE 3

a. MEAN RESPONSE TIME IN PHASE 2

BIRD	R_1T_1	R_2T_1	R_2T_1	R_2T_2	CORRECT	INCORRECT	ALL TRIALS
1	.76	.84	1.76	1.65	1.15	1.14	1.15
2	.87	.85	.60	.51	.76	.80	.77
3	.93	.92	.81	.67	.81	.88	.82
4	2.85	2.51	2.0	1.91	2.04	2.06	2.05
$\bar{x}$	1.35	1.28	1.29	1.19	1.19	1.22	1.20
5	1.39	1.35	.99	.89	1.08	1.12	1.10
6	1.41	1.27	1.43	1.34	1.38	1.34	1.37
7	1.11	1.11	.67	.69	.91	.91	.91
8	1.61	1.61	1.64	1.51	1.54	1.56	1.55
$\bar{x}$	1.38	1.34	1.16	1.11	1.23	1.23	1.23
9	.71	.68	.99	.83	.76	.76	.76
10	3.51	3.63	1.08	1.09	1.87	1.35	1.71
11	1.08	1.03	.81	.81	1.01	1.00	1.00
12	.57	.64	2.24	1.90	1.27	1.54	1.35
$\bar{x}$	1.47	1.50	1.28	1.16	1.23	1.16	1.21
13	1.39	1.33	1.51	1.71	1.50	1.36	1.45
14	1.00	.96	.64	.62	.80	.77	.79
15	1.58	2.11	1.77	1.83	1.70	1.96	1.76
16	1.53	1.47	.57	.36	.61	.73	.67
$\bar{x}$	1.38	1.47	1.12	1.13	1.15	1.21	1.17
OVERALL $\bar{x}$	1.40	1.40	1.21	1.15	1.20	1.21	1.20

TABLE 3

b. MEAN RESPONSE TIME IN PHASE 3

BIRD	R_1T_1	R_1T_2	R_2T_1	R_2T_2	CORRECT	INCORRECT	ALL TRIALS
1	.96	.94	1.19	1.23	1.07	.99	1.05
2	.89	.83	.72	.59	.75	.78	.76
3	1.11	1.07	.95	.83	1.00	1.03	1.01
4	2.66	2.51	2.04	2.23	2.24	2.05	2.14
$\bar{x}$	1.41	1.34	1.23	1.22	1.27	1.21	1.24
5	1.55	1.57	1.25	1.14	1.28	1.33	1.30
6	2.06	2.12	2.59	2.48	2.31	2.42	2.36
7	1.10	1.01	.73	.69	.84	.81	.83
8	2.77	2.77	2.28	2.05	2.28	2.39	2.32
$\bar{x}$	1.87	1.48	1.71	1.59	1.68	1.74	1.70
9	1.05	.92	.78	.72	.93	.90	.92
10	1.65	1.85	1.23	1.19	1.44	1.62	1.48
11	1.47	1.29	.82	.79	1.24	1.19	1.22
12	.68	.67	1.82	2.02	1.33	1.21	1.30
$\bar{x}$	1.21	1.18	1.16	1.18	1.24	1.23	1.23
13	1.37	1.33	1.92	1.99	1.58	1.44	1.53
14	1.03	1.02	.89	.85	.93	.94	.93
15	1.34	1.55	2.80	3.06	2.10	1.95	2.06
16	1.68	1.61	.58	.43	.82	.80	.81
$\bar{x}$	1.36	1.38	1.55	1.58	1.36	1.28	1.33
OVERALL							
$\bar{x}$	1.46	1.34	1.41	1.39	1.39	1.37	1.38

the perceptual process represented in the RT's, except for a weak tendency to make one response slightly faster than the other in some birds.

Phase two: quartiles of a session. In order to analyze the way in which discrimination might change during the course of a session, each of the final 12 sessions was divided into quartiles and estimates of p_1, p_2, p_C and p_L were obtained for each quartile.[15] The probability estimates p_1 and p_2 changed in a variety of ways for different birds as the session progressed, but there did not appear to be a characteristic trend for all birds. Probability of a correct response (p_C) seemed to be relatively fixed throughout the session for most birds. There were no apparent changes in p_L during the course of a session.

Phase three. The data from the final 12 sessions of phase 3 were used to evaluate the effect that reduction of the probability of reinforcement had in this type of discrimination situation. The probabilities $\hat{p}_1$ and $\hat{p}_2$ are plotted in 4 ROC graphs in Figure 9, A, B, C, and D, for Groups 1, 2, 3 and 4, respectively, and reflect the effect of this variable. Open symbols represent performance over the final 12 sessions of phase 2 and closed symbols the final 12

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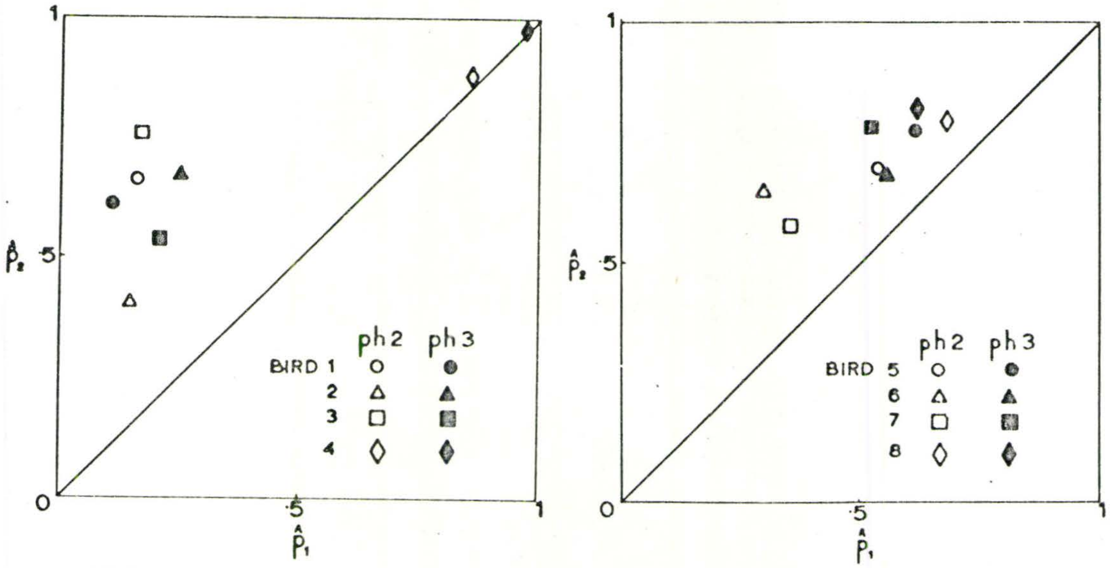
[15] These probability estimates for successive quartiles of a session, based on 12 sessions for each bird, are given in Appendix J.

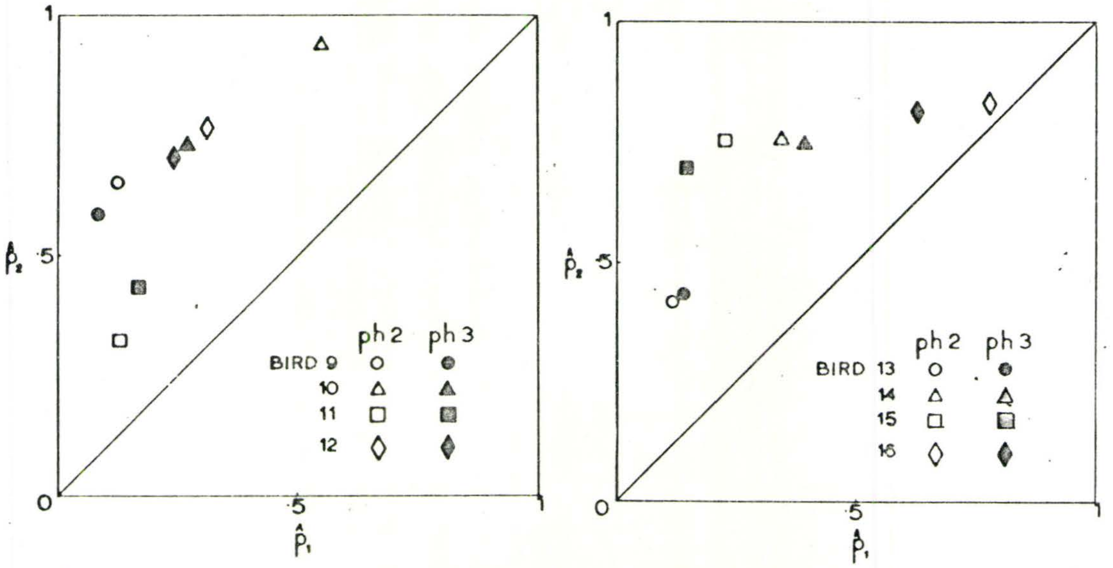
FIGURE 9

ROC graphs showing $\hat{p}_1$ and $\hat{p}_2$ for individual birds in phase 2 and phase 3. A, Group 1; B, Group 2; C, Group 3; D, Group 4.



A: GROUP 1

B: GROUP 2



C: GROUP 3

D: GROUP 4

FIGURE 9

sessions of phase 3. The probabilities $\hat{p}_C$ and $\hat{p}_L$ for phases 2 and 3 are provided in Table 4.[16]

For Group 4, Fig. 9D, phase 3 consisted of a minimum of 24 sessions after attainment of the stationarity criterion in phase 2, during which there were no changes in the experimental contingencies. Consequently, Group 4 can be viewed as providing an indication of the way in which performance was modified as a result of extended exposure to this type of task. Birds 13 and 14 changed very little. Bird 15 appeared to develop a slightly lower R_1 response tendency, and bird 16 improved in discrimination as well as shifted in response tendency.

For Group 1 birds, Fig. 9A, both π_1 and π_2 were decreased to .7. For two birds an improvement in discrimination seemed apparent, c.f., nos. 2 and 3. For another bird, bird no. 1, however, discrimination remained about the same, although p_L decreased, c.f., Table 4; while for the final bird, bird no. 4, discrimination, which was already weak, became weaker, and p_L increased. Apparently the decrement in probability of reinforcement altered performance of the birds in group 1, but there was not a systematic effect.

For Group 2, π_1, $P(E_1|R_1T_1)$ was reduced to .7, and

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[16] Numerical values of the probability estimates p_1 and p_2, along with p_C and p_L, for phase 3 are in Appendix D.

TABLE 4

Estimates of p_C and p_L for each bird in phase 2 and phase 3.

Table 4

GROUP	BIRD	p_C		p_L	
		PHASE 2	PHASE 3	PHASE 2	PHASE 3
1	1.	.750	.747	.411	.360
	2.	.627	.712	.277	.456
	3.	.795	.662	.464	.377
	4.	.519	.502	.868	.981
	$\bar{x}$	.693	.656	.505	.544
2	5.	.577	.579	.619	.696
	6.	.672	.574	.474	.621
	7.	.614	.636	.466	.657
	8.	.564	.602	.740	.720
	$\bar{x}$	.607	.598	.575	.674
3	9.	.758	.727	.387	.312
	10.	.689	.775	.740	.438
	11.	.605	.641	.237	.302
	12.	.729	.733	.535	.480
	$\bar{x}$	.695	.719	.475	.383
4	13.	.652	.652	.266	.283
	14.	.701	.678	.542	.564
	15.	.764	.775	.486	.412
	16.	.531	.607	.794	.724
	$\bar{x}$	.662	.678	.522	.496
OVERALL	$\bar{x}$	.659	.663	.519	.524

π_2 remained at 1.0. The effect of this, as can be seen in Fig. 9, was to increase p_1 and p_2 for all birds except bird 8. Results for Group 3, in which π_2, $P(E_2|R_2T_2)$, was reduced to .7 while π_1 remained at 1.0, are shown in Fig. 9C. The estimates for p_1 and p_2 decreased for all birds other than bird 11.

A Chi-Square test for homogeneity between phases 2 and 3 was significant for all birds except two of the birds in Group 4, nos. 13 and 14. The Phi-coefficient was lowest for group 4 (.07). For groups 1, 2 and 3 it was .184, .140 and .189, respectively.[17]

The mean p_C over all birds, .663, did not represent an increase beyond 1 of its value in phase 2, i.e., .659; and changes in p_C for individual birds were not systematic. When p_L is compared for phases 2 and 3, it appears that the probability of an R_2 increased for group 2 birds, with the exception of bird 8, was decreased for group 3 birds, with the exception of bird 11, and was not systematically altered for the other two groups.

Phase three: sequential analysis. The "first-order" conditional probabilities for phase 3 shows the same sequential dependency noted for phase 2, i.e., a higher $P(R_2|T_{1,n})$

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[17] Chi-Squares and ϕ coefficients are provided in Appendix K.

following an R_2T_1 on trial n-1, for some of the birds. Reduction of the conditional probability of reinforcement did not appear to have produced a consistent sequential effect within a given group.[18] An order test performed on the data of individual birds was significant for only 3 birds ($p < .01$), nos. 6, 11 and 16. The index of association was not markedly changed for individual birds, from .078 in phase 2 to .064 in phase 3.[19]

The sequential effect of the preceding response that was evidenced in phase 2 was maintained in phase 3, i.e., $P(R_{2,n}|R_{2,n-1}) > P(R_{2,n}|R_{1,n-1})$ for 15 of the 16 birds ($p < .001$, sign test). There was no apparent interaction of the reinforcement contingencies in groups 1, 2 and 3 with this response contingent effect. Group means and overall means for both phases also reflected the sequential dependency.

Analysis of $P(R_{2,n})$ conditional on preceding stimulus or preceding reinforcement events failed to yield any apparent consistent dependencies within or across groups. Nor did conditional probability of a correct response appear to be

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[18] Numerical values of "first-order" conditional probabilities in phase 3 are given in Appendix E.

[19] Order Test Results and ϕ coefficients for phase 3 are in Appendix F.

correlated with correctness of the previous trial.[20]

Analysis of $P(R_{2,n})$ conditional on response run length in phase 3 revealed that the tendency for $P(R_2)$ to decrease with R_1 run length was a feature of the performance of some of the birds in phase 3 as in phase 2.[21]

Phase three: response time analysis. Response time histograms in phase 3 were similar in almost all regards to those shown in Figure 8, except for shifts to the right of the modes for some birds. Means in Table 3 show an increase in overall RT from 1.20 to 1.38 sec. There is not a marked difference in RT for correct and incorrect responses. The difference in the overall mean RT between R_1 and R_2 responses is no longer in evidence, although several individual birds still exhibit the trend, c.f., Table 3.

Phase four. Finally, behavior of the birds during extinction, i.e., π_i was reduced to 0 for i equal to 1, 2, was evaluated over 5 consecutive daily sessions of 1 hour each. Since all trials were response-initiated in this experiment, statistics based on the number of trials also provide information about this trial-initiating response.

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[20] Numerical values of these "first-order" conditional probabilities are given in Appendix G.

[21] Numerical values of the "higher-order" sequential probabilities conditional on response runs for phase 3 are provided in Appendix I.

Analysis of extinction results showed the mean number of trials for Groups 1, 2, 3 and 4 were 340, 444, 333, and 337, respectively. Variability among birds within groups was high and there was considerable overlap between groups in number of trials emitted.[22] In Figure 10 the number of trials for each of the 5 extinction days is shown graphically for each bird. For most birds the number of trials drops off rapidly after the first day of exposure to extinction, however, for birds 2, 3, 5, 6 and 7 there is not a noticeable reduction in number of trials until day 3 of extinction.

Plots of $\hat{p}_1$ and $\hat{p}_2$ for successive days of extinction are shown in Fig. 11. A group difference does not emerge and neither does there appear to be a systematic trend among the birds. For some birds, e.g., 5 and 15, the discrimination appears to weaken first, followed by shifts in bias; for others, e.g., 11 and 16, large bias shifts occur first and then discrimination deteriorates. There is also some suggestion of discrimination reversal occurring for particcular birds, e.g., 6 and 14. However, the points toward the end of extinction are based on a very small number of trials.

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[22] Extinction results are presented in Appendix I.

FIGURE 10

Number of trials in each day of extinction shown separately for each bird.

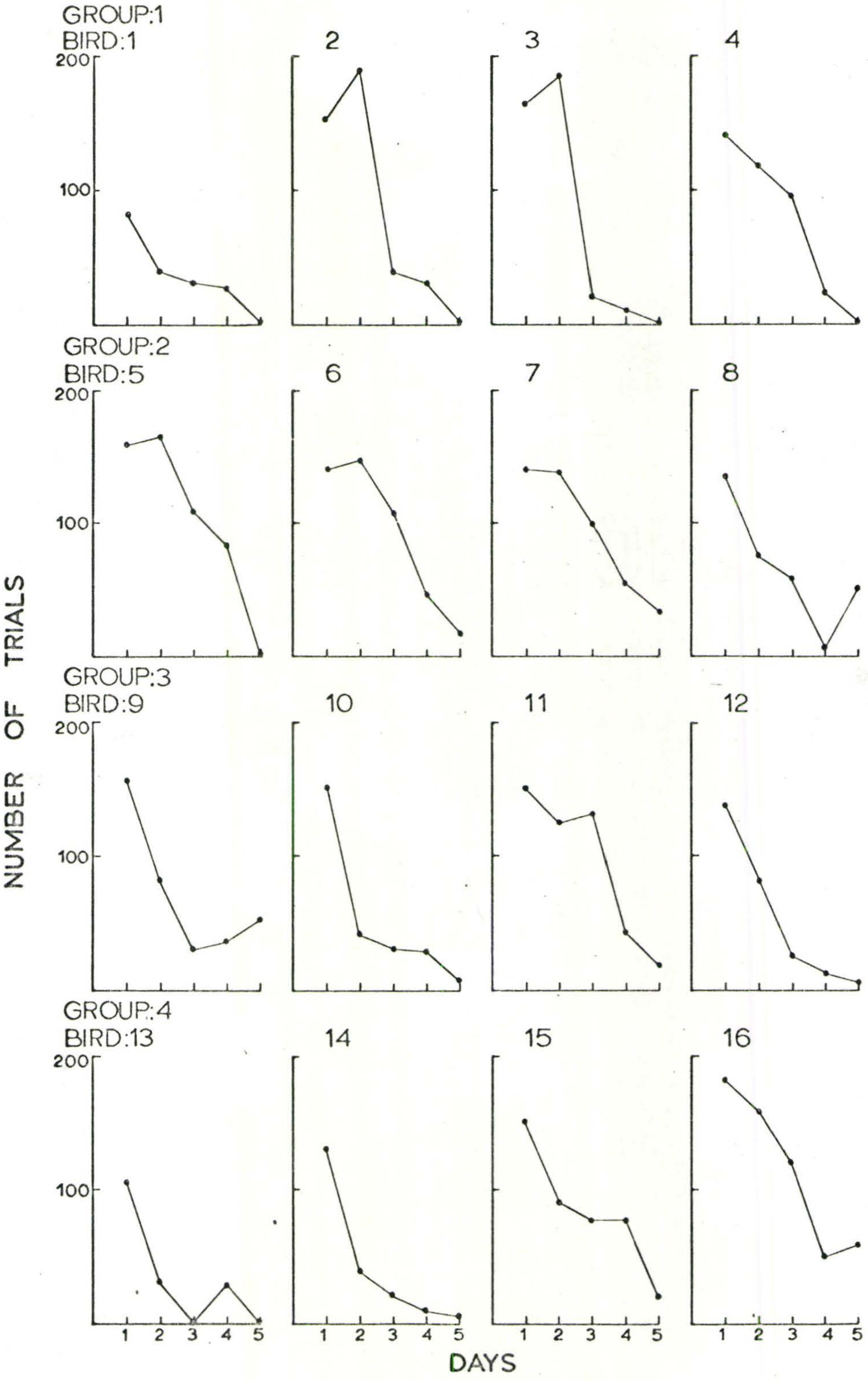

GROUP:1
BIRD:1
2
3
4
GROUP:2
BIRD:5
6
7
8
GROUP:3
BIRD:9
10
11
12
GROUP:4
BIRD:13
14
15
16
200
100
NUMBER OF TRIALS
1
2
3
4
5
DAYS

FIGURE 10

FIGURE 11

Estimates for p_1 and p_2 for successive days in extinction for each bird.

