An analysis of stimulus control in two-color matching-to-sample behaviors of Japanese monkeys (*Macaca fuscata fuscata*)

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Matching behaviors of Japanese monkeys were analyzed. In Experiment 1, two subjects trained on a matching-to-sample task with red and purple. After acquisition, transfer of this were discrimination to yellow and yellowgreen was tested with "non-effective" trials inserted among baseline trials. In non-effective trials, intertrial interval immediately followed the subject's response without differential reinforcement. Although this procedure guaranteed stable responding during tests, matching accuracy severely deteriorated for these novel colors and marked preference for familiar baseline colors was observed. In Experiment 2, two new subjects were trained to discriminate between two of four colors (blue, bluegreen, yellowgreen, and yellow) before matching training with red and purple. After acquiring matching behavior, transfer to the four colors was tested with non-effective trials. Both subjects matched the two previously-trained test colors somewhat successfully, though the preference for baseline colors was not suppressed. Thus, evidence that the identity between sample and comparison stimuli controlled, at least partly, two-color matching-to-sample behaviors of Japanese monkeys was obtained after establishing the discrimination between the test stimuli.

Key words: monkeys, operant conditioning, key press, stimulus control, concept formation, stimulus generalization, conditional discrimination, matching-to-sample.

Matching-to-sample is one of the conditional discrimination tasks, which requires subjects to select the "same" comparison stimulus as the sample. The task has been widely used as a standard paradigm to investigate animals' intellectual abilities (Weinstein, 1941, 1945), short-term memory (D'Amato, 1973), and other physiological problems (Glick & Jarvik, 1970; Mello, 1971; Mishkin, Prockop, & Rosvold, 1962).

The fact that some nonhuman animals are able to solve the matching-to-sample task on the conceptual basis of "sameness"—that is, performances safely transfer to new stimuli—has been demonstrated in apes (Nissen, Blum, & Blum, 1948), monkeys (Mishkin et al., 1962), and dol-

phins (Herman & Gordon, 1974). But, as French (1965) pointed out, if a limited number of stimuli are used, some specific aspects of the stimuli other than the physical identity of the sample and comparison stimuli might control animals' responding. Although most of the studies which utilized this task as a paradigm employed only a limited number of stimuli, the basic question of what aspects of the stimuli actually control the subjects' responding if a small number of stimuli are used, has not been extensively studied except in pigeons.

Carter and Werner (1978) reviewed the literature on pigeons. According to them, there are three possible ways of solving the matching-to-sample task. The first is what they call "the configuration model": subjects learn a set of rules to respond in a special way for each possible configuration of sample and comparison stimuli (e.g. to respond to the left, or red, for red-red-green configuration). The second is

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"the multiple-rule model": subjects learn a set of "if . . . , then . . ." rules for each sample stimulus (e.g. if the sample is red, then choose red.). The third is "the single-rule model": subjects learn only one general rule to choose the same comparison as the sample. In terms of stimulus control, the three cases are labeled here: "configuration control", "specific-relation control", and "general-relation control", respectively. They stressed the following two points with regard to pigeons' performances. First, performances were not affected so long as the samples were the trained stimuli, but severely deteriorated if the samples were new stimuli. Second, no differences were found among the mastering processes for the three similar tasks, (a) matching-to-sample, (b) oddity-from-sample, and (c) symbolic matching, providing the number of "if . . . , then . . ." rules to be learned was the same. From these considerations, they concluded that pigeons learned only a set of "if . . . , then . . ." rules.

However, Carter and Werner's conclusions might not be appropriate for monkeys. Monkeys' matching performances with a small number of stimuli were analyzed by Jackson and Pegram (1970a, b), Mello (1971), and, recently, by Kojima (1979). Jackson and Pegram (1970a) reported "perfect" intradimensional transfer to a fourth color, but "no" extradimensional transfer to a new form. Their later work (1970b) also failed to demonstrate any extradimensional transfer from color to form. In the experiment of Mello (1971), who conducted transfer tests from form to a variety of intradimensional, extradimensional, and photographic stimuli, one of the three monkeys showed somewhat successful transfer to all types of stimuli, but the other two monkeys did not. Similarly, in Kojima's (1979) transfer tests from form to form, one of the two monkeys appeared to show very weak transfer, but the other monkey showed no transfer. Thus, previous experimental

reports on monkeys' performances did not obtain consistent results, and the basic question asked earlier receives no clear answer.

