



Pigeons learn two matching tasks, two nonmatching tasks, or one of each

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Abstract

When pigeons learn matching-to-sample or nonmatching-to-sample there is good evidence that they can transfer that learning to novel stimuli. But early evidence suggests that in the rate of task acquisition, there is no benefit from a matching relation between the sample and the correct or incorrect comparison stimulus. In the present research we trained three groups of pigeons, each on two two-stimulus tasks simultaneously, matching-matching, nonmatching-nonmatching, or matching-nonmatching. If a common matching or nonmatching relationship benefits acquisition, the first two groups should acquire their tasks faster than the third group, for which the two tasks ought to be incompatible. The results indicated that all three groups acquired their tasks at about the same rate. A secondary goal of the experiment was to determine the basis of learning for the each of the three groups. During testing, for each task, there were test trials in which one of the stimuli from the other task replaced either the correct or the incorrect comparison stimulus. Surprisingly, neither comparison stimulus appeared to show complete control over comparison choice. Although replacing either comparison stimulus resulted in a decrement in task accuracy from about 90% to 70% correct, independent of which comparison stimulus was replaced, the pigeons chose correctly at well above chance accuracy. Suggestions to explain this unexpected outcome are discussed.

Keywords Acquisition of matching · Acquisition of mismatching · Same/different concept · Select/reject learning · Pigeons

Same difference learning by non-human animals has interested psychologists at least since Skinner (1950) described it. He famously asserted that a conditional discrimination, in which the conditional stimulus indicates which of two discriminative stimuli is correct, is learned by a pigeon as a simple stimulus-response chain involving the conditional stimulus and the correct discriminative stimulus. This statement implies that nothing is learned about the relation between the conditional stimulus and the incorrect stimulus. Furthermore, the statement implies that the physical relation between the conditional signal (the sample) and the correct or incorrect discriminative stimuli (the comparison stimuli) is not meaningful to the animal. That is there is no special advantage to learning when the sample and the correct comparison match (matching-to-sample) or the sample and the incorrect comparison match (nonmatching-to-sample).

Several years later, Cumming and Berryman (1961) tested this hypothesis. They trained pigeons on a conditional discrimination in which the samples and comparison stimuli were the colors red, green, and blue, and to obtain a reinforcer the pigeons were required to choose the comparison stimulus that was the same color as the sample. To determine what the pigeons had learned, Cumming and Berryman replaced all of the blue stimulus lights with yellow lights. Consistent with Skinner's hypothesis, when the sample was red or green and a yellow stimulus replaced the incorrect blue comparison stimulus, (the correct comparison stimulus remained) the pigeons' accuracy was not impaired. When the yellow stimulus replaced both the blue sample and the correct blue comparison stimulus, however, the pigeons' accuracy fell to chance.

Zentall and Hogan (1974) argued that on Cumming and Berryman's test trials involving the yellow comparison stimulus, the pigeons were offered a choice between a familiar red or green comparison stimulus and a novel yellow comparison stimulus. This choice was likely to bias the pigeons to choose the familiar red or green color rather than the novel yellow comparison stimulus. On test trials, in

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which the sample was red or green, the familiar comparison stimulus would have been correct, however, when the sample was yellow, the familiar red or green comparison stimulus would have been incorrect. Thus, preference for the more familiar comparison stimulus can account for the Cumming and Berryman results. Interestingly, if neophobia were the only mechanism involved, the pigeons should have been below chance on novel yellow sample trials. Thus, perhaps there was some conflict between responding to the familiar (incorrect) nonmatching comparison stimuli and the novel (correct) matching comparison stimulus.

To remove the bias to select the familiar comparison stimulus, Zentall and Hogan (1974) trained pigeons on a matching task with only two colors, red and green. They trained a second group on a nonmatching task with the same two colors. Following acquisition, they transferred half of the pigeons in each group to matching or nonmatching with two novel colors, yellow and blue. For half of the pigeons in each group, the transfer task was the same as the training task, matching or nonmatching. For the remaining pigeons, the transfer task was different from the training task. That is, if they were trained with red/green matching, they were transferred to yellow/blue nonmatching and if they were trained with red/green nonmatching, they were transferred to yellow/blue matching. The transfer results indicated that pigeons that were transferred to the novel colors, but the task was the same as in training (matching to matching or nonmatching to nonmatching) transferred at a higher level of accuracy than pigeons that were transferred to the novel colors but the transfer task was different from the training task (matching to nonmatching or nonmatching to matching).

In a later study, to rule out the possible effects of primary stimulus generalization (because there could have been some generalization from red to yellow and from green to blue), Zentall and Hogan (1976) repeated this transfer design with pigeons using shapes (circle and plus) for the original matching and nonmatching tasks, and colors (red and green) for the transfer tasks. Although the differences between the same-task and different-task transfer were somewhat smaller, the same-task pigeons still acquired the transfer task faster than the different-task pigeons.

