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GENERALIZATION DURING ACQUISITION, EXTINCTION, AND TRANSFER OF MATCHING WITH AN ADJUSTABLE COMPARISON[1]

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Three groups of pigeons were given conditional discrimination training in which the number of standard stimuli was varied across groups. In the presence of each standard, a pigeon adjusted the comparison stimulus on a second key until the two keys matched. A report of this match (response on the first key) was reinforced. Transfer of the matching performance was investigated by adding new standards to the ones already available. All pigeons were exposed to two extinction sessions after 155 sessions of training. Rapidity of acquisition was inversely related to the number of standards presented. Generalization gradients derived from the several comparison stimuli showed that all pigeons reached a high level of accuracy in the presence of at least one standard, and some pigeons did so in the presence of as many as four of the six standards. There was no evidence of a systematic effect of extinction upon overall accuracy, or the individual generalization gradients. When a new standard was added, a given pigeon's performance (in terms of responding to the comparisons) was similar to performance in the presence of one of the old standards. However, the pigeons did not show evidence of confusion among the comparisons.

In a conditional discrimination, the relationship between the discriminative stimuli and the reinforcement contingencies depends upon the stimulus context in which they appear (Cumming and Berryman, 1965). A variety of experimental procedures has been used to study conditional discriminations. In such studies, the background stimulus (frequently referred to as the standard or sample) determines the discriminative performance with respect to other stimuli (referred to as comparisons) which are presented simultaneously. Although in some studies the standard stimulus was not present at the same time as the comparison stimuli (*e.g.*, Blough, 1959; Berryman, Cumming, and Nevin, 1963), the comparison stimuli were always presented simultaneously.

In the present study, the standard and only one of several comparison stimuli were presented simultaneously. The additional comparisons were presented in a temporal sequence. The pigeon adjusted the wavelength of the comparison by changing the alternatives sequentially until an appropriate match occurred and was "reported".

In particular, this study examined the course of stimulus generalization during acquisition, transfer, and extinction of matching with an adjustable comparison. Generalization gradients were based on the percentage of trials in which each comparison was reported in the presence of each standard. The forms of these generalization gradients, obtained from successive sessions, yielded a more detailed analysis of acquisition than would an overall measure of accuracy. An increase in "instructional control" (Cumming and Berryman, 1965) by a given standard would be shown by an increase in the slope of the generalization gradient for that standard, while a slope of zero would be taken to indicate no stimulus control along the dimension being studied (Terrace, 1966).

The study was also concerned with transfer of performance to novel standards. Earlier work on transfer of a conditional discrimination, with a three-key procedure in which the comparisons were presented simultaneously (Berryman, Cumming, Cohen, and Johnson, 1965; Cumming, Berryman, and Cohen, 1965),

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indicated that pigeons discriminated novel comparisons from old comparisons, but responded in the presence of a novel standard as if it were one of the "old" standards.

Following acquisition, the effect of extinction on the accuracy of matching was examined. Several earlier studies using simple discrimination situations have shown that during stimulus control, a pigeon's key pecking could be reduced without affecting the discrimination (Jenkins, 1961; Honig, 1962; Terrace, 1963; Nevin, 1967). Similarly, Cumming, Berryman, Cohen, and Lanson (1967) found that extinction of well-established matching-to-sample behavior, using a three-key situation in which two comparisons were presented simultaneously, reduced the number of trials completed by the pigeons but had little or no effect upon the accuracy of their matching. The extinction phase of the present study determined whether a comparable reduction in response strength in matching with an adjustable comparison would also fail to reduce the accuracy of the performance.

METHOD

Subjects

Nine adult, experimentally naive, White Carneaux pigeons, from Palmetto Pigeon Plant, Sumter, South Carolina, were maintained at 75% of their free-feeding body weights throughout the experiment.

Apparatus

The modified Lehigh Valley Electronics pigeon chamber contained a stimulus panel with two translucent keys symmetrically placed around the vertical midline of the panel, 51 mm center-to-center. Each key required a minimum force of 20 g for operation. The grain hopper aperture was also centered on the midline of this panel, 133 mm below the keys.

Chamber illumination was provided by two General Electric 7-w frosted Nitelights mounted at the extreme sides of the houselight compartment. The light from the bulbs was diffused over the entire ceiling by a white diffusing plastic sheet and then passed through a polarizing plastic sheet in such a way as to minimize reflection on the keys. A blower located on the chamber wall opposite the stimulus panel provided ventilation and some masking noise.

The experimental stimuli were monochromatic lights projected on the translucent keys. The light sources used were General Electric No. 1493 bulbs operated at the rated 6.3 v and radiating at a color temperature of 2800° K. Bulbs were replaced every five days. A lens collimated the light from each bulb into a 31.75 mm beam which then passed through a Kodak Wratten neutral density filter, a Kodak Wratten filter used to eliminate the secondary peaks, and a Bausch and Lomb interference filter. The peak values of the interference filters were chosen as equally spaced, in terms of generalization units (Shepard, 1965), along the wavelength continuum. Specifications of the interference filters for each of the two keys are given in Table 1, along with the value of the neutral density filter, and the Kodak catalog number of the blocking filter used with each. The neutral density filters were used to assure that within a range of ±0.1 log units the monochromatic lights were of equal luminance for the pigeon. They were combined with the interference filters, when necessary, to correct partially for three factors: the relative energy distribution of the bulb, the pigeon photopic luminosity function (Blough, 1957), and differences in spectral transmission of the interference filters.