The purpose of the present experiments was to determine which of the three models of stimulus control is appropriate for matching-to-sample behaviors of Japanese monkeys with a small number of stimuli, by analyzing transfer of this discrimination to new stimuli. Two experiments were conducted. In Experiment 1, transfer was tested with a condition that excluded both decrease in the rate of reinforcement and the learning factor resulting from the differential reinforcement in tests. In Experiment 2, based on the results of Experiment 1, novelty of the test stimuli and their functions as discriminative stimuli were controlled, by establishing the simultaneous and the successive discriminations between the stimuli.

Experiment 1

In testing transfer performances to new stimuli, previous workers (Jackson & Pegram, 1970a, b; Kojima, 1979; Mello, 1971) employed the same dependencies of reinforcement as in baseline sessions. Such procedures raise two problems. First, the subject's responding might become unstable as a result of a decrease in the rate of reinforcement in test sessions. Second, rapid learning might occur in test sessions. The first problem makes transfer performances inconsistent, and the second problem makes them difficult to interpret. The following experiments attempted to overcome these difficulties by introducing "non-effective" trials. For non-effective trials, no differential reinforcement is made regardless of the subject's responding. At the same time, the subject's matching behavior is intermittently reinforced according to a variable-ratio (VR) schedule. When non-effective trials are inserted among other "effective" trials,

the value of the VR is correspondingly lowered so as to keep the rate of reinforcement unchanged. Test stimuli are introduced in such non-effective trials. By using this strategy, almost all possibilities of learning in the test trials will be excluded. Furthermore, it is possible to keep the rate of reinforcement in the test sessions approximately the same as that in the baseline sessions, without regard to the accuracy of the subject's performance on test trials, as long as the baseline performance does not deteriorate severely. One purpose of this experiment is to examine the stimulus control in two-color matching-to-sample behaviors of Japanese monkeys using such a non-effective trial procedure.

Another purpose is, though a minor one, to examine whether there are any transformations of stimulus control during acquisition processes. In simple discriminations, Nevin (1973) suggested that a generalization gradient transforms with the training duration. Similar phenomena might be observed for complex discriminations such as matching-to-sample. For example, the general-relation control might temporarily strengthen at some stages of acquisition. In order to check such a possibility, a set of test stimuli is presented during the acquisition processes in the form of non-effective trials. (Another set of stimuli is used for transfer tests.)

Method

Subjects. The subjects were two five-year-old male Japanese monkeys (*Macaca fuscata fuscata*), T320 and K371. Both subjects had experience with a symbolic matching task, but not with a task incorporating the same/different judgment. Body weights of the subjects remained at 90–95% of their free-feeding weights throughout the experiment.

Apparatus. The experimental chamber (70 cm×70 cm×70 cm) was located in a dark room filled with masking white noise. The experimental panel was at-

tached to one wall of the chamber. A houselight was at the top of the panel. Three transparent acrylic keys (50 mm×35 mm) were installed in the middle of the panel, each key separated by 60 mm, center to center. Another small key (25 mm×35 mm), placed 85 mm above the top of the center key, was used as a self-start key. I.E.E. in-line projectors were attached behind these keys. A feeder tray was at the bottom of the panel. A 24-V tungsten lamp could illuminate the tray. Soybeans were used as reinforcers, which were presented in the tray by a pellet dispenser. A minicomputer (DEC PDP-8/f) controlled the equipment. Data were collected by the minicomputer and a cumulative recorder (Ralph Gerbrands). Subjects' performances were monitored with a TV camera.

Procedure. Preliminary training: After responses to a white-lighted key were stabilized, the sequence of responses appropriate to matching-to-sample was trained. A trial started with the white illumination of the selfstart key. Three responses to the key (fixed-ratio 3: FR3) turned the center key (sample key) lighted white. Ten responses to the center key (FR10) turned off the center stimulus, and a white light appeared on either of the two side keys (comparison keys). A response to the lighted side key turned off all the stimuli on the keys, and the response was reinforced by a soybean, accompanied by 1-s buzzer (reinforcement-buzzer) sound and 2-s illumination of the feeder tray. A response to the unlit side key was followed by a 5-s timeout accompanied by another buzzer (timeout-buzzer) sound of 1 s. The houselight was turned off during timeout periods. Intertrial intervals of .5 s followed the reinforcement cycles or the timeout periods. Any response to the keys during intertrial intervals or timeout periods reset the clock.

