EFFECTS OF SEQUENTIAL RESPONDINGS ON SPATIAL DELAYED MATCHING-TO-SAMPLE IN PIGEONS (Columba livia)

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In Experiment 1, three groups of pigeons were trained in delayed matching-to-sample procedures to investigate the effects of successive responses to a pair of sample or comparison stimuli as compared to responses to a single key. The group that was required to respond sequentially both to the sample and comparison stimuli (Group SEQ-SEQ) was the slowest to reach the criterion. Group SEQ-SG, which was required to respond sequentially only to the samples reached criterion faster and performed better when much longer delay intervals were introduced. In Experiment 2, Group SEQ-SG was further analyzed to determine which contributed to its performance, the sequentiality or the number of responses to the sample. The results showed that the latter was more effective, consistent with prior reports that accuracy on delayed matching-to-sample increases as the number of responses to the sample increases.

In what is called the “chaining theory,” some theorists on learning have argued that sequential behaviors could be interpreted as chaining that involves integrated association of stimuli and responses (e.g., Guthrie, 1952; Hull, 1943; Logan, 1960; Skinner, 1938; Spence, 1950). This theory assumes that the outcome of a response functions as a discriminative stimulus, or a cue to the next response.

For example, Grayson and Wasserman (1979), pioneers in the research on sequential response in pigeons, tested the birds on tasks requiring them to respond to left and right keys two successive times, and revealed that they could acquire and differentiate the four possible response sequences. They found that most errors occurred between the sequences in which the correct choice in the second response was the same. This behavioral pattern could

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be accounted for in terms of contiguity to reinforcement from the second response in a response chain, which made it acquire discriminative property rather than the first response within a chain.

However, some researchers claimed that sequential behaviors could not be interpreted as stimulus-response association (Lashley, 1951). In the late 1970s, Terrace and his colleagues started to conduct experiments using their "simultaneous chaining paradigm" to examine sequential responses to color stimuli (Straub, Bever, & Terrace, 1979; Straub & Terrace, 1981; Terrace, 1983). One unique feature of their procedure was that no feedback was given for responses until subjects completed the whole sequence. In other words, no external discriminative stimuli or cues were given while the subjects worked on a sequence of responses. Because their pigeons were required to rely only on visual stimuli while producing sequential responses, Terrace concluded that the acquisition of this type of response sequence could not be explained by the traditional chaining theory and, therefore, must be controlled by internal processes.

These studies revealed that animals could not only differentiate, but also produce sequential responses based only on stimulus-stimulus relations without the help of external discriminative stimuli (see also D'Amato & Colombo, 1988, for an experiment with monkeys). However, as these sequential responses were observed only in limited experimental situations, it was still unclear whether animals could acquire "conditional" response sequences.

One possible approach to answering this question was offered by Richardson and Kresch (1983), who trained pigeons to produce two different response sequences conditional to their background color stimuli. The subjects were able to generalize the matching task to 10 novel positions of stimulus presentation. However, when the conditional color stimuli were presented on a key instead of as the background of the figure stimuli, performance significantly deteriorated. The latter result has left it unanswered whether the pigeons actually "matched" their response sequences conditionally to colors, or they saw each sequence combined with a background color as an individual stimulus set. Thus, the aim of this study was to assess the possibility of arbitrary matching-to-sample which requires sequential responses to either the sample or comparison stimuli, or both, in pigeons.

**Experiment 1**

To examine whether pigeons can acquire arbitrary matching-to-sample requiring sequential responses, it is necessary to make sample stimuli and comparison stimuli independent of each other, unlike the previous study by Richardson and Kresch (1983). In this experiment, we employed an arbitrary matching-to-sample task using four keys, and we required subjects to emit two successive responses. Three groups were used to investigate the effects of successive responses to a pair of sample or comparison stimuli as compared to responses to a single key.
Method

Subjects
Nine experimentally naive pigeons (*Columba livia*) were used. They were housed in individual home cages and maintained at about 80-85% of their free-feeding weights. If they did not get sufficient food during a session, additional food (mixed grain) was given at least 30 minutes after they returned to their home cages, where grit and water were freely available. The laboratory was lit from 8:00 a.m. to 8:00 p.m. throughout the experimental period.