The unit holding the interference filters (Johnson, 1966) could accommodate up to six filters for any experimental session. A change in stimuli resulted in a dark key while two filters simultaneously interrupted the light beam. The key could also be darkened by interrupting the light beam with a vane shutter mounted behind each key.

Stimulus changes, reinforcement contingencies, and recordings were scheduled automatically by a system of relays, timers, counters, and punched-tape readers housed in a separate control room.

Procedure

Preliminary training. After each subject was trained to approach and eat from the hopper, 50 responses on each of the two keys were followed by reinforcement (3-sec access to grain) when that key was illuminated with white light. After this training, both keys were illuminated simultaneously and approximately 40 reinforcements were arranged for the following chain of responses: peck on the left key, at least one peck on the right key, peck on

Table 1

Characteristics of Interference Filters

	Modal Wavelength (nm)	*Per Cent Transmission*	*Half-Width Bandpass*	*Neutral Density Filter Added*	*Blocking Filter Added*[b]
		Filters for Left Key			
1[a]	518	33	15	0.0	#2A
2	530	31	11	0.1	#2A
3	540	34	10	0.1	#2A
4	549	28	10	0.2	#8
5	570	35	14	0.4	#8
6	591	22	15	0.3	#15
7	610	32	15	0.3	#15
		Filters for Right Key			
1[a]	513	38	15	0.0	#2A
2	531	31	13	0.1	#2A
3	539	32	10	0.1	#2A
4	549	28	10	0.2	#8
5	568	37	14	0.6	#8
6	595	27	15	0.3	#15
7	610	33	16	0.3	#15

[a] Filters designated by the same ordinal number were considered to be "matching".
[b] Kodak Catalogue number.

the left key. The next day, the left (standard) key was illuminated again with white light, while the right (comparison) key was illuminated with one of the six monochromatic stimuli. Forty reinforcements were again given for the chain of key pecks described above, with the addition that every second peck on the right key changed the wavelength illuminating this key. These changes in wavelength did not affect the availability of reinforcement for a return to the left key. The stimuli were presented on the right key in a cycle of 240 comparison stimuli presented in 40 random permutations of the six possible stimuli, thereby permitting a stimulus to appear only twice in immediate succession. Scheduled reinforcements were independent of the wavelength present on the right key.

Conditional discrimination training. On the next day, the birds were put on the trial procedure. Trials were initiated by presenting one of the monochromatic lights to be used as a standard stimulus on the left key. A peck on this key produced one of the six comparison stimuli on the right key. Additional pecks on the standard key were not effective until the comparison key had been pecked at least once. Every second peck on the comparison key changed the light illuminating this key in the order described above. After the comparison key had been pecked at least once, a response to the standard key turned off both the standard and the comparison stimuli. If this response occurred while both keys were illuminated with "matching" stimuli (as indicated in Table 1), the grain hopper was activated for 3 sec. If, however, the standard key was pecked when the keys were illuminated with non-matching stimuli, the overhead illumination was turned off for 3 sec (blackout). After either 3 sec of reinforcement or blackout, a 15-sec intertrial interval ensued with the houselight on, both keys dark, and all responses ineffective. At the end of this interval, the next trial was started by once more illuminating the standard key with one of the possible standard stimuli. The standards were presented in random permutations of the number of standards available, without regard to the subject's response on the previous trial. A session consisted of 120 trials.

All subjects were given one session on this trial procedure in which the light presented on the standard key was always white, the six monochromatic stimuli were presented on the comparison key, and approximately 20 of the 120 trials ended with reinforcement. Then, the birds were randomly assigned to each of three groups differing in the number of standard stimuli to be used during various phases of acquisition of the conditional discrimination. *Two standards* refers to 549 nm and 570 nm; *four standards* refers to 530 nm, 549 nm, 570 nm, and 591 nm; and *six standards* refers to 518 nm, 530 nm, 549 nm, 570 nm, 591 nm, and 610 nm. For all groups there were always six comparisons available: 513 nm, 531 nm, 549 nm, 568 nm, 595 nm, and 610 nm.

Extinction. After 155 sessions of training, all birds were exposed to two extinction sessions with six standards, no reinforcement or blackout, and an 18-sec intertrial interval. The birds were given 120 trials in each extinction session unless the session was terminated first by 15 min of no responding on either key.

RESULTS

The course of acquisition of the conditional discrimination for each group is shown in Fig. 1 which gives the mean number of correct trials as a function of experimental sessions. Since all groups always had six comparisons available from which to choose, "chance" performance would be one-sixth of the trials correct or 20 out of 120 trials in a daily session. During the first 65 sessions Group 1 had two standards, Group 2 had four standards, and Group 3 had six standards available in a single experimental session. The mean acquisition function for Group 1 showed the first consistent deviation from chance performance after the eleventh daily session, and this function approached its asymptotic level of around 85 correct trials after Session 39. Groups 2 and 3 showed a more gradual rise from chance performance and reached a level of 55 (for Group 2) and 49 (for Group 3) correct trials only by the end of these 65 experimental sessions. Throughout these sessions Group 2 showed a slightly but consistently more accurate performance than Group 3.

