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Object preferences, trial 1 outcome effects, and intra-session transfer during minimal stimulus object-discrimination learning-set acquisition by bluejays (Cyanocitta cristata).

John Eugene Mauldin
University of Massachusetts Amherst

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Object Preferences, Trial 1 Outcome Effects, and Intra-session Transfer During Minimal Stimulus Object-Discrimination Learning-Set Acquisition by Bluejays (*Cyanocitta cristata*)

A Thesis presented

by

John E. Mauldin

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Approved as to style and content by:

(Chairman of the Committee)

(Head of the Department)

(Member)

(Member)

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Several aspects of the behavior of a group of naive bluejays (Cyanocitta cristata) were examined during minimal stimulus object-discrimination learning-set (ODLS) acquisition. ODLS was acquired during the presentation of three blocks of 96 problems each and performance was comparable to that observed under normal ODLS procedures. Trial 1 (Trl) outcome effects differed in size and influence on performance under the two Trl procedures used. Analyses of two object Trl choice responses indicated the presence of large, relatively stable object preferential tendancies, which reliably predicted independent performance on one object Trl problems, during each problem block. Transfer effects on performance from reward assignment to the objects during the previous session remained stable across trials, and decreased only slightly between blocks. Initially large transfer effects, from one presentation of a problem across several sessions, to the next presentation of the same problem, were eliminated during ODLS acquisition. This procedure allowed analyses of the complex interaction of behavioral tendencies and stimuli utilized by bluejays in response mediation during ODLS acquisition. These data demonstrate several potential sources of qualitative species differences in behavioral tendencies, which may cause differences in the ODLS performance of various species. These results were interpreted as further evidence for the comparative generality of response strategy models of ODLS behavior.

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The purpose of the present experiment was to investigate object-discrimination learning-set (ODLS) acquisition by bluejays (Cyanocitta cristata) under minimal stimulus conditions (Riopelle, 1955). This procedure provides for the construction of sequences of ODLS problems from a few stimulus objects and with proper counterbalancing allows simultaneous investigation of object preferences, trial 1 (Tr1) outcome effects, and transfer effects from previous reward assignment. Theoretical interpretations of behavioral changes occurring during ODLS acquisition by various primate species have assumed that these factors play an important fole in ODLS response mediation (Harlow, 1949, 1959; Levine, 1965; Bessemer and Stollnitz, 1971; Medin, 1972). The influence of these variables has only been indirectly demonstrated through Tr1 outcome analyses of acquisition and retention performance and through hypothesis analyses (Levine, 1965). This study was designed to provide detailed information on the qualitative and quantitative effects of object preferences, Tr1 outcome and previous reinforcement history through a direct demonstration of the effects on these variables on performance during ODLS acquisition.

Hunter and Kamil (1971) demonstrated ODLS acquisition by a group of naive bluejays, who attained Trial 2 asymptotic performance of 75% correct responding. Hypothesis analysis (Levine, 1965) indicated that estimates for the

"win-stay, lose-shift object" hypothesis increased during training, as did the "percentage variance explained" (P.V.E.). Although these data indicated a qualitative similarity between the behavior displayed by bluejays and Levine's (1965) macaque monkeys, the asymptotic performance of the jays was lower than that of macaque monkeys.

A potential source of this difference was indicated by the relatively high hypothesis estimates for "stimulus perseveration" and "third trial learning" obtained throughout training with the bluejays. These hypotheses are indicative of perseverative incorrect responding to objects chosen on Trl. Initially large estimates for these hypotheses displayed by Levine's (1965) naive pigtail macaques declined rapidly to low levels during ODLS acquisition. This perseverative tendency in naive rhesus monkeys has been attributed to the expression of large differences in approach and avoidance tendencies, elicited by the attributes of the stimulus objects, resulting in a differential Trl outcome effect on later performance (Harlow, 1949, 1959; Levine, 1965; Bessemer and Stolinitz, 1971). That is, performance on problems in which the Trl choice is correct (Trl + problems) is facilitated, relative to performance on problems in which the Trl choice is incorrect (Trl - problems). Thus, similar preferential tendencies may account for a large proportion of the incorrect responding displayed by ODLS experienced bluejays.

This inference was supported by Kamil, Lougee, and Shulman (1973) who found large Trl outcome effects on ODLS performance of experienced bluejays, and Kamil and Mauldin (1974) who found similar effects on the ODLS performance of naive bluejays. Kamil et al. (1973) demonstrated that the most significant decreases in retention performance, probed between Trials 2 and 3 (retention durations 0-8 minutes and 24 hours), occurred during the first 4 minutes after acquisition. Trial 1 outcome analysis of these data indicated large Trl outcome effects on retention performance at all retention durations, except zero. Kamil and Mauldin (1974) found that naive bluejays displayed no retention loss when retention was probed (duration of 0-5 minutes), either between acquisition Trials 3 and 4 or after attainment of a criterion of 5 consecutive correct responses. Trl outcome effects were, however, observed on retention performance during both retention tests. After ODLS acquisition, the results of Kamil et al. (1973) were replicated in terms of the rapid loss of intraproblem information and the large Trl outcome effects on retention performance.

Kamil et al. (1973-Exp. 2) sought to differentiate between potential object preferences and reinforcement interpretations (Bessemer and Stolinitz, 1971) of these Trl outcome phenomena through utilization of the one object Trl procedure (1Trl procedure), which randomizes preferential properties of the objects manipulated on Trl. Trial 1

outcome analysis of acquisition and Trial 3 retention performance (durations 0-8 minutes and 24 hours) indicated large Moss-Harlow effects (Moss and Harlow, 1947), or facilitated performance on Trl- problems. This tendency to shift responding from the object chosen on Trl of 1Trl problems is characteristic of both naive and experienced primates of several species (Boyer, 1966). Similar tendencies, displayed by sophisticated rhesus monkeys during two object Trl testing (2Trl procedure), have been attributed to the expression of a general exploratory response shift tendency (Riopelle, 1953). Kamil et al. (1973-Exp. 3) found that probing retention between 1Trl acquisition Trials 5 and 6 eliminated all Trl outcome effects on retention performance, thus providing support for the object preference interpretation of the Trl outcome effects observed under 2Trl procedures.

In general, these data provide further evidence of the qualitative similarity between the ODLS behavior of the bluejay and various primate species. The conditional discrimination model of ODLS behavior (Bessemer and Stolinitz, 1971), which accounts for most phenomena reported in the extensive literature on complex learning by primates, is thus provided with some degree of species generality.

This model postulates two qualitatively different classes of response tendencies mediating choice behavior during ODLS problem solution. Habits are defined as rela-

tively stable approach and avoidance tendencies, based on innate or learned manipulatory and exploratory tendencies elicited by aspects of the current stimulus situation. Perseverative responding to a particular position or object, regardless of response outcome, would be an example of an habitual response tendency. Hypotheses, on the other hand, are defined as transient response tendencies to repeat or avoid repeating prior choice responses on the basis of information stored in a dynamic memory for recent stimulus and response outcome events. Hypothesis behavior thus acts as a conditional discrimination in mediating current responding on the basis of prior trial events, according to the strategy used by the experimenter for assignment of reinforcement to the objects. During ODLS problem solution reinforcement is consistently associated with one of the stimulus objects and thus the appropriate hypothesis to be acquired is "win-stay, lose-shift object" (Levine, 1965). Object preference habits are assumed to mediate ODLS responding prior to acquisition of appropriate hypothesis behavior (naive monkey) and when intraproblem information is not available (Tr1 or following a retention interval). The level of ODLS acquisition or intraproblem learning displayed therefore reflects the proportion of problems that Tr1 response information is retained and used to mediate appropriate hypothesis behavior, suppressing object preferences.

This model is consistent with a great deal of previous data, through postulation of a few behaviorially defined response tendencies and processes. The acquisition of hypothesis behavior, and the increasing reliance on transient memory cues in response mediation has been supported indirectly through response strategy and Trl outcome analysis (Harlow, 1949, 1959; Levine, 1965) and directly through analyses of intraproblem retention loss (Bessemer and Stolinitz, 1965; Deets, Harlow, and Blomquist, 1970; Bloomquist, Deets, and Harlow, 1973; Kamil _et_ _al_. 1973; and Kamil and Mauldin, 1974). These techniques have also provided indirect evidence of the existence and influence of habitual response tendencies on ODLS behavior, but they have not illustrated the detailed characteristics and origin of these tendencies. Development of an ODLS technique, capable of directly assessing the effects of these habitual tendencies on performance during ODLS acquisition would assist the further development and evaluation of this model. Acquisition of this information would allow meaningful assessment and specification of the potentially complex species differences underlying differences in asymptotic ODLS performance displayed by various species.

This study was designed to assess the extent to which ODLS performance by bluejays, during ODLS acquisition, is influenced by object preferences, Trl outcome, and previous reinforcement history. This was accomplished by using a

modified minimal stimulus technique (Riopelle, 1955) for the construction and presentation of ODLS problems.

Riopelle (1955) found that naive rhesus monkeys acquired ODLS when presented with different sequences of problems, constructed from the exhaustive recombinations of 4 stimulus objects. (6 problems x 2 possible reward assignments = 12 distinct problems.) Each problem was solved to a criterion of 5 consecutive correct responses and 40 trials were presented, during each daily session. Special counterbalancing procedures assured that each object was paired equally often with all other objects, counterbalanced for reward and position assignment. In addition, at least one object of a pair was replaced in the construction of consecutive problems, so that at least one problem intervened between re-presentations of problems. Positive transfer occurred when stimulus objects were retained from one problem to the next with the same reinforcement assignment, and negative transfer occurred when the reinforcement assignment to the retained objects was reversed. The size of these transfer effects decreased with training. Transfer effects occurred across an intervening problem only when the reinforcement assignment to both objects was reversed from the previous presentation. ODLS acquired under these conditions transferred completely to performance on novel ODLS and discrimination reversal problems.

This technique was modified in the current experiment

such that ODLS problems were constructed from the exhaustive within-set pairings of the objects, contained in two different sets of four stimulus objects each. In this way, each object occurred in only one problem during each daily 4 problem session, eliminating potential within session transfer effects, and allowing assessment of potential between session (intra-session) transfer effects on performance. Trl choice responses during 2Trl problems was assumed to reflect object preferences and the influence of these tendencies was assessed through analyses of 1Trl performance. The effects of Trl outcome on later performance under each Trl procedure were assessed independently during each 96 problem block.