Other researchers reasoned that the development of same and different concept transfer likely requires the use of many exemplars of the concept, and they have used pairs of photographs or icons that could be “sorted” by same and different (e.g., Katz & Wright, 2006; Wright et al., 1988). Still others have used matrices of simultaneously presented icons that could also be responded to with a “same” or a “different” response (e.g., Young & Wasserman, 1997). In general, the more stimuli used in training, the greater has been the transfer found to novel stimuli (Katz, Wright, & Bachevalier, 2002; Wright et al.). However, the more stimuli used in training the greater the likelihood that elements from

the stimuli used in training will be similar to elements of the testing stimuli and stimulus generalization between the training and testing stimuli cannot be ruled out.

Similar to the procedure used when the training involved a smaller stimulus set, the test of concept transfer is typically trials involving novel same and different stimuli. The typical finding of excellent transfer to novel sets of stimuli provides credible evidence that pigeons can learn to use the abstract concepts of same and different. The concepts are abstract in the sense that they can be applied to any pair of stimuli. That is, rather than being physically similar, the same and different concepts require a relationship between two or more stimuli.

The advantage of using many exemplars in training is it encourages the animal to use a same/different concept rather than allowing the animals to learn a small number of associative sample-comparison choice responses. That is, it makes it very difficult for the animals to learn a stimulus-response association to each different pair (or set) of training stimuli. The disadvantage of using a large set of training stimuli, however, is it is difficult to rule out the possibility that some degree of primary stimulus generalization might account for the transfer that is typically found from the training stimuli to novel test stimuli. For example, if one of the training stimulus photographs included a flower there could have been stimulus generalization from the training flower to a flower first seen on a test trial – or even a patch of color on the slide. Furthermore, the greater the number of stimuli used during training, the greater the likelihood that some component of a training stimulus would be similar to some component of one of the test stimuli.

In a novel approach to the question of what is learned when a pigeon learns a matching or nonmatching task, Zentall, Andrews, and Case (2018) trained pigeons on a four-color matching or nonmatching task in which for each sample stimulus color, there was only one comparison color that did not match the sample (the other comparison matched the sample). Then following training, on selected probe trials, one of the colors not seen with that sample in training replaced either the matching or nonmatching comparison color. The results of the probe trials for the pigeons that were trained to match the color of the sample were consistent with Skinner’s (1950) hypothesis. Whenever the untrained color replaced the matching comparison stimulus (the one that was correct in training), accuracy dropped to chance. Whenever the untrained color replaced the nonmatching comparison stimulus (the one that was incorrect in training), however, accuracy dropped somewhat but remained relatively high.

The results of the probe trials for the pigeons that were trained on the nonmatching task, however, were quite different. Whenever the untrained color replaced the nonmatching comparison stimulus (the one that was correct in training), accuracy remained relatively high. Furthermore, whenever

the untrained color replaced the matching comparison stimulus (the one that was incorrect in training), accuracy dropped to chance. Clearly, the pigeons in the two groups learned different things. For the Matching Group, the pigeons had learned to select the matching stimulus. For the Nonmatching Group, however, the pigeons had learned to reject the matching stimulus. For both groups the basis of learning depended on the stimulus that matched the sample (see also Zentall, Edwards, Moore, and Hogan, 1981).

In an effort to determine what pigeons learned when they learned matching and nonmatching, O'Donoghue et al. (in press) used a more complex procedure in which on a given trial, the pigeons learned to choose two same colored squares or two different colored squares depending on the color of the surrounding frame. Thus, the correct pair of squares, same or different color, was conditional on the color of the background frame. During testing, when they replaced one pair of stimuli (either the one with the same colors or the one with the different colors), with a neutral gray rectangle, they found results quite different from those of Zentall et al. (2018). O'Donoghue et al. found that the pigeons had learned to reject the different colored squares when the matching stimuli were correct and to reject the same colored squares when the nonmatching stimuli were correct. The authors attributed the pigeons' *reject learning* to the difficulty of the task. It appears that initially the pigeons had learned that selecting either the same or different pairs of squares would provide a reinforcer half of the time. In their study, what they needed to learn was the color of the border that determined when to reject the same pair and when to reject the different pair.

Do concepts facilitate acquisition?

Most research on same different learning has focused on transfer to novel stimuli (e.g., Cook, Cavoto, & Cavoto, 1995; Katz, Wright & Bodily, 2007; Wasserman, Hugart, & Kirkpatrick-Steger, 1995; Zentall & Hogan, 1974, 1976). The finding of concept transfer suggests that if pigeons are required to learn two matching tasks, each with a different pair of colors (e.g., red and green matching and yellow and blue matching) or a nonmatching task with those same colors (e.g., red and green nonmatching and yellow and blue nonmatching), the two tasks should facilitate each other because they both involve the same concept. Following this logic, it should be easier for pigeons to learn two matching or two nonmatching tasks than if they are required to learn one matching task (e.g., red and green matching) and a different nonmatching task (e.g., yellow and blue nonmatching) because the two tasks presumably involve different concepts. We could find only one study that attempted to address this issue (Carter & Eckerman, 1975). In that study

the authors compared a matching to sample task with a task in which the sample matched neither comparison stimulus (a symbolic matching task). That is, in symbolic matching the relation between the sample and correct and incorrect comparison stimulus is arbitrary (neither comparison matches the sample).