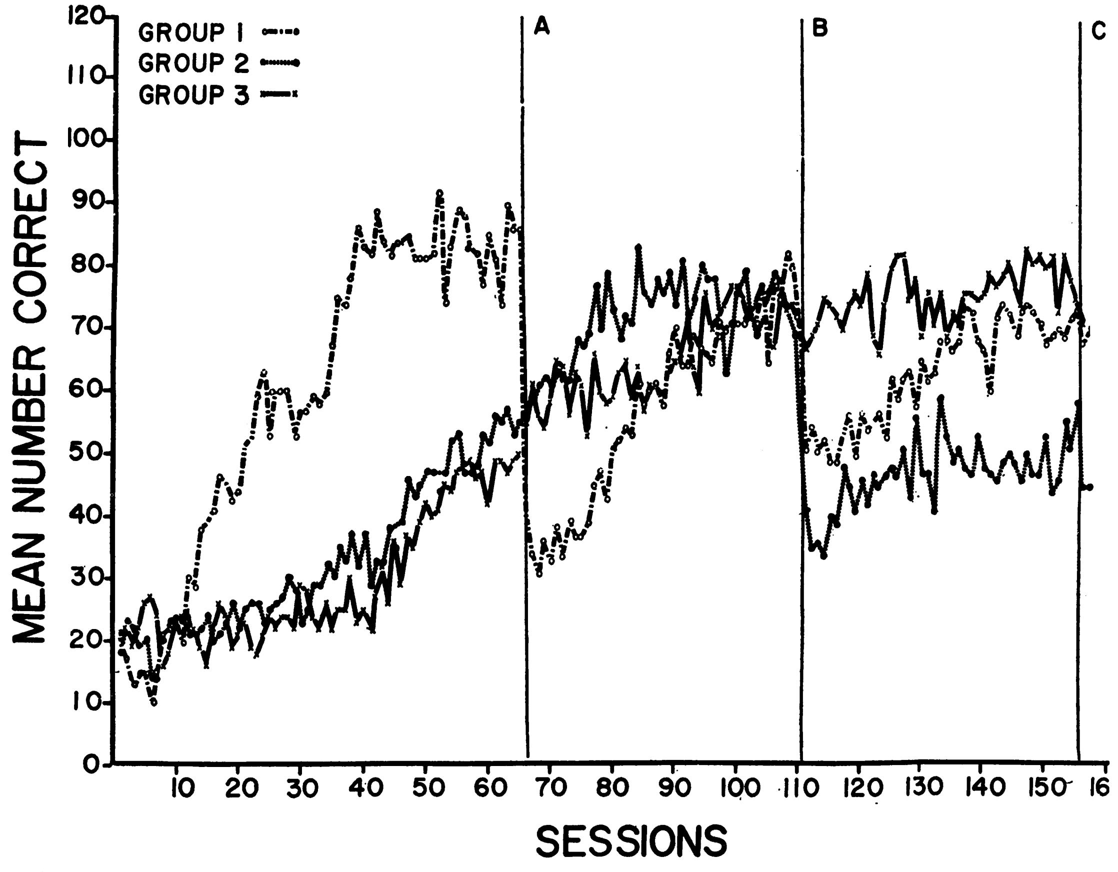

Fig. 1. Mean number of trials correct, for each group of three subjects, as a function of sessions. At point "A", Group 1 was changed from the two-standard condition to the four-standard condition. At point "B", Groups 1 and 2 were changed from the four-standard condition to the six-standard condition. At point "C", all groups were exposed to two sessions in extinction.

At A on Fig. 1, the procedure was changed for Group 1: in Session 66 two additional standards were presented, making a total of four. This change reduced the mean number of correct trials to 39; however, performance did not return to chance level. After 11 sessions with the two new standards, Group 1 again showed a steady increase in accuracy until all three groups converged, by Session 102, at approximately two-thirds correct. During this phase, Group 2 reached its terminal level of accuracy about 18 sessions before Group 3 reached this same level.

At B on Fig. 1, the procedure was changed for Groups 1 and 2: in Session 111, two new standards were added, a change from four standards to six. This change reduced the number of correct trials for both groups. Group 2 showed a slightly greater decrement in accuracy than Group 1, a decrease of 28 trials as compared with one of 21 trials. Group 1 also showed a greater increment in accuracy during the 45 sessions of this experimental phase than Group 2. In fact, Group 1 had converged again with Group 3 by Session 155, while Group 2 was still 16 trials below these final accuracy levels, and showed signs of only slight increases.

At C on Fig. 1, all three groups were exposed to two sessions of extinction. Complete data were obtained for both sessions for Groups 1 and 2, but only for the first session for Group 3. During the second session, two subjects in Group 3 met the extinction criterion before completing 120 trials. The mean accuracy levels for all three groups during the extinction sessions were not different from the previous levels.