METHOD

Subjects. The subjects were six bluejays (*Cyanocitta cristata*) obtained locally around Amherst, Massachusetts when approximately 12 days old, and hand reared in the laboratory. After rearing, the birds had been maintained for 10 months with free access to food and water. The jays were maintained on a food deprivation schedule at 80%-85% *ad lib* weight during experimentation.

Apparatus. The apparatus employed was a modified Wisconsin General Test Apparatus (WGTA), described in detail by Kamil and Hunter (1970). This consisted of a masonite subject chamber (26.7 x 33 x 33 cm) which was inserted into

a large accountically tiled cubicle, equipped with a white noise source. The subject chamber contained a wooden perch positioned in front of three small rectangular ports, providing access to the foodwell area. The foodwell area consisted of a wooden box, attached to the side of the bird chamber and was lit with two 10-W bulbs. Between trials a guillotine door separated the two enclosures and the hinged rear wall of the foodwell area allowed access to the three shallow foodwells, located on the interior floor of the enclosure (2 sidewell , 7.1 cm off the midline of the center well).

The two sets of four stimulus objects each (Set X composed of objects A, B, C, D and Set Y composed of objects E, F, G, H), employed to construct ODLS problems, were selected from the laboratory collection of 200 multi-dimensional "junk" objects (toys, wooden blocks, etc.) as a representative sample of the range of objects normally presented to bluejays in the WGTA, during ODLS acquisition. Several individuals, actively involved in ODLS research with bluejays, participated in the object selection, attempting to choose objects differing in physical attributes including size, shape, color, and material. It was agreed that object A in set X would probably be preferred by most jays and object D in the same set would be relatively nonpreferred. The remaining objects in Set X and all objects in Set Y were chosen on the basis of physical dissimiliarity without regard

for potential preferential properties.

Reinforcers were freshly cut halves of meal worms (Tenebrio larvae).

Procedure. A mean free feeding weight was determined for each bird over a six day period. During the next fifteen days, all birds were reduced to 80% ad lib weight by successively reducing the amount of food available each day in the home cage. During this time, each bird was handled daily and placed in the WGTA several times, with the guillotine door closed and the white noise on, for habituation to handling and the apparatus.

The response of displacing a stimulus object from a foodwell was shaped through training on successive approximations to the final response during daily sessions. First, the birds were placed in the apparatus and allowed to obtain single reinforcers from any of the three baited foodwells, with a 15 second door closure occurring after each response. When the birds were freely feeding from all three foodwells, trials were presented with only one foodwell baited at a time, in a random order, until a criterion of 10 responses per foodwell within one session was reached, and an equal number of reinforcers had been obtained from each foodwell. Next, trials were presented with a plain wooden block (present in the rear of the foodwell area from the beginning of shaping), partially covering the baited center foodwell. On successive trials, the degree to which the block covered the

foodwell was increased until the birds were obtaining reinforcers by displacing the block when it completely covered the foodwell. After the response was established, the position of the block was changed randomly between trials to cover all three foodwells equally during each session, until a criterion of 10 responses per foodwell was met during one 30 minute session.

Experimental sessions were conducted on six days per week and consisted of the presentation of four 10 trial ODLS problems per session to all subjects. All problems presented were constructed from the exhaustive within set pairings of the stimulus objects in the two different sets of four objects each. Two object Trl (2Trl) preference testing problems were presented on the odd days (1, 3, 5) of a week and single object Trl (1Trl) performance testing problems were presented on the even days (2, 4, 6). The procedure for presentation of problems on alternating days differed only in that during 2Trl sessions, both objects were presented on Trl of each problem, whereas during 1Trl sessions only one of the objects was presented on Trl of each problem. During 2Trl sessions, the objects covered the side foodwells on Trl, one baited and the other empty, while during 1Trl sessions the object presented on Trl covered one of the side foodwells either baited or empty. The object covering the baited foodwell on Trl of 2Trl sessions defined the correct object for the remaining trials of that problem. When the object pre-

sented on Tr1 of 1Tr1 problems covered an empty foodwell, the object introduced during Tr2 defined the correct object for the remaining trials of that problem.

Special counterbalancing procedures were used in the construction of problems and the serial order of problem presentation, so that various analyses could be performed and systematic cues to problem solution minimized. Six pairings are possible from the combinations of the four objects in a set taken two at a time. There are three groups of two problems each, which exhaust all the objects in a set. Each daily session consisted of the presentation of four problems, constructed from one exhaustive group of problems from each object set. The order of presentation of these problems was randomly counterbalanced within each of the three 96 problem blocks presented. Each week, all exhaustive groups of each object set were presented twice, once during a 2Tr1 session and once during a 1Tr1 session. There are only six weekly orders of exhaustive groups of each object set that meet the restriction that no identical problems are presented during succeeding sessions. Four such weekly orders for each object set were used to construct each 96 problem block. In this way, during each 96 problem block, each of the 12 possible problems occurred four times during 2Tr1 sessions and four times during 1Tr1 sessions.

There are four configurations of relative position and reward assignment that may be used for the presentation of

each object pair on Tr1 of 2Tr1 sessions. Each of these configurations was employed once for each object pair during a 2Tr1 session during each 96 problem block. Similarly, for each pair there are eight configurations of relative position, reward assignment and object presented on Tr1, that may be used for the presentation of the pair on Tr1 of 1Tr1 sessions. Four of these configurations were randomly assigned once for each object pair during a 1Tr1 session, in such a way, that all eight configurations were used equally often during each 96 problem block. This assured that during 2Tr1 sessions within each 96 problem block, all objects appeared equally often, covering each of the two side foodwells, half the time baited and half the time empty. Similarly, each object appeared equally often on Tr1 of 1Tr1 sessions, covering one of the side foodwells, half the time baited and half the time empty, during each 96 problem block.

There are four ways that the Tr1 position configuration of the objects may change during Trials 2 and 3. Since there are two possible positions of bait on Tr1, there are a total of eight possible combinations of position configuration change on Trials 2 and 3 by position of bait on Tr1. Each of these combinations occurred approximately equally often during 2Tr1 and 1Tr1 sessions during each 96 problem block. Changes in the relative position configuration of the two objects on Trials 4 through 10 of all problems were assigned randomly with two restrictions. First, the correct object

could remain in the same position for a maximum of three consecutive trials. Secondly, within each problem the correct object was presented covering each position for a total of five trials.

The assignment of reward value to the objects occurred such that each object appeared randomly and equally often covering baited and empty foodwells during both 2Trl and 1Trl sessions within each 96 problem block.

There are four ways that the reward assignment for any object may change between one session and the next, two of which result in the reward value of the object being the same (S) during both sessions (Object A-correct during session N and correct during session N + 1, or object A-incorrect during session N and incorrect during session N + 1). In the remaining cases reward assignment is reversed (R) from one session to the next (Object A-correct during session N and incorrect during session N + 1, or object A-incorrect during session N and correct during session N + 1).

Thus, each problem presented could be classified under one of the following four problem types, according to the relationship between current reward assignment to the objects and that during the previous session:

	Reward Assignment during Session N + 1			
	Correct	Incorrect	Problem Type	Code
Reward Assignment During Session N	Correct	Incorrect	Same-Same	SS
	Correct	Correct	Same-Reversed	SR
	Incorrect	Incorrect	Reversed-Same	RS
	Incorrect	Correct	Reversed-Reversed	RR

The problem sequences were constructed such that each of these four problem types occurred roughly equally often during each 96 problem block (See Appendix for actual values). This procedure assured that there was no systematic relationship between current and previous reward assignments and allowed analyses of potential transfer effects on performance from reward assignment during the previous session.

Identical problems were re-presented after either 1, 2, 3, or 4 intervening sessions. The problem sequences were constructed such that each object pair was re-presented randomly and approximately equally often with the same and reversed reward assignment relative to the previous presentation of the problem, during each block (See Appendix for actual values). Thus, each problem could be identified on the basis of the relationship between current and previous reward assignment, allowing assessment of potential transfer effects on performance from the previous presentation of the problem, across several intervening sessions.

RESULTS

This section is divided into 4 sub-sections. The first sub-section examines ODLS performance and Trl outcome effects during successive problem blocks. The second sub-section deals with object preferences, displayed on Trl of 2Trl problems, and the relationship of these preferences to performance on 1Trl problems. The third sub-section illustrates the

