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THREE-CONFIGURATION MATCHING-TO-SAMPLE IN THE PIGEON[1]

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Pigeons were trained on a zero-delay matching-to-sample procedure during which only three of the four possible stimulus configurations were presented. Subsequently, all birds were exposed to all four configurations as a transfer test. A high degree of negative transfer from the three training configurations was obtained in Experiment 1. The results of Experiment 2 indicated that three-configuration training produced differential position-preference effects. During the transfer test, responding after one sample stimulus was apparently based on position, while responding after the other sample was based on color.

In the usual two-stimulus, three-key matching-to-sample experiment (Cumming and Berryman, 1961) there are four possible stimulus configurations that can be presented to the subject on any particular trial. For example, when red (R) and green (G) are used as stimuli, the four configurations on the three keys are R*RG, GRR*, G*GR, and RGG* (where the asterisk represents the correct comparison stimulus). Typically, all four configurations are presented an equal number of times during acquisition training. Counterbalancing ensures that any color or position preference will result in reinforcement on no more than 50% of the trials. The purpose of the present experiment was to investigate whether training with only three configurations would produce positive transfer to the fourth configuration when it was subsequently introduced. No transfer to the new configuration would suggest that the subjects had learned to respond differentially to the three configurations, and that learning was limited to the stimuli employed during training. Positive transfer would suggest that a more general type of learning had taken place, which could be generalized to a new stimulus configuration.

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EXPERIMENT 1

METHOD

Subjects

Four naive male Carneaux pigeons, approximately 12 months of age, obtained from the Palmetto Pigeon Plant, were maintained at 75 to 80% of their free-feeding weights for seven days before and throughout the experiment by controlled daily feedings of Purina Pigeon Grain.

Apparatus

The operant chamber was constructed of Masonite and Plexiglas and measured 13.5 by 13.5 by 12.75 in. (34 by 34 by 32 cm). It was placed in a sound attenuating plywood enclosure with white noise always present. Three transparent Lehigh Valley Electronics keys (Model #121-15) were mounted on one wall and behind each key was an IEE multiple-stimulus projector (stimulus pattern #696, type 1820 bulbs). The keys were mounted 3.25 in. (8 cm) apart and 8.25 in. (21 cm) above the floor. A food magazine mounted 4 in. (10 cm) below the center key was illuminated whenever food was available. A small houselight (Type 1829) was mounted on top of the chamber in a manner that ensured that it would not shine directly on the keys. All stimulus events and schedules were arranged by relay equipment in an adjacent room.

Procedure

After two to three days of habituation to the chamber, each pigeon was magazine trained by presenting 5-sec access to grain (Purina Pigeon Grain) after variable periods of time with an average interval between presentations of 1 min. During these sessions, all keys were dark. The pecking response was then shaped by approximation to one of the side keys. Half of the birds were initially trained to peck the left key and half to peck the right key. Each peck of a lighted key was reinforced with 3-sec access to grain. For each subject there were 15 reinforcements after pecks on each of the three keys. Only one key was illuminated at any given time, and only white light was used.

Following this training, three of the four possible stimulus configurations were displayed on the keys and grain was presented following correct matching responses. The three configurations were R*RG, GRR*, and RGG*. G*GR was never presented during this phase of the experiment. Each trial began with the onset of a sample stimulus on the center key. A response to this key removed the sample and presented a comparison stimulus on each of the side keys. A response to the correct comparison stimulus was reinforced with 3-sec access to grain. A response to the incorrect stimulus produced a 10-sec blackout during which all lights in the chamber were extinguished. A new trial began immediately after either food presentation or blackout. Each of the three configurations was presented 40 times in random sequence during each daily, 120-trial session; four different sequences were used in different sessions. All birds were exposed to this procedure until a criterion of three consecutive sessions at 90% correct matching or better was maintained. Each bird was then exposed to a procedure in which all four possible stimulus configurations were presented 30 times in random sequence during each 120-trial session (four different sequences were again used). This procedure was continued until the criterion of 90% or better correct matching was reached, or for a maximum of 15 sessions.

Results

Figure 1 shows the session-by-session percentage of correct matching responses on each configuration for all four subjects. Each bird showed a clear and consistent right-position preference early in acquisition (Subject #2 showed a brief red preference in Session 1). It should be noted that either a complete red-color preference or a complete right-position preference would result in reinforcement on 67% of the trials. In every pigeon, the right-position preference eventually weakened and the percentage of correct matches on R*RG trials increased rapidly, accompanied by a temporary decline in correct matches on RGG* trials. These changes can be seen clearly in Figure 1, and most dramatically in the case of Subject #6. The subjects required from 12 to 33 sessions to achieve criterion performance during acquisition.