Carter and Eckerman (1975) used matching tasks consisting of line orientations or colors and symbolic matching tasks consisting of line orientation samples and color comparisons or color samples and line orientation comparisons. Because line orientations are more difficult to discriminate than colors, they used a derived method of correcting for the differential difficulty of the stimuli. They independently assessed the relative difficulty of simultaneous and successive discriminations for lines and colors, and then adjusted the scale of sessions accordingly for the two matching tasks (color-color, and line-line) and two symbolic matching tasks (color-line and line-color). For example, if the successive line discrimination took twice as long to learn as the successive color discrimination they scaled the line sample color comparison task accordingly. Although this is a clever way of comparing the Matching and Symbolic Matching Groups, it is rather indirect. After rescaling the abscissa (sessions) for simultaneous and successive stimulus discriminability, they found that symbolic matching (line samples and color comparisons or color samples and line comparisons) was no more difficult for the pigeons to acquire than line matching and color matching. Based on their results, they concluded that "identity between a sample and one of comparison stimuli plays no role for pigeons." (p. 663).

Given that transfer of matching and nonmatching to novel stimuli often had been found to result in positive transfer, one might have expected somewhat faster acquisition of the task when an identity relation existed between the sample and the correct comparison stimulus. It may be, however, that the failure to find a difference in acquisition between matching and symbolic matching tasks could be attributed to their derived method for comparing the two tasks.

In the present experiment, we attempted to use a more direct approach to ask if there is any benefit that might be seen in the rate of acquisition if one of the comparison stimuli matched or nonmatched the sample stimulus. To accomplish this, we trained pigeons on two concurrent matching or nonmatching tasks and asked if they would learn those tasks faster than pigeon trained on a mixture of one matching and one nonmatching task. That is, would pigeons learn faster if the sameness relation between the sample and the correct comparison (or the incorrect comparison) was compatible, than if the two tasks were incompatible? Specifically, we asked if pigeons would learn a red-green matching task and a yellow-blue matching task or a red-green nonmatching task and a yellow-blue

nonmatching task faster than pigeons that learned a red-green matching task and a yellow-blue nonmatching task (or a red-green nonmatching task and a yellow-blue-matching task). If Carter and Eckerman (1975) were correct, sameness compatibility between the two tasks should not influence learning; learning should be similar, and all three groups should learn at the same rate.

We were also interested in whether there might be a difference in the rate of learning when both tasks were matching compared to when both tasks were nonmatching. If Zentall et al. (2018) are correct that sameness is a natural concept for pigeons, one might expect pigeons to learn faster when both tasks are matching than when both tasks are nonmatching.

A second purpose of the present experiment was to determine what the pigeons learned when they learned the matching and nonmatching tasks. Zentall et al. (2018) found that when pigeons learned matching and nonmatching, they learned to use the matching relation between the sample and the comparison stimulus for both tasks. That is, when it was a matching task, the pigeons learned to *select* the matching comparison, but when it was a nonmatching task, they learned to *reject* the matching comparison. On the other hand, O'Donoghue et al. (in press), using a quite different procedure, found that pigeons tended to learn to reject the incorrect alternative, independently of whether that task was matching or nonmatching.

In the present experiment, because the pigeons in all three groups learned two tasks with different stimuli, following acquisition, probe trials were included in which either the matching or the nonmatching comparison stimulus was replaced with one of the stimuli from the other task. If the pigeons were using the matching comparison as the basis for comparison choice, when the correct comparison is replaced by one of the stimuli from the other task, accuracy on the matching task should be poor but when the incorrect comparison is replaced, accuracy on the nonmatching task should be poor. This prediction would be expected to be true not only for the Matching-Matching and Nonmatching-Nonmatching Groups, but also for the mixed Matching-Nonmatching Group.

Method

Subjects

The subjects were twenty four unsexed White Carneau pigeons. The pigeons had previously taken part in an unrelated experiment involving successive color discriminations. The pigeons were maintained at 85% of their free-feeding weight throughout the experiment. They were individually

housed in wire cages with free access to water and grit in a temperature-controlled colony room, on a 12:12-h light:dark cycle. The pigeons were cared for in accordance with the University of Kentucky Animal Care Guidelines.

Apparatus

The experiment was conducted in a BRS/LVE (Laurel, MD) sound attenuating standard operant test chamber with inside measurements 35 cm high, 30 cm long, and 35 cm across the response panel. There were three horizontally aligned round (2.5 cm diameter) response keys 25 cm above the floor on the response panel. The response keys were spaced 6.0 cm apart, and behind each key was a 12-stimulus in-line projector (Industrial Electronics Engineering, Van Nuys, CA). The left, right, and center keys could project red, green, yellow, and blue hues (Kodak Wratten Filter Nos. 26, 38, 9, 60, respectively). The bottom of the center-mounted feeder was 9.5 cm from the floor. Reinforcement consisted of 1.5 s access to Brown's Premium Pigeon Feeds. A microcomputer in an adjacent room controlled the experiment.

Design

Eight pigeons were trained on a red-green matching task and a yellow-blue matching task. Eight pigeons were trained on a red-green nonmatching task and a yellow-blue nonmatching task. Four pigeons were trained on a red-green matching task and a yellow-blue nonmatching task, and the remaining four pigeons were trained on a red-green nonmatching task and a yellow-blue matching task. Thus, eight pigeons were trained on two compatible matching tasks, eight pigeons were trained on compatible nonmatching tasks and eight pigeons were trained on incompatible mixed matching and nonmatching tasks. One of the pigeons in the mixed group became ill during the study and was dropped from all calculations.