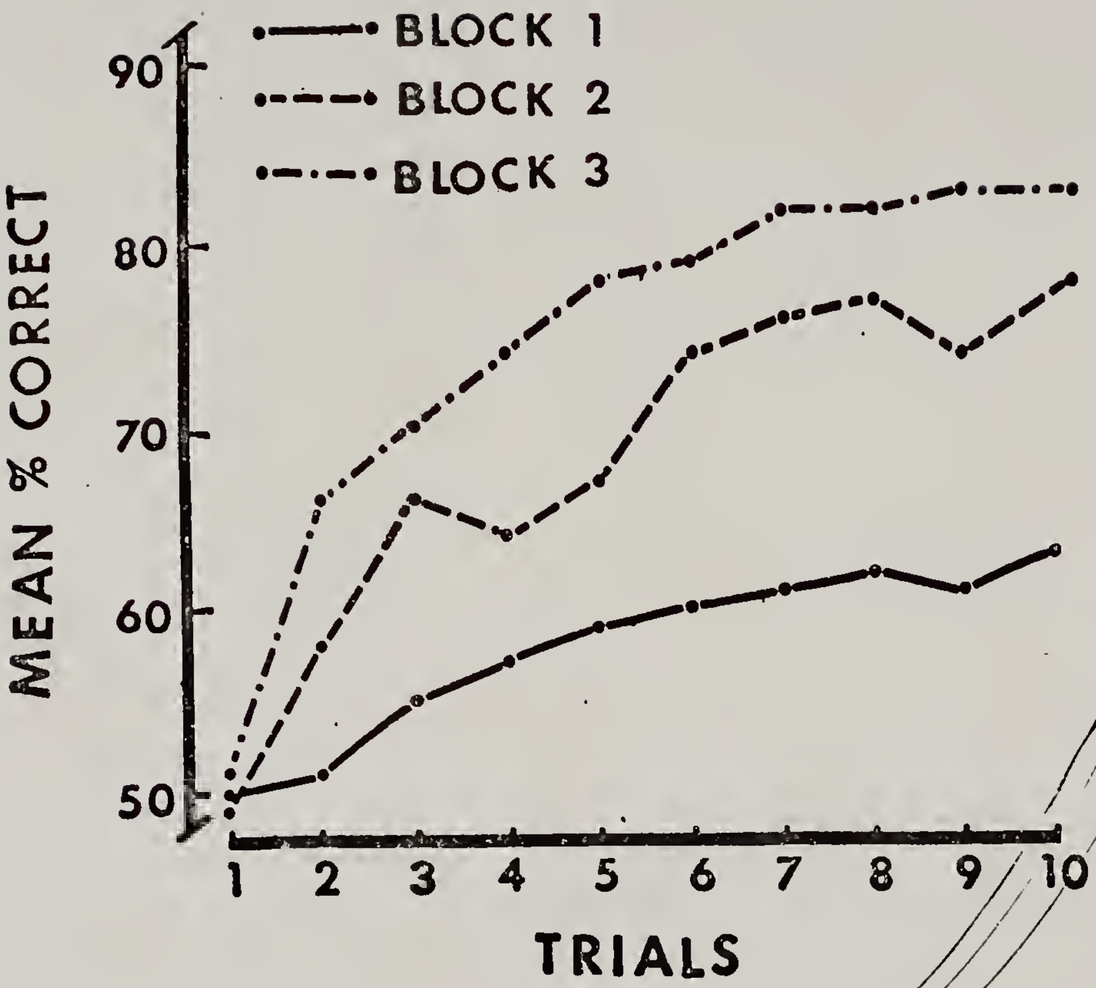
transfer effects on performance from reward assignment to the objects during the previous session. The last subsection assesses the transfer effects on performance from reward assignment to the objects during the previous presentation of the same problem.

<u>ODLS Acquisition and Trl Outcome Effects:</u>

Figure 1 shows the mean percentage correct for all birds on Trials 1-10, during the three 96 problem blocks of acquisition. These results clearly indicate ODLS acquisition across problem blocks, evidenced by the large improvement in performance between Trials 1 and 2 displayed during Block 3. Analysis of Variance (ANOVA) of performance on Trials 2-10 (Trl performance was excluded as this would have inflated Trl outcome effects) is included in Table 1. There was a significant increase in performance across Trials ($F = 11.89$, $df = 8.40$, $p < .001$) and between Blocks ($F = 47.28$, $df = 2.10$, $p < .001$). Thus, the jays solved individual problems, with performance increasing across Trials 2-10 by approximately 13% during each Block. The improvement in overall performance between Blocks is therefore due to the rapid increase in performance between Trials 1 and 2 displayed during Block 3, indicating ODLS acquisition.

While there was no difference in overall performance on 2Trl and 1Trl problems, mean performance across Trials 1-10 was slightly greater (2%) during Blocks 1 and 3. During Block 2, however, performance on 2Trl problems was

Figure 1



Mean percentage correct on Trials 1-10 for the three successive blocks of 96 problems each presented during acquisition.

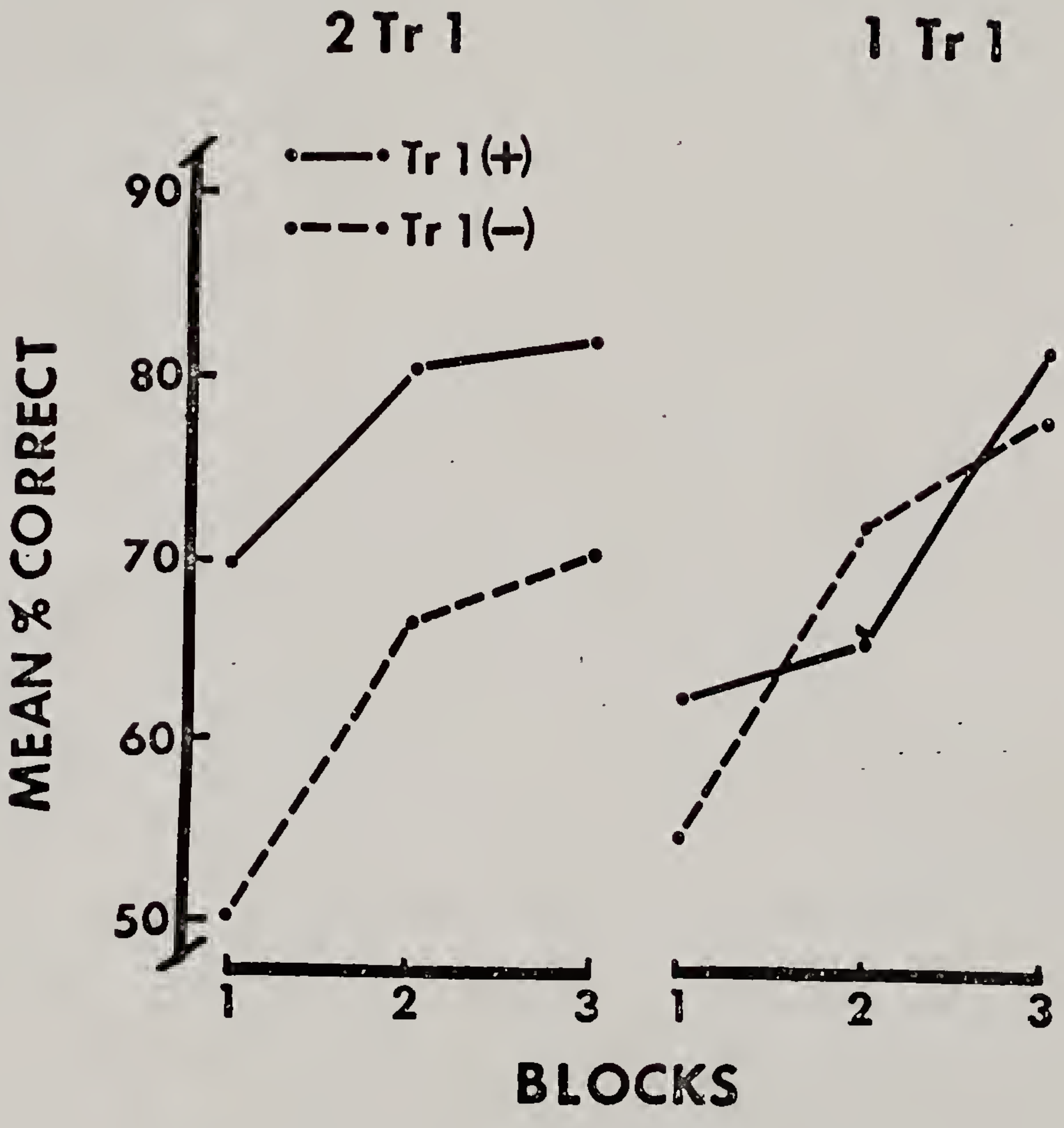
Table 1: ANOVA for ODLS acquisition and Trl Outcome Analyses

SV	df	SS	MS	F	Sign.
Subjects (S)	5	.5149	.1030		
Blocks (B)	2	3.8397	1.9198	47.28	p < .001
Number of objects on Trl (N)	1	.0114	.0114	.682	NS
Trl Outcome (O)	1	1.1150	1.115	11.45	p < .025
Trials (T)	8	1.7982	.2248	11.89	p < .001
S X B	10	.4064	.0406		
S X N	5	.0837	.0167		
B X N	2	.2086	.1043	12.27	p < .005
S X O	5	.4866	.0973		
B X O	2	.2660	.1330	10.31	p < .005
N X O	1	.7456	.7456	7.6551	p < .05
S X T	40	.7549	.0189		
B X T	16	.1697	.0106	1.55	NS
N X T	8	.0563	.0070	1.20	NS
O X T	8	.0709	.0089	1.08	NS
S X B X N	10	.0852	.0085		
S X B X O	10	.1289	.0129		
S X N X O	5	.4869	.0974		
B X N X O	2	.1097	.0548	2.28	NS
S X B X T	80	.5532	.0069		
S X N X T	40	.2330	.0058		
B X N X T	16	.0462	.0029	.725	NS
S X O X T	40	.3294	.0082		
B X O X T	16	.1021	.0064	1.25	NS
N X O X T	8	.1914	.0239	3.79	p < .005
S X B X N X O	16	.2405	.0240		
S X B X N X T	80	.3175	.0040		
S X B X O X T	80	.4117	.0051		
S X N X O X T	40	.2529	.0063		
B X N X O X T	16	.0615	.0038	.730	NS
S X B X N X O X T	80	.4162	.0052		
TOTAL	653	14.494			

facilitated (5%), resulting in a significant Blocks x Number of Objects on Trl interaction ($F = 12.27$, $df = 2,10$, $p < .05$).

Figure 2 presents the results of independent Trl outcome analyses of 2Trl and 1Trl performance during each problem block. Trl outcome effects were largest during 2Trl problems (Left panel) with average performance on Trials 2-10 much higher on Trl+ problems than on Trl- problems. In contrast, the Trl outcome effects during 1Trl problems (Right panel) were generally smaller and less consistent, with better performance on Trl+ problems during Blocks 1 and 3, and the opposite Moss-Harlow effect occurring during Block 2. Thus, while there was a significant effect of Trl Outcome ($F = 11.45$, $df = 1,5$, $p < .025$), there was also a significant interaction of Trl Outcome x Number of Objects on Trl ($F = 7.65$, $df = 1,5$, $p < .05$), reflecting differences in the size and influence of Trl outcome effects on performance under the two Trl procedures. Similarly, while Trl outcome effects on 2Trl performance remained relatively stable across Trials, there was a substantial reduction of these effects on later Trials of 1Trl problems, resulting in a significant interaction of Trl Outcome x Number of Objects on Trl x Trials ($F = 3.79$, $df = 8,40$, $p < .005$). Finally, the size of Trl outcome effects, under both Trl procedures, decreased across Blocks contributing to the significant interaction of Trl Outcome x Blocks ($F = 10.31$, $df = 2,10$, $p < .005$).