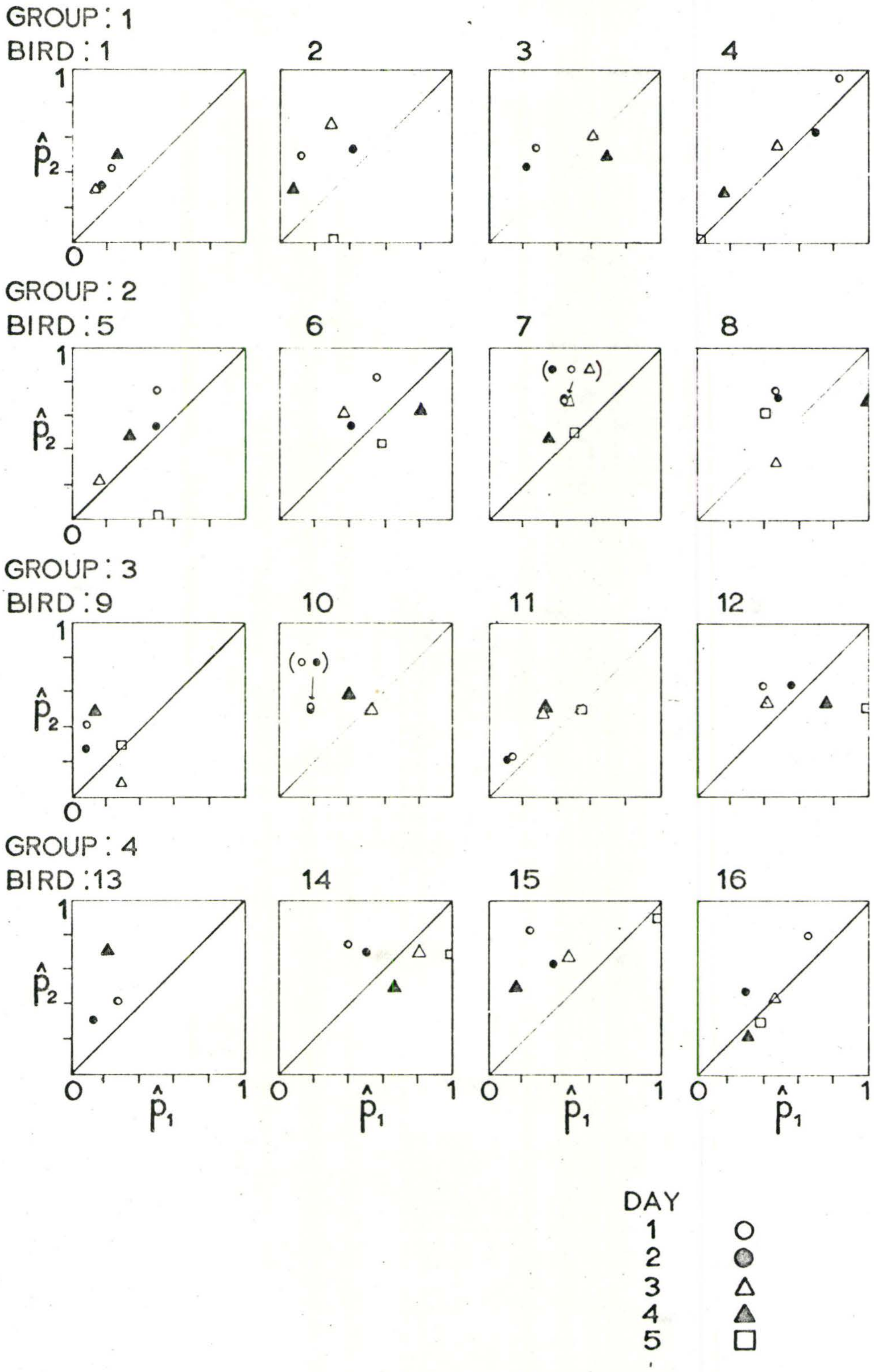

GROUP : 1
BIRD : 1
2
3
4
GROUP : 2
BIRD : 5
6
7
8
GROUP : 3
BIRD : 9
10
11
12
GROUP : 4
BIRD : 13
14
15
16
1
0
$\hat{p}_2$
$\hat{p}_1$
(● ○ △)
(○ ●)
DAY
1 ○
2 ●
3 △
4 ▲
5 □

FIGURE 11

In general, no systematic effects, other than a decrease in the number of trials, occurred during extinction.

Discussion

Phase one. In Figure 3 it appears that for most birds the increments in T_1 occurred gradually enough so that the discrimination was not seriously disturbed until the final increment to 4 sec., which, for many birds, decreased $\hat{p}_2$ and increased $\hat{p}_1$. Where discrimination was weakened by an increment in T_1 there was not always an immediately discernable effect, c.f., birds 7, 11, 13 and 16 at the 4 sec. increment.

Occasionally an apparent response fixation developed during phase 1, c.f., 3 and 6, but this was followed by subsequent improvement of the discrimination. Thus the presence of a strong fixation did not necessarily preclude subsequent development of good discriminative behavior. Fixations developed early in phase 1 seemed typically to be toward R_1, the short stimulus response.

It will be recalled that after the 4 sec. increment in T_1 had been in effect for several sessions, reinforcement duration was reduced from 3 to 2 sec. for the remainder of the experiment. This decrease in the amount of reinforcement might have been expected to alter the performance in some fashion. With the exception, perhaps, of bird no. 5, there is no strong evidence that this happened.

Phase two. The only clear sequential effect found in the results of this experiment was a tendency on the part of some birds to repeat responses. Response dependencies of this type have been observed elsewhere in studies of a psychophysical nature with humans (Verplanck, Collier and Cotton, 1952; Verplanck and Collier, 1958; Kinchla, 1966).

On the whole the data are surprisingly similar to an independent-trials process and are not consistent with those detection models which predict specific sequential effects. For example, a variable-sensitivity model, in which both bias and sensitivity may vary from trial to trial (Atkinson, 1963), can be rejected, since in the present experiment there was no evidence that $\hat{P}(C_{1,n}|C_{1,n-1})$ and $\hat{P}(C_{1,n}|C_{0,n-1})$ were unequal. The variable sensitivity model predicts a sequential dependency between p_C and the correctness of the previous trial. Note that a sequential effect of this sort has considerable intuitive appeal since it could be argued that an animal's efficiency or accuracy might slowly vary during a session; if so, his accuracy on one trial would be related to his accuracy on the subsequent trial. However, no empirical support for this argument was obtained.

Stimulus dependent sequential properties have been found in human performance in psychophysical tasks by Tanner, Haller and Atkinson, 1967; Kinchla, 1966; Parducci and Sandusky, 1965; Kinchla, 1964; Triesman, 1963; Atkinson, Carterette and Kinchla, 1962. The study by Triesman is particularly interesting since it dealt with a related temporal problem, time estimation in humans. Sequential analysis revealed shifts in bias as a function of runs of similar stimuli. The results were interpreted as consistent with a model derived from Adaptation Theory. A learning model was found to provide satisfactory fit to the data reported by Kinchla (1964) and Atkinson, Kinchla and Carterette (1962). However, strong sequential stimulus dependencies were not found in the present analysis, either in terms of bias or sensitivity shifts, so that such models would seem inappropriate for this duration discrimination situation.

Learning models that predict bias shifts dependent on prior reinforcement are difficult to compare with the present situation, since they deal with non-response-contingent reinforcement events, and the present experiment used response-contingent reinforcement. This latter fact is relevant in evaluating the observed response dependencies. In phase 2 the probability of reinforcement, given a correct response, was always equal to one, thus it is difficult to separate the effect of a response on n-1 from a reinforcing event on n-1 for this phase. In phase 3, however, the effect of a reinforcement could be evaluated separately from the effect of a response on the preceding trial, since $P(E_{i,n-1} \mid T_iR_i) < 1$ for i equal to 1 (Group 2), 2 (Group 3) or both (Group 1). The results did not seem to show a uniform difference between $P(R_2 \mid R_2T_2E_2)$ and $P(R_2 \mid R_2T_2E_0)$ or $P(R_2 \mid R_1T_1E_1)$ and $P(R_2 \mid R_1T_1E_0)$ for the birds in these groups as can be seen in Fig. 16. Thus the response-response correlations observed in phase 2 do not appear to be simply a reinforcement effect.

This result is particularly interesting in regard to the role of individual reinforcements. They do not seem to alter the probability of response in the way some learning models would suggest, e.g. an Estes type of stimulus sampling process in which each reinforcement increases the probability of a particular response.

Stereotyped, overt activity has been noted by many investigators in studies requiring the discrimination of temporal intervals (Laties et al., 1965; Malott and Cumming, 1964; Nevin and Berryman, 1963; Segal and Hollaway, 1963; Hodos, Ross and Brady, 1962; Wilson and Keller, 1953). Similar types of overt activity were observed in this discrimination situation during the period that the tone was on. Visual monitoring of the birds revealed that for some birds this activity could be differentiated into T_1 and T_2 segments but not for all birds. Differentiation of the behavior while the tone was on did not appear to be correlated with the accuracy of discrimination. For instance, birds 1 and 15 each had $p_C \approx .75$, but only for bird 15 were differentiable components of the behavior observable.

Response times were often influenced by the behavior that prevailed during the stimulus. Generally, the tendency was for the response time to be lengthened by activities that persevered after the tone terminated, such as holding on to the houselight, pecking the area around the key, etc. However, bird 16 had an extremely low R_2 latency which was correlated with a regular pattern of pecking key 2 at a high rate while the tone was on. Thus it would seem that response times in this experiment must be considered to be a function of other factors in addition to the simple motor response time and the decision time.

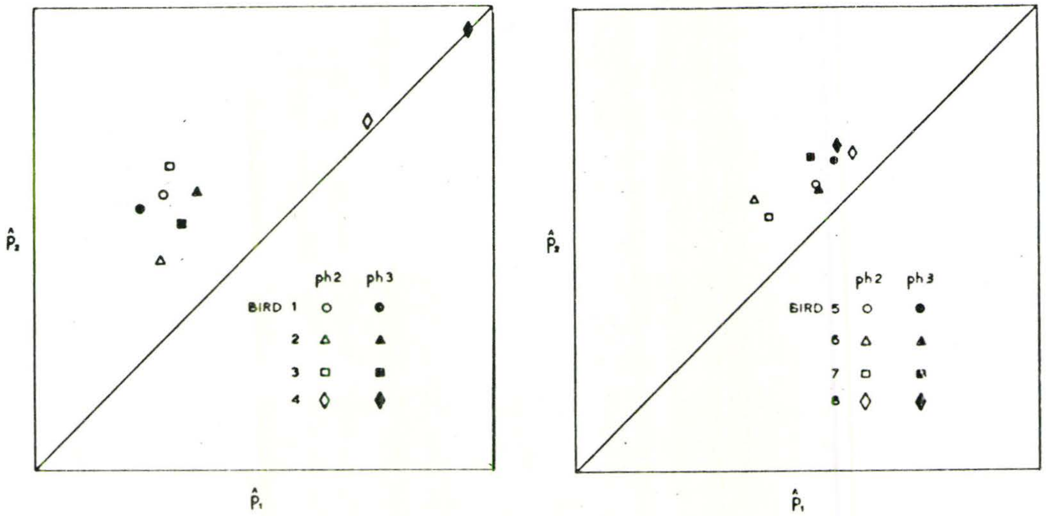
Phase three. The graphs of $\hat{p}_1$ and $\hat{p}_2$ in Figure 3 provide an interesting view of how the reduction in reinforcement manifested itself from session to session. Initial effects of the reduction can be seen to be different for individual cases. For instance, within a few session after the asymmetrical reduction in reinforcement bird 6, Group 2, and bird 10 in Group 3 adopted very strong fixations toward the response which had the higher reinforcement probability. These were later modified and discrimination improved, although the response tendencies never returned to the earlier value. Whereas for bird 7 the alteration occurred gradually with $\hat{p}_1$ and $\hat{p}_2$ shifting slowly upwards over a number of sessions. Thus it is difficult to characterize in a general fashion the way in which behavior changed prior to asymptotic performance.

A significant difference between phase 2 and phase 3 was found for all birds except nos. 13 and 14. According to TSD changing the "pay-off" structure should affect the response criterion but not the sensitivity. For Group 2 the criterion should shift to a lower value, increasing $\hat{p}_1$ and $\hat{p}_2$; for Group 3 the criterion should shift to a higher value, and $\hat{p}_1$ and $\hat{p}_2$ should decrease. Decreasing the pay-off equally for both stimuli as in Group 1 is not predicted to have any effect on criterion or sensitivity. To help evaluate the extent to which the data conform to the predictions from TSD, performance points from Fig. 9 are plotted in Figure 12 on normal-normal coordinates. Binomial standard deviation of the points is approximately plus or minus .012 for phase 2, and .011 for phase 3.

The change in performance is in the predicted direction for Groups 2 and 3 with the exception of one bird in each group, nos. 8 and 11. A relevant factor in considering the absence of an effect for these birds may be that each of these birds had adopted a criterion in the direction of the predicted change before π_1 was reduced. The data do

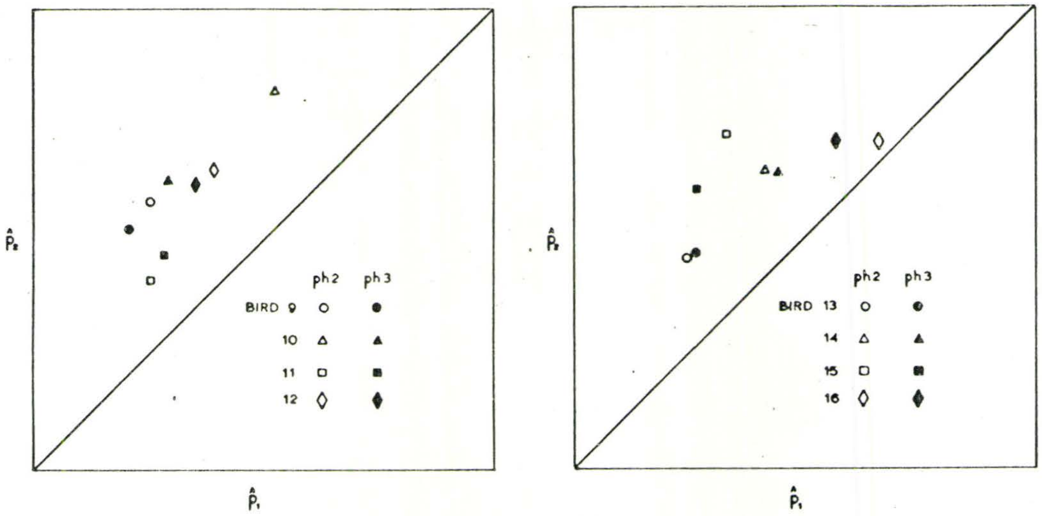
FIGURE 12

Gaussian-scaled ROC graphs showing $\hat{p}_1$ and $\hat{p}_2$ in phase 2 and phase 3. A, Group 1; B Group, 2; C, Group 3; D, Group 4.



A : GROUP 1

B : GROUP 2



C : GROUP 3

D : GROUP 4

FIGURE 12

not allow satisfactory tests to be made for linearity of the functions since there are only two points per curve.

The systematic shifts shown by Groups 2 and 3 may be compared with the data for Groups 1 and 4. Alterations in performance are not predicted by TSD for Group 1, and while there were indications of shifts in criterion, c.f., bird no. 2, as well as in sensitivity, c.f., bird no. 3, there did not appear to be uniform changes for all birds. Similar statements can be made for Group 4.

The theoretical measure, d', was derived for these data.[23] The mean value of d' over all birds was .923 in phase 2, and .934 in phase 3. Shifts in d' did not appear correlated with reinforcement probability. Mean values of d' in phases 2 and 3 respectively, for Group 1 were .995 and .85; for Group 2 were .57 and .55; for Group 3 were 1.19 and 1.29; and for Group 4 were .935 and 1.02. That is, in Groups 1 and 2 d' was decremented, for Groups 3 and 4 it incremented. It appears from these results that in this type of experimental situation partial reinforcement does not affect accuracy of the performance as compared to continuous reinforcement.[24]

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[23] Estimates of theoretical measures d' as well as estimates of α and β are in Appendix M.

[24] If the reader prefers a non-theoretical measure to evaluate this issue he may refer to estimates of P(correct)

The signal detection model, which assumes an underlying continuous distribution of sensory states may be contrasted with a model which proposes discrete sensory states. For purpose of comparison a discrete-state detection model that has been applied in a psychophysical task with auditory stimuli (Atkinson and Kinchla, 1965) will be discussed. Both the discrete-state and signal-detection model assume that two processes are involved, a sensory, or activation process, and a decision process. In the discrete-state model, as in the signal detection model, the sensory process is considered to be fixed over trials, while the decision process may be varied by changing such parameters as a-priori probability of the stimulus or the outcome structure.

The model proposed by Atkinson and Kinchla the continuous sensory variable can be considered as being divided into three discrete states: the state in which the observer is certain an S_1 occurred, in which case an R_1 occurs with probability 1; the state in which an observer is certain an S_2 occurred, and an R_2 occurs with probability 1, and a third state in which the observer is uncertain as to which stimuli occurred and makes an R_2 with probability β. The model has two parameters: the sensitivity parameter α_1, the probability that the observer will

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given in Appendix E, which parallel findings with the theoretical measure d'.

detect an S_i (for purposes of this discussion the simplifying assumption that α_i is equal to α_2 will be made); and the bias parameter, β. (The reader is referred to Atkinson and Kinchla, 1965, for a more detailed discussion.)

If α is fixed and β is systematically varied, the conditional probabilities $\hat{p}_1$ and $\hat{p}_2$ should describe a linear function with slope equal to 1 and intercept equal to α (as compared to the curved function predicted by TSD). Specifically: (substituting the notation of this experiment T_i, for S_i)

$$\hat{p}_1 = \hat{P}(R_2|T_1) = (1 - \alpha)$$

$$\hat{p}_2 = \hat{P}(R_2|T_2) = \alpha + (1 - \alpha)\beta = \hat{p}_1 + \alpha$$

Thus, on the coordinates of Figure 14, data points for phases 2 and 3 would be predicted to lie on a straight line with a slope equal to one. Reducing π_1 should increase β and shift the probabilities toward the right; reducing π_2 should decrease β and data points should move left. This has been noted to have occurred for several birds in groups 2 and 3 respectively.

In Appendix M estimates of the theoretical parameters α and β are given, where

$$\hat{\alpha} = \hat{p}_2 - \hat{p}_1$$

$$\hat{\beta} = \frac{p_1}{1 - \hat{\alpha}}$$

Here mean estimates indicate the sensitivity parameter, α, varied between $\pm$ .046 from phase 2 to phase 3 for different groups. Changes in β from phase 2 to phase 3 were within this range for groups 1 and 4 but were larger for groups 2 and 3, -.135 and .168 respectively. In other words, there does appear to be a correlation between the magnitude and direction of changes in $\hat{\beta}$ and experimental alterations of π_i.

In as much as the experiment was not explicitly designed to test between the predictions of these two theories the foregoing theoretical discussion should be considered only suggestive. However, one further point may be made regarding the evaluation of these two models. An alternate form of the discrete state model which is considered here includes a learning process by which β is modified. This form of the model predicts sequential effects dependent on preceding stimuli. As we have seen, the behavior in this situation appears to be independent of the preceding stimuli for most of the birds. Thus the sequential analysis of this data does not support the form of the Atkinson and Kinchla model which represents a trial-by-trial learning process, and the consequent sequential effects.

Phase four. That partial reinforcement produces greater resistance to extinction than continuous reinforcement in some situations is a well-known effect (Kimble, 1961, Ch. 10). Extrapolation of this effect to the present situation might lead to the prediction that the number of trials in extinction would be ordered as follows: Group 1 > Group 4, with Groups 2 and 3 at intermediate levels. The data did not conform to this prediction. Total mean number of trials for Group 1 was 340 and for Group 4 was 337. A Mann-Whitney U Test (Siegel, 1956) between the two groups was not significant.

Group 2 birds had the highest mean number of trials over the five days of extinction, and for three of the four birds in Group 2 there was a slower decrement in number of daily trials during the course of extinction. However, considerable overlap between groups was noted. In conclusion, the performance during extinction did not appear to be related to the partial reinforcement schedules that obtained in phase 3 in any clear way.

Other investigators (Blough, 1966, Jenkins & Harrison, 1960) have found evidence that discrimination improved in extinction, as revealed by a sharpening of stimulus generalization curves. However, no general trend toward improved discrimination in extinction was found in this experiment, c.f., Fig. 11.

Pooled data. For Group 4 subjects the data for the last 12 sessions of phase 2 and the first and last 12 sessions of phase 3 were pooled. "First" and "higher-order" conditional probability estimates could then be obtained over a larger number of trials, i.e. total n was over 4000. In general, they tended to provide additional support of an independent trials view of the discrimination process except for response conditional sequential effects.[25]

Stationarity. The Chi-Square Test employed to evaluate stationarity over the final 12 sessions assumes that under the null hypothesis response frequencies over the first block of 6 sessions will not differ from response frequencies over the last block of 6 sessions. Other procedures for testing stationarity are possible. For instance, the data of the entire 12 sessions may be divided into blocks of 4 sessions each or blocks of 3 sessions each.[26] The assumption under the null hypothesis is essentially the same, i.e. that response frequencies over the blocks of sessions will not differ. Chi-Squares were obtained for each bird using each of the above procedures, i.e. dividing 12 sessions into blocks of 4 sessions each and 3 sessions each. The criteria for stationarity was a value of χ^2, X, such that $P(\chi^2 = X)$ .01. The resulting Chi-Squares showed

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[25] Numerical values of the pooled conditional probabilities are available in Appendix N, along with the number of trials on which each estimate is based. Estimates of p_1, p_2, p_C and p_L are given as well.

[26] These Chi-Square values are given in Appendix O along with the values for blocks of 6 sessions each.

that the stationarity criteria were not consistently met when these alternate procedures were employed.