After the subjects showed consistent performances, 24 non-effective trials were randomly inserted in every 100 trials.

In non-effective trials, no differential reinforcement was made without regard to the subject's responding, correct or incorrect. That is, intertrial intervals immediately followed a side key response. Three sessions were given with a limit of 80 reinforcements per session. The baseline 0-delay matching-to-sample training was begun on the next day.

Baseline training with test 1: In baseline training, the temporal sequence of events was exactly the same as that of the preliminary training, but four color stimuli, instead white lighting, were presented on the sample and comparison keys, and a response to the comparison key which had a color matching the sample key was a "correct" response. Among the four color stimuli, red and purple were used for training, while blue and bluegreen were used as test stimuli. Test trials on which only blue and bluegreen were presented (T(TT) trials which will be described later) consistently occupied half of the non-effective trials which were included in the proportion 24/100. On all other trials, effective or non-effective, only red and purple were presented.

Initially, every correct response on effective trials was reinforced. In later sessions, correct responses were intermittently reinforced according to VR schedules. Correct responses which did not satisfy the VR were followed by a short reinforcement-buzzer sound of .5 s. Responses in non-effective trials had nothing to do with the VR counter. A non-correction method was employed. Eighty reinforcements ended each session. This was continued until the percent of correct responses (the accuracy score) in baseline trials (with red and purple) exceeded 90 for three successive sessions.

Test 2: After reaching the criterion, blue and bluegreen were removed. Then, the number of non-effective trials were increased to 48 per 100 trials, and, simultaneously, VR values were equalized to two for the two subjects. The following tests were conducted after six sessions on this condition.

Two new colors, yellow and yellow-green, were introduced. By combining these new stimuli with baseline stimuli (red and purple), three types of test trials were constructed. That is, (a) B(BT) trials: samples were baseline stimuli and

Fig. 1. The accuracy scores (upper panel) and the percent of right key preference (lower panel) on the baseline (red and purple) and the test trials (blue and bluegreen) during the acquisition of the 0-delay two-color matching-to-sample for individual subjects.

incorrect comparisons were test stimuli, (b) T(TB) trials: samples were test stimuli and incorrect comparisons were baseline stimuli, and (c) T(TT) trials: both samples and incorrect comparisons were test stimuli. Every 100 trials contained the following trials: 52 effective baseline trials, 28 non-effective baseline trials, eight non-effective B(BT) trials, eight non-effective T(TB) trials, and four non-effective T(TT) trials. The VR value was kept to two. Three test sessions were conducted with the limit of 80 reinforcements per session.

Results

The results of the baseline training and test 1 are shown in Fig. 1. The accuracy score of performance was shown as the percent of correct responses in the upper panel, and the strength of the position preference was shown as the percent of right key responses in the lower panel. Both subjects reached high levels of accuracy in the baseline trials (filled and

open squares), while strong position preferences kept the accuracy scores in test trials at almost a chance level throughout the training period (triangles).

The results of test 2 are shown in Fig. 2, in the same way as in Fig. 1. The baseline performances (circles) were not impaired during the test period. Both subjects showed almost 100% accuracy on B(BT) trials (squares), but nearly 0% on T(TB) trials (triangles) on the first day. That is, they kept responding to the baseline stimuli without regard to the sample stimuli. On T(TT) trials (diamonds), accuracy scores were at almost a chance level. No transfer was observed. As for K371, these tendencies were not changed in three sessions. But T320 fell into a strong position preference as the sessions repeated (lower-left panel), and accuracy scores came to a chance level on all types of test trials by the third day.

The mean number of reinforcements per minute in the preceding baseline session and in each of the test sessions was as follows: 1.99, 1.94, 1.89, and 2.00 for T320, and 2.71, 2.81, 2.77, and 2.55 for K371.