Apparatus
A standard operant chamber (ENV-007, MED Associates, Inc.), 29 cm (w) x 24 cm (d) x 30 cm (h), was used. The bottom was a 1.3-cm-spaced (center to center) grid of 23 stainless steel rods 4.8 mm in diameter. The front panel was equipped with response keys that were made of transparent acrylic boards, and all the walls and the roof were made of aluminum. A feeder (ENV-205, MED Associates, Inc.) was attached to the back of the front panel to present food reinforcements (hemp seeds). A 6- x 6-cm entrance for food access was provided in the center bottom of the front panel. A lamp inside the window was lit simultaneously with feeder operation.

There were four response keys on the front panel: two vertically and two horizontally arrayed. The vertical keys (1.5 cm in diameter, handmade) were 6.0 cm apart from each other (center to center) and illuminated in white by inline projectors (00360-14, IEE) from the rear. The horizontal keys (2.5 cm in diameter, MED Associates, Inc.) were 15.7 cm apart from each other (center to center) and illuminated the same way as the vertical keys. A room lamp (32 V, 1 A) was installed 1.1 cm from the top of the back panel to provide reflected illumination to the inside of the chamber. The chamber was enclosed in a wooden box for sound attenuation. During the experiment, a ventilator located on the left side of the box was kept running, and white noise was presented from outside the box. For controlling the experiment and recording data, a real-time multitask experiment control system, MED-PC (MED Associates, Inc.), running on a PC (Deskpro XE466, Compaq) was located next to the experimental room. In the delayed matching-to-sample training phase described later, the door of the wooden box was opened in order to record the subjects' behavior using an 8-mm video cassette recorder (VCR) from the right side of the chamber.

Procedure
Preliminary training. All birds were given autoshaping sessions, each consisting of 80 trials, in which they were trained to peck the lower one of the vertically arrayed keys. If a response occurred, a reinforcement immediately followed and continuous reinforcement (CRF) was then introduced and continued until 40 responses. Next, they were trained to peck each of the four keys, first with CRF, then with fixed-ratio-2 (FR2).
In all groups, birds were required to respond twice to a key. When two successive responses to a key were detected, the light of that key was extinguished. No feedback was given until the second response to one key. A trial began when either upper or lower key was illuminated.

The subjects were divided into three groups in Experiment 1, as shown in the three left columns of Figure 1. Group SEQ-SEQ was required to respond sequentially both to the sample and comparison stimuli. If the response sequence to the samples was upper to lower, the correct sequence to the comparison stimuli was left to right; if the response sequence to the samples was lower to upper, the correct sequence to the comparison was right to left. Group SG-SEQ was required to peck either upper or lower key as a sample response. If the upper key was pecked, left-to-right response sequence should follow; if the lower was pecked, right-to-left response sequence should follow. Group SEQ-SG was required to respond sequentially to the samples only. When they responded in the order of upper to lower, choosing left was the correct response; after responding in the order of lower to upper, right was correct.

In the groups required to respond sequentially to the samples (Group

Figure 1. Schematic representation of the procedures of Groups SEQ-SEQ, SG-SEQ, and SEQ-SG in Experiment 1, and Groups SGSG-SEQ and SEQ-SGSG in Experiment 2. These were the case of correct choice in which a subject chose the left key among the comparison stimuli and then got reinforcement. All keys were lit in white and the subjects responded twice to each key, except for the sample requirements of Group SGSG-SEQ and the comparison requirements of Group SEQ-SGSG.
SEQ-SEQ and Group SEQ-SG), either of the two vertically arrayed keys was lit first and, after two responses were detected, the light of that key was extinguished, and the other key was lit immediately. For all the three groups, the left and right keys were lit simultaneously. In the groups required to respond sequentially to the comparisons (Group SEQ-SEQ and Group SG-SEQ), whichever of the two comparison keys was first pecked was extinguished, and the other key remained lit. That is, the birds were forced to respond to the key that they did not first choose. A complete response sequence was followed by either a reinforcement or blackout.

For all three groups, the food hopper was presented for 3 s after a correct sequence of responses or responses, followed by a 10-s intertrial interval (ITI). After an incorrect sequence of responses or responses, all lights in the chamber were turned off for 10 s (blackout, BO), and correction trials were continued until a correct one occurred, which was followed by the feeder lamp for 0.5 s. The delay between the last response to the sample and presentation of the comparison stimuli was 0.5 s.

After the subjects learned to respond to all the four keys, they were guided to respond successively to the sample and/or comparison keys for one session. In this procedure, the key lights were lit one at a time. In Group SEQ-SEQ, the order of sample/comparison response training sessions was counterbalanced among the subjects.