Procedure

As the pigeons had previous experience pecking all four colors they did not require pretraining and were immediately placed on their respective tasks.

Training All trials began with the onset of the sample stimulus on the center response key. Five pecks to the sample lit the two comparison stimuli, one on the left the other on the right response key (the sample stayed on). In all cases, for one task, the sample stimuli were either red or green and one comparison stimulus was red, and the other comparison stimulus was green, and for the other task the sample stimuli were either yellow or blue and one comparison stimulus was yellow, and the other comparison stimulus was blue. Red-green and yellow-blue stimulus trials were randomly

intermixed with the following constraints: in each 80 trial session there was an equal number of trials with each task, the number of each colored sample (red or green, and yellow or blue), and the spatial location of the correct and incorrect comparison stimulus (left or right) were counter-balanced. Training consisted of 32 sessions.

Testing As we had not initially intended to conduct the testing sessions, the pigeons in all three groups were taken off task for 10 days following the last day of training. To ensure baseline training accuracy, the pigeons were given 5 additional training sessions before the start of testing. On the day following the last training session, all pigeons were given 5 testing sessions. Each testing session consisted of 4 trials involving each sample color with either the correct or incorrect comparison stimulus replaced by one of the two stimuli from the other task. For example, on a red sample trial, the matching red comparison stimulus could be replaced by either the yellow or blue stimulus, or the nonmatching green comparison stimulus could be replaced by either the yellow or blue stimulus. Thus, for each of the sample colors there were 16 test trials for a total of 64 test trials. Each testing session also included 16 training trials. Responding on test trials was reinforced according to whether the pigeon chose the comparison that in training was correct with the presented sample or whether it avoided the comparison that was incorrect with the presented sample. The testing trial and training trials were presented as random permutations within each testing session.

Results

Training

The Matching-Matching, Nonmatching-Nonmatching, and Matching-Nonmatching Groups all learned their tasks quickly and to a high level of accuracy within about 15 sessions (see Fig. 1). A mixed two-way ANOVA with sessions as a repeated measure and group as the independent factor indicated that the effect of session was statistically significant, $F(31,465) = 69.28, p < .001, \eta_p^2 = .822$, but the effect of group was not significant, $F < 1$. There was, however, a significant Session x Group interaction, $F(2,465) = 1.58, p = .005, \eta_p^2 = .0067$. Planned comparisons indicated that the difference between the Matching-Matching and Nonmatching-Nonmatching Groups combined versus the Matching-Nonmatching Group was not significant $F < 1$, nor was there a significant interaction of group with sessions, $F < 1$. A separate planned comparison of the difference between the Matching-Matching and Nonmatching-Nonmatching Groups indicated that although there was not a significant group effect, $F < 1$, there was a significant Matching-Matching

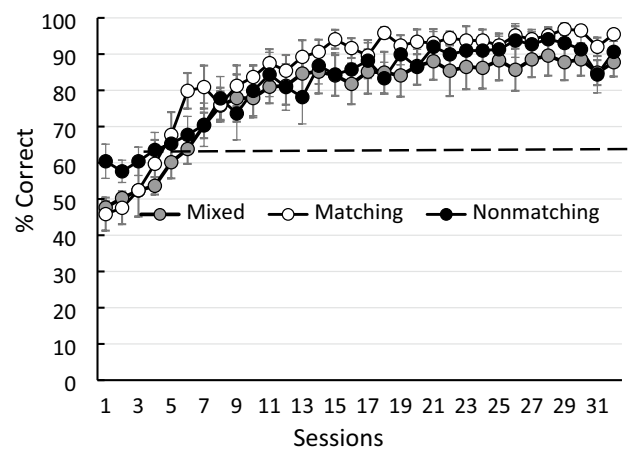


Fig. 1 Acquisition of Matching-Matching Group (Matching), Nonmatching-Nonmatching Group (Nonmatching), and Matching-Nonmatching Group (Mixed). Error bars indicate ± 1 standard error of the mean

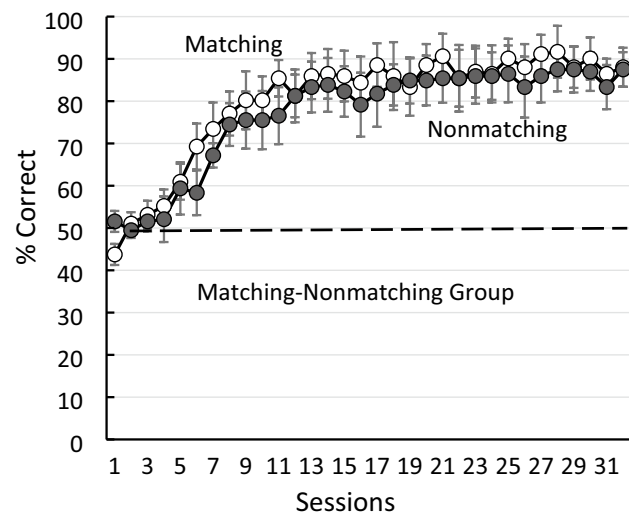


Fig. 2 Acquisition of the matching and nonmatching tasks for the Matching-Nonmatching Group. Error bars indicate ± 1 standard error of the mean

versus Nonmatching-Nonmatching Groups x Sessions effect, $F(1,465) = 1.95, p = .002, \eta_p^2 = .0042$. Examination of the data presented in Fig. 1 suggests that the significant interaction can be attributed to the better initial accuracy by the pigeons in the Nonmatching-Nonmatching Group than the pigeons in the Matching-Matching Group, but after several training sessions, accuracy by pigeons in the Matching-Matching group caught up and slightly surpassed that of pigeons in the Nonmatching-Nonmatching group.