All three mean acquisition functions, at their highest levels, were around 66% correct. This finding could represent qualitatively different individual performances in terms of accuracy levels in the presence of each standard. Therefore, generalization gradients for each standard are shown in Fig. 2 through 4 for individual birds, one from each group, chosen for their high levels of terminal accuracy. These figures are three-dimensional plots on isometric coordinates of the per cent of trials with a specific standard (standard X) on which a match was reported in the presence of each of the six comparison stimuli. In other words, in the trials on which standard X was present, on what percentage of these trials did the bird peck the standard key (report a match) in the presence of each comparison stimulus? The vertical axis represents this per cent of reports in the scale in the lower left corner of each figure. The axes along the floor of these three-dimensional plots represent the comparison stimuli in nm (x axis) and the experimental session for which the gradient is plotted (z axis). The arrows indicate the comparison stimulus which is a correct match to the standard stimulus for a given set of gradients. The number of available standards (2, 4, or 6) is indicated beside the actual number of the experimental session. The dotted lines parallel with the x axis indicate a procedural change; for example, a change from 2 to 4 standards for Group 1 between Sessions 65 and 66.

To facilitate the description of these individual generalization gradients, the following expressions are used. A gradient that shows the distribution of reports in the presence of standard X is referred to as the *Standard X gradient*. Also, when the number of standards is changed from 2 to 4, or from 4 to 6, there are *new standards* and *old standards*. The comparison stimuli equivalent to these standards are called *new comparisons* and *old comparisons* respectively. It should be recalled, however, that actually all six comparison stimuli were presented throughout the experiment. Therefore, an *old comparison* refers to one that had already served as a correct comparison, while a *new comparison* refers to one for which reports had not yet been reinforced. A *sharply peaked* gradient is one in which at least 60% of the reports occur at the modal comparison.

The data for S 301, Group 1, are plotted in Fig. 2. After 65 sessions the gradients for each of the two available standards (549 and 570 nm) were sharply peaked around the correct comparison value. When two new standards were made available in Session 66, all three birds showed the same effect shown here for S 301. The gradients in the presence of the new standards (530 and 591 nm) showed sharp peaks at old comparison values (549 and 568 nm). Both gradients also peaked at one of the old comparison values (the 549-nm comparison) for one other subject in this group. After 45 days with four standards the 530-nm and the 591-nm standard gradients peaked rather sharply over the correct comparison values.

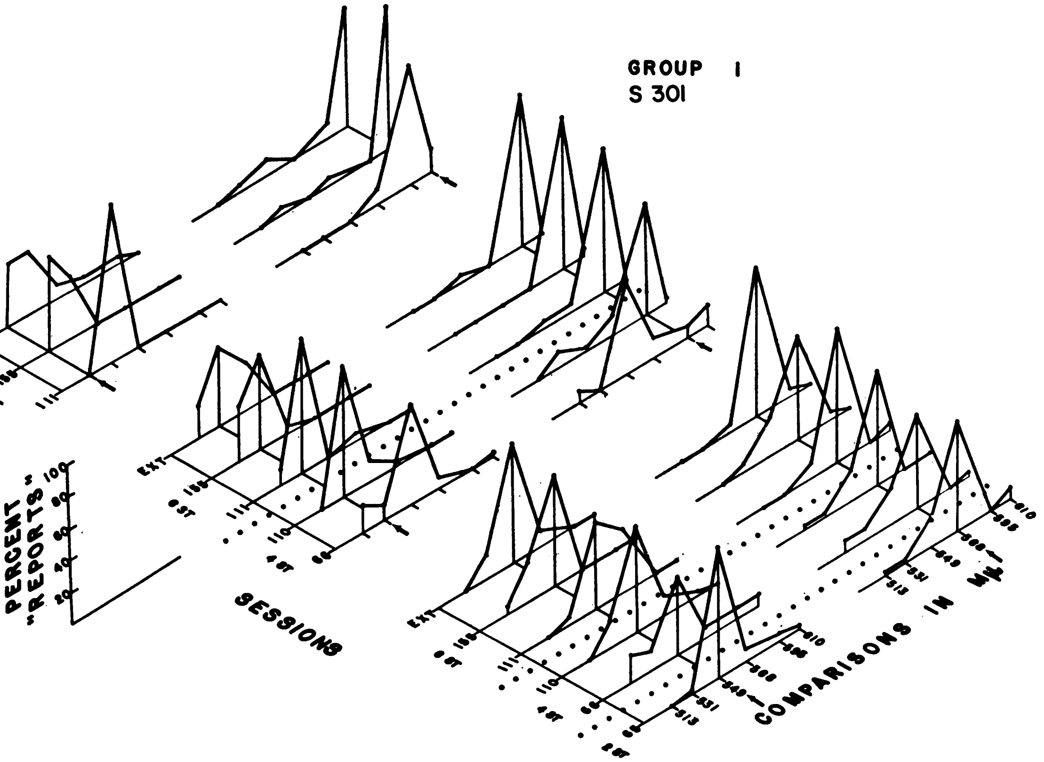

Fig. 2. Sequential wavelength generalization gradients for S 301, Group 1, for each of the six standards. The arrows on the abscissae indicate the comparison stimulus in mμ (nm) which is equivalent to the standard for a given set of gradients. The number of standards available during particular sessions is indicated alongside the session number. The dotted lines indicate the addition of two standards.