CONCLUSION

These experiments have demonstrated that a duration discrimination could be developed using the procedure described here. They showed that not only were pigeons capable of performing a partial discrimination but also were able to maintain it in a relatively stable fashion over an extended period of time. The presentation of the two stimuli on a random schedule from the very beginning appeared to be an important aspect of the shaping procedure in preventing a fixation from developing.

The duration discriminations obtained here with pigeons displayed characteristics that were analogous to discriminative behavior of humans in detection tasks. Changing the length of the durations altered d' accordingly. Also, reducing the probability of reinforcement produced changes in in response bias, and, for many birds, left the sensitivity unchanged. It appears promising that use of this method would lead to a model that will allow independent estimates to be made of "sensitivity" and "response bias" factors. Further work is necessary to select the best fitting detection model. In the present experiment a wide range of individual differences were found which made parameter estimation difficult.

Sequential properties of the behavior came surprisingly close to resembling an independent-trials process. Although a tendency to repeat response was found for some of the birds, analysis failed to reveal the existence of any other sequential dependencies for all birds.

In conclusion, the method developed here would seem to be a highly useful one in extending the investigation of temporal discrimination in animals.

APPENDIX A

EXPERIMENT ONE

Procedure

Major features of the procedure have been given in the main text of this report under Experiment One. The only additional aspect which has not been discussed was the consequences in this experiment for pecking an unlighted key. Whenever a dark key was pecked a 30-second time-out would occur, during which the chamber was dark. A trial during which a time-out occurred was re-initiated at the termination of a time-out, that is, the trial began with the center key lighted, and a peck to that key produced the same duration programmed when the time-out occurred. In this way every trial was completed before a new one was initiated. The time-out was introduced in step 2 of shaping.

In this investigation three independent variables were manipulated: the auditory durations to be discriminated, amount of training, and methods for shifting the subjects from one pair of durations to another. After the birds were shaped and were found to be reliably discriminating between two widely differing values of T, the long duration T_2 was fixed at 5 seconds, and the value of the shortest duration T_1 was varied from 2 seconds to 3 seconds, to 4 seconds, in that order, for every bird.

A second variable that was manipulated was the number of days subjects were run at T_1 equal to 3 seconds.

Subjects were randomly divided into 2 groups, and Group 1 was given 30 sessions at T_1 equal to 3 sec; Group 2 received only 5 sessions at that value.

The third variable was the procedure for making the transition from the lower to the higher value of T_1. Two methods were explored. One method, designated M_1, could be considered a technique involving temporal fading, that is, T was gradually increased in .25 second steps until it was at its new value after 3 sessions. The other method, M_2, involved changing T_1 to its higher value immediately but removing the key light for the incorrect response. Thus subjects were given a brightness cue to associate the correct response with T_1 and T_2. After 2½ sessions brightness of the light of the incorrect key was faded in until both keys were equally bright at the end of the session.

On the 20th to 23rd sessions at T_1 equal to 3 sec. the subjects in Group 1 were given three sessions with the incorrect key light removed, following method M_2, except there was no increase in T_1. See Table 1 for an outline of procedure.

A random 2 subjects in each of Groups 1 and 2 received each of the methods, M_1 and M_2, at the transition to T_1 equal 4 seconds. Subject assignment was as follows:

Group 1 M_1: Birds 1 and 3
M_2: Birds 2 and 5

Group 2 M_1: Birds 4 and 7

M_2: Birds 6 and 9

Results for bird no. 3 are reported separately from the seven male birds.

Results

Table 1 shows $\hat{p}_1$, $\hat{p}_2$, $\hat{p}_C$ and d' for blocks of 5 sessions for each bird. It can be seen from Table 1 that different birds had different values of $\hat{d}'$. They also suggest that for a given bird a clear decrease in $\hat{d}'$ occurred as T_1 increased. (The estimates $\hat{p}_1$ and $\hat{p}_2$ are shown graphically in Figure 1, A, B and C and in Figure 2 in the main text).

After the 20th session on T_1 equal 3 sec. each bird in Group 1 was given exposure to two and a half sessions in which the incorrect key failed to light up, followed by a half session in which the key light was gradually faded back to full brightness. The effect of this can be evaluated in Fig. 2 in the main text, where it can be seen that in the block following removal of the key light a slight decrement in discrimination resulted for two of the birds, but it did not appear to be a permanent decrement and performance recovered by the next block.

A group difference does appear to emerge from the final portions of Figs. 1C and Fig. 2 in the main text. In

TABLE 1

Statistics in 5-session blocks for individual birds in Experiment One.

TABLE 1

EXPERIMENT ONE

STATISTICS IN 5-SESSION BLOCKS

BIRD	BLOCK	$\hat{p}_1$	$\hat{p}_2$	$\hat{p}_C$	d′	BIRD	BLOCK	$\hat{p}_1$	$\hat{p}_2$	$\hat{p}_C$	d′
1	T_1=2" 1	.12	.805	.843	1.39	2	T_1=2" 1	.058	.933	.938	3.02
	2	.089	.885	.897	2.52		2	.068	.979	.955	3.52
	3	.030	.982	.976	3.93		3	.08	.991	.955	3.72
	T_1=3" 4	.166	.668	.751	1.39		T_1=3" 4	.306	.710	.702	1.06
	5	.152	.846	.847	2.08		5	.248	.688	.72	1.18
	6	.086	.933	.923	2.81		6	.077	.818	.87	2.28
	7	.075	.80	.863	2.24		7	.093	.831	.869	2.29
	8	.045	.908	.932	3.09		8	.188	.763	.788	1.62
	9	.022	.969	.973	3.93		9	.142	.867	.862	2.21
	T_1=3"10	.132	.557	.714	1.28		T_1=3"10	.401	.513	.644	.28
	11	.086	.551	.669	1.42		11	.305	.572	.634	.68
	12	.037	.318	.646	1.28		12	.415	.671	.63	.64
5	T_1=2" 1	.085	.712	.819	1.96	3	T_1=2" 1	.067	.923	.928	2.87
	2	.05	.918	.935	3.04		2	.021	.953	.967	3.69
	3	.122	.88	.879	2.35		3	.046	.937	.945	3.19
	T_1=3" 4	.169	.724	.779	1.53		T_1=3" 4	.119	.537	.711	1.28
	5	.318	.797	.740	1.28		5	.116	.462	.674	1.10
	6	.077	.818	.87	2.28		6	.293	.624	.666	.86
	7	.093	.831	.869	2.29		7	.42	.650	.617	.58
	8	.189	.835	.822	1.83		8	.460	.569	.554	.28
	9	.075	.736	.833	2.04		9	.22	.374	.572	.44
	T_1=4"10	.06	.256	.605	.91		T_1=4"10	.436	.54	.552	.25
	11	.089	.346	.629	.96		11	.393	.525	.566	.36
							12	.293	.321	.516	.08

TABLE 1

EXPERIMENT ONE

STATISTICS IN 5-SESSION BLOCKS

BIRD	BLOCK	$\hat{p}_1$	$\hat{p}_2$	$\hat{p}_C$	d′	BIRD	BLOCK	$\hat{p}_1$	$\hat{p}_2$	$\hat{p}_C$	d′
4	T_1=2" 1	.145	.63	.743	1.37	6	T_1=2" 1	.437	.647	.605	.54
	2	.26	.822	.78	1.56		2	.26	.822	.78	1.56
	3	.04	.904	.932	3.03		3	.13	.861	.865	2.21
	T_1=3" 4	.165	.696	.765	1.48		T_1=3" 4	.134	.828	.847	2.08
	T_1=4" 5	.142	.179	.526	.43		T_1=4" 5	.18	.309	.565	.41
	6	.153	.274	.556	.43		6	.07	.117	.525	.30
	7	.20	.32	.562	.37		7	.07	.127	.534	.34
7	T_1=2" 1	.234	.921	.843	2.14	9	T_1=2" 1	.178	.682	.752	1.42
	2	.099	.963	.932	3.03		2	.111	.858	.874	2.27
	3	.03	.996	.982	4.20		3	.027	.786	.879	2.68
	T_1=3" 4	.21	.88	.835	1.98		T_1=3" 4	.09	.618	.762	1.64
	T_1=4" 5	.185	.299	.558	.36		T_1=4" 5	.55	.644	.546	.23
	6	.426	.582	.578	.38		6	.64	.813	.588	.52

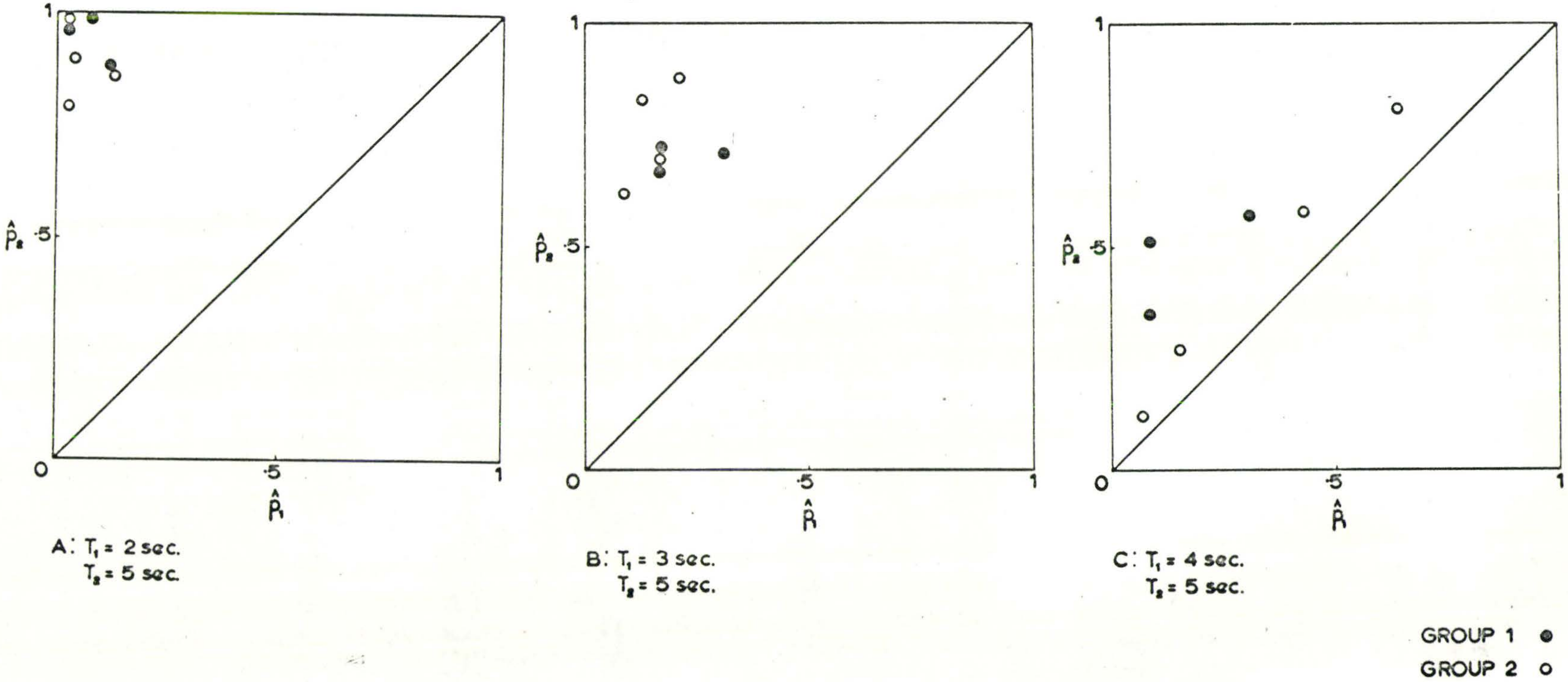
Fig. 1C the performance points for Group 1 fall above those of Group 2, and in Fig. 2 the separation between the functions of Group 1 birds appeared to be greater than for any of the birds in Group 2. The mean $\hat{p}_C$ was .644 for Group 1 and .562 for Group 2 for the 2nd block of sessions at T_1 equal 4 sec.

The two procedures used to increase T_1, M_1 and M_2 appeared to produce equivalent behavior. The relevant comparison is between birds 1, 4 and 7 and birds 2, 5, 6 and 9. There was no evidence of a difference between these subjects.

The data for the female, bird 3, is shown in Fig. 1. In part a the conditional probabilities for all blocks of 5 sessions are plotted in an ROC graph. Early performance parallels that of male subjects. However, the change to T_1 equal 3 sec. produced much weaker discrimination than with the 7 male birds, and, instead of improving with exposure to the schedule, discrimination appeared to worsen. Further, there did not appear to be a differential effect of reducing the difference between T_1 and T_2 still further. By the 12th block of 5 sessions performance nearly falls on the positive diagonal in the ROC graph. This is also shown in Fig. 1B by the gradual convergence of $\hat{p}_1$ and $\hat{p}_2$, and by the slowly deccreasing function, $\hat{p}_C$, in Fig. 1C also. By the final five sessions the subject appeared no longer to be discriminating.

FIGURE 1

Estimates of p_1 and p_2 in 5-session blocks for Bird 3 throughout the Experiment. A, in an ROC graph; B as functions of blocks of sessions, C, the probability of a correct response, p_C, as a function of blocks of sessions.



A: $T_1 = 2$ sec.
$T_2 = 5$ sec.

B: $T_1 = 3$ sec.
$T_2 = 5$ sec.

C: $T_1 = 4$ sec.
$T_2 = 5$ sec.

FIGURE 1

Discussion

It is of interest to note the extent to which birds were able to maintain a partial discrimination even when the stimulus difference was small, c.f., 3rd portions in Fig. 2 (main text). The overall mean $\hat{p}_C$ for the 2nd block of sessions at this value of T_1 equal to 4 sec. was .599. Some birds were performing slightly better than chance, yet they maintained a consistent degree of partial discrimination.

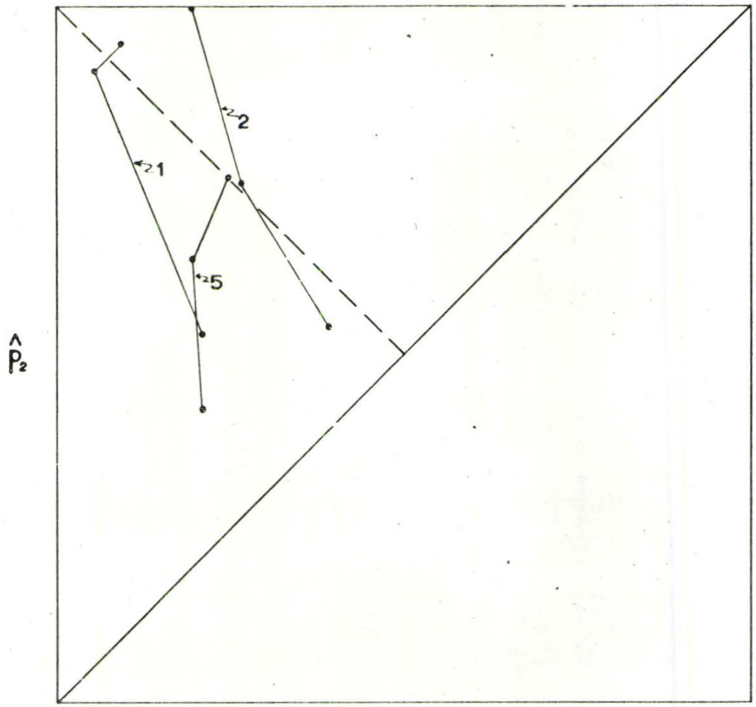
The effect of differential amount of training on 'Groups 1 and 2 seems to indicate the apparent dependence of discrimination on past history as well as on the immediate experimental situation. The past history of Group 1 differed in two ways from that of roup 2, i.e., it was exposed to more sessions with T_1 equal to 3 sec., and was given a different experimental procedure for 3 days. It is difficult to specify which of these was most related to the better discrimination observed for that group. However, it is important to note that in human signal-detection the theoretical measure d' is considered to be a function of physical stimulus and of sensitivity of the particular observer. The sensitivity is assumed to be a relatively stable feature of the perceptual process. The data obtained here from pigeons seem to suggest that a similar sensitivity measure may not always be a stable feature of the animal's behavior but only becomes stable after relatively long periods of acquisition or training.

One feature of performance which is of interest is the response bias. This term will be used here to denote the tendency to make one response more than another independently of the stimulus. In Fig. 2A and B performance is plotted at 3 values of T_1 for each bird (connected points are for a single bird). According to the theory of signal detection changing the discriminability of the stimuli should not necessarily produce changes in c. To evaluate this prediction the data were plotted on normal-normal coordinates. While one bird did maintain a relatively stable response bias (no. 7) the others exhibited great diversity of behavior and particularly when T_1 and T_2 differed by only 1 sec. It seems most accurate to say the birds behaved idiosyncratically when the discrimination became more difficult. There were clear differences in response bias among the birds initially as well, before any manipulations had occurred, as shown by the uppermost point for each bird, although none of these biases reached the point of a fixation on one response.

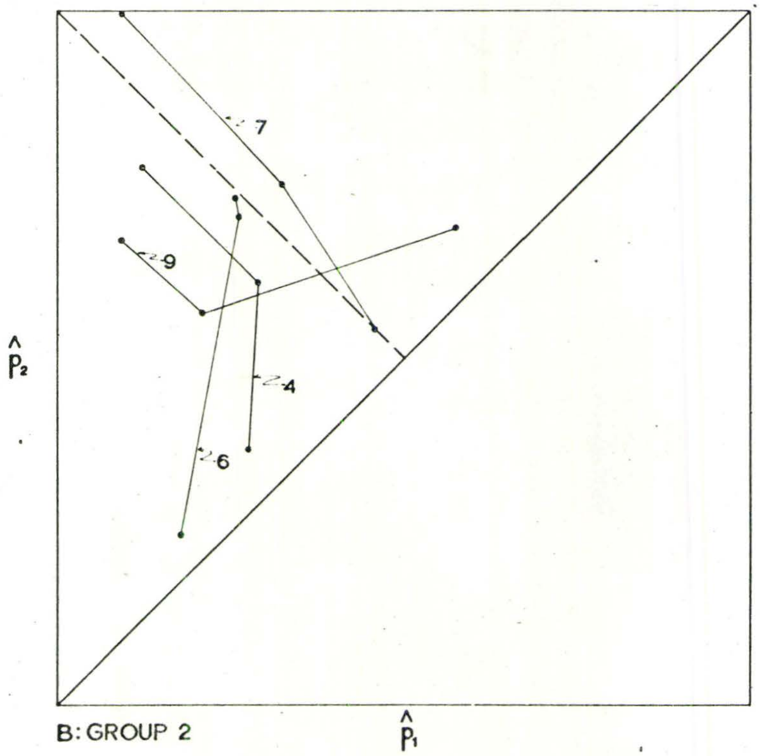
A time-out (TO) occurred very seldom during a session; most birds, in fact, never received a TO. An exception to this was bird 5, whose behavior paralleled that of the others until T_1 was increased to its highest value and discrimination became difficult, at which point he began to receive a large number of TOs. This behavior continued until the experiment

FIGURE 2

Gaussian-scaled values of p_1 and p_2. Lines connect each value of T for individual birds. A, Group 1, B, Group 2.



A: GROUP 1



B: GROUP 2

FIGURE 2.

terminated, but there was no apparent effect on performance by the large number of TOs. The TO contingency was originally considered a means of preventing long runs of key pecking during the tone that might serve to mediate the time interval. However, it was apparent in this study that the probability of emission of a key peck during the tone was quite low, and in fact for some birds was zero, so that a TO for this purpose was not necessary. Further, where there was a high probability of pecking during the tone, as with bird 5, the TO was ineffective in reducing it. Thus in Experiment Two the TO contingency was removed.

APPENDIX B

AUTOSHAPING

Autoshaping

For nine of the subjects an autoshaping procedure (Brown and Jenkins, 1968) was used to attempt to shape the key-peck response. Following magazine training the following schedule was put into effect:

> An ITI of 5 sec. was followed by a 7 sec. key light, at the end of which reinforcement was presented for 4 sec. Either a right or left key light could occur with an a priori probability of .5. A peck to the lighted key would produce reinforcement immediately. On the second day the ITI was increased to a random value between 10 and 20 seconds, with a mean of 15 sec.

The nine subjects received between 90 and 180 trials, with a mean of 122 trials, over the two days in which the autoshaping procedure was in effect. Only one bird acquired the key peck response, requiring 174 trials. The eight birds who did not autoshape were then returned to the conventional procedure used with the remaining seven birds, in which approach to the lighted key was gradually shaped into a key peck by visually monitoring the behavior.

Appendix C

The performance of each animal during each session of the experiment is characterized in the following tables. Four descriptive statistics are defined for the data from each session: p_1, the proportion of R_2 responses on T_1 trials; p_2, the proportion of R_2 responses on T_2 trials; p_C, the proportion of correct responses; and p_L, the proportion of R responses.

Asterisks indicate the particular session numbers where T_1 assumed a new value for each animal. (Sessions with T_1 equal to 1 sec. are not shown). A double asterisk marks the first session of phase 2, phase 3 and phase 4.