Next, all the groups were trained in the guided procedure. In this procedure, all keys were used as in MTS training, but the keys were lit one at a time. All the pigeons had to do to get a reinforcer was to peck each of the lit keys.

Then, pre-MTS training was introduced. In this procedure, responses to the samples were followed by lighting of one of the comparison keys, the one to be pecked first to make a correct sequence in MTS training. After one response to that key, the other comparison key was lit. If pigeons failed to respond twice successively before moving to the other key, 10 seconds' blackout followed and correction trials continued until a correct sequence occurred. They learned to make few incorrect responses generally within 1 or 2 sessions. After that, MTS training sessions were started.

**MTS training.** After confirming that the subjects performed consistently well in the pre-MTS procedure, MTS training sessions started.

A correct comparison responding was followed by 2 to 3 seconds' presentation of the feeder depending on the subject's deprivation level, and an incorrect one was followed by a blackout and correction trials. In the pre-MTS and MTS training procedures, one session consisting of 80 trials (excluding correction trials) was conducted per day, six or seven times a week. The two types of trial (starting with upper or lower key response) were randomized in a session, 40 trials each, with a restriction that the same type should not be presented more than three times consecutively.

**Delayed MTS training.** After the pigeons met the minimum criterion of 85% correct for two consecutive sessions, delay intervals were
introduced between sample and comparison responses. During the delay interval, only the house light was lit and responses had no effect. A set of three different delay intervals was used in a session as shown in Table 1. These delay intervals were interspersed quasi-randomly, 26 or 27 times each in a session. If more than 75% correct performance was observed at the longest delay interval of the session, a longer delay set was introduced at the start of the next session. The shortest of the three delays was fixed at 0.5 s. The medium delay was increased by 1 s and the longest delay by 4 s. This delayed MTS training was continued until a bird failed to reach the criterion of 75% correct at the longest delay after 12 sessions.

### Results

#### Acquisition

The number of sessions required for reaching the minimum criterion of 85% in two consecutive sessions is shown in the three lefthand graphs of Figure 2. The three subjects required 33, 20, and 30 (average: 27.7) sessions in Group SEQ-SEQ, 14, 5, and 15 (average: 11.3) sessions in Group SG-SEQ, and 3, 7, and 4 (average: 4.7) sessions in Group SEQ-SG. Group SEQ-SEQ was the slowest to learn, followed by Group SG-SEQ, then Group SEQ-SG.

#### Delayed MTS Training

The results of the delayed MTS are depicted in the upper three
graphs of Figure 3, which show the percentage of correct responses at the longest delay interval until the birds failed to attain the criterion of 75% within 12 training sessions. In the sessions where subjects passed the criterion, the percentages of correct responses at the longest interval of the respective sessions are plotted. In the sessions where they failed to reach the criterion, the best performance among the 12 sessions is plotted. Note that the horizontal scale varies between groups, reflecting the substantial differences in the maximum delay interval at which the birds failed the criterion.

In Group SEQ-SEQ, the longest delays of the 3 subjects were 2, 6, and 6 s. In Group SG-SEQ, they were 2 s for 2 birds and 10 s for 1 bird.

In Group SEQ-SG, although Subject A13 failed to pass the criterion at 6 s, the other 2 birds maintained accuracy at longer intervals: up to 66 s for Subject E22 and 30 s for Subject A34. Additionally, videotaped observation revealed that these 2 birds moved to the correct comparison key as soon as a delay interval began and stayed there until the stimuli were lit. Subject E22 frequently showed stereotyped behavior: During the delay interval, it directed its head alternately to the ceiling and the key to be pecked. Also, when the correct key was on the right, it did not respond immediately after the comparison stimuli were lit, but responded only after pecking the screw in the upper part of the front panel. In Subject A34, such a mediating behavior was not observed.

**Discussion**

**Acquisition**

Using sequential responses as sample or comparison requirements seemed to affect the subjects' acquisition significantly. Comparing between the performance of Group SEQ-SEQ and Group SEQ-SG,
Figure 3. Performance with the longest delay in delayed matching-to-sample of each subject in Experiments 1 and 2. The broken line inside the figures indicates the criterion of 75% correct.
requiring sequential responses to the comparison stimuli may have an inhibitory effect on acquisition in Group SEQ-SEQ. Also, 2 birds in Group SG-SEQ spent more sessions than any bird in Group SEQ-SG, suggesting that sequential responses to the comparison stimuli also may have a disruptive effect on acquisition.