Discussion

The chance-level accuracy on test trials of test 1 (Fig. 1) suggests that the general-relation control does not become strong in any stages of acquisition. It is possible, however, that some accidental responses (position preferences in this case) on test trials became fixed by receiving negative reinforcement, because no time-out or buzzer sound were contingent on the response. Therefore, the notion that the general-relation control temporarily strengthens during acquisition cannot be rejected completely. Unfortunately, the non-effective trial method was not appropriate to long-term tests, since the results of later stages are biased by the negative reinforcement.

During the sessions of test 2, the rate of reinforcement was kept at almost the

Fig. 2. The results of test 2 of Experiment 1 for individual subjects. The accuracy score for each of the four types of trials (see text) is shown in the upper panel, and the percent of right key preference is shown in the lower panel. Transfer performances were tested with two novel colors, yellow and yellowgreen, added to baseline stimuli (red and purple). No transfer to the new colors (diamonds) was observed.

same level as the preceding baseline session. Stable responding was obtained for both subjects. It was confirmed that this non-effective trial procedure was effective to guarantee stable responding in test sessions.

In test trials, one subject (T320) showed a gradual increase of left-key preference (Fig. 2, lower-left). As the preference seems to be a consequence of the negative reinforcement, only the first session should be referred to as a proper test for this subject. The fact that both subjects showed accurate performances on B(BT) trials but near chance accuracy scores on T(TT) trials appears to support the specific-relation control. However, such a conclusion should be made with much caution, since the performances on T(TB) trials are extremely poor. The poor performances are clearly the results of a preference for the baseline stimuli. The same preference might have favored the accuracy scores on B(BT) trials. Such a preference for familiar stimuli, which was also observed in Jackson and Pogram's (1970a) extradimensional transfer test and in Kojima (1979), seems to occur quite often so far as novel test stimuli are combined with familiar baseline stimuli. Accordingly, the preference for the baseline stimuli must be weakened by some operation in order to examine the appropriateness of the specific-relation control model.

On T(TT) trials, accuracy scores were consistently at a near chance level, and no transfer was observed. But this result may not reject the general-relation control, because performances might be disrupted by a simple presentation of novel stimuli, and, also, because the discrimination between the two test stimuli might not be established. Thus the general-relation control should not be rejected until similar results (i.e., no transfer) are obtained using a set of familiar test stimuli which are well discriminated each other. Considering these points, a more pointed design

had to be formulated, as presented in the next experiment.

Experiment 2

As Carter and Eckerman (1975) pointed out, the matching-to-sample task includes two basic discriminations. One is the successive discrimination between samples, and the other is the simultaneous discrimination between comparison stimuli. In order to establish these two basic discriminations between test stimuli and to familiarize subjects with the stimuli, repeated discrimination reversal training is given to the subjects with the test stimuli before matching-to-sample training. The appropriateness of the three models of stimulus control ought to be better evaluated using this procedure.

Method

Subjects. The subjects were two three-year-old Japanese monkeys, T378 (male) and T387 (female). They had been artificially reared since birth, and had chain-pulling experiences, lever-pressing experiences, discriminations in WGTA, and so on. They had not experienced the matching-to-sample task, nor any problems which incorporated the same/different judgment. Their body weights remained at 90–95% of their free-feeding weights.

Apparatus. The same equipment as in Experiment 1 was used.

Procedure. Preliminary training: After shaping responses to a lighted key, response sequences necessary for discrimination reversal training was initiated. Each trial started with white illumination of the self-start key. Three responses to the key (FR3) turned on either the center key or one of the two side keys, in white. When the center key was turned on (center key trial), the tenth response to the center key was reinforced (FR10). On the other hand, when one of the two side keys was illuminated (side key trial), a response to the lighted side key was reinforced (con-

tinuous reinforcement: GRF), but a response to the unlit side key was followed by a 5-s timeout. The same events as in Experiment 1 (buzzer sounds and feeder-light) accompanied the reinforcement and the timeout. An intertrial interval of 5 s followed reinforcement or timeout periods. Center key trials and side key trials were randomly presented, with the same frequency. Eighty reinforcements ended each session. This continued until the subjects' responses were stabilized.