The sequence of values of T_1 during phase 1 and the number of sessions each was in effect were as follows:

T_1	No. sessions
1	3 - 10
2	3 - 7
2.5	3, 4
3	3 - 8
3.25	12 - 14
3.5	8 - 11
4	10 - 12

BIRD # 1

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
1.	.869	.373	.750	.625
2.	.814	.311	.750	.558
3.	.471	.094	.682	.288
4.	.619	.190	.714	.405
5.	.833	.667	.583	.750
6.	.866	.536	.662	.699
7.	.789	.237	.776	.509
8.	.636	.262	.687	.450
9.	.514	.217	.647	.367
10.	.500	.185	.645	.355
11.	.750	.288	.732	.528
12.	.789	.417	.695	.618
13.	.487	.274	.604	.383
14.	.563	.156	.703	.359
15.	.625	.105	.752	.380
16.	.563	.127	.717	.346
17.	.661	.117	.776	.379
18.	.792	.037	.882	.392
19.	.594	.070	.752	.347
20.	.732	.183	.776	.448
21.	.821	.200	.811	.514
22.	.759	.140	.811	.441
23.	.846	.148	.849	.491
24.	.758	.189	.783	.496
25.	.741	.180	.783	.443
26.	.593	.033	.782	.311
27.	.633	.161	.738	.393
28.	.725	.054	.841	.374
29.	.684	.019	.826	.367
30.	.500	.032	.738	.262
31.	.619	.056	.769	.359
32.	.868	.137	.865	.510
33.	.746	.233	.756	.487
34.	.579	.081	.756	.319
35.	.642	.190	.720	.432
36.	.655	.100	.783	.365
37.	.565	.127	.720	.344
38.	.551	.235	.657	.394
39.	.500	.235	.625	.375
40.	.600	.215	.692	.408
41.	.476	.063	.709	.268
42.	.690	.206	.744	.438
43.	.576	.246	.667	.407
44.	.672	.150	.763	.407
45.	.613	.088	.756	.361
46.	.594	.148	.720	.376
47.	.617	.117	.750	.367
48.	.635	.194	.720	.416
49.	.690	.074	.804	.393
50.	.596	.018	.789	.307

BIRD # 2

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
1.	.862	.344	.756	.597
2.	.824	.521	.647	.669
3.	.849	.580	.641	.718
4.	.948	.426	.756	.681
5.	.833	.132	.850	.486
6.	.941	.192	.874	.563
7.	.948	.379	.784	.664
8.	.807	.397	.692	.577
9.	.514	.143	.677	.338
10.	.851	.611	.623	.733
11.	.735	.429	.652	.580
12.	.682	.193	.740	.455
13.	.812	.397	.717	.622
14.	.915	.629	.645	.773
15.	.787	.432	.662	.585
16.	.872	.722	.573	.796
17.	.753	.760	.492	.757
18.	.763	.579	.592	.671
19.	.620	.352	.634	.486
20.	.561	.416	.572	.491
21.	.488	.405	.542	.446
22.	.420	.325	.549	.372
23.	.440	.278	.584	.357
24.	.304	.154	.573	.229
25.	.116	.160	.476	.138
26.	.234	.100	.573	.166
27.	.371	.123	.629	.245
28.	.287	.139	.572	.214
29.	.354	.173	.584	.266
30.	.730	.286	.722	.508
31.	.615	.265	.677	.436
32.	.244	.195	.533	.219
33.	.333	.212	.559	.273
34.	.667	.088	.789	.377
35.	.803	.180	.811	.523
36.	.852	.154	.849	.509
37.	.687	.353	.667	.519
38.	.729	.266	.732	.488
39.	.621	.140	.732	.398
40.	.723	.306	.709	.520
41.	.746	.358	.692	.546
42.	.675	.356	.662	.537
43.	.770	.232	.769	.513
44.	.667	.303	.682	.485
45.	.700	.406	.647	.554
46.	.797	.435	.677	.609
47.	.839	.271	.783	.548
48.	.704	.375	.667	.548
49.	.758	.385	.687	.573
50.	.818	.463	.677	.639

Bird # 1 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
51.	.685	.086	.804	.375
52.	.804	.151	.826	.486
53.	.719	.125	.796	.425
54.	.643	.115	.769	.368
55.	.691	.088	.804	.384
56.	.621	.100	.763	.356
57.	.754	.145	.804	.455
58.	.661	.183	.738	.426
59.	.578	.209	.687	.389
60.	.678	.180	.750	.425
61.	.684	.136	.776	.405
62.	.746	.207	.769	.479
63.	.694	.254	.720	.472
64.	.684	.089	.796	.389
65.	.571	.156	.709	.362
66.	.673	.145	.769	.393
67.	.603	.161	.720	.384
68.	.533	.128	.704	.328
69.	.427	.113	.658	.269
70.	.427	.022	.702	.225
71.	.570	.057	.757	.312
72.	.581	.122	.727	.355
73.	.553	.093	.731	.322
74.	.671	.134	.768	.402
75.	.604	.109	.749	.355
76.	.510	.076	.713	.298
77.	.639	.106	.768	.369
78.	.737	.120	.806	.439
79.	.696	.101	.797	.399
80.	.696	.215	.741	.456
81.	.783	.319	.730	.546
82.	.793	.207	.793	.500
83.	.699	.224	.738	.458
84.	.647	.202	.722	.426
85.	.520	.270	.625	.395
86.	.495	.235	.628	.367
87.	.644	.169	.737	.408
88.	.587	.167	.709	.379
89.	.527	.079	.722	.306
90.	.549	.110	.720	.330
91.	.712	.053	.832	.376
92.	.695	.067	.809	.395
93.	.646	.154	.743	.406
94.	.686	.133	.778	.403
95.	.619	.106	.757	.361
96.	.565	.011	.779	.285
97.	.547	.058	.744	.302
98.	.419	.231	.585	.329
99.	.316	.182	.585	.244
100.	.294	.143	.548	.226
101.	.500	.250	.643	.357

Bird # 2 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
51.	.855	.563	.643	.707
52.	.885	.345	.776	.629
53.	.780	.279	.750	.525
54.	.714	.297	.709	.504
55.	.768	.413	.682	.598
56.	.797	.493	.652	.645
57.	.652	.384	.634	.514
58.	.672	.164	.756	.412
59.	.652	.319	.667	.481
60.	.515	.164	.677	.338
61.	.507	.280	.616	.390
62.	.276	.092	.592	.184
63.	.312	.057	.612	.190
64.	.240	.101	.578	.169
65.	.457	.159	.647	.309
66.	.267	.054	.604	.161
67.	.429	.157	.636	.293
68.	.479	.214	.629	.350
69.	.582	.282	.652	.428
70.	.453	.153	.662	.294
71.	.329	.107	.621	.214
72.	.389	.054	.670	.220
73.	.340	.050	.645	.195
74.	.404	.336	.552	.365
75.	.569	.255	.657	.412
76.	.558	.108	.723	.335
77.	.433	.101	.668	.265
78.	.500	.098	.703	.297
79.	.556	.161	.699	.355
80.	.490	.269	.612	.379
81.	.552	.234	.658	.395
82.	.705	.157	.774	.429
83.	.700	.221	.739	.466
84.	.551	.144	.704	.346
85.	.592	.308	.643	.449
86.	.734	.165	.785	.449
87.	.604	.144	.729	.376
88.	.753	.284	.734	.511
89.	.711	.365	.674	.539
90.	.778	.360	.709	.570
91.	.726	.351	.688	.540
92.	.705	.220	.743	.458
93.	.627	.170	.731	.392
94.	.628	.178	.723	.408
95.	.617	.258	.681	.435
96.	.507	.128	.693	.314
97.	.542	.411	.565	.476
98.	.684	.300	.692	.487
99.	.313	.067	.613	.194
100.	.000	.333	.667	.333

BIRD # 3

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
1.	.960	.150	.900	.518
2.	.774	.273	.750	.516
3.	.754	.169	.793	.457
4.	.800	.053	.879	.402
5.	.788	.037	.877	.406
6.	.833	.423	.701	.620
7.	.820	.333	.742	.573
8.	.929	.791	.557	.858
9.	.976	.903	.511	.938
10.	.934	.768	.570	.848
11.	1.000	.904	.551	.952
12.	1.000	.633	.708	.831
13.	.912	.538	.671	.712
14.	.219	.168	.524	.194
15.	.179	.088	.560	.131
16.	.061	.065	.487	.063
17.	.061	.094	.477	.077
18.	.957	.905	.521	.931
19.	.011	.040	.503	.026
20.	.041	.051	.446	.045
21.	.010	0.000	.490	.005
22.	.033	.020	.459	.027
23.	0.000	.031	.485	.015
24.	.033	.022	.503	.027
25.	.069	.073	.487	.071
26.	.019	.075	.449	.046
27.	.073	.075	.492	.074
28.	.312	.080	.612	.197
29.	.526	.278	.622	.405
30.	.672	.221	.727	.439
31.	.603	.188	.712	.386
32.	.676	.246	.713	.473
33.	.906	.193	.855	.536
34.	.742	.324	.709	.530
35.	.623	.133	.736	.395
36.	.571	.200	.681	.393
37.	.657	.267	.692	.477
38.	.642	.200	.723	.416
39.	.727	.241	.742	.500
40.	.943	.128	.910	.560
41.	.919	.606	.662	.766
42.	.940	.500	.722	.722
43.	.864	.226	.821	.563
44.	.828	.130	.848	.491
45.	.733	.167	.786	.437
46.	.905	.463	.715	.677
47.	.761	.333	.715	.554
48.	.631	.254	.689	.439
49.	.549	.161	.684	.368
50.	.754	.328	.713	.543
51.	.561	.203	.681	.378

BIRD # 4

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
1.	.958	.022	.968	.505
2.	.930	.373	.776	.647
3.	.563	.143	.709	.354
4.	.979	.119	.925	.505
5.	.846	.080	.882	.471
6.	.958	.120	.918	.531
7.	.920	.120	.900	.520
8.	.939	.083	.928	.515
9.	.788	.039	.874	.417
10.	.857	.236	.811	.550
11.	.655	.100	.783	.365
12.	.500	.017	.738	.262
13.	.312	.043	.616	.185
14.	.413	.059	.687	.229
15.	.275	.092	.709	.150
16.	.049	.012	.518	.030
17.	.045	.034	.508	.040
18.	.365	.280	.539	.323
19.	.728	.763	.476	.746
20.	.542	.483	.529	.512
21.	.356	.370	.495	.363
22.	.364	.463	.448	.412
23.	.458	.477	.489	.467
24.	.538	.415	.563	.475
25.	.417	.473	.471	.444
26.	.393	.368	.511	.381
27.	.330	.299	.514	.314
28.	.442	.342	.545	.394
29.	.467	.473	.497	.470
30.	.590	.518	.536	.554
31.	.449	.451	.500	.450
32.	.458	.240	.612	.347
33.	.566	.482	.542	.524
34.	.603	.473	.559	.528
35.	.520	.477	.521	.500
36.	.438	.389	.529	.412
37.	.576	.224	.677	.398
38.	.481	.350	.566	.415
39.	.407	.301	.555	.354
40.	.557	.481	.539	.521
41.	.573	.536	.520	.555
42.	.507	.304	.608	.399
43.	.519	.279	.612	.408
44.	.709	.564	.573	.637
45.	.654	.471	.596	.570
46.	.747	.575	.592	.664
47.	.734	.508	.625	.632
48.	.839	.811	.508	.825
49.	.875	.730	.584	.805
50.	.780	.789	.497	.785
51.	.782	.633	.573	.707

Bird # 3 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
52.	.625	.136	.740	.390
53.	.493	.162	.664	.328
54.	.521	.123	.691	.331
55.	.697	.193	.748	.463
56.	.683	.210	.736	.448
57,	.741	.155	.793	.448
58.	.592	.098	.735	.364
59.	.696	.300	.698	.512
60.	.563	.085	.732	.333
61.	.868	.170	.849	.519
62.	.750	.186	.783	.461
63.	.782	.193	.795	.482
64.	.765	.121	.826	.422
65.	.895	.250	.826	.587
66.	.750	.186	.783	.461
67.	.796	.145	.826	.468
68.	.729	.145	.789	.447
69.	.684	.150	.769	.410
70.	.863	.132	.865	.490
71.	.688	.281	.703	.484
72.	.714	.159	.777	.440
73.	.733	.205	.764	.472
74.	.793	.383	.704	.586
75.	.912	.373	.767	.638
76.	.731	.359	.686	.546
77.	.842	.375	.738	.617
78.	.839	.396	.723	.620
79.	.892	.345	.780	.633
80.	.776	.259	.759	.518
81.	.787	.367	.712	.582
82.	.750	.383	.684	.568
83.	.774	.303	.736	.544
84.	.830	.474	.677	.651
85.	.747	.261	.743	.503
86.	.690	.167	.762	.429
87.	.759	.241	.759	.506
88.	.732	.305	.713	.518
89.	.692	.245	.724	.465
90.	.629	.269	.679	.453
91.	.578	.380	.599	.480
92.	.750	.244	.753	.489
93.	.615	.239	.689	.426
94.	.688	.253	.718	.468
95.	.560	.189	.685	.376
96.	.471	.240	.617	.354
97.	.587	.878	.356	.732
98.	.479	.250	.617	.362
99.	.427	.121	.656	.272
100.	.584	.119	.728	.358
101.	.537	.245	.646	.392
102.	.449	.102	.673	.276
103.	.511	.089	.709	.302
104.	.714	.167	.774	.440
105.	.595	.107	.744	.351

Bird # 4 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
52.	.700	.707	.495	.703
53.	.820	.813	.500	.817
54.	.951	.816	.554	.881
55.	.932	.909	.511	.920
56.	.497	.500	.497	.497
57.	.989	.978	.500	.983
58.	.966	.957	.497	.961
59.	.848	.709	.570	.778
60.	.846	.696	.573	.771
61.	.857	.857	.514	.857
62.	.933	.934	.497	.934
63.	.976	.900	.549	.939
64.	.977	.944	.508	.960
65.	.948	.945	.513	.947
66.	.480	.920	.346	.627
67.	.880	.908	.505	.893
68.	.944	.935	.497	.939
69.	.920	.889	.533	.905
70.	.923	.937	.484	.930
71.	.955	.945	.500	.950
72.	.922	.921	.503	.922
73.	.766	.795	.495	.780
74.	.827	.723	.549	.774
75.	.698	.647	.526	.673
76.	.894	.833	.533	.864
77.	.902	.812	.539	.856
78.	.955	.944	.506	.949
79.	.930	.873	.545	.903
80.	.913	.909	.511	.911
81.	.992	.926	.537	.959
82.	.984	.984	.502	.984
83.	.985	1.000	.494	.992
84.	1.000	1.000	.502	1.000
85.	1.000	.992	.504	.996
86.	1.000	1.000	.502	1.000
87.	1.000	1.000	.502	1.000
88.	.992	1.000	.494	.996
89.	1.000	.976	.510	.988
90.	1.000	.977	.502	.988
91.	1.000	1.000	.496	1.000
92.	.992	.985	.494	.989
93.	1.000	.992	.508	.996
94.	1.000	.992	.500	.996
95.	.992	.945	.521	.969
96.	.969	.976	.504	.972
97.	1.000	1.000	.500	1.000
98.	.977	.985	.492	.981
99.	.977	.984	.502	.980
100.	1.000	1.000	.498	1.000
101.	.932	.957	.480	.945
102.	.977	.976	.506	.976
103	1.000	.960	.518	.980
104.	.976	.984	.498	.980
105.	.944	.833	.552	.888

Bird # 3 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
106.	.545	.060	.737	.310
107.	.543	.289	.628	.415
108.	.426	.209	.605	.319
109.	.625	.600	.500	.611
110.	.500	.667	.444	.556

Bird # 4 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
106.	.649	.694	.471	.672
107.	.565	.480	.542	.521
108.	.300	.167	.591	.227
109.	0.000	0.000	1.000	0.000

BIRD # 5

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
1.	.961	.241	.857	.590
2.	.960	.137	.911	.545
3.	.875	.040	.918	.449
4.	.857	.077	.891	.455
5.	.840	.059	.891	.446
6.	.613	.133	.738	.377
7.	.821	.185	.818	.509
8.	.649	.097	.782	.361
9.	.462	.079	.709	.255
10.	.800	.167	.818	.455
11.	.733	.233	.750	.483
12.	.632	.161	.726	.419
13.	.581	.129	.726	.355
14.	.425	.192	.616	.308
15.	.440	.250	.596	.344
16.	.381	.306	.538	.343
17.	.358	.250	.558	.303
18.	.438	.337	.554	.386
19.	.558	.422	.569	.487
20.	.686	.380	.652	.532
21.	.878	.653	.611	.765
22.	.824	.623	.596	.722
23.	.768	.464	.652	.616
24.	.686	.328	.679	.515
25.	.667	.292	.687	.481
26.	.614	.373	.621	.490
27.	.553	.517	.517	.534
28.	.617	.487	.565	.553
29.	.758	.375	.692	.569
30.	.844	.675	.584	.760
31.	.781	.832	.476	.806
32.	.963	.866	.549	.915
33.	.941	.875	.526	.908
34.	.950	.800	.600	.880
35.	.931	.709	.596	.815
36.	.938	.797	.584	.870
37.	.963	.852	.556	.907
38.	.775	.654	.559	.714
39.	.513	.370	.573	.439
40.	.443	.402	.520	.423
41.	.513	.354	.581	.432
42.	.532	.364	.584	.448
43.	.671	.377	.647	.525
44.	.681	.388	.647	.540
45.	.463	.325	.566	.396
46.	.631	.258	.687	.443
47.	.568	.463	.552	.515
48.	.781	.365	.709	.575
49.	.709	.541	.588	.627
50.	.764	.453	.662	.618

BIRD # 6

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
1.	.920	.170	.874	.534
2.	.854	.020	.918	.429
3.	.979	.023	.978	.522
4.	.977	0.000	.989	.462
5.	.863	.098	.882	.480
6.	.203	0.000	.604	.101
7.	0.000	0.000	.503	0.000
8.	.012	.011	.514	.011
9.	.023	.011	.514	.017
10.	0.000	0.000	.506	0.000
11.	.128	.012	.545	.072
12.	.902	0.000	.947	.484
13.	.759	.179	.789	.474
14.	.094	.058	.495	.077
15.	.054	.012	.506	.034
16.	.207	0.000	.566	.113
17.	.303	.118	.592	.211
18.	.315	.130	.600	.220
19.	.286	.041	.629	.161
20.	.719	.241	.738	.492
21.	.532	.066	.732	.301
22.	.655	.175	.744	.405
23.	.615	.123	.738	.385
24.	.661	.036	.811	.351
25.	.820	.039	.891	.426
26.	.852	.064	.891	.485
27.	.979	.045	.967	.533
28.	.850	.125	.862	.487
29.	.906	.222	.841	.561
30.	.922	.259	.826	.569
31.	.925	.180	.874	.563
32.	.865	.082	.891	.485
33.	.894	.059	.918	.459
34.	.981	.309	.833	.639
35.	.925	.196	.865	.567
36.	.293	.042	.616	.171
37.	.754	.096	.826	.440
38.	.836	.200	.818	.518
39.	.842	.176	.833	.528
40.	.849	.118	.865	.490
41.	.885	.154	.865	.519
42.	.873	.288	.789	.570
43.	.677	.143	.763	.424
44.	.813	.415	.698	.612
45.	.394	.086	.662	.235
46.	.203	.063	.584	.130
47.	.471	.197	.638	.333
48.	.452	0.000	.726	.226
49.	.500	.066	.709	.291
50.	.603	.197	.698	.411

Bird # 5 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
51.	.674	.640	.514	.657
52.	.750	.610	.573	.682
53.	.691	.585	.552	.638
54.	.762	.690	.536	.726
55.	.690	.640	.520	.665
56.	.457	.369	.545	.412
57.	.320	.376	.466	.347
58.	.233	.233	.500	.233
59.	.180	.196	.497	.188
60.	.221	.289	.469	.255
61.	.286	.267	.517	.276
62.	.205	.120	.542	.163
63.	.500	.175	.703	.297
64.	.365	.190	.619	.265
65.	.056	.023	.511	.039
66.	.046	.011	.523	.028
67.	.138	.060	.529	.100
68.	.222	.122	.552	.172
69.	.181	.189	.489	.185
70.	.236	.226	.511	.231
71.	.293	.212	.545	.251
72.	.390	.318	.539	.353
73.	.382	.360	.511	.371
74.	.379	.359	.514	.369
75.	.608	.436	.586	.522
76.	.506	.464	.520	.486
77.	.515	.176	.672	.343
78.	.327	.345	.479	.335
79.	.581	.512	.535	.547
80.	.652	.632	.511	.642
81.	.701	.512	.572	.610
82.	.763	.605	.573	.682
83.	.737	.534	.604	.638
84.	.696	.551	.573	.624
85.	.705	.570	.567	.637
86.	.675	.556	.559	.615
87.	.684	.513	.584	.597
88.	.704	.480	.610	.589
89.	.764	.507	.629	.636
90.	.716	.500	.608	.608
91.	.702	.638	.532	.670
92.	.819	.650	.589	.736
93.	.841	.767	.534	.803
94.	.824	.663	.579	.743
95.	.742	.562	.590	.652
96.	.911	.679	.612	.794
97.	.859	.713	.570	.785
98.	.900	.712	.594	.806
99.	.902	.844	.533	.874
100.	.920	.835	.536	.877