The procedural difference between Group SEQ-SEQ and Group SG-SEQ was whether sample responses were sequential or not. The former subjects spent more than 20 sessions whereas the latter needed only about 10 sessions to reach the criterion. These results could be explained by either of two parameters: the number (four vs. two) and type (sequential vs. nonsequential) of responses. To identify which parameter is critical, it is necessary to test with another group which is required to respond to the sample stimuli the same number of times and stay in for the same duration as Group SEQ-SEQ, but nonsequentially.

**Delayed MTS Training**

In an earlier study using the delayed matching-to-sample with color as the sample and line orientations as the comparisons, Honig and Wasserman (1981) found that pigeons could maintain around 70% correct performance up to 20-s delay in a conditional discrimination task. In this experiment, using key positions as discriminative keys and requiring sequential responses, delayed matching performance of pigeons in Group SEQ-SEQ and Group SG-SEQ was rather lower than that of Honig and Wasserman (1981). However, the outstanding performance of the 2 pigeons in Group SEQ-SG is worth analyzing from a different perspective.

Facilitation of the acquisition in Group SEQ-SG could be understood by means of differential sample response effect, for which several explanations have been proposed. First, by differentiating the response requirements, the response-produced feedback may give separate cues in the course of acquiring stimulus control (Lyderson & Perkins, 1974). Second, associating the visual sample stimuli and sample-specific behaviors, more salient configural cues may be formed (Zentall, Hogan, & Edwards, 1984). Third, requiring differentiated responses may increase the discriminability of the sample stimuli (Urcuioli & Honig, 1980). In addition, Hogan, Zentall, and Pace (1983) found that if pigeons could utilize both sample-specific responses and visual cues, the former were more determinant. They argued that the acquisition of conditional discrimination was facilitated because sample-specific responses gave more salient, additional, and separate cues.

Considering all these possibilities, performance facilitation as observed in Group SEQ-SG may be partly attributed to differential sample responses, which allowed the subjects to use not only the position of the keys but also their own motor responses as discriminative stimuli. In addition, the subjects were required to respond only twice to either comparison key. The shorter delay to reinforcement than in the other two groups may also have helped improve the performance.
The videotaped observation during the delay interval revealed that both subjects E22 and A34 moved in front of the correct comparison key. This suggests that these subjects were able to establish "prospective coding" (e.g., Santi & Roberts, 1985) of the sample sequence. If this "coding" was critical to the accuracy of responses, the poor performance of Groups SEQ-SEQ and SG-SEQ may be interpreted in terms of an interfering effect by the sequential responses to the comparisons. It should be noted, however, that one subject in Group SEQ-SG, A13, performed accurately only at the 2-s delay. So such "coding" may fail to occur even with no sequential responding to comparison stimuli.

The slower acquisition in Group SEQ-SEQ may be related to the lack of feedback after each incorrect response. A blackout or reinforcement followed only after a whole response sequence. Richardson and Bittner (1982) trained pigeons on a stimulus stringing task involving four colors. In their original training, three kinds of feedback were given upon each selection of a stimulus: an "on-key" feedback, in which the brightness of the pecked key was changed from dim to light; an "off-key" feedback, in which the color of the just-pecked key appeared in another key array; and a buzzer for an incorrect selection. Then, they removed either of these feedbacks to test for a change in accuracy. They found that the decrease in accuracy was similar among different feedback removal combinations. This finding suggests that the feedback for each correct selection of a key was critical to making stimulus-stringing responses, even though the strings consisted of only two keys.

Experiment 2

In order to determine which parameter, the number of responses or sequentiality, was more effective in producing the distinctive performance of Group SEQ-SG on the delayed matching-to-sample task, we used two additional groups, Group SGSG-SG and Group SEQ-SGSG, in Experiment 2.