Repeated discrimination reversal training: The reversal training was conducted with half of four test stimuli. For T378, blue and bluegreen were used in this training, while yellow and yellowgreen were not used. Conversely, yellow and yellowgreen were used for T387, while blue and bluegreen were not used. In the discrimination training, these color stimuli were presented in the same temporal sequence as in the preliminary training. The only difference was that the two color stimuli were simultaneously presented in the side key trials. One of the two colors was S+ and the other was S-. A response to S+ was reinforced and a response to S- was followed by a timeout. In the center key trials, the tenth response was reinforced in the presence of S+ (FR trial), but if S- was presented, responses were extinguished, and the stimulus stayed on until subjects paused for 5 s (EXT trial). Intertrial intervals were 5 s in length and each session ended with 2 h or 80 reinforcements, whichever came first.

Each subject received fifteen reversals of S+ and S-. The following response indices were used as the criterion in making reversals: the percentage of correct responses on side key trials, the percentage of FR trials on which no inter-response time was longer than 5 s, and, that of EXT trials on which no response occurred. The first three reversals were made at the criterion that all of the three

indices were above 90% for three successive sessions. Later reversals were made at a lower criterion, that the indices were above 85% for one session. When the subjects did not easily satisfy these criteria, the duration of the intertrial interval and timeout periods were appropriately operated.

Matching-to-sample training: After reaching the criterion in the fifteenth reversal, subjects were trained for one session to master the response sequence necessary for matching-to-sample, with white light, as was done in Experiment 1. In the next two sessions, the same training continued with the stimuli which were to be used in the baseline matching-to-sample training (red and purple). On the next day, baseline training started.

Matching-to-sample training was almost the same as Experiment 1. But no test stimuli were presented and no non-effective trials were inserted during the training period. Intertrial intervals were .5 s in duration, and each session was ended after 2 h or 80 reinforcements, whichever came first. The VR reinforcement of correct responses was appropriately introduced, and non-correction procedures were used as in Experiment 1.

The baseline training continued until subjects reached the criterion such that the percents of correct responses were above 90 for three successive sessions. Next, the VR values for both subjects were gradually equalized to four. Then, non-effective trials were inserted. The number of non-effective trials was gradually increased to 48 per 96 trials, and, at the same time, the VR value was lowered to two. The following tests were carried out after the above criterion was again satisfied.

Test: Four test stimuli were divided into two groups. One group contained blue and bluegreen, and the other group contained yellow and yellowgreen. Colors of each group was combined with the baseline stimuli (red and purple) to make

up 20 configurations of test trials for each group. Colors were not combined across two groups. The test trials were presented in the form of non-effective trials.

There were three types of test trials, as in Experiment 1. That is, B(BT) trials, T(TB) trials, and T(TT) trials. Each of the three types may be divided into two: whether the test stimuli were used in the previous discrimination reversal training, or, not. To distinguish these two cases, the representations of B(BD), D(DB), D(DD) will be used for test trials with previously-trained stimuli. Every 96 trials consisted of the following trials: 48 effective baseline trials, eight non-effective baseline trials, eight non-effective B(BT) trials, eight non-effective T(TB) trials, four non-effective T(TT) trials, eight non-effective B(BD) trials, eight non-effective D(DB) trials, and four non-effective D(DD) trials. Three test sessions of 80 reinforcements were conducted with VR2.

Results

The number of sessions necessary for fifteen discrimination reversal trainings was 112 for T378, and 163 for T387. The last two reversals needed four and two sessions for T378, and five and four for T387 (criterion sessions were excluded).

Baseline matching-to-sample was mastered in 18 sessions by T378, and in 29 sessions by T387. The reinforcement schedule when the subjects reached criterion was VR2 for T378, and VR4 for T387.

The results of the tests are shown in Fig. 3. Both subjects maintained accurate responding on baseline trials (filled circles) during test periods, except that T387 showed slightly, but not severely, deteriorated accuracy in her first test session. On B(BT) and B(BD) trials (filled and open squares), in which samples were the baseline stimuli, high accuracy scores were obtained (all of which were significantly above chance, $p < .01$).

But accuracy scores were almost at chance level on T(TT) trials (filled diamonds), in which only novel test stimuli were presented. In the first and the second sessions, intermediate levels of accuracy were seen on D(DD) trials (open diamonds), in which only the familiar test stimuli which had been used in the previous discrimination reversal training were presented (significantly above chance at a 5% level in the second session for T387, but the remainder not significant because of the small sample size.). These observations were consistent for both subjects.