Data from the Mixed Matching-Nonmatching Group, plotted separately for matching and nonmatching trials appear in Fig. 2. A repeated measures ANOVA performed on the data from this group, with sessions and task (matching or nonmatching) as factors indicated that the effect of

sessions was significant, $F(31,124) = 40.93, p < .002, \eta_p^2 = .911$, but neither the effect of condition (matching vs. non-matching), $F < 1$, nor the Session \times Group interaction, $F < 1$, was statistically significant. Thus, the tasks were not differentially difficult to learn. By the end of training all three groups were performing at about 90% correct. A one-way analysis performed on the overall accuracy of the three groups pooled over the last 5 sessions of training confirmed the absence of a significant difference among the three groups, $F(2,17) = 1.1, p = .36, \eta_p^2 = .115$.

Testing

Overall accuracy, defined by choice of the originally correct stimulus (the former S+) or avoidance of the originally incorrect stimulus (the former S-), did not change significantly over the five test sessions for any of the three groups, all $F_s < 1$, (see Fig. 3), thus, the data from the testing sessions were combined for analysis. The testing data were considered separately for each of the three groups, for trials on which the originally correct stimulus was present and the originally incorrect stimulus was replaced by one of the stimuli from the other task and for trials on which the originally correct stimulus was absent and was replaced by one of the stimuli from the other task. The results from the Matching-Matching and Nonmatching-Nonmatching Groups appear in Fig. 4.

Surprisingly, although both matching and nonmatching accuracy declined by about 20% from training to testing, there was little difference in accuracy between trials on which the original S+ was replaced and trials on which the original S- was replaced. That is, when the originally correct stimulus was replaced, accuracy was not substantially reduced relative to when the original incorrect stimulus was replaced. Statistical tests on the data from the pooled test

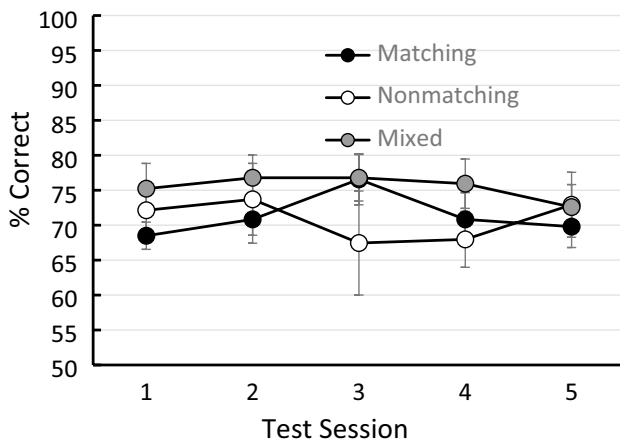


Fig. 3 Percentage correct for each of the training groups plotted as a function of testing session. Error bars indicate ± 1 standard error of the mean

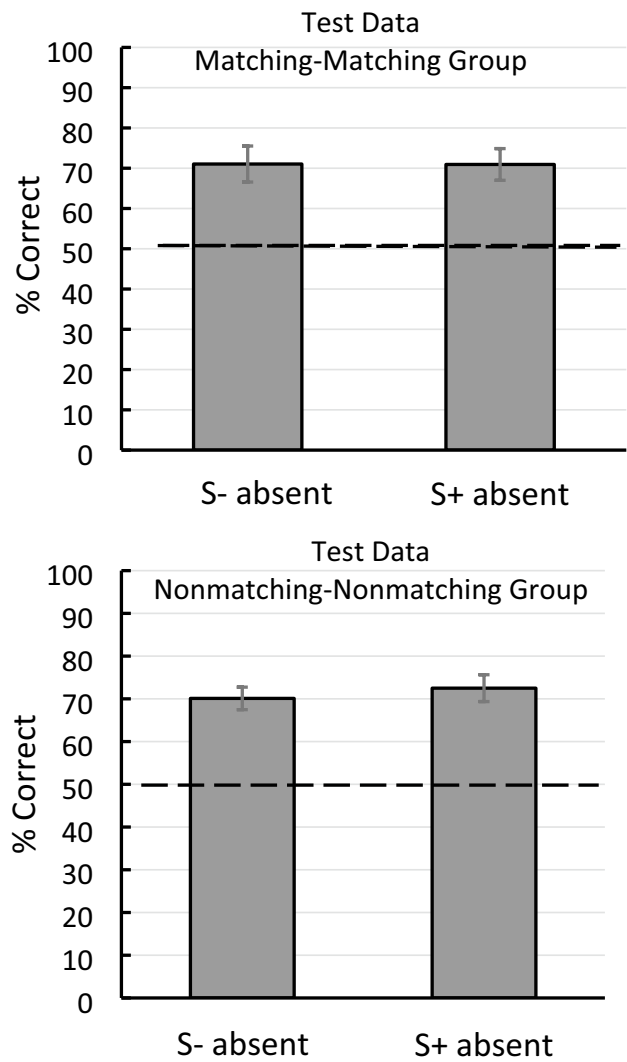


Fig. 4 Transfer accuracy with the former S+ present versus former S+ absent for the Matching-Matching Group (top) and the Nonmatching-Nonmatching Group (bottom). Error bars indicate ± 1 standard error of the mean