One possibility is that sequential responses to the sample stimuli in Experiment 1 facilitated the acquisition and retention of the matching performance in Group SEQ-SG. Alternatively, another possibility is that simply responding four times to the sample stimuli helped improve the performance. The purpose of using Group SGSG-SG was to identify the determinant parameter of the above two. The subjects in this group pecked only one of the two sample stimuli, either the upper or lower. They were required to peck the sample keys four times, with a 0.2-s period of extinction of the key light between the second and third responses. The aim of this procedure was to equate the number of the required responses to the sample stimulus and treatment for sample responses with Group SEQ-SG. The only difference between the two groups was the requirement in sample responses: sequential responses to two sample stimuli in Group SEQ-SG versus repeated responses to a single sample stimulus in Group SGSG-SG.
The conditions of Group SEQ-SGSG were the same as for Group SEQ-SG, except that two more responses were required to the comparison stimulus. The additional responses were introduced to examine the effect of the number of responses to the comparison stimulus on acquisition and retention. Another objective of Group SEQ-SGSG was to test whether the relatively slow acquisition observed in Group SEQ-SEQ, which was required to respond sequentially both to the sample and comparison stimuli, was caused by the delay of reinforcement or the sequentiality in responses to the comparison stimuli.

Method

Subjects and Apparatus
Six experimentally naive pigeons (Columba livia) were used. They were maintained in the same condition as the subjects in Experiment 1. The same operant chamber as in Experiment 1 was used.

Procedure
The subjects were trained in autoshaping sessions to learn pecking a key, then exposed to the FR-2 schedule to learn to peck all the four keys on the front panel, as in Experiment 1. After this, the subjects in Group SEQ-SGSG were given training on sequential responses to the sample stimuli. This training was omitted in Group SGSG-SG because sequential responses to the sample stimuli were not required in this group. Then, each group was trained in a guided procedure designed for it. In Group SGSG-SG, the key lights were turned on in the order of upper to left, or lower to right. Four responses were required at the sample key. In order to equate the time spent on sample responses with Group SEQ-SG, a 0.2-s period of stimulus extinction was interposed between the second and third pecking responses to the sample stimulus. This interval was determined based on the average sample response time measured for Group SEQ-SG. In Group SEQ-SGSG, the correct choice was the left key when the sample sequence was upper to lower, and the right key when it was lower to upper. The subjects in this group were required to respond twice each to both sample stimuli, and four times to either comparison stimulus with a 0.2-second interval between the second and third responses. This interval was also introduced to equate the time spent on comparison responses with Group SEQ-SEQ, and it was determined based on the average duration measured for comparison responses.

Next, all birds were trained in the same pre-MTS procedure as in Experiment 1, in which either of the comparison stimuli was lit and, after a response to that key, the other key was also lit. After accuracy became consistently high in the pre-MTS sessions (usually within two sessions), training sessions were started, in which both comparison stimuli were lit simultaneously. The correct sequences of sample and comparison responses are shown in the right two columns of Figure 1. In Group SGSG-SG, after the subject responded four times (with a 0.2-second
interval between the second and third responses) to upper as the sample response, correct choice was two responses to the left key; if the sample stimulus was the lower key, responding to the right key was correct. In Group SEQ-SGSG, after responding in the order of upper to lower keys, a total of four responses to the left key was required; when the sample sequence was lower to upper, the correct choice was four responses to the right key. After a correct choice, the feeder was presented for 2 or 3 s depending on the subject's deprivation level. After an incorrect choice, correction trials continued until a correct choice was made, as in Experiment 1. Each training session comprised 80 trials, excluding correction trials.

Results and Discussion

Acquisition

The number of sessions required before reaching the minimum criterion of 85% in two consecutive sessions is shown in the right two panels of Figure 2. The result was 6, 5, and 11 (average: 7.3) in Group SGSG-SG, and 3, 4, and 7 (average: 4.7) in Group SEQ-SGSG. These results were about the same as those for Group SEQ-SG (average: 4.6) as observed in Experiment 1.

Although Group SEQ-SGSG was required to respond two more times to the comparison stimulus than Group SGSG-SG, the numbers of sessions before reaching the acquisition criterion were about the same between the two groups. Moreover, the results were close to that in Group SEQ-SG. This fact suggests that sequentiality in sample responses does not affect the acquisition provided that the number of responses to the sample stimulus (stimuli) is the same (four), unless responses to the comparison stimuli are sequential.

The more rapid acquisition in Group SEQ-SGSG in comparison with Group SEQ-SEQ indicates that sequential responding to the comparison stimuli in the latter disrupted performance. In other words, what interfered with acquisition in Group SEQ-SEQ in Experiment 1 was not the delay of reinforcement from the first response to the correct comparison, but the sequentiality in responses to the comparison stimuli.