Figure 2



Percentage correct responding averaged across Trials 2-10 as a function of Trl outcome on 2Trl problems (Left panel) and 1Trl problems (Right panel) for three successive blocks of 96 problems each presented during acquisition.

<u>2Tr1 Object Preferences and 1Tr1 Performance:</u>

Tr1 choice responses during 2Tr1 problems were assumed to reflect the expression of differential preferences for the objects in each set. Thus, the frequency with which each object was chosen on Tr1 of 2Tr1 problems by each bird was determined during each problem block. Since each object was paired equally often with every other object in the set on Tr1 of 2Tr1 problems during each block, objects chosen during more than 50% of the problems were assumed to be preferred relative to the other objects in that set. On the other hand, objects chosen less than 50% of the time were considered to be relatively non-preferred. The strength of these preferences was reflected by the amount of variation from 50% with which a particular object was chosen. Similar analyses were carried out on Tr2 choice responses during 1Tr1 problems to determine whether object preferences were expressed after the forced choice on Tr1 of these problems.

The individual choice data was summarized in two different ways, to provide information on the similarity of these individual object preferences and the average strength of these preferential tendencies. First, the average frequency with which each object was chosen on Tr1 of 2Tr1 problems during each block was calculated. Evidence of differential object selection in this analysis would indicate the presence of similar object preferences between individual birds. Non-differential object selection would indicate either weak preferential tendencies or dissimilar preferences for particular objects

expressed by different birds. Tr2 choice responses during 1Trl problems were also subjected to similar analyses.

The second analysis was carried out so that the average strength of object preferential tendencies could be determined, regardless of disagreement between individual preferences. Each birds Trl choice data on 2Trl problems was used to arrive at a rank ordering of the objects in each set during each block. The most frequently chosen objects were assigned a Preference Rank of 1, the second most frequently chosen objects were assigned a Preference Rank of 2, etc. The average frequency with which the objects of each Preference Rank were chosen on Trl of 2Trl problems, during each block, was then determined. Thus, the average strength of these preferential tendencies would be indicated by the amount of variation from 50% that the objects of each Preference Rank were chosen. Choice responses on Tr2 of 1Trl problems were also subjected to similar analyses.

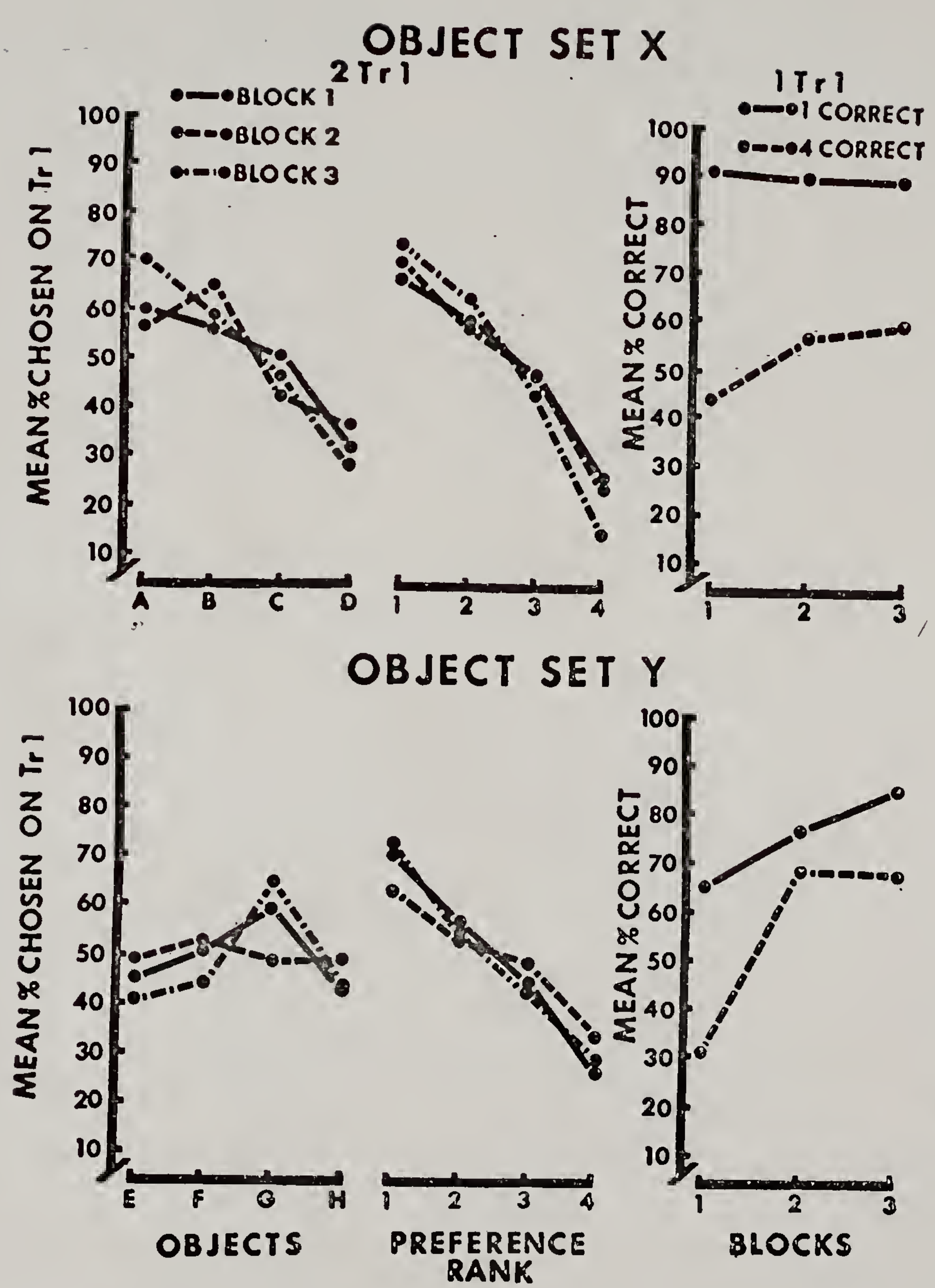
An independent assessment of the effects of these preferences on ODLS performance was carried out through analyses of 1Trl performance on the basis of predictions derived from Trl choice responses on 2Trl problems. The previous analyses were used to identify the objects, from each set, which were Most (1) and Least (4) preferred by each bird on Trl of 2Trl problems, during each block. Average performance on 1Trl problems, consisting of these objects during each block was then analyzed, as a function of reward assignment to the

objects.

Figure 3 shows the results of each of these analyses for Object Set X (Top panels) and for Object Set Y (Bottom panels). The Left panels indicate the mean percentage that each object was chosen on Trl of 2Trl problems. The Center panels represent the mean percentage that the objects of each Preference Rank were chosen on Trl of 2Trl problems. The Right panels show average performance on Trials 2-10 of 1Trl problems consisting of the objects which had been chosen the Most (1) and Least (4) frequently on Trl of 2Trl problems by each bird, during each block.

The Top-Left panel of Figure 3 shows that the jays expressed a similar pattern of preferences for the objects in Set X during each block. The objects were ranked A > B > C > D during Blocks 1 and 3 and B > A > C > D during Block 2. There were small differences between objects A, B, and C during Block 1 and all were preferred over object D. During Block 2 and 3, the differences between each object were larger. ANOVA of these data, combined with similar data on Tr2 responses during 1Trl problems (See Appendix for actual values) is presented in Table 2. There was a significant difference in the frequency with which the objects were chosen ($F = 8.1$, $df = 3,15$, $p < .005$), which failed to interact with either Blocks or the Number of Objects on Trl. Thus, a consistent pattern of preferences were expressed for the objects in Set X, on Trl or 2Trl problems and on Tr2 of 1Trl

Figure 3



Mean percentage of Trl choice responses during 2Trl problems to each object in Set X (Top-left panel) and Set Y (Bottom-Left panel) during each problem block. ~~The center panel~~ illustrates the mean percentage of Trl choices during 2Trl problems to each object in Set X (Top-center panel) and Set Y (Bottom-center panel) arranged according to the individual jays Preference Ranking of the objects. The Right panels indicate average performance on Trials 1-10 of 1Trl problems, during each block, consisting of each birds Most (1) and Least (4) preferred objects from Set X (Top-right panel) and from Set Y (Bottom-right panel), as a function of reward assignment to the objects.

Table 2: ANOVA for Object Set X Preferences expressed on Trl of 2Trl problems and on Tr2 of 1Trl problems.

SV	df	SS	MS	F	Sign.
*Subjects (S)	5	0	0		
*Blocks (B)	2	0	0		
*Number of objects on Trl (N)	1	0	0		
Objects (O)	3	340.16	113.38	8.118	$p < .005$
S X B	10	0	0		
S X N	5	0	0		
B X N	2	0	0		
S X O	15	209.5	13.96		
B X O	6	49.66	8.27	1.83	NS
N X O	3	19.16	6.38	1.75	NS
S X B X N	10	0	0		
S X B X O	30	135.66	4.52		
S X N X O	15	54.5	3.63		
B X N X O	6	9.0	1.5	.93	NS
S X B X N X O	30	48.33	1.61		
TOTAL	143	865.97			

*In this analysis these factors function as dummy variables, since an equal number of Trl choices must be made by each S and during each Block. Similarly, the number of Tr2 responses made during 1Trl sessions is equal to the number of Trl responses made during 2Trl sessions. These variables are included in this analysis in order to assess potential interactions with the main variable, the Objects.

problems, throughout ODLS acquisition.

The Top-Center panel of Figure 3 shows that there were large differences in the frequency with which Set X objects of each Preference Rank were chosen on Tr1 of 2Tr1 problems, during each block. There was a difference of at least 10% in the frequency with which objects of adjacent Preference Rank were chosen and there was a difference of more than 40% between the Most and Least preferred objects, during each block. ANOVA of these data, combined with similar data on Tr2 responses on 1Tr1 problems (See Appendix for actual values) is presented in Table 3. Preference Rank of the object had a significant effect on the frequency of object selection ($F = 32.7$, $df = 3,15$, $p < .001$). Close inspection of this panel indicates that the size of differences between Preference Ranks increased across blocks, and this was supported by the significant Preference Rank x Blocks interaction ($F = 2.81$, $df = 6,30$, $p < .05$). Thus, there was a strong tendency to express differential preferences for the objects in Set X on Tr1 of 2Tr1 problems and on Tr2 of 1Tr1 problems during each block.