sessions confirmed the absence of significant differences between accuracy on S+ present trials and S+ absent trials, for the Matching-Matching Group, $t < 1$, and the Nonmatching-Nonmatching Group, $t < 1$.

The testing data from the Matching-Nonmatching Group were considered separately for the matching and nonmatching tasks and are presented in Fig. 5. Again, statistical tests indicated that the difference between accuracy on S+ present trials and S+ absent trials was not significant for the Matching-Nonmatching Group on either the matching task, $t < 1$, or the nonmatching task, $t < 1$.

For comparisons purposes, overall accuracy on testing sessions for the Matching-Matching, Nonmatching-Nonmatching, and Matching-Nonmatching Groups appears in Fig. 6. A one-way analysis of variance performed on the

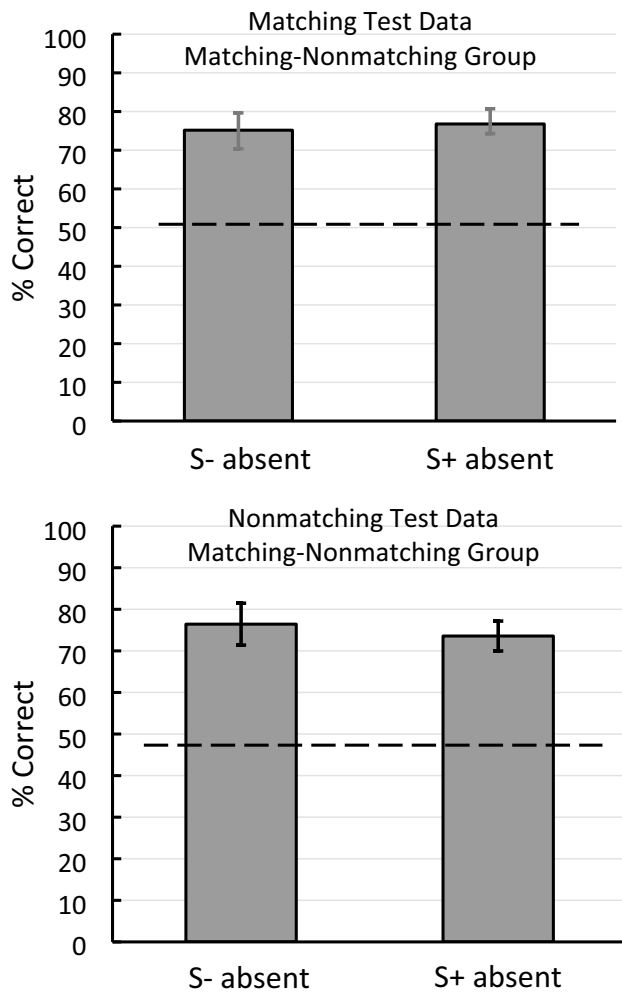


Fig. 5 Transfer accuracy with the former S+ present versus former S+ absent for the Matching-Nonmatching Group for the matching task (top) and the nonmatching-task (bottom). Error bars indicate ± 1 standard error of the mean

testing data (combined) with Group as the factor indicated that the three groups did not differ significantly, $F < 1$.

Analysis of testing accuracy for each of the groups relative to chance (50% correct) indicated that all three groups were more accurate than chance: $t(5) = 5.68, p < .002$, Cohen's $d = 5.08$; $t(5) = 8.09, p < .0005$, Cohen's $d = 7.24$; $t(7) = 8.45, p < .0004$, Cohen's $d = 6.39$, for the Matching-Matching, Nonmatching-Nonmatching, and Matching-Nonmatching Groups, respectively. Analysis of testing accuracy for each of the groups relative to the mean of the last three sessions of training indicated that there was a significant drop in accuracy on testing trials for the Matching-Matching Group, $t(10) = 8.05, p = .0005$, Cohen's $d = 5.09$, the Nonmatching-Nonmatching Group, $t(10) = 3.91, p = .003$, Cohen's $d = 2.47$, and the Matching-Nonmatching Group, $t(14) = 3.46, p = .006$, Cohen's $d = 1.85$. Thus, although there was a significant drop in accuracy from training to