During transfer testing, all four birds showed considerable negative transfer to the new G*GR configuration. Every subject made at least 30 consecutive errors on G*GR when it was first introduced, and one bird (Subject #6) made over 150 consecutive errors.

Discussion

The inverse relationship between R*RG performance and RGG* performance observed during acquisition is interesting since these two configurations differed only in the color of the sample. The stimulus complexes present when the choice responses were made were identical since the sample had been removed. Thus, it seems that as the subject learned to choose red on the left on R*RG trials this tendency generalized somewhat and interfered with avoiding red-left and choosing green-right on RGG* trials. Furthermore, since there was no decrement in choosing red-right on GRR* trials the subjects may have been responding to particular position-color stimulus complexes during the choice period of each trial. It should be pointed out that the inverse relationship between R*RG and RGG* performance was probably not due to a general change in responding when the position preference first broke down. If this were the case, one would expect performance on GRR* trials to show a decrement, but this did not occur.

The extremely high percentage of incorrect, nonmatching responses obtained to the new configuration during the transfer test was surprising. Even three-configuration acquisi-

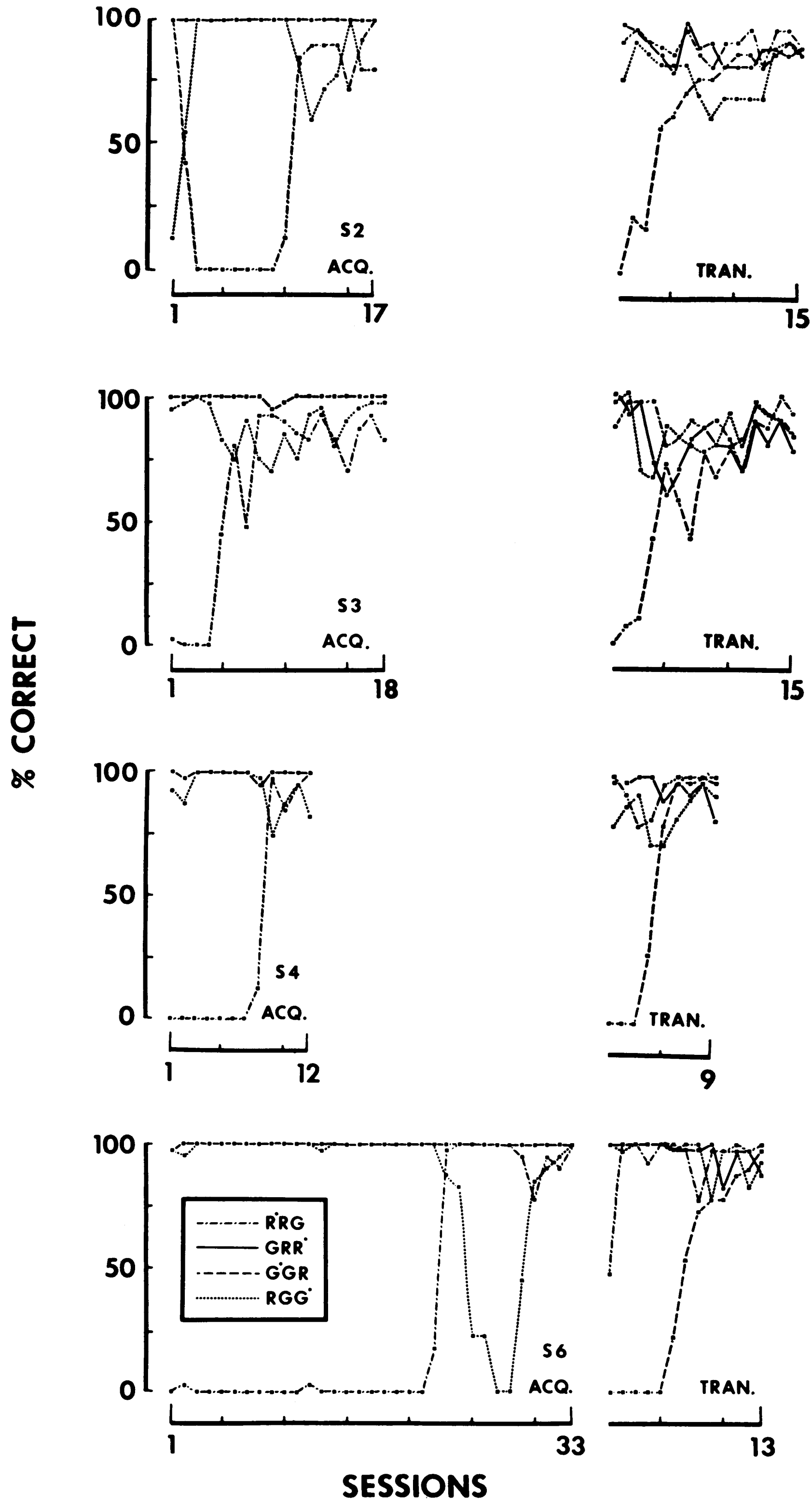

Fig. 1. Percentage correct matching responses on each configuration in each session of Experiment 1 for four pigeons.