Bird # 6 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
51.	.523	.176	.677	.346
52.	.712	.213	.750	.458
53.	.690	.167	.763	.424
54.	.697	.343	.677	.519
55.	.461	.247	.604	.356
56.	.710	.179	.763	.458
57.	.571	.143	.714	.357
58.	.662	.203	.726	.444
59.	.544	.254	.647	.396
60.	.550	.081	.738	.311
61.	.828	.288	.769	.556
62.	.780	.302	.738	.533
63.	.742	.397	.672	.567
64.	.551	.246	.652	.399
65.	.481	.221	.621	.359
66.	.658	.467	.596	.563
67.	.708	.343	.682	.523
68.	.694	.277	.709	.480
69.	.494	.346	.573	.420
70.	.758	.420	.667	.585
71.	.689	.257	.715	.479
72.	.691	.425	.634	.559
73.	.864	.584	.646	.728
74.	.890	.750	.566	.819
75.	.878	.820	.531	.849
76.	.954	.874	.540	.914
77.	.989	.953	.523	.971
78.	.989	.955	.520	.972
79.	.989	.976	.520	.983
80.	.989	.978	.503	.983
81.	1.000	.976	.523	.988
82.	1.000	1.000	.506	1.000
83.	1.000	1.000	.489	1.000
84.	1.000	1.000	.500	1.000
85.	.989	1.000	.471	.995
86.	.957	.978	.492	.967
87.	1.000	1.000	.503	1.000
88.	.967	.958	.495	.962
89.	.989	.875	.650	.944
90.	.944	.905	.508	.924
91.	.927	.765	.575	.844
92.	.877	.725	.578	.801
93.	.955	.911	.517	.933
94.	.988	.855	.566	.922
95.	.810	.598	.602	.702
96.	.907	.750	.582	.829
97.	.892	.711	.578	.798
98.	.955	.892	.547	.924
99.	.889	.646	.625	.769
100.	.696	.400	.648	.547

Bird # 5 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
101.	.871	.750	.555	.809
102.	.747	.573	.585	.659
103.	.678	.608	.529	.642
104.	.782	.628	.578	.705
105.	.775	.703	.521	.737
106.	.679	.459	.608	.566
107.	.687	.544	.549	.618
108.	.817	.612	.599	.713
109.	.707	.578	.566	.643
110.	.882	.757	.558	.819
111.	.829	.642	.595	.736
112.	.854	.679	.595	.761
113.	.786	.571	.607	.673
114.	.763	.703	.533	.734
115.	.795	.583	.605	.689
116.	.778	.549	.613	.663
117.	.744	.500	.625	.625
118.	.537	.494	.521	.515
119.	.218	.167	.523	.193
120.	.477	.325	.571	.405
121.	0.000	.500	.333	.333

Bird # 6 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
101.	.659	.489	.587	.575
102.	.626	.500	.563	.563
103.	.681	.621	.529	.651
104.	.571	.404	.584	.486
105.	.589	.438	.576	.513
106.	.717	.648	.536	.683
107.	.729	.698	.516	.714
108.	.604	.432	.586	.516
109.	.694	.548	.574	.621
110.	.867	.756	.563	.813
111.	.829	.556	.634	.690
112.	.541	.413	.564	.477
113.	.618	.370	.624	.495
114.	.640	.810	.435	.717
115.	.444	.571	.438	.500

BIRD # 7

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
1.	.987	.867	.552	.926
2.	.873	.675	.603	.776
3.	.900	.620	.638	.759
4.	.873	.311	.776	.578
5.	.894	.537	.677	.714
6.	.806	.344	.732	.577
7.	.954	.556	.703	.758
8.	.721	.217	.752	.471
9.	.612	.310	.652	.457
10.	.685	.156	.750	.468
11.	.793	.185	.804	.500
12.	.893	.200	.849	.566
13.	.889	.160	.865	.538
14.	.754	.286	.734	.516
15.	.727	.153	.789	.430
16.	.797	.283	.756	.538
17.	.825	.246	.789	.535
18.	.859	.352	.763	.627
19.	.962	.200	.882	.588
20.	.922	.232	.841	.561
21.	.836	.250	.796	.566
22.	.770	.295	.738	.533
23.	.855	.246	.804	.545
24.	.839	.339	.754	.602
25.	.875	.328	.772	.596
26.	.759	.127	.817	.440
27.	.889	.300	.789	.579
28.	.758	.317	.720	.536
29.	.738	.288	.726	.524
30.	.800	.138	.833	.444
31.	1.000	.467	.763	.729
32.	.859	.540	.672	.709
33.	.844	.368	.744	.620
34.	.951	.439	.763	.703
35.	.739	.437	.650	.586
36.	.862	.728	.565	.795
37.	.868	.687	.539	.760
38.	.831	.756	.533	.793
39.	.867	.854	.523	.860
40.	.819	.732	.545	.776
41.	.786	.721	.529	.753
42.	.826	.514	.655	.669
43.	.750	.435	.657	.591
44.	.625	.405	.608	.500
45.	.482	.393	.545	.437
46.	.301	.354	.476	.328
47.	.270	.236	.517	.253
48.	.337	.232	.552	.285
49.	.260	.103	.581	.181
50.	.423	.253	.586	.338

BIRD # 8

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
1.	.719	.093	.811	.414
2.	.720	.648	.529	.682
3.	.568	.457	.556	.512
4.	.545	.311	.638	.394
5.	.889	.460	.714	.675
6.	.900	.446	.720	.664
7.	.850	.350	.750	.600
8.	.710	.258	.726	.484
9.	.651	.246	.703	.445
10.	.766	.359	.703	.563
11.	.486	.295	.600	.387
12.	.439	.062	.687	.252
13.	.672	.140	.763	.415
14.	.610	.156	.732	.374
15.	.373	.154	.593	.271
16.	.585	.200	.692	.392
17.	.453	.090	.687	.267
18.	.541	.123	.714	.325
19.	.406	.045	.687	.221
20.	.556	.098	.726	.331
21.	.800	.179	.811	.486
22.	.770	.218	.776	.509
23.	.821	.241	.789	.526
24.	.815	.233	.789	.509
25.	.891	.328	.779	.602
26.	.839	.218	.811	.532
27.	.741	.074	.833	.407
28.	.782	.041	.865	.433
29.	.782	.078	.849	.443
30.	.788	.058	.865	.423
31.	.913	.077	.918	.469
32.	.882	.211	.833	.528
33.	.920	.120	.900	.520
34.	.857	.176	.841	.533
35.	.829	.500	.672	.672
36.	.769	.412	.677	.586
37.	.360	.137	.608	.250
38.	.516	.136	.692	.323
39.	.800	.323	.738	.557
40.	.860	.212	.826	.550
41.	.855	.173	.841	.523
42.	.764	.127	.818	.445
43.	.522	.115	.692	.331
44.	.661	.117	.776	.379
45.	.625	.083	.776	.345
46.	.559	.268	.647	.410
47.	.671	.317	.677	.504
48.	.806	.365	.720	.584
49.	.785	.409	.687	.595
50.	.652	.299	.677	.474

Bird # 7 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
51.	.542	.410	.565	.478
52.	.393	.326	.535	.359
53.	.488	.380	.552	.436
54.	.479	.313	.588	.392
55.	.615	.475	.570	.544
56.	.434	.269	.584	.351
57.	.514	.350	.584	.429
58.	.537	.203	.669	.368
59.	.629	.333	.647	.482
60.	.560	.273	.638	.426
61.	.612	.300	.657	.453
62.	.613	.429	.592	.520
63.	.648	.353	.647	.504
64.	.635	.419	.608	.527
65.	.603	.456	.573	.529
66.	.560	.360	.600	.460
67.	.700	.406	.647	.554
68.	.558	.373	.592	.467
69.	.438	.269	.589	.351
70.	.529	.260	.638	.390
71.	.662	.295	.684	.477
72.	.667	.337	.665	.503
73.	.551	.310	.623	.426
74.	.675	.435	.619	.554
75.	.538	.360	.587	.453
76.	.707	.446	.630	.576
77.	.696	.430	.633	.563
78.	.687	.450	.620	.571
79.	.762	.512	.625	.637
80.	.731	.435	.644	.577
81.	.821	.549	.631	.681
82.	.787	.417	.687	.605
83.	.738	.456	.644	.601
84.	.800	.640	.579	.719
85.	.842	.553	.645	.697
86.	.779	.461	.660	.621
87.	.822	.455	.680	.633
88.	.829	.573	.629	.702
89.	.824	.663	.579	.743
90.	.726	.476	.625	.601
91.	.790	.545	.627	.671
92.	.718	.516	.597	.614
93.	.833	.500	.676	.676
94.	.676	.441	.620	.563
95.	.691	.437	.626	.561
96.	.673	.460	.606	.566
97.	.481	.357	.564	.418
98.	.500	.467	.515	.485

Bird # 8 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
51.	.561	.209	.677	.383
52.	.587	.159	.714	.373
53.	.643	.100	.776	.362
54.	.370	.192	.596	.278
55.	.299	.173	.570	.234
56.	.486	.167	.652	.333
57.	.656	.262	.698	.457
58.	.253	.176	.549	.213
59.	.347	.085	.629	.217
60.	.364	.225	.573	.293
61.	.552	.131	.703	.352
62.	.477	.119	.682	.295
63.	.529	.117	.692	.338
64.	.508	.079	.714	.294
65.	.315	.130	.600	.220
66.	.162	.083	.549	.122
67.	.294	.250	.521	.272
68.	.833	.828	.508	.831
69.	.912	.911	.529	.912
70.	.828	.841	.514	.834
71.	.935	.776	.582	.856
72.	.885	.747	.567	.815
73.	.867	.788	.536	.827
74.	.689	.412	.641	.556
75.	.795	.750	.529	.773
76.	.855	.667	.596	.762
77.	.887	.620	.634	.754
78.	.795	.574	.617	.688
79.	.750	.571	.589	.661
80.	.824	.500	.662	.662
81.	.814	.365	.722	.583
82.	.605	.381	.612	.494
83.	.849	.431	.710	.641
84.	.818	.461	.680	.641
85.	.779	.462	.658	.619
86.	.811	.380	.717	.600
87.	.718	.444	.636	.580
88.	.753	.438	.658	.596
89.	.842	.533	.656	.689
90.	.853	.513	.669	.682
91.	.703	.602	.553	.654
92.	.862	.600	.631	.731
93.	.784	.628	.580	.707
94.	.897	.658	.618	.777
95.	.875	.646	.611	.759
96.	.927	.737	.599	.833
97.	.915	.762	.580	.840
98.	.895	.824	.538	.860
99.	.966	.918	.529	.942
100.	.886	.807	.540	.847

Bird # 7 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$

Bird # 8 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
101.	.953	.898	.523	.925
102.	.906	.750	.580	.828
103.	.886	.462	.807	.789
104.	.859	.820	.505	.839
105.	.956	.888	.536	.922
106.	.977	.956	.506	.966
107.	1.000	.978	.506	.989
108.	1.000	.942	.526	.971
109.	.952	.846	.537	.897
110.	.852	.735	.567	.795
111.	.805	.608	.602	.708
112.	.880	.568	.658	.725
113.	.791	.625	.580	.707
114.	.813	.714	.549	.764
115.	.805	.631	.584	.717
116.	.857	.728	.551	.790
117.	.911	.700	.604	.805
118.	.675	.440	.617	.557
119.	.721	.534	.592	.626
120.	.904	.592	.651	.745
121.	.877	.527	.673	.701
122.	.750	.456	.647	.603
123	.700	.457	.627	.587
124.	.333	.483	.424	.407
125.	.667	1.000	.400	.800
126.	.630	.400	.615	.519

BIRD # 9

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
1.	.753	.736	.506	.744
2.	.286	.185	.545	.236
3.	.239	.014	.621	.124
4.	.475	0.000	.738	.238
5.	.508	.032	.744	.264
6.	.627	.102	.763	.364
7.	.476	.062	.711	.266
8.	.111	0.000	.558	.055
9.	.055	.066	.495	.060
10.	.022	.022	.497	.022
11.	.012	.011	.514	.011
12.	.045	.034	.506	.039
13.	.076	0.000	.552	.037
14.	.156	0.000	.581	.077
15.	.143	.060	.539	.102
16.	.165	.037	.566	.101
17.	.200	.116	.554	.157
18.	.525	.063	.738	.287
19.	.388	.015	.684	.203
20.	.500	.188	.655	.345
21.	.514	.217	.647	.367
22.	.529	.194	.667	.363
23.	.646	.284	.682	.462
24.	.425	.189	.619	.306
25.	.280	.080	.600	.180
26.	.409	.060	.677	.233
27.	.521	.288	.616	.404
28.	.519	.364	.576	.443
29.	.472	.188	.638	.333
30.	.795	.507	.648	.655
31.	.914	.278	.821	.607
32.	.698	.258	.720	.480
33.	.754	.217	.769	.479
34.	.716	.263	.726	.508
35.	.727	.382	.672	.552
36.	.625	.219	.703	.422
37.	.556	.113	.720	.336
38.	.537	.194	.672	.366
39.	.455	.118	.672	.284
40.	.492	.147	.677	.316
41.	.530	.203	.667	.363
42.	.565	.113	.726	.339
43.	.836	.241	.796	.531
44.	.606	.107	.738	.377
45.	.646	.324	.662	.478
46.	.541	.123	.714	.325
47.	.678	.242	.720	.448
48.	.617	.131	.744	.372
49.	.636	.143	.738	.410
50.	.485	.159	.667	.319

BIRD # 10

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
1.	.758	.365	.698	.566
2.	.731	.388	.672	.560
3.	.754	.217	.769	.479
4.	.808	.111	.849	.453
5.	.804	.109	.849	.443
6.	.764	.094	.833	.435
7.	.885	.137	.874	.515
8.	.789	.167	.811	.486
9.	.849	.237	.804	.527
10.	.875	.288	.791	.574
11.	.824	.414	.714	.635
12.	.930	.260	.841	.617
13.	.904	.140	.882	.529
14.	.887	.173	.857	.533
15.	.896	.113	.891	.485
16.	.824	.074	.876	.438
17.	.944	.226	.860	.589
18.	.898	.117	.890	.468
19.	.900	.128	.888	.561
20.	.922	.157	.882	.539
21.	.827	.186	.820	.486
22.	.827	.041	.891	.446
23.	.906	.140	.883	.534
24.	.922	.135	.893	.524
25.	.926	.149	.891	.564
26.	.842	.208	.818	.536
27.	.902	.043	.929	.490
28.	.936	.130	.901	.505
29.	.922	.064	.929	.510
30.	.915	.077	.919	.475
31.	.907	.176	.867	.552
32.	.961	.106	.929	.551
33.	.808	.074	.868	.434
34.	1.000	.235	.883	.621
35.	.915	.309	.807	.623
36.	.934	.333	.813	.661
37.	.898	.127	.885	.490
38.	.849	.098	.875	.481
39.	.904	.189	.857	.543
40.	.962	.524	.662	.691
41.	.857	.259	.798	.553
42.	.750	.250	.750	.517
43.	.652	.254	.699	.451
44.	.891	.317	.783	.591
45.	.942	.648	.643	.793
46.	.964	.379	.789	.667
47.	.903	.435	.734	.669
48.	.981	.264	.858	.623
49.	.902	.224	.835	.541
50.	.860	.288	.784	.569

Bird # 9 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
51.	.627	.102	.763	.364
52.	.473	.230	.592	.375
53.	.682	.250	.714	.476
54.	.754	.279	.738	.516
55.	.656	.172	.738	.426
56.	.719	.183	.769	.444
57.	.456	.132	.662	.294
58.	.485	.174	.657	.328
59.	.603	.175	.727	.372
60.	.439	.090	.677	.263
61.	.710	.200	.754	.459
62.	.649	.103	.774	.374
63.	.724	.143	.789	.439
64.	.633	.129	.754	.377
65.	.732	.058	.833	.407
66.	.677	.242	.717	.465
67.	.597	.117	.738	.361
68.	.695	.200	.748	.445
69.	.603	.035	.783	.322
70.	.673	.098	.796	.363
71.	.551	.047	.811	.224
72.	.586	.197	.699	.384
73.	.473	.014	.720	.252
74.	.380	.066	.652	.226
75.	.644	.171	.734	.413
76.	.500	.072	.712	.288
77.	.325	.041	.624	.191
78.	.557	.139	.711	.345
79.	.406	.080	.674	.236
80.	.606	.153	.732	.370
81.	.683	.088	.802	.374
82.	.642	.078	.779	.366
83.	.676	.176	.748	.432
84.	.636	.090	.774	.361
85.	.846	.103	.870	.496
86.	.692	.138	.777	.415
87.	.571	.139	.718	.353
88.	.373	.120	.620	.247
89.	.558	.208	.675	.383
90.	.574	.071	.754	.319
91.	.543	.087	.727	.317
92.	.382	.041	.683	.204
93.	.444	.080	.687	.259
94.	.559	.088	.735	.324
95.	.642	.046	.795	.348
96.	.635	.032	.802	.333
97.	.516	.028	.744	.241
98.	.692	.131	.778	.421
99.	.387	.105	.635	.250
100.	.268	.098	.585	.183

Bird # 10 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
51.	.828	.288	.769	.556
52.	.875	.283	.793	.569
53.	.750	.123	.81[illegible]	.434
54.	.780	.290	.74[illegible]	.529
55.	.898	.350	.773	.622
56.	.762	.183	.789	.480
57.	.844	.394	.723	.615
58.	.794	.400	.703	.609
59.	.627	.097	.769	.355
60.	.870	.224	.821	.536
61.	.742	.333	.705	.543
62.	.862	.305	.778	.581
63.	.778	.164	.809	.452
64.	.776	.224	.776	.500
65.	.908	.410	.754	.667
66.	.897	.367	.763	.627
67.	.981	.333	.818	.645
68.	.941	.581	.692	.769
69.	.983	.500	.738	.738
70.	.914	.629	.643	.771
71.	.875	.620	.629	.748
72.	.949	.789	.584	.870
73.	.938	.547	.698	.744
74.	.953	.567	.687	.756
75.	.938	.552	.687	.740
76.	.923	.656	.672	.739
77.	.886	.588	.659	.732
78.	.692	.411	.641	.552
79.	.598	.221	.690	.405
80.	.398	.120	.632	.263
81.	.247	.034	.602	.142
82.	.065	0.000	.530	.033
83.	.071	0.000	.554	.034
84.	.141	.045	.539	.094
85.	.473	.069	.699	.274
86.	.545	.195	.675	.370
87.	.709	.247	.730	.487
88.	.681	.231	.728	.442
89.	.487	.175	.656	.331
90.	.600	.182	.711	.388
91.	.588	.103	.743	.346
92.	.676	.169	.763	.410
93.	.739	.203	.768	.471
94.	.714	.164	.777	.431
95.	.646	.130	.761	.381
96.	.758	.141	.810	.444
97.	.750	.209	.770	.481
98.	.735	.164	.785	.452
99.	.809	.275	.766	.540
100.	.730	.121	.806	.419

Bird # 9 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
101.	.083	.294	.448	.207
102.	.500	.158	.686	.314
103.	.320	.308	.510	.314

Bird # 10 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
101.	.742	.147	.799	.440
102.	.689	.174	.755	.441
103.	.513	.178	.662	.351
104.	.474	.190	.650	.325
105.	.500	.529	.483	.517
106.	.583	.400	.593	.481
107.	1.000	1.000	.500	1.000

BIRD # 11

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
1.	.914	.302	.811	.622
2.	.902	.228	.833	.546
3.	.406	.117	.628	.271
4.	.980	.045	.968	.538
5.	.898	.080	.909	.485
6.	.938	.082	.928	.505
7.	.768	.078	.841	.439
8.	.683	.169	.756	.429
9.	.754	.457	.647	.604
10.	.729	.451	.638	.589
11.	.652	.288	.682	.470
12.	.597	.194	.698	.403
13.	.600	.265	.669	.429
14.	.589	.319	.634	.458
15.	.614	.365	.625	.486
16.	.656	.284	.687	.466
17.	.419	.235	.596	.325
18.	.388	.086	.657	.234
19.	.270	.136	.581	.200
20.	.133	.071	.536	.101
21.	.389	.173	.612	.279
22.	.588	.319	.635	.453
23.	.683	.266	.709	.472
24.	.583	.273	.652	.435
25.	.708	.228	.738	.484
26.	.789	.274	.756	.521
27.	.617	.159	.732	.383
28.	.456	.169	.647	.309
29.	.561	.033	.769	.291
30.	.912	.370	.786	.670
31.	.606	.230	.682	.432
32.	.306	.105	.608	.203
33.	.759	.109	.826	.431
34.	.643	.085	.783	.357
35.	.745	.093	.826	.422
36.	.776	.151	.811	.477
37.	.726	.196	.763	.475
38.	.772	.258	.756	.504
39.	.647	.220	.709	.449
40.	.615	.219	.698	.419
41.	.702	.180	.763	.432
42.	.468	.264	.596	.371
43.	.537	.164	.687	.351
44.	.493	.200	.647	.345
45.	.618	.314	.652	.464
46.	.615	.219	.698	.419
47.	.303	.152	.581	.226
48.	.448	.118	.667	.281
49.	.439	.103	.672	.269
50.	.600	.215	.692	.408