Delayed MTS Training

Performance in delayed matching-to-sample in Groups SGSG-SG and SEQ-SGSG is shown in the lower part of Figure 3. The longest delay intervals at which the subjects could maintain their performance over 75% correct level were 34, 46, and 38 s (average: 39.3 s) in Group SGSG-SG, and 2, 2, and 14 s (average: 6 s) in Group SEQ-SGSG. As shown in Figure 2, the average level in Group SGSG-SG was about the same as in Group SEQ-SG, whereas the levels of Group SEQ-SGSG resembled those of Groups SEQ-SEQ and SG-SEQ. The birds in Group SGSG-SG showed good retention, even though they did not respond sequentially to the sample stimuli as did those in Group SEQ-SG. In contrast, the birds
in Group SEQ-SGSG performed poorly although they were not required to respond sequentially to the comparison stimuli, suggesting that requiring two additional responses impaired their retention in the delayed matching-to-sample, as in Groups SEQ-SEQ and SG-SEQ.

General Discussion

The present experiments examined the effects of sequential responses to the sample and comparison stimuli. The results showed that sequential responses to the comparison stimuli interfered with acquisition in the spatial matching-to-sample task. Although there were some differences between subjects in each group, the overall trend deduced from the number of sessions required to reach the criterion was as follows: Group SEQ-SEQ was the slowest followed by Group SG-SEQ; all other groups, Group SEQ-SG, Group SGSG-SG, and Group SEQ-SGSG, were about the same.

The only difference in the experimental conditions between Groups SEQ-SEQ (Experiment 1) and SEQ-SGSG (Experiment 2) was the requirement of sequential responses to the comparison stimuli. This difference resulted in slower acquisition by the former, but suppressed the performance about equally in the delayed matching-to-sample, as shown in Figure 3. The fact that both groups showed poor performance in the delayed matching-to-sample is consistent with the finding from prior experiments that requiring more responses to the comparison decreases matching accuracy (Wilkie & Spetch, 1978). The difference between Groups SEQ-SG and SEQ-SGSG may be understood by the same way. On balance, the slow acquisition in Group SEQ-SEQ needs a different interpretation. The matching task for this group, involving sequential responses to two different keys as comparisons, may have required the subjects to combine two separate response strings into one consisting of four stimuli: upper-lower-left-right or lower-upper-right-left. This account is consistent with the report that a four-item response sequence is much more difficult to learn for pigeons than two- or three-item ones (e.g., Straub & Terrace, 1981).

The only difference between Group SEQ-SG and Group SGSG-SG was whether sample responses were emitted to two different keys or to a single key. The subjects in both groups showed relatively fast acquisition and good retention over 30 seconds in the delayed matching-to-sample except one subject in Group SEQ-SG (A13). This fact supports the prior findings that an increased number of responses to the sample resulted in improved accuracy (e.g., Eckerman, Lanson, & Cumming, 1968; Lydersen, Perkins, & Chairez, 1977; Wilkie & Spetch, 1978). It seems that it had no impact whether sample responses were sequential or not.

It would be possible that sequential responses to the sample and comparison stimuli had quite different quality: The former were guided by the experimenter, whereas the latter were produced by the subjects. This design, as a result, would have required the subjects to respond
sequentially to the sample stimuli, but not to necessarily discriminate between the two response sequences: They might have discriminated between sample stimuli only from the second response positions. The procedure might be improved by using visual stimuli as cues, instead of key positions.

In the present experiments, if the first response to the comparison stimuli was incorrect, a feedback (blackout) was given only after the whole comparison sequence was completed. This design is similar to that by Wilkie and Spetch (1978), in which the first response determined the outcome of the choice. They found, however, little difference in accuracy between two different numbers of comparison responses, 1 and 4. In contrast, slower acquisition and poor retention performances of the groups with sequential comparison responses in Experiment 1 could be due not only to the number of comparison requirements, but mainly to the contiguity between the response to the second key position and reinforcement.

In short, requiring sequential responses to the comparison stimuli seemed to interfere with acquisition and retention in the present experiments. Any facilitating effect of sequential responses was limited to the sample stimuli, as found in prior researches on the matching-to-sample task. Also, the crucial parameter that facilitates matching-to-sample acquisition is the number of responses to the sample and comparison stimuli. However, not only requiring response sequence, but also requiring more responses to comparison stimuli had interfering effects on acquisition and retention. Because the present experiment used four different keys as discriminative stimuli, the subjects were able to emit mediating behavior during the delay interval. For more detailed examination, it is necessary to test using, say, color stimuli instead of spatial position of the keys or other experimental designs that would prevent mediating behavior.

References