tion, when continued to a stringent criterion of correct matching responses as in the present experiment, ensures that the subject has abandoned any simple position or color preference and has consistently chosen the comparison stimulus that matches the sample. However, this result is predictable if the subjects have learned to respond on the basis of color following a red sample, but on the basis of position following a green, or perhaps simply any non-red, sample.

Although this interpretation is consistent with the transfer results of Experiment 1, it suggests that the subjects had learned to attend to different dimensions of the situation in making a choice response after different samples, even though a single dimension, color, contained all the necessary information. It is possible that the position preference pattern of response shown by all subjects at the beginning of three-configuration acquisition, which was inhibited only on trials with red samples, is also important to this transfer phenomenon. If this explanation of the transfer effects is appropriate, one would expect that birds trained on three-configuration matching (omitting G*GR) should show right position preference response patterns after a green sample but not after a red sample. Experiment 2 was an attempt to demonstrate differential position preferences following the different samples when hue had been removed as a cue during the choice response period of each test trial.

EXPERIMENT 2

Method

Subjects and Apparatus

Six naive Carneaux pigeons, approximately 12 months of age, were maintained on the same schedule and tested in the same apparatus employed in Experiment 1.

Procedure

All birds were treated exactly as the subjects of Experiment 1 through the completion of three-configuration matching training. All subjects were then given one 120-trial session of position preference testing. On each trial during this session, the comparison stimuli were identical, with neither matching the sample, and all choice responses were reinforced 50% of the time. The first two subjects were tested with white comparison stimuli, receiving 60 WRW trials and 60 WGW trials, in random sequence. The other four subjects were tested with identical red or green comparison stimuli. Thus, they received 60 RGR and 60 GRG trials each. Following this session, all subjects were given one standard 120-trial four-configuration matching session, with each configuration presented 30 times, in random sequence.

Results

The results during three-configuration acquisition were very similar to those of Experiment 1 (Figure 2). Four of the subjects showed right-position preferences during early acquisition sessions while two showed color preferences. There was a marked interaction (an inverse relationship) between percentage correct on R*RG and RGG* in all subjects. Acquisition to criterion required 11 to 22 sessions.

As shown in Table 1, all subjects showed stronger right preferences following green samples than following red during the position preference testing. Following a red sample, three birds showed left preferences and 3 showed right preferences.

As in Experiment 1, performance on the novel G*GR configuration during the single-session transfer test was poor. Mean percentage correct on G*GR trials was 5%, while mean percentage correct following red sample stimuli was 95%. To present the results in another way, the red comparison stimulus was chosen 95% of the time following a red sample whereas the right position comparison stimulus was chosen 92% of the time following a green sample during the transfer session.

Discussion

The results of the position preference test indicate that three-configuration training produced differential position preferences following different sample stimuli even if the comparison stimuli were identical in hue during each choice response period. It seems clear that the birds were responding to different dimensions of the stimulus complex present when the choice response was made following the different sample stimuli. The external stimulus complexes present during the choice response part of each trial when the differen-