BIRD # 12

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
1.	.586	.253	.675	.401
2.	.661	.298	.685	.452
3.	.779	.385	.699	.586
4.	.794	.420	.686	.606
5.	.625	.278	.674	.451
6.	.746	.246	.750	.485
7.	.649	.112	.788	.336
8.	.544	.130	.708	.336
9.	.736	.079	.836	.379
10.	.796	.100	.851	.430
11.	.873	.133	.870	.487
12.	.772	.206	.783	.475
13.	.854	.068	.897	.421
14.	.868	.164	.852	.509
15.	.772	.148	.814	.449
16.	.796	.156	.822	.449
17.	.827	.138	.845	.464
18.	.813	.063	.883	.387
19.	.865	.103	.882	.464
20.	.936	.077	.929	.485
21.	.959	.122	.918	.541
22.	.904	.154	.875	.529
23.	.842	.266	.785	.537
24.	.792	.057	.868	.425
25.	.909	.295	.802	.586
26.	.830	.167	.832	.462
27.	.877	.299	.782	.565
28.	.836	.478	.676	.654
29.	.774	.071	.853	.413
30.	.804	.193	.805	.496
31.	.759	.145	.805	.460
32.	.736	.089	.826	.404
33.	.696	.109	.784	.431
34.	.893	.231	.833	.574
35.	.880	.158	.860	.495
36.	.864	.344	.758	.600
37.	.882	.196	.841	.523
38.	.535	.267	.616	.425
39.	.621	.300	.662	.456
40.	.592	.329	.632	.458
41.	.158	.465	.526	.491
42.	.770	.554	.608	.662
43.	.605	.525	.542	.566
44.	.494	.471	.511	.483
45.	.466	.287	.595	.373
46.	.343	.136	.611	.236
47.	.486	.236	.625	.361
48.	.600	.235	.684	.414
49.	.671	.369	.652	.529
50.	.465	.167	.616	.342

Bird #11 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
51.	.525	.065	.732	.293
52.	.581	.053	.756	.328
53.	.485	.081	.692	.292
54.	.276	.080	.596	.179
55.	.343	.083	.634	.211
56.	.275	.105	.577	.192
57.	.397	.113	.647	.252
58.	.260	.078	.600	.167
59.	.305	.058	.596	.192
60.	.338	.097	.616	.219
61.	.247	.115	.560	.182
62.	.493	.143	.662	.331
63.	.337	.256	.536	.298
64.	.235	.165	.542	.199
65.	.457	.171	.643	.314
66.	.471	.230	.625	.347
67.	.540	.152	.698	.341
68.	.162	.025	.566	.094
69.	.270	.041	.612	.156
70.	.138	.046	.546	.092
71.	.284	.037	.621	.161
72.	.231	0.000	.615	.115
73.	.218	.013	.584	.120
74.	.212	.024	.587	.120
75.	.127	0.000	.579	.061
76.	.182	.101	.542	.141
77.	.151	.035	.558	.093
78.	.176	.048	.549	.114
79.	.267	.110	.571	.190
80.	.375	.052	.671	.208
81.	.371	.065	.667	.211
82.	.459	.247	.602	.355
83.	.361	.091	.625	.231
84.	.365	.253	.558	.308
85.	.539	.139	.696	.345
86.	.586	.129	.729	.357
87.	.521	.182	.673	.347
88.	.750	.380	.684	.561
89.	.680	.260	.709	.473
90.	.300	.061	.623	.179
91.	.293	.073	.610	.183
92.	.174	.035	.567	.105
93.	.289	.063	.619	.174
94.	.219	.115	.563	.166
95.	.197	.095	.556	.145
96.	.476	.313	.585	.392
97.	.524	.364	.581	.442
98.	.500	.556	.471	.529

Bird # 12 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
51.	.506	.233	.612	.395
52.	.719	.183	.769	.444
53.	.719	.241	.738	.492
54.	.750	.172	.789	.456
55.	.757	.422	.672	.597
56.	.887	.435	.726	.661
57.	.656	.254	.701	.457
58.	.606	.265	.672	.433
59.	.814	.300	.756	.555
60.	.815	.207	.804	.500
61.	.842	.288	.776	.560
62.	.710	.270	.720	.488
63.	.730	.214	.756	.487
64.	.870	.559	.657	.715
65.	.719	.290	.714	.508
66.	.736	.246	.745	.496
67.	.761	.197	.782	.481
68.	.758	.147	.808	.438
69.	.742	.322	.711	.540
70.	.589	.211	.688	.403
71.	.878	.444	.710	.652
72.	.712	.127	.791	.426
73.	.794	.221	.787	.507
74.	.718	.152	.781	.445
75.	.712	.136	.788	.424
76.	.726	.320	.703	.520
77.	.740	.324	.709	.536
78.	.714	.260	.728	.476
79.	.602	.393	.605	.497
80.	.522	.087	.717	.304
81.	.687	.108	.788	.402
82.	.864	.258	.803	.561
83.	.736	.282	.727	.510
84.	.833	.284	.777	.568
85.	.757	.206	.775	.486
86.	.726	.303	.711	.510
87.	.718	.378	.669	.544
88.	.813	.436	.690	.627
89.	.629	.192	.720	.406
90.	.661	.048	.808	.352
91.	.623	.391	.580	.471
92.	.628	.564	.537	.598
93.	.538	.417	.560	.480
94.	.500	.750	.333	.667
95.	.500	1.000	.166	.833

BIRD # 13

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
1.	1.000	.397	.796	.690
2.	.940	.218	.857	.562
3.	.364	0.000	.682	.182
4.	.618	.018	.804	.313
5.	.923	.263	.826	.578
6.	.842	.276	.783	.557
7.	.721	.270	.726	.492
8.	.576	.067	.756	.319
9.	.797	.259	.769	.530
10.	.651	.197	.726	.427
11.	.563	.206	.672	.396
12.	.551	.133	.698	.357
13.	.750	.127	.811	.441
14.	.786	.148	.818	.473
15.	.684	.136	.776	.405
16.	.524	.162	.687	.336
17.	.593	.098	.750	.342
18.	.409	.061	.674	.235
19.	.684	.164	.763	.415
20.	.885	.083	.900	.500
21.	.900	.082	.909	.495
22.	.860	.078	.891	.465
23.	.926	.216	.857	.581
24.	.885	.140	.873	.520
25.	.907	.212	.849	.566
26.	.867	.296	.789	.596
27.	.869	.339	.769	.615
28.	.878	.115	.881	.485
29.	.854	.148	.853	.480
30.	.717	.217	.750	.467
31.	.898	.148	.874	.505
32.	.750	.172	.789	.456
33.	.833	.100	.865	.481
34.	.955	0.000	.978	.457
35.	1.000	.220	.891	.614
36.	.897	.283	.811	.604
37.	.772	.148	.811	.468
38.	.690	.091	.796	.398
39.	.412	0.000	.706	.206
40.	.568	.128	.725	.341
41.	.719	.058	.826	.404
42.	.796	.096	.849	.453
43.	.940	.085	.928	.526
44.	.733	.246	.744	.488
45.	.588	.180	.698	.395
46.	.459	.222	.616	.342
47.	.600	.182	.714	.381
48.	.574	.141	.720	.352
49.	.414	.116	.647	.266
50.	.397	.176	.612	.286

BIRD # 14

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
1.	.857	.286	.782	.555
2.	.729	.210	.760	.463
3.	.783	.321	.738	.582
4.	.388	.029	.684	.206
5.	.250	.167	.535	.209
6.	.524	.076	.729	.295
7.	.280	.104	.579	.195
8.	.306	.115	.607	.207
9.	.244	.086	.577	.166
10.	.333	.132	.608	.230
11.	.378	.128	.632	.250
12.	.408	.147	.637	.274
13.	.581	.123	.732	.340
14.	.836	.200	.818	.518
15.	.667	.159	.758	.400
16.	.727	.143	.797	.415
17.	.759	.150	.807	.439
18.	.852	.179	.836	.509
19.	.815	.190	.813	.491
20.	.767	.246	.760	.504
21.	.895	.271	.810	.578
22.	.804	.262	.769	.521
23.	.842	.297	.769	.554
24.	.923	.182	.869	.542
25.	.915	.388	.754	.635
26.	.907	.305	.796	.593
27.	.700	.230	.736	.463
28.	.750	.237	.756	.496
29.	.814	.204	.805	.522
30.	.764	.127	.818	.445
31.	.807	.120	.841	.486
32.	.702	.091	.804	.402
33.	.815	.233	.789	.509
34.	.911	.361	.769	.624
35.	.778	.268	.756	.538
36.	.857	.300	.776	.569
37.	.758	.290	.734	.524
38.	.507	.316	.596	.411
39.	.638	.258	.687	.458
40.	.656	.226	.714	.444
41.	.721	.281	.720	.496
42.	.741	.277	.732	.496
43.	.441	.155	.647	.295
44.	.472	.243	.616	.356
45.	.600	.089	.744	.364
46.	.485	.134	.677	.308
47.	.389	.114	.634	.254
48.	.484	.145	.677	.308
49.	.635	.123	.750	.392
50.	.463	.132	.667	.296

Bird # 13 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
51.	.351	.059	.634	.211
52.	.563	.085	.732	.333
53.	.457	.183	.638	.319
54.	.143	.071	.536	.107
55.	.241	.167	.539	.204
56.	.265	.200	.536	.232
57.	.237	.134	.556	.185
58.	.174	.149	.503	.162
59.	.207	.040	.556	.130
60.	.579	.050	.769	.308
61.	.413	.119	.634	.275
62.	.463	.145	.662	.301
63.	.449	.157	.647	.302
64.	.412	.101	.657	.255
65.	.179	.062	.566	.119
66.	.300	.068	.625	.181
67.	.529	.100	.703	.328
68.	.500	.094	.703	.297
69.	.554	.129	.709	.346
70.	.695	.125	.783	.417
71.	.714	.153	.783	.426
72.	.698	.313	.692	.500
73.	.373	.151	.608	.264
74.	.314	.029	.643	.171
75.	.324	.120	.604	.221
76.	.389	.151	.621	.269
77.	.532	.095	.720	.312
78.	.441	.130	.657	.285
79.	.479	.188	.643	.336
80.	.333	.120	.612	.224
81.	.524	.109	.709	.315
82.	.492	.077	.714	.278
83.	.443	.102	.667	.275
84.	.366	.111	.629	.238
85.	.515	.152	.682	.333
86.	.631	.234	.698	.434
87.	.678	.194	.744	.430
88.	.593	.141	.732	.358
89.	.477	.063	.703	.273
90.	.408	.129	.638	.270
91.	.635	.180	.726	.411
92.	.486	.270	.608	.378
93.	.478	.219	.634	.345
94.	.347	.145	.608	.243
95.	.213	.026	.596	.119
96.	.241	.101	.570	.171
97.	.338	.110	.612	.224
98.	.268	.150	.556	.210
99.	.361	.169	.604	.262
100.	.286	.128	.581	.206

Bird # 14 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
51.	.303	.141	.584	.221
52.	.356	.086	.629	.224
53.	.492	.134	.682	.311
54.	.548	.164	.698	.349
55.	.377	.099	.643	.236
56.	.153	.013	.552	.086
57.	.386	.100	.643	.243
58.	.357	.110	.629	.231
59.	.576	.138	.726	.347
60.	.529	.185	.667	.363
61.	.508	.049	.726	.282
62.	.581	.129	.726	.355
63.	.639	.164	.738	.402
64.	.769	.344	.714	.563
65.	.769	.355	.709	.567
66.	.681	.487	.592	.579
67.	.600	.233	.683	.417
68.	.629	.387	.621	.503
69.	.700	.494	.596	.589
70.	.770	.587	.584	.675
71.	.710	.500	.597	.597
72.	.793	.708	.532	.749
73.	.771	.527	.618	.646
74.	.742	.408	.664	.569
75.	.818	.455	.682	.636
76.	.738	.311	.714	.532
77.	.734	.328	.703	.531
78.	.781	.403	.687	.588
79.	.721	.276	.723	.496
80.	.722	.465	.629	.594
81.	.686	.377	.655	.532
82.	.778	.200	.789	.474
83.	.754	.302	.726	.524
84.	.763	.250	.756	.504
85.	.708	.344	.682	.527
86.	.808	.662	.570	.734
87.	.841	.373	.738	.615
88.	.662	.338	.662	.500
89.	.719	.297	.711	.508
90.	.818	.453	.685	.638
91.	.710	.414	.655	.547
92.	.620	.370	.625	.493
93.	.727	.364	.682	.545
94.	.701	.354	.682	.477
95.	.597	.329	.636	.457
96.	.662	.288	.687	.473
97.	.683	.277	.703	.477
98.	.723	.306	.709	.520
99.	.655	.338	.667	.468
100.	.688	.246	.720	.472

Bird # 13 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
101.	.395	.221	.588	.307
102.	.338	.156	.596	.245
103.	.325	.156	.584	.240
104.	.556	.127	.714	.341
105.	.441	.104	.667	.274
106.	.357	.097	.634	.225
107.	.484	.063	.709	.276
108.	.400	.139	.634	.268
109.	.415	.087	.672	.246
110.	.603	.161	.720	.384
111.	.613	.148	.732	.382
112.	.407	.288	.557	.349
113.	.294	.143	.548	.226
114.	.000	.000	.000	.000
115.	.733	.214	.759	.483
116.	1.000	0.000	1.000	1.000

Bird # 14 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
101.	.641	.279	.682	.455
102.	.764	.507	.629	.636
103.	.768	.486	.638	.624
104.	.727	.391	.667	.556
105.	.776	.433	.672	.604
106.	.729	.443	.643	.586
107.	.800	.400	.700	.600
108.	.848	.444	.705	.651
109.	.794	.383	.707	.593
110.	.754	.412	.667	.574
111.	.700	.500	.605	.605
112.	.700	.818	.429	.762
113.	.500	.667	.400	.600
114.	.667	1.000	.400	.800

BIRD # 15

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
1.	.880	.148	.865	.500
2.	.882	.063	.909	.485
3.	.878	.130	.874	.485
4.	.941	.140	.901	.545
5.	.852	.356	.750	.608
6.	.855	.383	.738	.623
7.	.919	.476	.720	.696
8.	.900	.393	.752	.645
9.	.817	.328	.744	.570
10.	.850	.278	.789	.579
11.	.902	.383	.760	.645
12.	.506	.250	.604	.403
13.	.903	.435	.734	.669
14.	.947	.296	.829	.631
15.	.857	.259	.798	.553
16.	.979	.170	.900	.550
17.	.966	.426	.767	.692
18.	.877	.288	.793	.578
19.	.868	.494	.641	.634
20.	.943	.231	.857	.590
21.	.982	.407	.784	.690
22.	.877	.492	.692	.685
23.	.585	.172	.705	.380
24.	.585	.209	.689	.394
25.	.415	.036	.694	.222
26.	.717	.019	.849	.368
27.	.827	.130	.849	.472
28.	.745	.169	.789	.447
29.	.820	.355	.732	.585
30.	.707	.169	.769	.436
31.	.656	.143	.750	.417
32.	.706	.400	.652	.551
33.	.803	.212	.796	.531
34.	.797	.283	.756	.538
35.	.813	.603	.608	.709
36.	.750	.435	.657	.591
37.	.828	.448	.687	.634
38.	.738	.344	.698	.543
39.	.754	.203	.776	.474
40.	.465	.197	.634	.331
41.	.738	.263	.738	.516
42.	.769	.375	.698	.574
43.	.790	.369	.709	.575
44.	.710	.270	.720	.488
45.	.652	.266	.692	.462
46.	.746	.164	.789	.465
47.	.871	.400	.738	.639
48.	.618	.434	.592	.526
49.	.656	.226	.714	.444
50.	.683	.161	.756	.437

BIRD # 16

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
1.	1.000	.302	.853	.661
2.	.881	.328	.778	.607
3.	.745	.159	.797	.432
4.	.667	.032	.829	.325
5.	.662	.257	.704	.452
6.	.745	.131	.810	.422
7.	.702	.162	.776	.408
8.	.823	.355	.734	.589
9.	.857	.270	.790	.546
10.	.613	.152	.734	.375
11.	.776	.333	.723	.562
12.	.678	.175	.754	.418
13.	.843	.346	.729	.543
14.	.783	.266	.758	.516
15.	.652	.226	.711	.445
16.	.800	.217	.791	.496
17.	.689	.254	.719	.461
18.	.797	.277	.758	.524
19.	.759	.138	.813	.438
20.	.836	.179	.829	.505
21.	.662	.234	.713	.450
22.	.792	.150	.823	.451
23.	.689	.177	.756	.431
24.	.719	.185	.770	.434
25.	.672	.143	.769	.397
26.	.843	.056	.895	.438
27.	.836	.242	.795	.521
28.	.732	.121	.807	.421
29.	.772	.210	.782	.479
30.	.627	.095	.770	.352
31.	.719	.254	.732	.496
32.	.635	.219	.709	.425
33.	.627	.131	.750	.375
34.	.591	.167	.706	.389
35.	.613	.212	.703	.406
36.	.683	.299	.692	.485
37.	.794	.385	.703	.586
38.	.683	.277	.703	.477
39.	.716	.432	.638	.567
40.	.815	.486	.659	.644
41.	.781	.610	.574	.690
42.	.667	.642	.503	.654
43.	.740	.513	.611	.624
44.	.840	.701	.549	.765
45.	.916	.866	.494	.889
46.	.953	.889	.520	.920
47.	.975	.875	.530	.923
48.	.824	.750	.545	.788
49.	.656	.690	.474	.674
50.	.622	.625	.484	.624

Bird # 15 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
51.	.750	.344	.703	.547
52.	.656	.294	.682	.470
53.	.676	.364	.657	.526
54.	.821	.254	.783	.530
55.	.912	.309	.804	.616
56.	.818	.211	.804	.509
57.	.793	.214	.789	.509
58.	.677	.213	.732	.447
59.	.870	.271	.796	.558
60.	.500	.108	.698	.302
61.	.617	.117	.750	.367
62.	.516	.066	.720	.296
63.	.729	.175	.776	.457
64.	.845	.226	.811	.550
65.	.864	.391	.732	.618
66.	.879	.350	.763	.610
67.	.840	.250	.791	.518
68.	.911	.291	.811	.604
69.	.864	.391	.732	.618
70.	.943	.298	.818	.609
71.	.847	.355	.744	.595
72.	.768	.148	.809	.464
73.	.717	.055	.833	.380
74.	.754	.145	.804	.455
75.	.907	.317	.789	.596
76.	.696	.121	.789	.404
77.	.893	.245	.826	.578
78.	.821	.154	.833	.500
79.	.830	.132	.849	.481
80.	.887	.283	.796	.566
81.	.878	.096	.891	.475
82.	.750	.073	.841	.402
83.	.462	.063	.698	.264
84.	.754	.161	.796	.460
85.	.704	.148	.783	.409
86.	.695	.183	.756	.437
87.	.581	.085	.744	.339
88.	.677	.226	.726	.452
89.	.754	.279	.738	.516
90.	.746	.258	.744	.496
91.	.557	.082	.738	.320
92.	.731	.037	.849	.377
93.	.811	.237	.787	.520
94.	.630	.386	.622	.511
95.	.676	.450	.610	.558
96.	.500	.184	.658	.342
97.	.889	1.000	.400	.950

Bird # 16 (Cont'd)

Session No.	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
51.	.644	.706	.442	.680
52.	.759	.652	.542	.702
53.	.637	.650	.475	.645
54.	.964	.941	.436	.950
55.	.892	.934	.423	.916
56.	.966	.945	.431	.954
57.	.977	.976	.415	.976
58.	.856	.860	.492	.858
59.	.852	.744	.560	.799
60.	.871	.839	.512	.855
61.	.894	.819	.542	.857
62.	.892	.807	.548	.765
63.	.759	.714	.526	.737
64.	.808	.603	.603	.705
65.	.791	.798	.500	.794
66.	.874	.839	.517	.856
67.	.707	.632	.533	.669
68.	.768	.690	.533	.728
69.	.918	.885	.512	.901
70.	.901	.787	.559	.845
71.	.770	.724	.529	.730
72.	.795	.704	.549	.750
73.	.767	.730	.514	.749
74.	.905	.829	.542	.867
75.	.930	.884	.523	.907
76.	.919	.872	.523	.895
77.	.917	.845	.536	.881
78.	.848	.727	.564	.788
79.	.595	.449	.573	.522
80.	.940	.591	.677	.767
81.	.892	.500	.698	.698
82.	.765	.449	.664	.599
83.	.857	.688	.584	.773
84.	.864	.515	.674	.689
85.	.973	.750	.604	.859
86.	.886	.600	.643	.743
87.	.712	.472	.621	.593
88.	.655	.573	.542	.614
89.	.831	.828	.495	.830
90.	.897	.747	.573	.822
91.	.895	.712	.597	.805
92.	.873	.600	.638	.738
93.	.768	.479	.643	.621
94.	.792	.635	.547	.702
95.	.462	.291	.586	.376
96.	.459	.441	.508	.450
97.	.200	.292	.449	.245
98.	.286	.379	.456	.333

APPENDIX D

Conditional probability estimates, p_1, p_2, p_C and p_L for each bird over the final 12 sessions of phase 2 and phase 3.