The Top-Right panel of Figure 3 shows that average performance on 1Tr1 problems, constructed from each birds Most (1) and Least (4) preferred objects differed substantially during each block, as a function of reward assignment to the objects. Performance averaged 90% correct when the Most preferred objects were correct throughout training. When the

Table 3: ANOVA for Object Set X Preference Ranks expressed on Trl of 2Trl problems and on Tr2 of 1Trl problems.

SV	df	SS	MS	F	Sign.
*Subjects (S)	5	0	0		
*Blocks (B)	2	0	0		
*Number of objects on Trl (N)	1	0	0		
Preference Rank (P)	3	654.88	218.29	32.70	$p < .001$
S X B	10	0	0		
S X N	5	0	0		
B X N	2	0	0		
S X P	15	100.11	6.67		
B X P	6	14.77	2.46	2.81	$p < .05$
N X P	3	2.66	.88	.72	NS
S X B X N	10	0	0		
S X B X P	30	26.22	.87		
S X N X P	15	18.33	1.22		
B X N X P	6	7.00	1.16	.883	NS
S X B X N X P	30	42.00	1.40		
TOTAL	143	865.97			

*In this analysis these factors function as dummy variables, since an equal number of Trl choices must be made by each S and during each Block. Similarly, the number of Tr2 responses made during 1Trl sessions is equal to the number of Trl responses made during 2Trl sessions. These variables are included in this analysis in order to assess potential interactions with the main variable, the Preference Rank.

Least preferred objects were correct, performance was much lower, averaging 43% correct during Block 1, but increasing to 60% during Block 3. ANOVA of these data, presented in Table 4, indicated that performance was significantly effected by Reward Assignment to the objects ($F = 7.88$, $df = 1,5$, $p < .05$). Performance increased significantly across Trials ($F = 3.17$, $df = 8,40$, $p < .01$), but there was only a slight increase in performance between Blocks. Thus, the objects chosen Most frequently on Tr1 of 2Tr1 problems were also strongly preferred during the solution of 1Tr1 problems, resulting in a large difference in performance, depending on reward assignment to the objects. Furthermore, although there was some improvement on these problems when the Least preferred objects were correct, overall performance on both problem types failed to improve during ODLS acquisition.

Turning to the data on Set Y, the Lower-Left panel of Figure 3 shows that there were relatively small differences in the mean percentages that each object was chosen on Tr1 of 2Tr1 problems during each block. The exception to this is object G, which was chosen more frequently than the other objects during Blocks 1 and 3. The remaining objects were chosen approximately equally often during these blocks, and all objects were chosen equally often during Block 2. ANOVA of these data, and similar data on object selection on Tr2 of 1Tr1 problems(See Appendix for actual values), is presented in Table 5. There was no overall difference in the

Table 4: ANOVA for performance on 1Tr1 problems constructed from each birds Most and Least Preferred objects from Set X as a function of reward assignment to the objects.

SV	df	SS	MS	F	Sign.
Subjects (S)	5	16.80	3.36		
Blocks (B)	2	1.33	.66	3.69	NS
Reward assignment to objects (R)	1	44.44	44.44	7.88	$p < .05$
Trials (T)	8	6.22	.77	3.17	$p < .01$
S X B	10	11.80	1.18		
S X R	5	28.18	5.63		
B X R	2	1.72	.86	1.19	NS
S X T	40	9.80	.24		
B X T	16	5.27	.32	1.30	NS
R X T	8	1.50	.18	.66	NS
S X B X R	10	7.20	.72		
S X B X T	80	20.24	.25		
S X R X T	40	11.20	.28		
B X R X T	16	3.66	.22		
S X B X R X T	80	16.07	.20	1.14	NS
TOTAL	323	185.43			

Table 5: ANOVA for Object Set Y Preference expressed on Trl of 2Trl problems and on Tr2 of lTrl problems.

SV	df	SS	MS	F	Sign.
*Subjects (S)	5	0	0		
*Blocks (B)	2	0	0		
*Number of objects on Trl (N)	1	0	0		
Objects (O)	3	71.33	23.77	3.05	NS
S X B	10	0	0		
S X N	5	0	0		
B X N	2	0	0		
S X O	15	116.66	7.77		
B X O	6	59.66	9.94	2.36	NS
N X O	3	11.11	3.70	.88	NS
S X B X N	10	0	0		
S X B X O	30	126.33	4.21		
S X N X O	15	62.88	4.19		
B X N X O	6	48.88	8.14	3.43	$P < .025$
S X B X N X O	30	71.11	2.37		
TOTAL	143	567.96			

*In this analysis these factors function as dummy variables, since an equal number of Trl choices must be made by each S and during each Block. Similarly, the number of Tr2 responses made during lTrl sessions is equal to the number of Trl responses made during 2Trl sessions. These variables are included in this analysis in order to assess potential interactions with the main variable, the Objects.

frequency with which the objects were chosen, although there was a significant interaction of Objects x Blocks x Number of Objects on Tr1 ($F = 3.43$, $df = 6,30$, $p < .025$). Thus, different patterns of preferences for the objects in Set Y were expressed on Tr1 of 2Tr1 problems and on Tr2 of 1Tr1 problems both during and between problem blocks. There were however only small differences in the frequency with which the objects were chosen, indicating either weak object preferences or large differences in individual preferences for the objects.

The Lower-Center panel of Figure 3 indicates that the latter interpretation of the flat preference gradients in the Lower-Left panel is probably correct. That is, the tendency to prefer particular objects was strong during each block, when the effects of individual differences in preferences were eliminated. There were large differences in the mean percentage that objects of adjacent Preference Rank were chosen on Tr1 of 2Tr1 problems, throughout training, although these differences were somewhat reduced during Block 2. ANOVA of these data, combined with similar data on Tr2 responses during 1Tr1 problems (See Appendix for actual values), is presented in Table 6. This analysis indicated that Preference Rank had a significant effect on the frequency of object selection ($F = 56.2$, $df = 3,15$, $p < .001$). Thus, there was a strong tendency to express differential preferences for the objects in Set Y during each

Table 6: ANOVA for Object Set Y Preference Ranks expressed on Trl of 2Trl problems and on Tr2 of lTrl problems.

SV	df	SS	MS	F	Sign.
*Subjects(S)	5	0	0		
*Blocks (B)	2	0	0		
*Number of objects on Trl (N)	1	0	0		
Preference Rank (P)	3	420.27	140.09	56.2	$p < .001$
S X B	10	0	0		
S X N	5	0	0		
B X N	2	0	0		
S X P	15	37.38	2.49		
B X P	6	15.88	2.64	2.38	NS
N X P	3	4.94	1.64	1.41	NS
S X B X N	10	0	0		
S X B X P	30	33.44	1.11		
S X N X P	15	17.38	1.15		
B X N X P	6	6.88	1.14	1.08	NS
S X B X N X P	30	31.77	1.05		
TOTAL	143	567.94			

*In this analysis these factors function as dummy variables, since an equal number of Trl choices must be made by each S and during each Block. Similarly, the number of Tr2 responses made during lTrl sessions is equal to the number of Trl responses made during 2Trl sessions. These variables are included in this analysis to assess potential interactions with the main variable, The Preference Rank.

block, but there were differences in the patterns of preferences displayed by individual birds, both during and between blocks.

Finally, the Lower-Right panel of Figure 3 shows that independent performance on 1Trl problems, consisting of the Set Y objects chosen Most and Least frequently on Trl of 2Trl problems differed substantially during each block, as a function of reward assignment to the objects. This effect was largest during Block 1 with very poor performance on problems in which the Least preferred objects were correct, averaging only 30% over Trials 2-10. Performance on these problems increased between Blocks 1 and 2, but remained stable during Block 3. In contrast, performance on problems in which the Most preferred objects were correct was initially facilitated and improved steadily across blocks, averaging 85% during Block 3. ANOVA of these data, presented in Table 7, indicated that Reward Assignment to the objects had a significant effect on performance ($F = 10.68$, $df = 1,5$, $p < .025$). Overall performance on these problems increased significantly across Trials ($F = 2.5$, $df = 8.40$, $p < .05$) and Blocks ($F = 11.86$, $df = 2,10$, $p < .005$), but there were no interactions of these factors with Reward Assignment to the objects. Thus, preferences expressed on Trl of 2Trl problems reliably predicted independent 1Trl performance throughout ODLS acquisition, and there was substantial improvement in performance on both problem types across Trials

Table 7: ANOVA for performance on 1Trl problems constructed from each birds Most and Least preferred objects from Set Y as a function of reward assignment to the objects.