For T387 (right panel), accuracy scores were extremely low on T(TB) and D(DB) trials (filled and open triangles), for which samples were test stimuli. For T378 (left

Fig. 3. The results of the test of Experiment 2 for individual subjects. The accuracy score for each type of trial (see text) is shown in the upper panel, and the percent of the right key preference is shown in the lower panel. Open symbols designate test trials in which familiar test stimuli (blue and bluegreen for T378, and yellow and yellowgreen for T387) were presented. These test stimuli had been well discriminated in the previous discrimination training with the reversed S+ and S-. Filled symbols, other than circle (baseline trials, red and purple), designate test trials in which novel test stimuli (yellow and yellowgreen for T378, and blue and bluegreen for T387) were presented. Both subjects showed weak transfer of their matching performances to the familiar test stimuli (open diamonds).

panel), accuracy scores were at almost chance level on both T(TB) and D(DB) trials in the first session, but dropped to a low level in the second session. In the third session, a significantly above-chance accuracy score ($p < .01$) was obtained on D(DB) trials, but on T(TB) trials accuracy was as low as that in the second session.

Position preferences (lower panel) were not extreme for most kinds of test trials except on the T(TT) trials of the second and the third sessions of T378. The mean number of reinforcements per minute in the preceding baseline session and the test sessions was as the following: 1.45, 1.39, 1.44, and 1.65 for T378, and 1.42, 0.89, 0.58, and 1.18 for T387.

Discussion

The slight deterioration of baseline performance shown by T387, which gave rise to a decrease in the rate of reinforcement, seems to have been caused by a simple presentation of test stimuli. This is, however, an inevitable problem in conducting tests with new stimuli. On the other hand, T378 performed consistently throughout the test period.

With regard to the stimuli which had not been used in the discrimination reversal training (yellow and yellowgreen for T378, blue and bluegreen for T387), accuracy scores were high on B(BT) trials and very low on T(TB) trials, which suggests a strong preference for baseline stimuli. The first session of T378 was an exception. On T(TT) trials accuracy scores were at almost chance level. These results were consistent with those of Experiment 1.

The discrimination reversal training ought to have had two effects. The first is the strengthening of the tendency of the subjects to choose test stimuli used in the previous reversal training. As a result of repeated reversal training, two test stimuli seemed to have acquired the same amount of strength. This effect will be

evident by comparing the results of B(BD) and D(DB) trials with those of B(BT) and T(TB) trials. The second effect is the formation of discrimination between the two test stimuli. From the result of the discrimination reversal training, it is clear that the simultaneous and the successive discriminations between the two test stimuli (blue and bluegreen for T378, yellow and yellowgreen for T387) were established. Comparison of the results of D(DD) trials with those of T(TT) trials will reveal the second effect.

The first effect will be explored further. When the sample was one of the baseline stimuli (red or purple), the performances on the trials with the familiar test stimuli used in the previous discrimination reversal training (B(BD) trials) were comparable to those on B(BT) trials. High accuracy scores were shown in both cases. Similarly, on the trials in which the sample was one of the test stimuli (T(TB) trials and D(DB) trials), no differences were found except the accurate performance shown by T378 on D(DB) trials on the third day. This peculiarly high accuracy was the result of consistent right key preference on two kinds of trials with specific configurations of stimuli, which was, incidentally, the correct response, and of almost consistent left key preference on the other kinds of trials. The negative reinforcement described earlier might have played some role in fixing this preference. Thus, it is dangerous to interpret this peculiarly high accuracy as a product of the general-relation control. It would be more prudent to consider that no differences were observed between T(TB) trials and D(DB) trials. Unfortunately, the first effect of the discrimination reversal training was not sufficient to rival the strong tendency of the subjects to choose baseline stimuli.

The second effect of the previous reversal training (i.e. establishment of discriminations) is apparent in D(DD) trials in comparison with T(TT) trials. On

T(TT) trials, accuracy scores were at approximately a chance level. On D(DD) trials, however, about 60–70% accuracy scores were shown in the initial two days. With regard to the initial two sessions, the difference between the accuracy scores on D(DD) trials and those on T(TT) trials was significant ($F=11.87$, $df=1, 4$, $p<.05$). The difference suggests that the identity between sample and comparison stimuli controlled the subjects' responding during the baseline matching-to-sample training, and prior establishment of two basic discriminations included in the matching-to-sample task made it possible to detect this relational control. But the control was not observed on the third day, probably an effect of the negative reinforcement described earlier.