PHASE 2

Group	Bird	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
1	1	.662	.164	.750	.411
	2	.404	.152	.627	.277
	3	.761	.170	.795	.464
	4	.884	.852	.519	.868
	$\overline{x}$	.678	.335	.693	.505
2	5	.698	.538	.577	.619
	6	.649	.303	.672	.474
	7	.580	.352	.614	.466
	8	.798	.680	.564	.740
	$\overline{x}$	.681	.469	.607	.575
3	9	.645	.132	.758	.387
	10	.932	.553	.689	.740
	11	.343	.128	.605	.237
	12	.763	.306	.729	.535
	$\overline{x}$	.671	.280	.695	.475
4	13	.418	.115	.652	.266
	14	.746	.343	.701	.542
	15	.752	.221	.764	.486
	16	.832	.769	.531	.794
	$\overline{x}$	.687	.362	.662	.522
OVERALL	$\overline{x}$	.679	.362	.659	.519

PHASE 3

Group	Bird	$\hat{p}_2$	$\hat{p}_1$	$\hat{p}_C$	$\hat{p}_L$
1	1	.606	.112	.747	.360
	2	.669	.246	.712	.456
	3	.538	.214	.662	.377
	4	.983	.979	.502	.981
	$\bar{x}$	.699	.388	.656	.544
2	5	.779	.615	.579	.696
	6	.694	.548	.574	.621
	7	.791	.521	.636	.657
	8	.824	.617	.602	.720
	$\bar{x}$	.772	.575	.598	.674
3	9	.541	.089	.727	.312
	10	.715	.167	.775	.438
	11	.443	.159	.641	.302
	12	.712	.248	.733	.480
	$\bar{x}$	.603	.166	.719	.383
4	13	.434	.132	.652	.283
	14	.743	.388	.678	.564
	15	.691	.141	.775	.412
	16	.831	.618	.607	.724
	$\bar{x}$	.675	.320	.678	.496
OVERALL	$\bar{x}$	.687	.362	.663	.524

APPENDIX E

"First-order" conditional probability estimates, $P(R_2|T_2\ R_jT_i)$ and $P(R_2|T_1\ R_jT_i)$, for each bird for phase 2 and phase 3. The column headings identify the R_jT_i th response on trial n; the marginal row headings identify the preceding R_jT_i th response. The number of trials, N, on which each estimate is based is also given.

"FIRST-ORDER" CONDITIONAL PROBABILITY ESTIMATES IN PHASE 2

	BIRD	$\hat{P}(R_2 \mid T_2)$	N	$\hat{P}(R_2 \mid T_1)$	N		BIRD	$\hat{P}(R_2 \mid T_2)$	N	$\hat{P}(R_2 \mid T_1)$	N
R_2T_1	1	.719	57	.220	59	R_2T_2	1	.607	233	.161	230
	2	.492	63	.1846	65		2	.479	163	.157	172
	3	.877	57	.250	56		3	.682	258	.157	248
	4	.939	439	.871	443		4	.897	465	.887	450
	5	.607	266	.584	243		5	.689	315	.530	319
	6	.682	129	.359	117		6	.695	249	.327	257
	7	.620	150	.313	160		7	.567	247	.389	255
	8	.838	327	.757	309		8	.849	384	.699	381
	9	.660	50	.178	45		9	.673	217	.105	229
	10	.961	205	.670	236		10	.916	371	.544	349
	11	.509	55	.179	56		11	.357	140	.152	158
	12	.862	116	.400	110		12	.753	279	.289	280
	13	.449	232	.065	241		13	.399	158	.118	178
	14	.812	149	.398	118		14	.714	259	.353	300
	15	.827	81	.425	73		15	.754	256	.218	261
	16	.859	404	.794	379		16	.840	407	.798	425
OVERALL	$\bar{x}$	.738		.416				.683		.368	

"FIRST-ORDER" CONDITIONAL PROBABILITY ESTIMATES IN PHASE 2

	BIRD	$\hat{P}(R_2\|T_2)$	N	$\hat{P}(R_2\|T_1)$	N		BIRD	$\hat{P}(R_2\|T_2)$	N	$\hat{P}(R_2\|T_1)$	N
R_1T_1	1	.622	302	.132	296	R_1T_2	1	.691	110	.167	132
	2	.379	364	.143	363		2	.359	251	.144	257
	3	.795	268	.164	286		3	.780	82	.122	82
	4	.707	82	.723	65		4	.630	54	.712	66
	5	.714	224	.548	199		5	.639	119	.506	166
	6	.590	266	.260	288		6	.592	152	.314	137
	7	.551	283	.321	277		7	.620	187	.381	181
	8	.688	154	.598	137		8	.641	103	.526	95
	9	.632	304	.145	303		9	.645	124	.136	125
	10	.928	180	.453	161		10	1.000	21	.437	32
	11	.347	395	.117	366		11	.258	302	.111	298
	12	.736	254	.251	247		12	.733	90	.414	87
	13	.402	368	.105	351		13	.444	49	.137	46
	14	.719	253	.311	241		14	.774	93	.392	102
	15	.751	269	.196	275		15	.651	86	.132	91
	16	.726	102	.682	129		16	.807	88	.650	80
OVERALL	$\bar{x}$	.643		.322				.642		.333	

"FIRST-ORDER" CONDITIONAL PROBABILITY ESTIMATES IN PHASE 3

FOR GROUP 1 AND GROUP 2

	Group 1						Group 2				
	BIRD	$\hat{P}(R_2\|T_2)$	N	$\hat{P}(R_2\|T_1)$	N		BIRD	$\hat{P}(R_2\|T_2)$	N	$\hat{P}(R_2\|T_1)$	N
$R_1T_1E_1$	1	.617	342	.114	297	$R_1T_1E_1$	5	.748	143	.618	131
	2	.677	288	.232	285		6	.569	160	.435	170
	3	.534	335	.170	265		7	.784	171	.490	145
	4	.917	12	.889	9		8	.786	159	.554	112
$R_1T_1E_o$	1	.586	152	.114	123	$R_1T_1E_o$	5	.750	56	.759	54
	2	.697	122	.266	128		6	.674	89	.406	64
	3	.520	127	.184	125		7	.750	76	.554	56
	4	1.000	3	1.000	5		8	.860	57	.479	48
$R_2T_1E_o$	1	.649	57	.190	63	$R_2T_1E_o$	5	.818	329	.655	296
	2	.699	153	.280	118		6	.750	304	.614	280
	3	.563	119	.400	100		7	.841	264	.531	228
	4	.985	801	.984	699		8	.853	320	.678	289
$R_1T_2E_o$	1	.652	204	.138	210	$R_1T_2E_o$	5	.698	106	.613	119
	2	.543	175	.201	184		6	.634	172	.487	160
	3	.474	232	.186	274		7	.755	94	.477	107
	4	1.000	13	.818	11		8	.794	78	.547	95
$R_2R_2E_2$	1	.539	180	.081	247	$R_2T_2E_2$	5	.779	362	.581	403
	2	.720	218	.272	272		6	.719	338	.583	391
	3	.574	183	.189	228		7	.770	339	.537	404
	4	.980	476	.981	564		8	.809	356	.618	437
$R_2T_2E_o$	1	.602	108	.103	97						
	2	.672	125	.243	103						
	3	.595	84	.180	78						
	4	.991	223	.991	231						

"FIRST-ORDER" CONDITIONAL PROBABILITY ESTIMATES IN PHASE 3

FOR GROUP 3 AND GROUP 4

	Group 3						Group 4				
	BIRD	$\hat{P}(R_2\|T_2)$	N	$\hat{P}(R_2\|T_1)$	N		BIRD	$\hat{P}(R_2\|T_2)$	N	$\hat{P}(R_2\|T_1)$	N
$R_1T_1E_1$	9	.556	392	.090	366	$R_1T_1E_1$	13	.378	357	.131	359
	10	.738	347	.184	320		14	.698	245	.336	232
	11	.396	404	.134	381		15	.701	301	.146	294
	12	.684	329	.212	306		16	.769	186	.514	144
R											
$R_2T_1E_o$	9	.611	36	.100	40	$R_2T_1E_o$	13	.508	61	.184	49
	10	.792	72	.238	63		14	.832	155	.438	153
	11	.542	83	.254	67		15	.737	57	.300	44
	12	.848	112	.441	111		16	.875	271	.644	289
$R_1T_2E_o$	9	.476	185	.081	198	$R_1T_2E_o$	13	.425	228	.126	239
	10	.590	95	.131	130		14	.738	107	.398	93
	11	.348	256	.126	269		15	.611	95	.086	117
	12	.738	122	.274	124		16	.738	80	.544	68
$R_2T_2E_2$	9	.576	144	.101	168	$R_2T_2E_2$	13	.509	165	.130	185
	10	.740	181	.133	211		14	.738	267	.393	305
	11	.627	134	.240	146		15	.705	227	.141	241
	12	.67	200	.202	223		16	.854	343	.666	386
$R_2T_2E_o$	9	.559	68	.094	64						
	10	.678	90	.185	81						
	11	.582	55	.181	72						
	12	.721	86	.278	97						

APPENDIX F

Results of order-tests and the ϕ coefficients for each bird in phase 2 and phase 3.

	PHASE 2			PHASE 3		
Bird	df	χ^2	ϕ	df	χ^2	ϕ
1	9	8.968	.048	25	14.313	.048
2	9	10.319	.045	25	20.59	.056
3	9	21.865**	.074	25	33.75	.072
4	9	98.285**	.126	25	27.49	.055
5	9	5.22	.031	16	16.22	.052
6	9	13.51	.053	16	42.7**	.082
7	9	7.74	.038	16	8.54	.039
8	9	174.323**	.175	16	17.05	.054
9	9	5.93	.037	16	5.39	.033
10	9	26.96**	.076	16	17.87	.061
11	9	19.25*	.060	16	54.69**	.099
12	9	21.04*	.069	16	25.7	.071
13	9	4.04	.029	9	9.995	.045
14	9	9.645	.046	9	13.43	.108
15	9	29.95**	.085	9	20.29*	.070
16	9	26.23**	.066	9	28.24**	.073
TOTAL	144	483.265**	.078		353.258**	.064

$^{*}p < .05$

$^{**}p < .01$

APPENDIX G

"First-order" conditional probability estimates, $P(R_2|T_i)$, $P(R_2|R_j)$, $P(R_2|E_k)$ and $P(C_l|C_m)$, for each bird for phase 2 and phase 3. The number of trials, N, each estimate is based on is also given.

"FIRST-ORDER" CONDITIONAL PROBABILITY ESTIMATES

$\hat{P}(R_2|T_j)$ AND $\hat{P}(R_2|R_j)$ FOR PHASE 2

BIRD	$\hat{P}(R_2\|T_2)$	N	$\hat{P}(R_2\|T_1)$	N	BIRD	$\hat{P}(R_2\|R_2)$	N	$\hat{P}(R_2\|R_1)$	N
1	.413	705	.395	714	1	.427	579	.388	840
2	.275	843	.273	855	2	.320	463	.257	1235
3	.431	670	.486	667	3	.451	619	.465	718
4	.867	1032	.787	1029	4	.898	1799	.697	267
5	.594	919	.641	934	5	.626	1143	.604	710
6	.491	795	.423	800	6	.515	752	.433	843
7	.487	870	.446	871	7	.470	812	.463	929
8	.733	966	.752	927	8	.784	1404	.622	489
9	.383	698	.394	709	9	.388	544	.388	863
10	.731	783	.761	773	10	.762	1161	.699	395
11	.207	899	.250	872	11	.276	410	.213	1361
12	.534	736	.541	727	12	.554	785	.518	678
13	.272	809	.258	814	13	.252	431	.269	1192
14	.535	754	.558	763	14	.556	826	.536	691
15	.458	694	.507	698	15	.519	671	.449	721
16	.804	1000	.799	1015	16	.823	1615	.715	400
OVERALL $\bar{x}$	.513		.524			.539		.482	

"FIRST-ORDER" CONDITIONAL PROBABILITY ESTIMATES,

$\hat{P}(R_2|E_k)$ AND $\hat{P}(C|C_m)$ FOR PHASE 2

BIRD	$\hat{P}(R_2\|E_1)$	N	$\hat{P}(R_2\|E_2)$	N	$\hat{P}(R_2\|E_o)$	N	BIRD	$\hat{P}(C\|C_1)$	N	$\hat{P}(C\|C_o)$	N
1	.381	598	.417	463	.425	358	1	.747	1061	.763	358
2	.261	727	.313	335	.267	636	2	.633	1062	.620	636
3	.469	554	.425	506	.498	277	3	.790	1060	.823	277
4	.714	147	.892	915	.878	1002	4	.513	1064	.521	1002
5	.636	423	.609	634	.616	794	5	.585	1059	.563	794
6	.419	554	.508	506	.492	535	6	.676	1060	.649	535
7	.438	560	.476	502	.483	678	7	.602	1063	.636	678
8	.646	291	.774	765	.746	834	8	.571	1059	.552	834
9	.389	607	.381	446	.396	344	9	.761	1063	.750	344
10	.704	341	.736	720	.790	494	10	.711	1062	.636	494
11	.237	761	.248	298	.211	711	11	.609	1060	.587	711
12	.497	501	.521	559	.610	403	12	.737	1060	.702	403
13	.257	719	.250	336	.284	568	13	.646	1055	.662	568
14	.521	494	.521	559	.606	462	14	.691	1055	.706	462
15	.471	544	.484	517	.502	331	15	.773	1061	.737	331
16	.701	231	.819	832	.811	951	16	.551	1064	.551	951
OVERALL $\bar{x}$	.484		.523		.538			.662		.654	

"FIRST-ORDER" CONDITIONAL PROBABILITY ESTIMATES,

$\hat{P}(R_2|T_j)$ AND $\hat{P}(R_2|R_j)$ FOR PHASE 3

BIRD	$\hat{P}(R_2\|T_2)$	N	$\hat{P}(R_2\|T_1)$	N	BIRD	$\hat{P}(R_2\|R_2)$	N	$\hat{P}(R_2\|R_1)$	N
1	.338	1046	.384	1034	1	.321	752	.384	1328
2	.438	1077	.475	1094	2	.485	989	.433	1182
3	.346	1079	.392	1071	3	.403	792	.349	1358
4	.982	1518	.984	1529	4	.984	2994	.925	53
5	.670	991	.728	1009	5	.706	1391	.686	609
6	.620	1061	.610	1067	6	.663	1313	.537	815
7	.636	944	.677	940	7	.665	1235	.639	649
8	.696	966	.739	985	8	.733	1402	.679	549
9	.300	827	.333	836	9	.327	520	.312	1146
10	.395	788	.481	804	10	.444	698	.434	894
11	.308	932	.292	935	11	.406	557	.255	1310
12	.460	852	.506	858	12	.497	829	.470	881
13	.288	817	.269	826	13	.322	460	.261	1183
14	.561	772	.567	789	14	.583	880	.539	681
15	.385	680	.444	696	15	.438	569	.399	807
16	.737	877	.719	891	16	.755	1289	.656	479
OVERALL $\overline{x}$	.510		.537			.546		.497	

"FIRST-ORDER" CONDITIONAL PROBABILITY ESTIMATES

$\hat{P}(R_2|E_k)$ AND $\hat{P}(C|C_m)$ FOR PHASE 3

BIRD	$\hat{P}(R_2\|E_1)$	N	$\hat{P}(R_2\|E_2)$	N	$\hat{P}(R_2\|E_o)$	N	BIRD	$\hat{P}(C\|C_1)$	N	$\hat{P}(C\|C_o)$	N
1	.383	639	.274	427	.384	1014	1	.743	1546	.753	534
2	.456	573	.471	490	.451	1108	2	.720	1541	.689	630
3	.373	600	.360	411	.370	1139	3	.681	1425	.635	725
4	.905	21	.980	1040	.985	1986	4	.470	1523	.535	1524
5	.686	274	.675	765	.722	961	5	.577	1150	.578	850
6	.500	330	.646	729	.630	1069	6	.570	1212	.575	916
7	.649	316	.643	743	.670	825	7	.620	1191	.658	693
8	.690	271	.704	793	.738	887	8	.602	1169	.602	782
9	.331	758	.321	312	.295	593	9	.733	1204	.715	459
10	.472	667	.413	392	.415	533	10	.781	1232	.761	360
11	.269	785	.425	280	.287	802	11	.651	1192	.621	675
12	.457	635	.423	423	.548	659	12	.733	1241	.719	469
13	.254	716	.309	350	.289	577	13	.649	1066	.653	577
14	.522	477	.554	572	.613	508	14	.673	1053	.689	508
15	.427	595	.415	468	.393	313	15	.780	1063	.760	313
16	.658	330	.755	729	.733	708	16	.600	1060	.607	708
OVERALL											
$\bar{X}$	.502		.523		.532			.662		.660	

APPENDIX H

"Higher-order" probability estimates, $P(R_2|T_2)$ and $P(R_2|T_1)$ conditional on preceding stimulus runs, for each bird in phase 2. The row heading identifies a preceding run of mT_i stimuli, where m assumes values from 1 to 5 and i is equal to 1 or 2. The number of trials, N, on which each estimate is based is also given.

"HIGHER-ORDER" PROBABILITY ESTIMATES, $\hat{P}(R_2|T_2)$ AND $\hat{P}(R_2|T_1)$

CONDITIONAL ON PRECEDING STIMULUS RUNS FOR BIRDS 1 & 2 PHASE 2

	BIRD 1				BIRD 2			
Y	$\hat{P}(R_2\|T_2Y)$	N	$\hat{P}(R_2\|T_1Y)$	N	$\hat{P}(R_2\|T_2Y)$	N	$\hat{P}(R_2\|T_1Y)$	N
1 T_1	.590	200	.171	193	.423	239	.171	260
2 T_1	.747	83	.119	84	.360	89	.125	104
3 T_1	.581	43	.077	39	.447	47	.152	46
4 T_1	.688	16	.067	15	.364	22	.067	15
5 T_1	.750	16	.167	12	.316	19	.182	11
1 T_2	.630	184	.116	164	.382	220	.187	193
2 T_2	.728	81	.173	104	.438	105	.137	117
3 T_2	.725	40	.143	42	.467	45	.115	61
4 T_2	.722	18	.136	22	.524	21	.120	55
5 T_2	.571	7	.389	18	.400	10	.095	21

"HIGHER-ORDER" PROBABILITY ESTIMATES, $P(R_2\ T_2)$ AND $P(R_2\ T_1)$

CONDITIONAL ON PRECEDING STIMULUS RUNS FOR BIRDS 3 & 4 PHASE 2

	BIRD 3				BIRD 4			
Y	$\hat{P}(R_2 \mid T_2 Y)$	N	$\hat{P}(R_2 \mid T_1 Y)$	N	$\hat{P}(R_2 \mid T_2 Y)$	N	$\hat{P}(R_2 \mid T_1 Y)$	N
1 T_1	.788	170	.142	176	.911	269	.851	269
2 T_1	.775	71	.177	85	.930	114	.853	129
3 T_1	.889	45	.178	45	.871	70	.846	65
4 T_1	.857	14	.400	20	.897	29	.769	26
5 T_1	.846	13	.167	6	.885	29	1.000	15
1 T_2	.693	179	.133	135	.891	284	.874	222
2 T_2	.645	76	.135	104	.865	126	.865	156
3 T_2	.800	40	.128	39	.881	59	.924	66
4 T_2	.682	22	.211	19	.957	23	.816	38
5 T_2	.889	9	.095	21	.818	11	.857	21

"HIGHER-ORDER" PROBABILITY ESTIMATES, $\hat{P}(R_2|T_2)$ AND $\hat{P}(R_2|T_1)$

CONDITIONAL ON PRECEDING STIMULUS RUNS FOR BIRDS 5 & 6 PHASE 2

	BIRD 5				BIRD 6			
Y	$\hat{P}(R_2\|T_2Y)$	N	$\hat{P}(R_2\|T_1Y)$	N	$\hat{P}(R_2\|T_2Y)$	N	$\hat{P}(R_2\|T_1Y)$	N
1 T_1	.714	220	.600	215	.650	203	.308	208
2 T_1	.772	127	.592	103	.629	89	.274	95
3 T_1	.691	68	.473	55	.554	56	.291	55
4 T_1	.676	37	.556	27	.722	18	.241	29
5 T_1	.633	30	.765	17	.438	16	.200	10
1 T_2	.705	239	.548	237	.677	217	.360	164
2 T_2	.711	120	.508	114	.636	88	.248	129
3 T_2	.628	63	.540	51	.659	44	.267	45
4 T_2	.438	36	.417	16	.522	23	.476	21
5 T_2	.556	16	.563	9	.857	14	.348	23