SV	df	SS	MS	F	Sign.
Subjects (S)	5	1.40	.28		
Blocks (B)	2	20.35	10.17	11.86	$p < .005$
Reward assignment to objects (R)	1	12.64	12.64	10.68	$p < .025$
Trials (T)	8	5.16	.64	2.50	$p < .05$
S X B	10	8.57	.85		
S X R	5	5.91	1.18		
B X R	2	3.45	1.72	.61	NS
S X T	40	10.31	.25		
B X T	16	5.70	.35	1.17	NS
R X T	8	3.63	.45	1.28	NS
S X B X R	10	28.21	2.82		
S X B X T	80	24.37	.30		
S X R X T	40	14.14	.35		
B X R X T	16	3.27	.20	.61	NS
S X B X R X T	80	26.72	.33		
TOTAL	323	173.83			

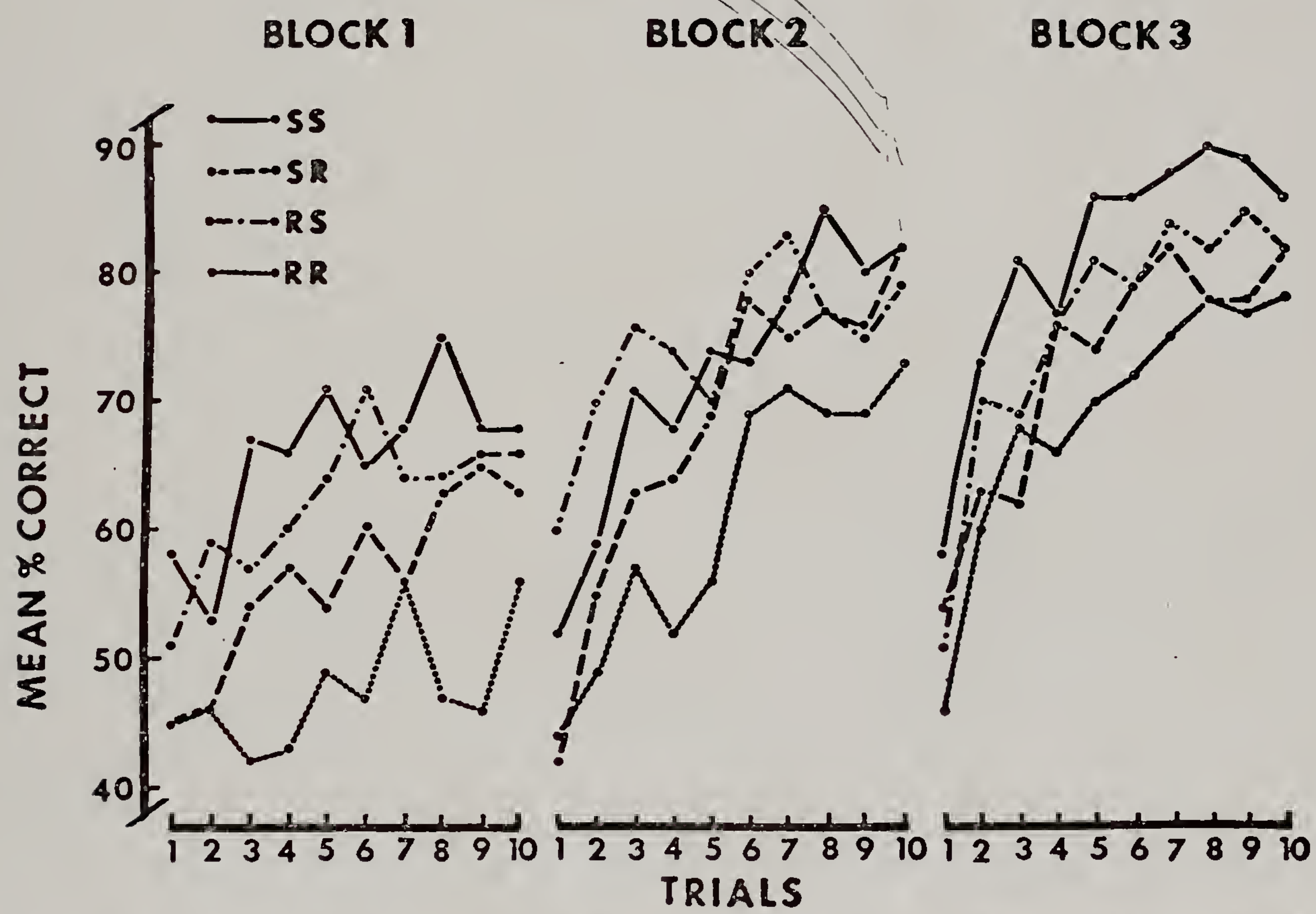
and Blocks.

Session to Session Transfer Effects:

Figure 4 illustrates mean percentage correct, during each block, on Trials 1-10 of the four problem types, defined by the relationship between current reward assignment to the objects and reward assignment during the previous session. Trial 1 performance in this figure is based only on the 2Trl problems of each type, since reward assignment on Trl of 1Trl problems was not counterbalanced within each problem type and inclusion of these data would have resulted in an inaccurate representation of transfer effects on Trl performance. Performance on Trials 2-10 was however based on all problems presented during each block.

Examining Figure 4, it is evident that there were clear transfer effects from reward assignment to the objects from the previous session, during each block. ANOVA of these data, presented in Table 8, showed that there was a significant effect on performance of Session to Session Transfer Value ($F = 22.62$, $df = 3,15$, $p < .001$). These effects were largest during Block 1 (Left panel) with good performance on problems retaining the same reward assignment to both objects from the previous session (SS), and very poor performance on problems with reversed reward assignment to the objects (RR). Performance on problems consisting of two previously incorrect objects (RS) was somewhat facilitated relative to performance on problems consisting of two pre-

Figure 4



Mean percentage correct on the four problem types, classified according to the relationship between each objects current reward assignment and reward assignment during the previous session, during each problem block.

Table 8: ANOVA of Session to Session transfer effects on performance.

SV	df	SS	MS	F	Sign.
Subjects (S)	5	.60	.12		
Blocks (B)	2	3.48	1.74	54.89	$p < .001$
Session to Session transfer value (Z)	3	2.07	.69	22.62	$p < .001$
Trials (T)	9	4.08	.45	24.80	$p < .001$
S X B	10	.31	.03		
S X Z	15	.45	.03		
B X Z	6	.20	.03	1.70	NS
S X T	45	.82	.01		
B X T	18	.48	.02	3.57	$p < .001$
Z X T	27	.28	.01	1.31	NS
S X B X Z	30	.61	.02		
S X B X T	90	.68	.007		
S X Z X T	135	1.08	.008		
B X Z X T	54	.37	.0069	.907	NS
S X B X Z X T	270	2.05	.0076		
TOTAL	719	17.56			

viously correct objects (SR), and performance on both of these problem types was intermediate to that on SS and RR problems.

During Block 2 (Center panel), the size of these effects were reduced. Performance on RS problems was facilitated on Trials 1-4, relative to that on other problem types, and equal to that on SS and SR problems during the remaining trials. Performance on RR problems was worse than all other problem types, except on Trl.

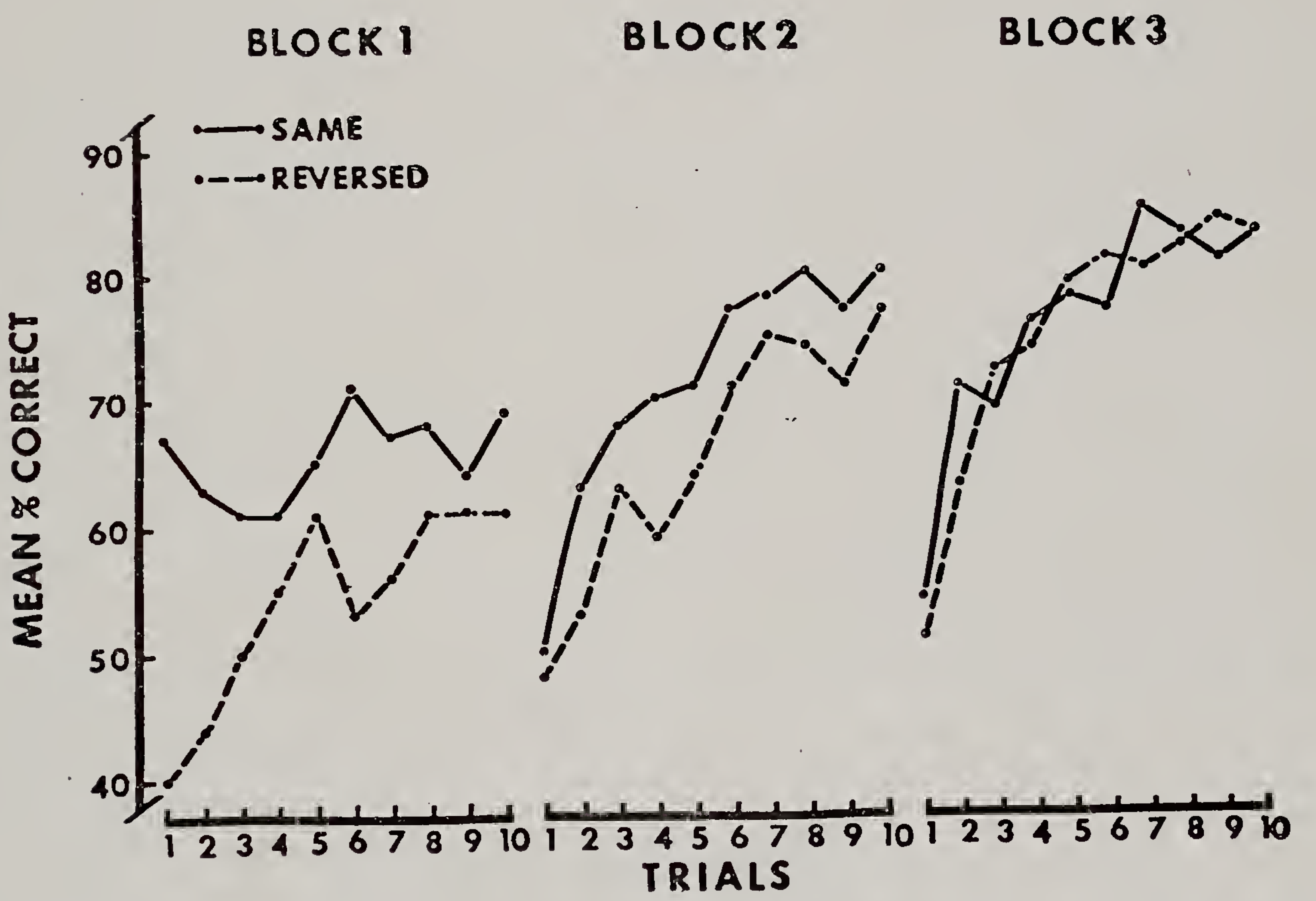
During Block 3 (Right panel) the pattern of transfer effects was similar to that observed during Block 1, although the size of these effects was reduced. That is, there was positive transfer on SS problems, and negative transfer on RR problems, while performance on SR and RS problems was approximately equal and intermediate to that on SS and RR problems.

As in previous analyses, performance increased significantly across Trials ($F = 24.8$, $df = 9.45$, $p < .001$) and between Blocks ($F = 54.89$, $df = 2,10$, $p < .001$). Due to the inclusion of data on Trl performance, there was also a significant interaction of Blocks x Trials ($F = 3.57$, $df = 18,90$, $p < .001$), reflecting ODLS acquisition. These transfer effects remained relatively stable across Trials and declined only slightly between Blocks.