When the remaining two standards were added (Session 111) the gradients in the presence of the new standards (518 and 610 nm) again peaked sharply over old comparison values. After 45 sessions with all six standards present, the new standards acquired stimulus control. The 530-nm standard gradient became less sharp in the 45 sessions with six standards; that is, reports at the correct comparison decreased from 85% on Session 111 to 60% on Session 155.

Figure 3 shows the individual gradients for S 311 in Group 2. This group had four standards available for the first 110 sessions. After 65 sessions, two of the four standard gradients (the 530-nm and the 591-nm) showed the degree of stimulus control exhibited in the comparable data for S 301 in Group 1. Even after 110 sessions this subject's gradients, like those for the other two pigeons in this group, did not peak sharply in the presence of all four standards. The standard that showed the highest degree of control varied across subjects. When two new standards were added in Session 111, Subject 311 tended to report a match to the new standards with an old comparison. This was also true for the other two subjects in this group. In addition, responding in the presence of some of the old standards was affected by this addition, *e.g.*, the 591-nm standard gradient for S 311 showed a decrease in reports at the correct comparison of 60%. However, the effect sustained during the 45 sessions with six standards for all three subjects in this group, is the broadening of the 530-nm standard gradient, *e.g.*, for S 311 there was a decrease from 83% reports at the correct comparison on Session 110 to only 40% reports at this comparison on Session 155. The subjects in Group 1 had also exhibited this sustained loss of control by the 530-nm standard after 518 nm had been introduced as standard.

The data for S 308 in Group 3, for which six standards were always available, are presented in Fig. 4. By Session 65 this subject was

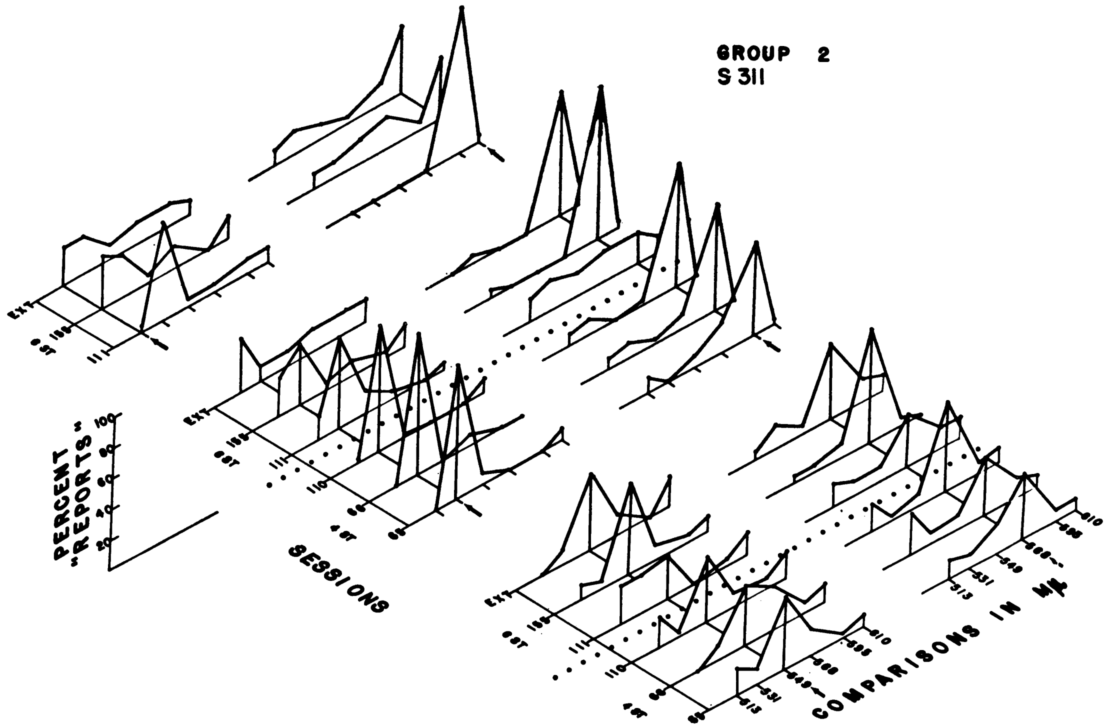

Fig. 3. Sequential wavelength generalization gradients for S 311, Group 2, for each of the six standards. For further details see Fig. 2.