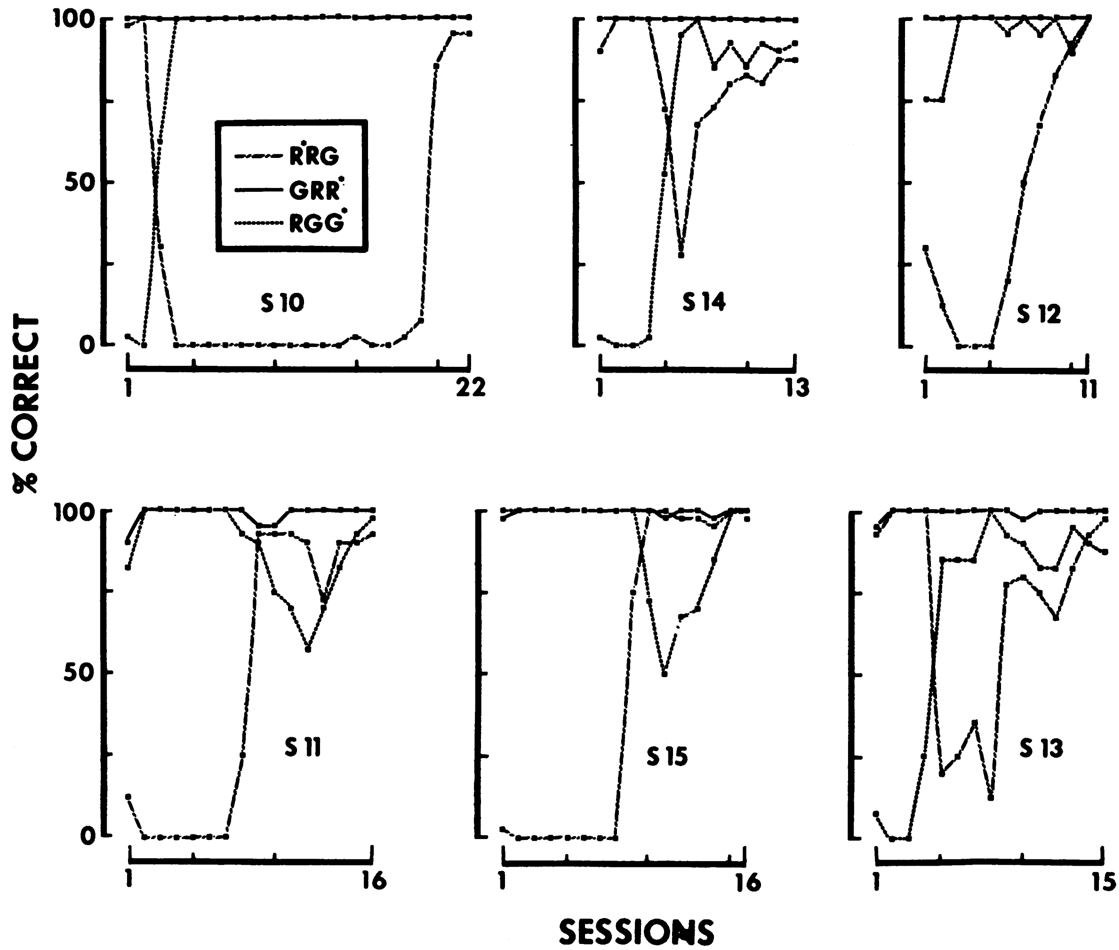

Fig. 2. Percentage correct matching responses on each configuration in each acquisition session of Experiment 2 for six pigeons.

Table 1

Percentage choices on the right key after the different samples in the position preference test and percentage correct on G*GR trials in the transfer test for each subject of Experiment 2.

	POSITION PREFERENCE TEST			TRANSFER Test
Subject	*Test Configuration*	*%Right Response After Red*	*%Right Response After Green*	*% Correct On G*GR*
1	WRW-WGW	83%	97%	0%
2	WRW-WGW	80%	89%	7%
3	GRG-RGR	25%	100%	0%
4	GRG-RGR	23%	93%	23%
5	GRG-RGR	87%	92%	0%
6	GRG-RGR	31%	98%	0%

tial responding was expressed were identical. Therefore, the existence of some other source of stimulation, which exerted discriminative control over the choice response, seems necessary to explain the differential responding following different samples.

General Discussion

The processes involved in matching acquisition have been referred to in several ways: as the learning of four problems, one for each configuration (Skinner, 1950; Eckerman, Lanson, and Cumming, 1968); as a single conceptual problem or "abstract generalization" (Nissen, Blum, and Blum, 1948); and in terms of the coding hypothesis (Cumming, Berryman, and Cohen, 1965). Cumming *et al.*, proposed that the choice response on individual trials during zero-delay matching-to-sample is under the control of specific mediating stimuli associated with each sample. According to the coding hypothesis, a red sample initiates a mediating response (r_R) the stimulus properties of which (s_R) are the discriminative stimuli for choosing the red comparison stimulus. The transfer data of the present experiments, in accord with the coding hypothesis, suggest that matching consists of one problem for each sample stimulus employed. Basically, the coding hypothesis holds that within a single matching problem the appropriate r_x associated with each sample stimulus must be established as an effective discriminative stimulus for the choice response. The present experiments demonstrated completely independent patterns of response on different dimensions of stimulation in the presence of the same external stimulus complex during the choice interval after different sample stimuli. These results strongly imply that in typical zero-delay matching acquisition with pigeons, each r_x becomes established as a discriminative stimulus, exerting control over choice responses made in its presence, independently of all other mediating stimuli associated with other sample stimuli.

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