<u>Transfer Effects Across Several Sessions:</u>

Figure 5 shows the mean percentage correct during each

Figure 5



Mean percentage correct on problems re-presented after several intervening sessions with reward assignment either the Same or Reversed relative to the previous presentation of the problem, during each problem block.

block on Trials 1-10 of problems re-presented after several intervening sessions (M = 2.5 sessions, range 1-4 sessions), as a function of the relationship between current reward assignment and that during the previous presentation of the problem. There were large transfer effects during Block 1, with facilitated performance on problems re-presented with the Same relative reward assignment and poor performance on problems re-presented with Reversed reward assignment. These effects were reduced during Block 2, and nearly eliminated during Block 3. ANOVA of these data, included in Table 9, indicated a significant difference in performance as a function of transfer value from the previous presentation ($F = 35.79$, $df = 1,5$, $p < .005$). There was a significant interaction of Transfer Values x Blocks ($F = 43,76$, $df = 2,10$, $p < .001$), reflecting the decline in these transfer effects during ODLS acquisition.

There were very large transfer effects on Trl performance during Block 1, which were reduced on later trials. During Block 2, transfer effects on Trl performance were small, but there was an increased effect of this transfer on later trials. During Block 3, these transfer effects were small and limited to performance on Trials 1 and 2. There was a significant interaction of Transfer Value x Trials ($F = 3.19$, $df = 9,45$, $p < .005$), reflecting the change in these transfer effects across trials.

This analysis also supported previous analyses, indicating a significant improvement in performance across Trials

Table 9: ANOVA of transfer effects on performance from one presentation of a problem across several intervening sessions to the next presentation of the same problem.

SV	df	SS	MS	F	Sign.
Subjects (S)	5	.34	.068		
Blocks (B)	2	1.42	.710	43.86	p < .001
Transfer value from the previous presentation (Q)	1	.34	.347	35.79	p < .005
Trials (T)	9	2.02	.225	23.21	p < .001
S X B	10	.16	.016		
S X Q	5	.03	.008		
B X Q	2	.14	.074	43.76	p < .001
S X T	45	.43	.009		
B X T	18	.30	.017	5.02	p < .001
Q X T	9	.10	.011	3.19	p < .005
S X B X Q	10	.01	.001		
S X B X T	90	.30	.003		
S X Q X T	45	.16	.003		
B X Q X T	18	.12	.007	1.51	NS
S X B X Q X T	90	.41	.0047		
TOTAL	359	6.28			

($F = 23.21$, df = 9,45, $p < .001$) and between Blocks ($F = 43.86$, df = 2,10, $p < .005$) and a significant interaction of Blocks x Trials ($F = 5.02$, df = 18,90, $p < .001$).

DISCUSSION

There were several major results of this study. ODLS was acquired under minimal stimulus conditions and Tr1 outcome effects on 2Tr1 performance were large, but these effects were small and inconsistent during 1Tr1 performance. Strong object preferences were expressed on Tr1 of 2Tr1 problems throughout ODLS acquisition, which reliably predicted independent 1Tr1 performance. Transfer effects from reward assignment during the previous session remained stable across trials and decreased slightly between blocks. Initially large transfer effects across several sessions, from one presentation of a problem to the next, were eliminated during ODLS acquisition. These results will be reviewed first, and then the potential implications of these data will be considered.

It was shown that bluejays acquire ODLS under modified minimal stimulus conditions (Riopelle, 1955), solving problems constructed from only 8 stimulus objects. The rate of ODLS acquisition and the asymptotic Tr2 performance was similar to that observed under normal ODLS procedures, requiring the solution of many different problems (Hunter and Kamil, 1971; Kamil and Mauldin, 1974). Tr1 outcome effects

on 2Trl performance were also similar to those previously observed during normal ODLS acquisition by bluejays (Kamil and Mauldin, 1974). That is, performance was consistently facilitated on Trl+ problems, and the size of these effects decreased during ODLS acquisition. Thus, there was a strong tendency to perseverate in responding to the objects chosen on Trl of these problems, but this tendency decreased substantially during ODLS acquisition.

In contrast, Trl outcome effects on 1Trl performance were small and inconsistent, especially after ODLS acquisition. Kamil et al. (1973) observed large Moss-Harlow effects (1947) on the 1Trl performance of experienced bluejays suggesting the presence of strong response shift tendencies during the solution of these problems. There were several procedural differences between the current study and the Kamil et al. (1973) study, however, which may have caused these contradictory results. First, the birds used by Kamil et al. (1973) had been trained on 2Trl problems during ODLS acquisition and were then shifted to testing on 1Trl problems. In the current study both 2Trl and 1Trl problems were presented throughout ODLS acquisition. Utilization of this special procedure may have disrupted the development of response shift tendencies. Alternatively, response shift behavior may result directly from the presentation of novel stimulus objects on Tr2 of 1Trl problems. In the current study, however, due to the continuous re-presentation of a

limited set of stimulus objects, the objects presented on Tr2 of these problems were all familiar. Therefore, little response shift behavior would be expected under these conditions. Although these data do not allow any specific conclusions concerning the development of the previously observed Moss-Harlow effects on the 1Trl performance of bluejays (Kamil, et al., 1973) during ODLS acquisition, they do indicate the potential importance of stimulus familiarity and Trl procedure to the occurrence of these effects. Future research in this area should begin with a simple demonstration of Trl outcome effects on 1Trl performance during ODLS acquisition. Succeeding studies could then attempt to determine the behavioral tendencies causing these effects through systematic investigation of the effects of stimulus familiarity, Trl procedure, and other relevant variables.

Strong object preferences were expressed on Trl of 2Trl problems and on Tr2 and 1Trl problems throughout ODLS acquisition. During each block, the birds displayed a continuum of preferences for the objects in each set., from strongly preferred to strongly non-preferred. There were differences between the object sets however, in the stability and similarity of individual preferences and the effects of these tendencies on performance. There was a similar pattern of individual preferences for the objects in one set throughout training and these preferences had large stable effects on performance. In contrast, preferences for the objects in the

other set varied between birds and changed across blocks. In addition, these preferences had smaller effects on performance which declined during ODLS acquisition. Thus, while the tendency to express object preferences remained stable during ODLS acquisition, some of these preferences remained stable and had a constant effect on performance, while other preferences changed substantially and had a decreasing effect on performance. This suggests that these preferences are complexly determined, probably resulting from an interaction of innate and learned tendencies to approach and avoid certain stimulus attributes and configurations. In general, these data are consistent with indirect evidence for the effects of object preferences on ODLS performance by bluejays provided by hypothesis analysis (Levine, 1965; Hunter and Kamil, 1971; Hunter, unpublished Doctoral Dissertation, 1971).

These data clarify the interpretation of the previously discussed Trl outcome effects on 2Trl and 1Trl performance. The tendency to perseverate in responding to the objects chosen on Trl of 2Trl problems was clearly due to the fact that these objects were strongly preferred. Similarly, preferences were also expressed during the solution of 1Trl problems, but these were random with respect to the objects chosen on Trl, and thus Trl outcome effects were small.

There were large, relatively stable positive and negative transfer effects on performance from reward assignment during the previous session. During Block 1 and 3, perform-

ance on the four problem types, defined by the relationship between current and previous reward assignment, was ranked SS > RS > SR > RR, while during Block 2 this ranking was RS > SS > SR > RR. These transfer effects on SS and RR problems probably reflect gradual changes in response tendencies for the objects due to association with reward or non-reward during the previous session. Thus, when reward assignment to both objects of a problem was retained from one session to the next, there would be a tendency to approach the correct object and avoid the incorrect object, even though these objects had been paired with different objects during the previous session. However, when reward assignment was reversed from one session to the next, these response tendencies were inconsistent with correct problem solution, resulting in poor performance. This interpretation is supported by the fact that the amount of positive and negative transfer on these problems during Block 3 was similar to the amount of facilitation of Trl retention performance by experienced bluejays after 24 hours (Kamil _et al_. 1973). This interpretation also provides a potential mechanism which accounts for the change in preferences for particular objects during ODLS acquisition. That is, association with reward or non-reward during problem solution probably resulted in a gradual change in the response tendencies for some of the objects, although this experience had relatively little effect on response tendencies for other objects.

This interpretation does not however account for the small, but consistent facilitation of RS performance over that on SR problems. These problems were constructed from objects with similar reinforcement histories, either both previously correct or incorrect, and therefore, equal performance on the two problem types would be expected. One potential explanation of this inconsistency is that these effects were caused by poor counterbalancing of these problem types with other factors, such as object preferences and Trl outcome. The consistency of this facilitation on RS problems across blocks argues against this possibility, since although not fully counterbalanced, the relationship between these factors was random. An alternative explanation is that performance on RS problems was facilitated due to a reduction in perseverative incorrect responding on these problems. That is, since both objects were incorrect during the previous session, there would be a tendency to avoid responding to both objects which may have caused greater flexibility in object selection on the basis of response outcome. There would be a tendency to approach both objects of SR problems, however, which may have augmented the tendency to perseverate in responding to incorrect objects. This interpretation is highly speculative and does not account for the large facilitation of Trl performance on RS problems during Block 2. Future research using this procedure could resolve this issue through carefully counter-

balancing preferences and Tr1 outcome across these problem types. This would allow analysis of performance on each problem type according to Tr1 outcome, which would indicate whether there was in fact a decrease in perseverative incorrect responding during RS problems.