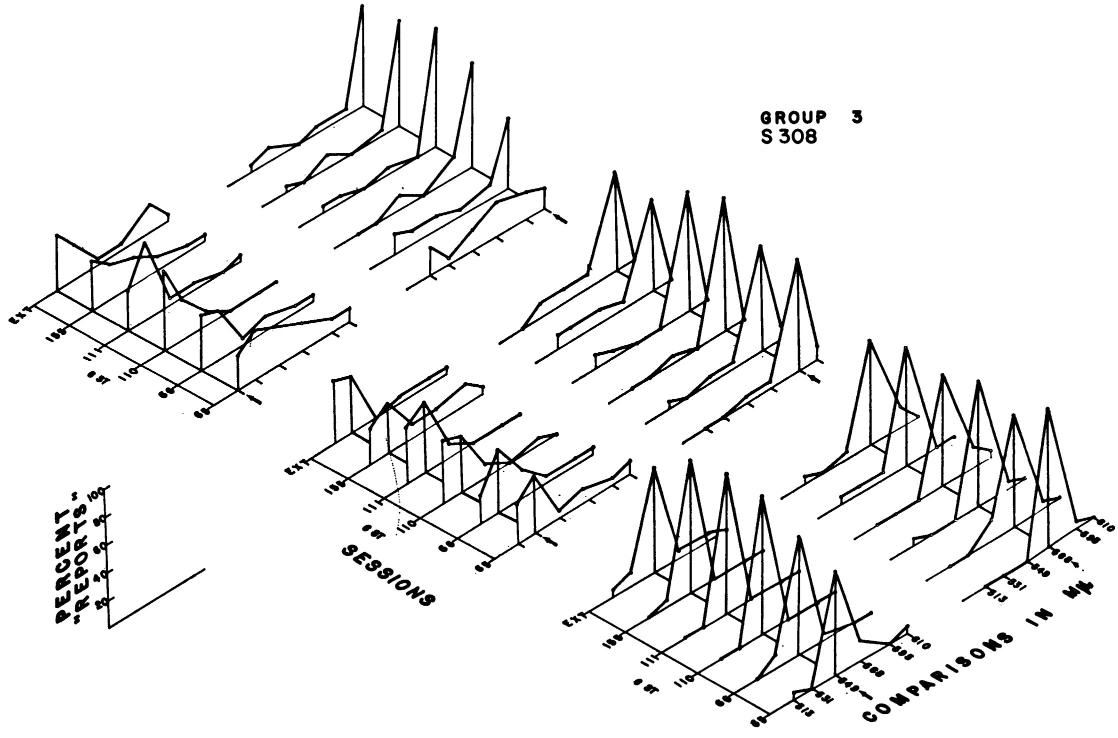

Fig. 4. Sequential wavelength generalization gradients for S 308, Group 3, for each of the six standards. For further details see Fig. 2.

already highly accurate in the presence of three of the standards (549 nm, 570 nm, and 595 nm). From Sessions 65 to 155, there was a general improvement (sharpening of the gradients) in the presence of all the standards for this subject, and many of the standards for the other two subjects in Group 3. No subject showed sharply peaked gradients in the presence of all six standards. One might have predicted, from the data for Groups 1 and 2 (which showed a loss of stimulus control by the 530-nm standard when the 518-nm standard was introduced) that, for Group 3, the gradients in the presence of these two standards would be broader than other gradients. This was true for all subjects in Group 3, including S 308, in spite of the fact that the latter showed the highest levels of overall accuracy of that group.

There was no evidence of a systematic effect, on the standard gradients, of extinction across the nine subjects, as exemplified in Fig. 2, 3, and 4. Extinction did, however, reduce pecking, as shown by lengthened sessions. In fact, two subjects in Group 3 met the extinction criterion of 15 min of no responding without completing the second extinction session.

In summary of these individual gradients, any one subject may have shown high accuracy in the presence of as many as four standards while still maintaining low accuracy for those remaining. In addition, some subjects, even after 155 sessions, showed high accuracy only in the presence of two of the six standards. However, every subject matched correctly in the presence of at least one standard. Also, many gradients with accuracy between 40 and 50% correct in the presence of a given standard were not characterized by random reporting across the six comparisons. Instead, these gradients showed reporting in the presence of the correct comparison and *one* of the neighboring comparisons along the wavelength continuum. Only two of the 54 generalization gradients remained flat throughout the 155 sessions of training.

DISCUSSION

Acquisition of matching with an adjustable comparison. Compared with the acquisition of simultaneous matching in the three-key situation (Cumming and Berryman, 1961), the present two-key matching procedure produced a more gradual increase in overall accuracy. In addition, the final levels of accuracy reached were considerably lower in the two-key case. Whereas three birds on the above three-key matching procedure, with three standards, required a mean of 700 trials to reach a criterion of 75% correct, only the subjects in Group 1 when confronted with two standards reached that level of accuracy. Group 1, which showed the most rapid deviation from chance performance, remained at chance for a mean of over 1300 trials. These differences in acquisition may be due to the difference between simultaneous discrimination between comparisons (in the three-key case) and adjustment of the comparison (in the two-key case). On the other hand, these experiments differed with respect to a number of other variables (*e.g.*, number of alternative comparisons and stimulus characteristics) which may be responsible for the differences in performance.