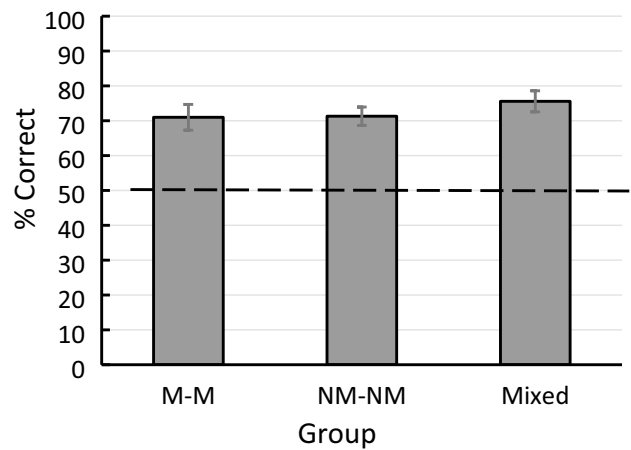


Fig. 6 Overall transfer accuracy for the three groups Matching-Matching (M-M), Nonmatching-Nonmatching (NM-NM), and one task matching the other nonmatching (Mixed). Error bars indicate ± 1 standard error of the mean

testing for all three groups, all three groups performed significantly above chance on testing trials.

Discussion

The results of training indicated that the pigeons in the Matching-Nonmatching Group did not learn their tasks slower than the pigeons in either the Matching-Matching Group or the Nonmatching-Nonmatching Group. Furthermore, the pigeons in the Matching-Matching Group did not learn their tasks faster than the pigeons in the Nonmatching-Nonmatching Group. For pigeons in the Matching-Matching group, the matching relation that was consistent between the two tasks did not facilitate task acquisition relative to that of pigeons in the Matching-Nonmatching group for which the two tasks involved different relations. Neither did the consistent nonmatching relation facilitate acquisition for pigeons in the Nonmatching-Nonmatching Group relative to pigeons in the Matching-Nonmatching Group.

The one significant effect other than the general learning effect was the significant Group x Sessions interaction. That interaction appeared to be attributable to better initial accuracy by pigeons in the nonmatching-nonmatching group than pigeons in the matching-matching group. Zentall and Hogan (1974) found a similar effect and attributed the difference to an artifact of initial training. At the start of training, the pigeons must respond to the sample stimulus to obtain access to the two comparison stimuli. Thus, those responses to the sample are never directly reinforced, whereas responses to the comparison stimuli are reinforced at least half of the time. Because of the difference between nonreinforced responses to the

sample and reinforced responses to the comparison stimuli, Zentall and Hogan suggested that the pigeons may have had an initial tendency to choose the nonmatching comparison stimulus. However, that bias did not persist during acquisition.

The absence of a main effect of group is consistent with Carter and Eckerman's (1975) conclusion that the relation between the sample and the correct comparison stimulus does not have an important effect on pigeons' learning of a conditional discrimination. These results would appear to be inconsistent with findings that following same/different training, pigeons show positive transfer when new stimuli involving the same relation are introduced (e.g., Cook, et al., 1995; Katz et al., 2007; Wasserman et al., 1995; Wright, 1997; Zentall & Hogan, 1974, 1976). A possible way to resolve the discrepancy between the acquisition data from the present experiment together with Carter and Eckerman (1975), and the transfer data from a large number of experiments, already mentioned, is to hypothesize that initially the pigeons learn the matching or mismatching tasks in terms of the specific training stimuli, without considering the nature of the same or different relation between those stimuli. That is, it may be that only after the matching or nonmatching tasks have been well acquired that the same or different relation between the sample stimulus and either of the comparison stimuli becomes relevant for pigeons. No experiment that we know of has manipulated the relation between the amount of training on the original discrimination and the degree of transfer, but it might be worthwhile to conduct such an experiment.

In the present experiment, the results of the test sessions do not support the hypothesis that pigeons learn if-then response rules. If they had, replacing the incorrect comparison would have resulted in little decrement in accuracy, however, there was a significant drop in the accuracy of both tasks when the incorrect stimulus was replaced. More important, replacing the correct comparison should have resulted in a much larger decrement in the accuracy of both tasks than was found. The similar effects on task accuracy of replacing either comparison stimulus suggests that what the pigeons learned was quite different from simple if-then (sample-correct-comparison) rules.

It is possible that the results of the training in the present experiment, or even conditional discriminations in general, can be interpreted as examples of occasion setting. Occasion setters are stimuli that signal when a conditioned stimulus predicts an unconditioned stimulus, but unlike higher order conditioned stimuli, occasion setters do not enter into direct association with either the conditioned stimulus or the unconditioned stimulus. The classic evidence for occasion setters (as different from conditioned stimuli) is that extinguishing the relation between the occasion setter and the unconditioned stimulus does not eliminate its effectiveness

in signaling the predictive relationship between the conditioned stimulus and the unconditioned stimulus (Holland, 1989).

As noted earlier, according to Skinner's (1950) hypothesis, when pigeons learn matching-to-sample, a stimulus response chain forms from the sample to the correct comparison, to the reinforcer. If the sample stimulus serves as an occasion setter, however, it would not enter into association with the correct comparison and replacing the correct comparison stimulus might not eliminate choice accuracy.