Early in training, there were large positive and negative transfer effects on performance from one presentation of a problem to the next. Performance on problems re-presented with the same reward assignment (Same problems) was facilitated and remained relatively stable across trials. On the other hand, performance on problems re-presented with reversed reward assignment was initially very poor, but increased across trials. Later in training, Tr1 performance on these problem types was similar, but there was a stable facilitation of performance on Same problems during later trials. After ODLS acquisition, this transfer had small effects on Trials 1 and 2 and no effect on performance during later trials. These transfer effects may not be attributed to gradual changes in response tendencies for each object occurring during problem solution, since these tendencies would be disrupted by problem solving experience with the same objects during the intervening sessions, between re-presentations of the problems. Therefore, these data provide evidence that in addition to these gradual changes in response tendencies for each object occurring during problem solution, there were also changes in the relative response

tendencies for the objects which were specific to particular problems, reflecting the retention of the solution to individual problems. Kamil and Mauldin (1974) observed a similar decrease in retention performance during ODLS acquisition and cited the Bessemer and Stolinitz (1971) conditional discrimination model to account for this phenomena. They proposed that naive bluejays solve problems gradually through non-reinforced responding for specific choice responses, causing relatively permanent changes in relative response tendencies for the objects. Thus, retention of problem solution would be stable. After ODLS acquisition problems are solved rapidly through hypothesis behavior, utilizing transient memory cues for prior trial events. Thus, retention would be transient, due to the nature of these cues and because there would be little perseverative incorrect responding and therefore little change in the original approach tendencies for the incorrect object. The current data are also consistent with this model and provide evidence that during problem solution response tendencies for the objects change in two ways. First, there is a change in the response tendencies for each object due to the association of that object with reward or non-reward. Secondly, there is a change in the relative response tendencies for the objects that is specific to that object pair. During ODLS acquisition the former process remains relatively stable, while the latter declines, probably due to the acquisi-

tion of hypothesis behavior.

This interpretation is consistent with the data, but there are several alternative explanations which must be considered due to the special procedures used in this study. First, retention of problem solution may have been reduced by proactive interference (Underwood, 1957) from the continuous re-presentation of problems with different reward assignments. In addition, retention may have been effected by retroactive interference (Underwood, 1957) due to the solution of interpolated problems, constructed from the same objects, between re-presentations of the problems. Another possibility is that this information was retained, but not utilized in response mediation, because the birds learned that reward assignment was inconsistent from one presentation of a problem to the next. This seems unlikely, however, as there was only a slight decline in the effects of Session to Session transfer, which also provided irrelevant stimulus information. Also, Kamil _et al_. (1973) observed that ODLS experienced bluejays displayed poor retention of problem solution over a 24 hour retention interval even though this information was always consistent with correct problem solution.

These data have potential implications for several general issues. First of all, these results demonstrate several advantages of the minimal stimulus technique over normal procedures. A common criticism of the ODLS paradigm

and other complex learning procedures is that the presentation of many problems constructed from different stimulus objects precludes analysis of the stimuli controlling responding and thus prevents exact specification of the learning process which occurs under these conditions. These results however, demonstrate that experience with many different stimulus objects is not a necessary condition for ODLS acquisition, by bluejays. Instead, this acquisition is probably more dependent on experience in solving individual problems in which the reward assignment is unpredictable on Trl. Thus, these results provide a more exact definition of the conditions under which ODLS acquisition occurs.

More importantly, however, these results illustrate that utilization of special counterbalancing procedures in conjunction with a small stimulus population allowed a direct demonstration of the effects of several stimulus variable on ODLS performance. Previous evidence for the existence of object preferences and transfer effects from previous reinforcement has been indirect, provided by analysis of Trl outcome effects on acquisition and retention performance (Kamil _et al_., 1973; Kamil and Mauldin, 1974). The current results provide a direct demonstration of the existence and properties of object preferences and intra-session transfer and their effects on performance during ODLS acquisition. Thus, this procedure would prove especially useful in comparative ODLS research, since analysis of the effects of

these stimulus variables would allow more meaningful interpretation of observed species differences in ODLS performance.

An important question which must be considered however, is whether the changes in behavioral tendencies occurring under these minimal stimulus conditions are similar to those occurring under normal ODLS procedures. That is, normally many different stimulus objects are used and problems are never re-presented. Even under these conditions, however, there is considerable stimulus redundancy due to the similarity of specific attributes of the stimulus objects such as size, weight, color, shape, texture, etc. Thus, it seems likely that the current procedure simply maximized the effects of objects preferences and intra-session transfer, without causing a qualitative change in the effects of these variables on ODLS performance. In general, the data support this conclusion, but the anamolous Trl outcome effects on 1Trl performance prevent final resolution of this issue. Future studies using this procedure should, therefore, provide corroborative evidence concerning the processes occurring during ODLS acquisition, such as that provided by hypothesis analysis (Levine, 1966).

These data also provide direct evidence for the validity of several important assumptions of the Bessemer and Stolinitz (1971) conditional discrimination model, at least for the ODLS behavior of bluejays under these conditions. This model assumes that object selection on Trl or 2Trl problems is

mediated by object preferences throughout ODLS acquisition and the current data support this assumption. Another important assumption of this model is that there is a qualitative change in the way problems are solved during ODLS acquisition which affects the retention of these problems. The current data also provide direct evidence for this assumption as the naive birds solved problems gradually but retained problem solution over a long retention interval and interpolated experience. After ODLS acquisition however, retention of this information was transient. Finally, these data provide direct evidence that an important learning process during ODLS acquisition, is acquisition of the potential to rapidly suppress object preferences when these tendencies are inappropriate to correct problem solution. These data also indicate that these preferences are only partially suppressed during problem solution by bluejays, and thus impose an upper limit on ODLS performance.

Finally, these data allow some speculation concerning possible behavioral differences between bluejays and rhesus monkeys that cause the large differences in ODLS performance by these species. There are several sources of indirect evidence which indicate that rhesus monkeys display object preferences during the solution of 2Trl ODLS problems. Trl outcome analysis (Harlow, 1949) and hypothesis analysis (Levine, 1965) of the performance of naive rhesus monkeys support this conclusion. Cho and Davis (1957) found that

sophisticated rhesus monkeys displayed consistent preferences for 12 stimulus objects presented for several randomly ordered, temporally spaced, non-reinforced choice trials. Tr1 outcome effects on the retention performance of sophisticated rhesus monkeys (Bessemer and Stolinitz, 1971) also indicate a strong tendency to repeat the Tr1 choice response. Tr1 outcome effects on the 2Tr1 performance of sophisticated rhesus monkeys contradict these data however, indicating a tendency to shift responding on Tr2 of these problems (Harlow, 1949, 1959). The current data support previous studies, (Kamil <u>et</u> <u>al</u>., 1973; Kamil and Mauldin, 1974), which indicated that this reversal of Tr1 outcome effects on 2Tr1 performance does not occur during or after ODLS acquisition by bluejays, although the size of these effects decline substantially. Thus, one potential difference between bluejays and rhesus monkeys may be the development of this response shift tendency, which would facilitate hypothesis behavior through the direct suppression of object preferences.

Evidence for another potential difference between these species is provided by the current data on the long term retention of problem solution. Conner and Meyers (1971) found that naive rhesus monkeys displayed substantial retention of ODLS problems re-presented after intervals of 2-6 days during which novel problems were solved. These effects declined rapidly during ODLS acquisition, but the insertion of a two week break from testing produced a full recovery of

these effects during the presentation of later problems. These effects declined rapidly again after the solution of 30 six-trial problems, but were reinstated after another two week break. Although a similar reduction in the retention of correct problem solution was observed during the current study, the decline in these effects was much more gradual, occurring during the solution of 288 ten trial problems. Furthermore, Kamil and Mauldin (1974) showed that a 30 day break from testing had little effect on the retention performance of experienced bluejays. It is interesting to note that Riopelle (1955) did not report the results of his analysis of intra-session transfer effects during minimal stimulus ODLS acquisition by rhesus monkeys and that the effects on inter-session transfer were initially small and declined rapidly during acquisition. Thus, these data provide evidence that differences in ODLS performance between bluejays and rhesus monkeys may be related to the potential to suppress the effects of previous problem solution.

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Appendix for frequency of each problem type according to relationship between current reward assignment and reward assignment to the objects during the previous session during each 96 problem block of acquisition.

Reward assignment relative to previous session			Frequency			
Correct object	Incorrect object	Code	Block 1	Block 2	Block 3	Overall
Same	Same	SS	27	28	26	81
Same	Reversed	SR	19	24	23	66
Reversed	Same	RS	21	20	22	63
Reversed	Reversed	RR	25	24	25	74
		SUM	*92	96	96	284

*Problems presented during session 1 (problems 1-4) have no transfer relation from a previous session, therefore the sum for this block is smaller than for later blocks.

Appendix for frequency of each problem type according to the relationship between current reward assignment to the objects and reward assignment during the previous presentation of the same problem, during each 96 problem block of acquisition.

Reward assignment relative to previous presentation of the same problem	Frequency			
	Block 1	Block 2	Block 3	Overall
Same (S)	36	45	42	123
Reversed (R)	48	51	54	153
SUM	*84	96	96	276

*Problems presented during sessions 1-3 (problems 1-12) have no transfer relation from a previous presentation, therefore the sum for this block is smaller than for later blocks.

Appendix for Set X object preference in terms of the relative frequency of object selection on Tr2 of 1Tr1 problems during each problem block.

		Objects			
		A	B	C	D
Mean Percentage chosen on Tr2 of 1Tr1 Problems	Block 1	.59	.54	.50	.36
	Block 2	.54	.59	.47	.38
	Block 3	.72	.54	.50	.29

Appendix for Set Y object preference in terms of the relative frequency of object selection on Tr2 of 1Tr1 problems during each problem block.

		Objects			
		E	F	G	H
Mean Percentage chosen on Tr2 of 1Tr1 Problems	Block 1	.51	.38	.62	.47
	Block 2	.48	.52	.54	.43
	Block 3	.45	.47	.63	.43

Appendix for the mean percentage of problems that the Set X objects of each Preference Rank were chosen on Tr2 of 1Tr1 problems, during each problem block.

		Preference Rank			
		1	2	3	4
Mean Percentage chosen on Tr2 of 1Tr1 Problems	Block 1	.69	.59	.43	.27
	Block 2	.66	.56	.50	.26
	Block 3	.73	.62	.43	.20

Appendix for the mean percentage of problems that the Set Y objects of each Preference Rank were chosen on Tr2 of 1Tr1 problems, during each problem block.

		Preference Rank			
		1	2	3	4
Mean Percentage chosen on Tr2 of 1Tr1 Problems	Block 1	.72	.55	.47	.25
	Block 2	.59	.54	.50	.32
	Block 3	.68	.56	.44	.30