On the matching task with an adjustable comparison, the mean acquisition functions differed among the three groups. The fewer the number of standards presented, the more rapid the increase in accuracy. While there was a marked difference between two standards and four standards, there was also a consistent, albeit smaller, difference in the same direction between the four- and six-standard groups. It should be mentioned here that at chance levels of performance, one-sixth of the trials correct, a different number of reinforcements would be associated with each standard in each group (*e.g.*, Group 1, 10 with each standard; Group 2, five with each standard; Group 3, three or four with each standard). The differences between Group 1 and the other two groups after 25 sessions, for example, may be due to a difference in the number of reinforcements in the presence of each standard. When Groups 1 and 2 were switched from four to six standards, Group 1 showed less disruption. It is not clear, from the present study, whether this difference was due to the fewer number of sessions with four standards for Group 1 or to its prior change from two to four standards.

One reason, as previously stated in Results, for examining the generalization gradients in the presence of each standard for an individual subject is that such an analysis allows one to determine what a group accuracy level represents. These gradients (Fig. 2 through 4) show that much information about a subject's performance on matching with an adjustable comparison would be lost if only the overall number of correct trials for each subject or group were examined.

By the end of acquisition (Session 155) there were only two flat gradients out of the 54 analyzed for the nine subjects (the 530-nm and 518-nm standard gradients for S 304). Thus, even low levels of overall accuracy did not reflect random performance in the presence of each standard. Whether the degree of stimulus control in the presence of some standards might have improved further with continued training is a matter for speculation. The only gradients which seemed to have approached asymptotic levels and yet displayed relatively low levels of accuracy were those for the 518-nm and 530-nm standards.

The shapes of these gradients (518-nm and 530-nm standard), for most subjects, were similar to those obtained by Blough (1961) on generalization tests in extinction after training in the presence of 530 nm. Blough described the gradient centered at 530 nm as being "high on the left"; that is, there was more responding at wavelengths shorter than 530 nm than at wavelengths longer than 530 nm. Similarly, in the present study, the 530-nm standard and the 518-nm standard gradients were also high on the left and decreased sharply at the longer wavelengths. In the same paper, Blough pointed out that this finding contrasted with the Guttman and Kalish (1956) gradient at 530 nm, which was high on the right. He attributed this difference to the fact that Guttman and Kalish's stimuli were not corrected for brightness. This lack of correction would have resulted, according to Blough, in a sharp decrease in brightness (for the pigeon) with a decrease in wavelength below 530 nm, and less change in brightness at the longer wavelengths. This may have "abnormally depressed responding below 530 nm and distorted the gradients in this region (p. 37)." Since the present stimuli were partially corrected for brightness, the similarity of these gradients to Blough's (1961) supports this explanation.

Blough shows gradients around 550 nm which are high on the right and symmetrical gradients around 570 nm. For some of the subjects on the present matching task, the gradients in the presence of one or both of these standards represent a relatively low level of accuracy and have not necessarily reached their final shapes. For the subjects with high levels of accuracy in the presence of these standards, the gradients show almost no responding at any of the incorrect comparison values and, therefore, the shape of the gradients is determined by the selection of the six comparison values along the wavelength continuum.

Extinction of matching with an adjustable comparison. Extinction after 155 sessions on the matching task did not reduce overall accuracy in any of the three groups, and had no systematic effect upon the standard gradients for the nine subjects. On the other hand, all subjects took longer to complete the extinction sessions than to complete the regular daily sessions. Two subjects (S 306 and S 308 from Group 3) did not complete the second extinction session, which was terminated after 15 min of no responding. Therefore, the reduction in responding was not accompanied by a change in accuracy. This finding is in accord with data on extinction following simple discrimination training (Jenkins, 1961; Honig, 1962; Terrace, 1963; and Nevin, 1967). Similarly, Cumming, Berryman, and Nevin (1965) decreased responding through satiation and observed no deterioration of accuracy on a three-key delayed matching task. Finally, Cumming *et al.* (1967) observed that extinction after extended exposure to a three-key simultaneous matching procedure also produced no decrement in accuracy. In other words, the birds performed accurately on the matching task as long as they continued to respond.

The greater decrement in responding for the subjects in Group 3 may have occurred because this was the first time the group was exposed to a reduction in reinforcement for a session. Both Groups 1 and 2 had undergone such reductions on the sessions when two standards were added.

Transfer of matching with an adjustable comparison. Several indices were used to assess a subject's performance when two standards were added to the two or four already available. The first of these were the standard gradients for both the old and new standards. The first time two standards were added (Session 66 for Group 1, and 111 for Group 2) there was an immediate disruptive effect upon the old standard gradients. Most of these gradients showed a slight broadening on the first session after an addition of standards, while others (*e.g.*, those for S 311) showed a much greater decrement in stimulus control. This finding conflicts with earlier observations on transfer of three-key simultaneous matching (Cumming and Berryman, 1961), and of three-key zero-delay matching (Cumming *et al.*, 1965) in which subjects showed no decrement in accuracy on trials with old stimuli after a single novel stimulus was introduced. In these studies the novel stimulus replaced one of the original stimuli. It is not clear if some aspect of the present matching task was responsible for this decrement in performance in the presence of the old standards, or if it was due to the addition of two new standard stimuli, as opposed to the substitution of one new stimulus for one old stimulus.