A theory of how occasion setters work that may apply to the results of the present experiment is based on the configuration produced by the three events: the occasion setter, the conditioned stimulus, and the unconditioned stimulus (e.g., Pearce, 1987, 1994). The configuration theory of occasion setters suggests that the configuration has properties in addition to those of the three events. In essence, "the whole is greater than the sum of its parts." Configuration theory suggests that the effects of an occasion setter will likely generalize to new conditioned stimuli, to the extent that there are elements in common between the training and testing stimuli. If one considers the configuration of the sample stimulus and the two comparison stimuli as a configuration, replacing either the correct or the incorrect comparison stimulus should result in a decrement in accuracy resulting from the change in the configuration. But given that the sample and one of the comparison stimuli from training remain, one would expect some generalization, leading to the above chance responding on test trials that was found.

Viewing the sample as an occasion setter makes an interesting prediction. If one were to present the sample stimulus by itself in extinction, that experience should have little effect on the relation between the samples and the correct or incorrect comparison stimuli. That would be an interesting test of the sample as an occasion setter.

The results of testing in the present experiment were quite different from the results obtained by Zentall et al. (2018) who found that for pigeons that learned a matching task, replacing the correct (matching) comparison stimulus resulted in near chance accuracy, whereas replacing the incorrect (nonmatching) comparison stimulus resulted in only a small decrease in matching accuracy. Thus, in the Zentall et al. experiment, the pigeons appeared to use the correct comparison as the basis for comparison choice. For pigeons that learned a nonmatching task, however, the reverse was true. Replacing the correct (nonmatching) comparison stimulus resulted in only a small decrease in nonmatching accuracy, whereas replacing the incorrect (matching) comparison stimulus resulted in in near chance accuracy. Thus, according to Zentall et al., the matching relation was the basis for learning both the matching and nonmatching task. In the case of matching, the pigeons learning to select the matching stimulus, whereas in the

case of nonmatching, the pigeons learned to reject the matching stimulus. Using a somewhat different procedure, O'Donoghue et al. (in press) found that pigeons learned to reject the S- comparison stimulus for both matching and nonmatching.

In contrast, the results of the present experiment suggest that how pigeons learn matching and nonmatching depends on the context of the task. In the case of the O'Donoghue et al. (in press) experiment, learning to reject the S- stimulus may be attributable to the complexity of the design. In that experiment, the pigeons were trained to discriminate between a simultaneously presented pair of matching stimuli and at the same time a pair of nonmatching stimuli. Which pair of stimuli was correct depended on the border surrounding the two pairs. This is a relatively difficult task which, in addition, was made more difficult because the colored stimuli themselves varied from trial to trial. These conditions may encourage the pigeons to learn what stimulus pairs to reject.

The design of the present experiment was not very different, however, from that of Zentall et al. (2018). In both experiments a sample stimulus presented on the center response key signaled which of two comparison stimuli was correct, the one that matched the sample or the one that did not match the sample. The most obvious difference between the two experiments was in the present experiment, the pigeons were asked to learn two independent matching or nonmatching tasks (for those two groups) whereas in the Zentall et al. experiment the pigeons were asked to learn four nonindependent matching or nonmatching tasks (sample stimuli from one task appeared as nonmatching stimuli with a different sample stimulus). However, it is unlikely that such a difference in procedure would account for the pigeons' learning both to select the S+ and reject the S- in the present experiment but not in the Zentall et al. (2018).

Another difference in procedure may ultimately be responsible for the difference in findings between the two experiments. In the Zentall et al. (2018) experiment, pecks to the sample stimulus turned off the sample stimulus and at the same time turned on the comparison stimuli (a procedure sometimes referred to as zero delay matching), whereas in the present experiment, pecks to the sample stimulus turned on the comparison stimuli but the sample stimulus remained on until the comparison stimulus was pecked (a procedure sometimes referred to as simultaneous matching). Why might that difference account for the difference in findings between the two experiments? In the present experiment, leaving the sample stimulus on in the presence of the comparison stimuli may have encouraged the pigeons to use the sample-comparison configuration as the basis for learning, whereas in the Zentall et al. (2018) experiment, turning the sample stimulus off may have encouraged the pigeons to learn an associative relation between the sample and one of the comparison stimuli. That is, in the Zentall et al. experiment the

pigeons appeared to have learned the association between the sample and one of the comparison stimuli, whereas in the present experiment the pigeons appeared to learn the relation between the sample and both comparison stimuli as all three stimuli appeared together. In the present research replacing either comparison stimulus resulted in a decrease in accuracy but neither comparison stimulus determined comparison choice on its own.

Interestingly, several experiments using minimal stimulus sets (only two stimuli in training) with the simultaneous stimulus matching procedure used in the present research have shown evidence for concept transfer (Zentall & Hogan, 1974, 1975, 1976, 1978). In this research, pigeons were trained with two colors, shapes, or brightness values and were transferred to novel stimuli, typically on a different dimension. But none of those experiments attempted to determine what was learned about the specific stimulus acquired during training.

The results of the present experiment together with those of earlier research (e.g., O'Donoghue et al. (in press) and Zentall et al. (2018) suggests that pigeons can learn conditional discriminations in various ways. Thus, unlike Skinner's (1950) prediction that in a conditional discrimination, all pigeons learn is the relation between the sample stimulus and the correct comparison stimulus, pigeons show remarkable flexibility in how they learn conditional discriminations depending on the context in which the learning occurs.

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