"HIGHER-ORDER" PROBABILITY ESTIMATES, $\hat{P}(R_2|T_2)$ AND $\hat{P}(R_2|T_1)$

CONDITIONAL ON PRECEDING STIMULUS RUNS FOR BIRDS 7 & 8 PHASE 2

	BIRD 7				BIRD 8			
Y	$\hat{P}(R_2\|T_2Y)$	N	$\hat{P}(R_2\|T_1Y)$	N	$\hat{P}(R_2\|T_2Y)$	N	$\hat{P}(R_2\|T_1Y)$	N
1 T_1	.572	217	.302	222	.784	241	.683	240
2 T_1	.620	100	.389	108	.783	115	.729	107
3 T_1	.576	66	.295	61	.797	59	.759	54
4 T_1	.421	19	.233	30	.767	30	.810	21
5 T_1	.500	18	.200	10	.792	24	.500	14
1 T_2	.611	239	.403	181	.820	256	.632	212
2 T_2	.585	94	.372	145	.780	118	.635	137
3 T_2	.545	46	.320	50	.808	52	.746	67
4 T_2	.609	23	.458	24	.833	24	.724	29
5 T_2	.412	17	.348	23	.708	24	.714	21

"HIGHER-ORDER" PROBABILITY ESTIMATES, $P(R_2\ T_2)$ AND $P(R_2\ T_1)$

CONDITIONAL ON PRECEDING STIMULUS RUNS FOR BIRDS 9 & 10 PHASE 2

	BIRD 9				BIRD 10			
Y	$P(R_2\ T_2Y)$	N	$P(R_2\ T_1Y)$	N	$P(R_2\ T_2Y)$	N	$P(R_2\ T_1Y)$	N
1 T_1	.627	193	.166	193	.951	203	.565	204
2 T_1	.645	76	.144	90	.952	84	.579	107
3 T_1	.697	33	.111	36	.917	48	.604	48
4 T_1	.696	23	.077	13	1.000	19	.682	22
5 T_1	.667	18	.167	6	.938	16	.400	10
1 T_2	.654	182	.127	166	.932	202	.551	167
2 T_2	.659	88	.099	91	.896	96	.557	106
3 T_2	.711	38	.100	50	.935	46	.396	48
4 T_2	.611	18	.143	21	.900	20	.539	26
5 T_2	.833	6	.111	18	.938	16	.632	19

"HIGHER-ORDER" PROBABILITY ESTIMATES, $\hat{P}(R_2|T_2)$ AND $\hat{P}(R_2|T_1)$

CONDITIONAL ON PRECEDING STIMULUS RUNS FOR BIRDS 11 & 12 PHASE 2

	BIRD 11				BIRD 12			
Y	$\hat{P}(R_2\|T_2Y)$	N	$\hat{P}(R_2\|T_1Y)$	N	$\hat{P}(R_2\|T_2Y)$	N	$\hat{P}(R_2\|T_1Y)$	N
1 T_1	.399	228	.108	232	.772	195	.293	191
2 T_1	.324	105	.158	101	.768	82	.264	91
3 T_1	.276	58	.135	52	.761	46	.263	38
4 T_1	.387	31	.050	20	.833	24	.583	12
5 T_1	.313	16	.090	11	.857	14	.125	8
1 T_2	.268	246	.124	194	.732	194	.274	164
2 T_2	.306	111	.133	135	.800	80	.343	105
3 T_2	.234	43	.132	68	.721	43	.447	47
4 T_2	.211	19	.083	24	.992	24	.350	20
5 T_2	.500	10	.053	19	1.000	6	.261	23

"HIGHER-ORDER" PROBABILITY ESTIMATES, $\hat{P}(R_2|T_2)$ AND $\hat{P}(R_2|T_1)$

CONDITIONAL ON PRECEDING STIMULUS RUNS FOR BIRDS 13 & 14 PHASE 2

	BIRD 13				BIRD 14			
Y	$\hat{P}(R_2|T_2Y)$	N	$\hat{P}(R_2|T_1Y)$	N	$\hat{P}(R_2|T_2Y)$	N	$\hat{P}(R_2|T_1Y)$	N
1 T_1	.377	223	.080	225	.763	177	.301	176
2 T_1	.425	80	.133	98	.774	106	.329	85
3 T_1	.448	58	.150	40	.727	55	.463	41
4 T_1	.571	28	.063	16	.667	33	.429	21
5 T_1	.313	16	.167	12	.850	20	.471	17
1 T_2	.407	216	.137	190	.746	197	.344	195
2 T_2	.469	96	.092	119	.685	92	.414	104
3 T_2	.400	35	.167	60	.784	37	.400	55
4 T_2	.400	15	.125	24	.733	15	.348	23
5 T_2	.444	9	.067	15	.667	6	.143	14

"HIGHER-ORDER" PROBABILITY ESTIMATES, $\hat{P}(R_2|T_2)$ AND $\hat{P}(R_2|T_1)$ CONDITIONAL ON PRECEDING STIMULUS RUNS FOR BIRDS 15 & 16 PHASE 2

	BIRD 15				BIRD 16			
Y	$\hat{P}(R_2\|T_2Y)$	N	$\hat{P}(R_2\|T_1Y)$	N	$\hat{P}(R_2\|T_2Y)$	N	$\hat{P}(R_2\|T_1Y)$	N
1 T_1	.779	195	.263	194	.829	287	.783	286
2 T_1	.805	77	.218	87	.854	103	.766	128
3 T_1	.625	32	.243	37	.789	52	.642	53
4 T_1	.688	16	.083	12	.794	34	.813	16
5 T_1	.737	19	.143	7	.900	20	.727	11
1 T_2	.743	175	.186	161	.860	264	.794	228
2 T_2	.736	87	.189	90	.817	131	.761	134
3 T_2	.691	42	.178	45	.736	53	.711	76
4 T_2	.684	19	.042	24	.800	25	.828	29
5 T_2	.667	6	.368	19	.917	12	.840	24

APPENDIX I

"Higher-order" probability estimates, $P(R_2)$, conditional on preceding response runs, for each bird in phase 2. The row heading identifies a preceding run of mR_j responses, where m assumes values from 1 to 5 and j is equal to 1 or 2. The number of trials, N, on which each estimate is based is also given.

"HIGHER-ORDER" PROBABILITY ESTIMATES, CONDITIONAL ON PRECEDING RESPONSE RUNS FOR BIRDS 1 - 4 IN PHASE 2

	BIRD 1		BIRD 2		BIRD 3		BIRD 4	
Y	$\hat{P}(R_2\|Y)$	N	$\hat{P}(R_2\|Y)$	N	$\hat{P}(R_2\|Y)$	N	$\hat{P}(R_2\|Y)$	N
1 R_1	.408	323	.279	309	.456	327	.753	178
2 R_1	.319	188	.293	222	.540	176	.711	45
3 R_1	.369	130	.250	156	.329	79	.692	13
4 R_1	.427	82	.280	118	.415	53	.000	4
5 R_1	.438	105	.237	388	.456	68	.625	8
1 R_2	.391	317	.286	311	.411	324	.769	181
2 R_2	.431	123	.405	89	.391	133	.826	144
3 R_2	.346	55	.429	35	.574	54	.780	118
4 R_2	.526	19	.333	15	.576	33	.891	92
5 R_2	.613	31	.286	7	.524	42	.934	1235

"HIGHER-ORDER" PROBABILITY ESTIMATES, CONDITIONAL ON PRECEDING

RESPONSE RUNS FOR BIRDS 5 - 8 IN PHASE 2

	BIRD 5		BIRD 6		BIRD 7		BIRD 8	
Y	$\hat{P}(R_2\|Y)$	N	$\hat{P}(R_2\|Y)$	N	$\hat{P}(R_2\|Y)$	N	$\hat{P}(R_2\|Y)$	N
1 R_1	.631	417	.467	353	.485	421	.722	299
2 R_1	.643	154	.444	187	.440	216	.615	83
3 R_1	.536	56	.435	108	.471	121	.406	32
4 R_1	.724	29	.339	62	.433	60	.368	19
5 R_1	.500	22	.376	109	.414	87	.234	47
1 R_2	.649	421	.509	354	.455	416	.700	297
2 R_2	.598	271	.458	179	.469	192	.692	208
3 R_2	.615	161	.494	83	.528	91	.803	142
4 R_2	.567	97	.585	41	.510	49	.845	115
5 R_2	.689	177	.662	71	.375	40	.833	603

"HIGHER-ORDER" PROBABILITY ESTIMATES, CONDITIONAL ON PRECEDING

RESPONSE RUNS FOR BIRDS 9 - 12 IN PHASE 2

	BIRD 9		BIRD 10		BIRD 11		BIRD 12	
Y	$\hat{P}(R_2\|Y)$	N	$\hat{P}(R_2\|Y)$	N	$\hat{P}(R_2\|Y)$	N	$\hat{P}(R_2\|Y)$	N
1 R_1	.412	323	.706	259	.274	288	.532	340
2 R_1	.368	190	.696	79	.216	208	.506	160
3 R_1	.430	121	.654	26	.195	164	.494	81
4 R_1	.286	70	.778	9	.199	131	.575	40
5 R_1	.402	127	.667	3	.183	551	.515	33
1 R_2	.394	325	.739	268	.244	283	.522	343
2 R_2	.413	126	.767	197	.265	68	.562	178
3 R_2	.275	51	.740	150	.316	19	.495	99
4 R_2	.500	14	.679	112	.333	6	.750	48
5 R_2	.417	12	.800	395	.600	5	.602	93

"HIGHER-ORDER" PROBABILITY ESTIMATES, CONDITIONAL ON PRECEDING RESPONSE RUNS FOR BIRDS 13 - 16 IN PHASE 2

	BIRD 13		BIRD 14		BIRD 15		BIRD 16	
Y	$\hat{P}(R_2\|Y)$	N	$\hat{P}(R_2\|Y)$	N	$\hat{P}(R_2\|Y)$	N	$\hat{P}(R_2\|Y)$	N
1 R_1	.303	314	.545	358	.466	309	.769	281
2 R_1	.290	217	.543	162	.458	168	.646	65
3 R_1	.340	153	.527	74	.418	91	.500	22
4 R_1	.208	101	.588	34	.396	91	.500	12
5 R_1	.213	376	.533	30	.400	80	.500	12
1 R_2	.221	312	.510	359	.510	308	.779	280
2 R_2	.257	70	.569	181	.494	158	.781	215
3 R_2	.529	17	.577	104	.525	80	.806	170
4 R_2	.222	9	.583	60	.476	42	.846	136
5 R_2	.667	6	.657	105	.618	55	.847	773

APPENDIX J

Conditional probability estimates, p_1, p_2, p_C, p_L, for successive quartiles of a session for each bird, based on the final 12 sessions of phase 2.

$\hat{p}_C$

BIRD	QUARTILE			
	1	2	3	4
1	.705	.767	.746	.781
2	.614	.615	.625	.655
3	.784	.787	.783	.827
4	.510	.518	.529	.516
5	.603	.560	.543	.603
6	.602	.646	.702	.736
7	.569	.618	.644	.625
8	.556	.553	.568	.581
9	.714	.762	.724	.827
10	.650	.702	.672	.730
11	.599	.547	.633	.640
12	.682	.767	.756	.709
13	.629	.625	.648	.706
14	.711	.721	.700	.673
15	.701	.791	.812	.754
16	.516	.523	.567	.519
OVERALL				
$\overline{X}$	.634	.656	.666	.680

$\hat{p}_L$

BIRD	QUARTILE			
	1	2	3	4
1	.408	.415	.398	.425
2	.248	.284	.310	.265
3	.543	.412	.415	.486
4	.814	.861	.877	.920
5	.566	.628	.652	.629
6	.460	.428	.479	.530
7	.548	.442	.414	.460
8	.796	.712	.739	.714
9	.368	.391	.359	.429
10	.764	.736	.767	.695
11	.287	.206	.175	.279
12	.602	.514	.480	.544
13	.259	.275	.261	.268
14	.475	.527	.560	.606
15	.497	.474	.474	.500
16	.789	.783	.804	.798
OVERALL				
$\overline{X}$	.527	.506	.510	.534

APPENDIX K

Results of Chi-Square Test for Homogeneity between phase 2 and phase 3 and phi-coefficients for each bird.

APPENDIX L

The number of trials and the conditional probability estimate, p_C, for each of the 5 days of extinction for each bird. The total number of trials over the five days are also shown, along with the mean total number of trials for each group and over all birds.

NUMBER OF TRIALS AND $\hat{p}_c$ IN EXTINCTION

DAY

		1		2		3		4		5			
	BIRD	NO. TRIALS	$\hat{p}_c$	NO. TRIALS	$\hat{p}_c$	NO. TRIALS	$\hat{p}_c$	NO. TRIALS	$\hat{p}_c$	NO. TRIALS	$\hat{p}_c$		TOTAL NO. TRIALS
Group 1	1	82	.59	41	.59	31	.55	28	.64	1	.0		183
	2	153	.69	191	.57	39	.69	31	.61	3	.67		417
	3	164	.63	185	.61	18	.50	9	.44	1	1.00		377
	4	143	.55	119	.69	96	.48	22	.17	2	.00		382
												$\bar{x}$	339.8
2	5	160	.63	165	.52	109	.52	84	.57	3	.33		521
	6	142	.63	149	.56	109	.62	46	.44	16	.44		462
	7	142	.62	139	.63	99	.61	55	.56	33	.52		468
	8	136	.65	75	.63	59	.42	5	.40	52	.62		325
												$\bar{x}$	444

NUMBER OF TRIALS AND $\hat{p}_c$ IN EXTINCTION

DAY

		1		2		3		4		5			TOTAL
	BIRD	NO. TRIALS	$\hat{p}_c$	NO. TRIALS	$\hat{p}_c$	NO. TRIALS	$\hat{p}_c$	NO. TRIALS	$\hat{p}_c$	NO. TRIALS	$\hat{p}_c$		NO. TRIALS
Group 3	9	156	.64	82	.59	29	.45	35	.69	51	.51		353
	10	151	.66	40	.65	29	.48	27	.59	6	.50		253
	11	151	.56	124	.56	130	.59	43	.58	17	.47		465
	12	138	.58	82	.58	25	.56	12	.33	6	.17		263
												$\bar{x}$	332.8
4	13	106	.56	31	.55	0	.00	29	.76	1	1.00		167
	14	129	.67	38	.61	21	.43	10	.40	5	.40		203
	15	150	.79	90	.62	77	.61	76	.66	20	.40		413
	16	181	.55	157	.59	120	.51	49	.45	57	.46		564
												$\bar{x}$	336.75

APPENDIX M

Values of the theoretical measures d', from the theory of signal detection, and α and β, from the Atkinson-Kinchla model for each bird for phase 2 and phase 3. Means for each group and overall means are also given.

THEORETICAL MEASURES

	d′		∝		β	
	PHASE		PHASE		PHASE	
BIRD	2	3	2	3	2	3
1	1.40	1.48	.498	.494	.325	.224
2	.78	1.12	.252	.423	.203	.426
3	1.66	.90	.591	.324	.416	.317
4	.14	0.00	.032	.004	.88	.983
$\bar{x}$	.995	.85	.343	.311	.456	.488
5	.42	.46	.159	.164	.641	.736
6	.91	.38	.346	.146	.463	.642
7	.58	.76	.228	.270	.456	.714
8	.37	.61	.118	.207	.771	.778
$\bar{x}$	.57	.55	.213	.197	.583	.718
9	1.52	1.44	.513	.452	.271	.162
10	1.32	1.57	.379	.548	.89	.369
11	.72	.89	.215	.284	.163	.222
12	1.21	1.26	.457	.464	.564	.463
$\bar{x}$	1.19	1.29	.391	.437	.472	.304
13	.98	.95	.303	.302	.165	.189
14	1.08	.94	.403	.355	.575	.602
15	1.44	1.58	.531	.55	.471	.313
16	.24	.64	.063	.213	.821	.785
$\bar{x}$	.94	1.02	.325	.355	.508	.472
OVERALL $\bar{x}$	.923	.936	.318	.325	.505	.496

APPENDIX N

Statistics based on 36 sessions for each bird in group 4: "first-order" conditional probability, "higher-order" probability estimates, and probability estimates, p_1, p_2, p_C and p_L, for successive quartiles. The number of trials, N, each estimate is based on is also given for the sequential probabilities.

"FIRST-ORDER" CONDITIONAL PROBABILITY ESTIMATES BASED ON 36 SESSIONS

FOR EACH BIRD IN GROUP 4

	BIRD	$\hat{P}(R_2 \mid T_2)$	N	$\hat{P}(R_2 \mid T_1)$	N		BIRD	$\hat{P}(R_2 \mid T_2)$	N	$\hat{P}(R_2 \mid T_1)$	N
R_1T_1	13	.404	1100	.122	1026	R_1T_2	13	.439	660	.137	716
	14	.689	750	.341	718		14	.735	309	.385	314
	15	.757	834	.192	818		15	.650	243	.127	253
	16	.756	431	.593	386		16	.754	236	.580	224
R_2T_1	13	.523	174	.155	155	R_2T_2	13	.471	490	.140	566
	14	.791	464	.412	418		14	.740	795	.375	899
	15	.828	215	.360	200		15	.775	733	.187	798
	16	.870	1030	.739	1012		16	.858	1136	.750	1229

"HIGHER-ORDER" PROBABILITY ESTIMATES CONDITIONAL ON PRECEDING STIMULUS RUNS, BASED ON 36 SESSIONS FOR EACH BIRD IN GROUP 4

	BIRD 13				BIRD 14			
Y	$\hat{P}(R_2\|T_2Y)$	N	$\hat{P}(R_2\|T_1Y)$	N	$\hat{P}(R_2\|T_2Y)$	N	$\hat{P}(R_2\|T_1Y)$	N
1 T_1	.418	620	.105	629	.716	563	.347	557
2 T_1	.416	315	.169	279	.720	314	.360	272
3 T_1	.437	167	.164	134	.765	153	.453	137
4 T_1	.483	89	.121	58	.724	99	.328	67
5 T_1	.298	47	.082	49	.768	69	.389	54
1 T_2	.448	629	.135	612	.740	592	.376	590
2 T_2	.449	296	.127	331	.744	289	.405	301
3 T_2	.438	112	.165	182	.738	126	.405	163
4 T_2	.511	47	.099	71	.776	49	.317	79
5 T_2	.346	26	.106	47	.619	21	.234	47
	BIRD 15				BIRD 16			
1 T_1	.797	522	.224	517	.830	759	.718	759
2 T_1	.745	259	.252	254	.839	354	.692	325
3 T_1	.734	109	.183	115	.831	172	.633	158
4 T_1	.714	70	.163	49	.855	83	.646	65
5 T_1	.797	59	.188	32	.912	57	.690	58
1 T_2	.758	525	.178	488	.849	729	.716	690
2 T_2	.733	255	.162	271	.820	350	.747	376
3 T_2	.676	111	.134	142	.815	151	.680	197
4 T_2	.750	44	.169	71	.841	69	.771	83
5 T_2	.846	13	.205	44	.897	39	.735	68

PROBABILITY ESTIMATES BASED ON 36 SESSIONS FOR EACH BIRD IN GROUP 4

	$\hat{p}_1$				$\hat{p}_2$			
	QUARTILE				QUARTILE			
BIRD	1	2	3	4	1	2	3	4
13	.167	.135	.139	.093	.478	.422	.417	.452
14	.317	.315	.400	.441	.690	.729	.743	.769
15	.247	.199	.155	.185	.707	.772	.783	.767
16	.732	.694	.681	.708	.812	.831	.859	.846

	$\hat{p}_C$				$\hat{p}_L$			
13	.655	.641	.639	.687	.241	.210	.210	.203
14	.687	.707	.672	.665	.376	.388	.429	.451
15	.728	.785	.815	.790	.350	.366	.359	.350
16	.654	.675	.678	.678	.578	.571	.577	.575

APPENDIX O

Results of stationarity tests of individual birds and over all birds, when the final 12 sessions are divided into k equal blocks, for k equal to 2, 3 and 4. Shown in columns 1, 2 and 3, respectively, for phase 2, and in columns 5, 6 and 7, respectively, for phase 3.

	PHASE 2			PHASE 3		
	BLOCKS OF			BLOCKS OF		
Bird	2	3	4	2	3	4
1	.123	5.511	5.58	8.64	19.622*	34.64*
2	1.996	13.508*	13.558	1.186	36.677*	22.503*
3	.404	4.232	6.614	39.15*	88.24*	94.388*
4	2.389	86.579*	62.19	3.88	13.428*	9.213
5	2.303	5.561	9.643	4.109	9.708	13.03
6	8.189	12.876	14.859	6.357	15.165*	16.4
7	7.994	9.147	15.176	2.164	2.913	4.841
8	8.37	20.306*	50.141*	3.838	25.707*	8.594
9	1.25	5.645	5.421	10.096*	22.436*	22.569*
10	6.758	23.76*	20.296*	4.267	2.998	9.445
11	.288	19.924*	27.628*	5.61	129.437*	95.819*
12	1.469	3.66	15.483	1.155	9.583	28.306*
13	1.7052	8.957	9.721	9.171	23.144*	21.931*
14	1.872	9.127	4.832	6.92	25.172*	17.26*
15	.285	49.949*	65.827*	3.218	6.583	12.794
16	7.598	11.891	9.642	7.627	14.157*	19.343*
TOTAL	52.993	290.633*	364.03*	117.388*	447.25*	431.08*

*p < .01

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