In most cases (15 of the 18 gradients) the new standard gradients were sharply peaked in the first session in which they were presented. The peaks of these gradients occurred at old comparison stimuli, rather than at the correct new comparison stimuli. (It should be recalled that an old comparison refers to one previously correlated with reinforcement, while a new comparison is one not previously correlated with reinforcement.) In other words, comparison responding in the presence of each new standard was similar to comparison responding in the presence of one of the old standards.

Some data on transfer in the three-key matching situation are in accord with the present findings. Using a zero-delay matching procedure in which the standard was removed when the comparisons were presented, Cumming *et al.* (1965) observed that pigeons responded in the presence of a novel yellow standard in the same way that they responded in the presence of an old red standard. These subjects did not, however, respond in the presence of the novel yellow comparison as if it were the old red comparison. Similarly, with simultaneous oddity, it was found (Berryman *et al.*, 1965) that the birds performed in the presence of the yellow standard, the novel one, as if it were the red standard, an old one, but did not perform in the presence of the yellow comparison as if it were the red comparison.

The transfer data from these two studies have been analyzed in terms of a stimulus "coding" model of matching behavior. This coding interpretation is based upon the assumption that a mediating event occurs between the presentation of a stimulus and the occurrence of a response. The response-produced stimulation from the mediating event is assumed to control subsequent responses. In the matching-to-sample situation, it was assumed that each standard comes to control a different "observing response" which serves as a "coding" (Lawrence, 1963) of the standard. The stimulus consequences of these coding responses, in turn, control comparison responding. That is, a particular response (R_x) was assumed to occur to a particular standard (ST_x) and the stimulus consequences of R_x (S_{R_x}) were assumed to determine the response to each of the comparisons. Schoenfeld and Cumming (1963) and Lawrence (1963) used this notion of response mediation in the same way.

One of the predictions of such a coding notion is that in a two-standard condition, for example, when a subject reached high accuracy levels, two distinct coding responses had been learned: R_x for ST_x, and R_y for ST_y. When a new standard was introduced, ST_z, the subject, if it responded at all, would respond with one of the two available coding responses. A subject's behavior in the presence of the comparisons would then be appropriate to the particular coding response made to ST_z. For example, if the subject, when presented with ST_z, made the response R_x, then this subject would match CO_x (Comparison X) to ST_z. The coding notion also predicts that the new comparison would not be correctly reported until the subject had learned a distinct coding response for ST_z which would then come to control responding in the presence of CO_z. The present results lend some support to such an interpretation of matching-to-sample performance.

Of further interest is the present finding that six of the 15 peaked new-standard gradients did not show these peaks at the old comparison which was most similar to the correct new comparison in terms of wavelength. This displaced peak was observed for all subjects in Group 1 in Session 66, and for one subject from Group 1 (S 303) and two from Group 2 (S 310 and S 312) in Session 111. An interpretation of matching performance which did not include a mediating event between the presentation of the standard and the response to the comparison could not have predicted these displaced peaks. The similarity between comparison responding in the presence of a new standard to such responding in the presence of an old standard would be taken as evidence of generalization between the new standard and the old one. Also, this generalization would have to be predicted on the basis of the similarity between the new and old standards in terms of wavelength. On the other hand, the coding model would predict that the particular old standard which comes to control responding in the presence of a new standard is determined by an interaction between the relative strengths of the coding responses already available and the similarity, in terms of wavelength, of the standards. If, for example, in a two-standard condition (ST_x and ST_y) the coding response R_x is stronger than R_y (as evidenced by higher accuracy in the presence of ST_x as compared with ST_y), then both new standards will be responded to with R_x, even though one of the new standards is actually more similar, in terms of wavelength, to ST_y. Also, the comparison responding in the presence of both new standards will be appropriate to the one old standard, ST_x. The data from Groups 1 and 2, for Sessions 66 and 111, substantiate this prediction. For example, in Session 66, S 303 showed both new-standard gradients peaking at the 568-nm comparison, and this bird had shown an accuracy level of 80% in the presence of the 570-nm standard as compared with 43% in the presence of the 549-nm standard. Similarly, in Session 111, S 312, for example, had shown a displaced peak for the 518-nm new-standard gradient. This gradient peaked at the old 549-nm comparison rather than at the 531-nm comparison. The accuracy levels for the two equivalent standards for the previous session were again in the predicted direction, 30% for the 530-nm standard and 40% for the 549-nm standard.

Does a subject learn two new standards faster, after having acquired the correct performance for two other standards, than before such acquisition? Some features of the present procedure hamper such an analysis. In matching with an adjustable comparison stimulus, when all six comparisons are always available, the subjects with two standards have a history of extinction for reporting in the presence of four of the comparisons. When two new standards are added, the subjects must first begin to report in the presence of the two appropriate comparisons before the two new standards can come to control such reporting differentially. Therefore, a variation of the present matching task should be explored. Such a procedure would hold the number of comparisons equal to the number of standards. Subjects on the two-standard condition, for example, would be presented with two standards and only their equivalent two comparisons. Then, when two new standards were added, two new comparisons would also be added, and acquisition would not be hampered by a history of extinction for reporting in the presence of these new comparisons.

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