Among the three stimulus control models, the configuration control model is rejected because it cannot explain the good performances on a number of test trials which had new configurations of stimuli. Unfortunately, the evaluation of the specific-relation control was not possible because it cannot be decided whether the high accuracy scores obtained on B(BT) and B(BD) trials suggest the specific-relation control or a simple preference for baseline stimuli. But the most important finding obtained in this experiment was that the existence of the general-relation control was demonstrated without differential reinforcement. Successful transfer to new stimuli was demonstrated previously by Jackson and Pegram (1970a) and by Mello (1971) (in only one monkey). But, because these workers maintained differential reinforcement in tests, the successful transfer shown by their monkeys might be due, at least partly, to a very rapid saving.² In this experiment,

there is no room for such a saving to occur. Thus, although only weak transfer was observed, the transfer was strong evidence that the general-relation of sample and comparison stimuli actually controlled, at least in part, two-color matching-to-sample behaviors of Japanese monkeys.

General Discussion

Stimulus control in two-color matching-to-sample behaviors of Japanese monkeys was analyzed using non-effective trials in which no differential reinforcement was made regardless of the subject's responding. Though this procedure introduces questions regarding the effects of negative reinforcement, the results obtained can be safely evaluated because such negative reinforcement has no tendency to favor transfer accuracy, as is the case with differential reinforcement employed in previous workers. Furthermore, as the rate of reinforcement is not affected by the accuracy of performances in test trials, emotional responding which results from a decrease in the rate of reinforcement will not occur. Thus, this non-effective trial procedure is also effective to guarantee stable responding during test sessions. This notion was confirmed in Experiment 1.

In the second experiment, evidence that the general-relation of sample and comparison stimuli actually controlled matching-to-sample behaviors was obtained in Japanese monkeys, despite the fact that only two color stimuli were used in the training. The general-relation control has not been demonstrated in pigeons with standard matching-to-sample task. For instance, Farthing and Opuda (1974) trained pigeons, beforehand, to peck at test stimuli presented alone, but successful transfer of their matching per-

² The number of stimuli used for training before transfer tests were conducted should also be considered. Jackson and Pegram (1970a) used three colors for baseline, and Mello (1971) trained subjects to match several new stimuli before testing.

Thus, successful transfer to new stimuli seems to have occurred more easily in their works than in the present experiments.

formances to the stimuli was not observed. Similarly, the general-relation control was not substantiated by Carter and Taten (1977), who used a learning-set procedure, or, Holmes (1979), who conducted a number of repeated transfer tests. These data on pigeons suggest that, as Carter and Werner (1978) concluded, the general-relation control is not strong in pigeons' usual matching-to-sample behaviors, even in those cases where fairly numerous stimuli are used for training.³ But, until transfer performances are examined for stimuli for which the two basic discriminations included in the matching-to-sample task are established, it cannot be presumed that the general-relation does not control pigeons' matching-to-sample behaviors whatsoever, nor that species differences in their abilities between pigeons and monkeys are critical.

The general-relation control detected here, however, appeared to be extremely weak, even though transfer performances were examined to familiar test stimuli for which the simultaneous and the successive discriminations between the stimuli were completely established. Two interpretations of this apparent weakness are possible. One is that the general-relation control actually is not weak, but the baseline stimuli themselves play a major part as the conditional discriminative stimuli on which the general-relation control works. If this is the case, the general-relation has difficulty exerting its control in the test trials, especially where the samples are not baseline stimuli. The other is the possibility that both the specific-relation and the general-relation simultaneously control subjects' responding, the former being relatively stronger.

It is not possible to decide which of these two interpretations is correct from the present experiments. In order to decide which is the case, transfer should be examined in a situation where another clear conditional discriminative stimulus is established in addition to the baseline stimuli both in the training and in the tests.

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³ The general-relation control, however, is thought to work in some modified procedures other than standard matching-to-sample. Refer to Honig (1965), Malott and Malott (1970), Urcuioli (1977), Urcuioli and Nevin (1975), and Zentall and Hogan (1975, 1978).

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