STIMULUS GENERALIZATION: THE ORDERING AND SPACING OF TEST STIMULI¹

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Twenty-four pigeons learned a successive discrimination between 500 $m\mu$ (S+) and 574 $m\mu$ (S-). When tested in extinction, some birds received stimuli around S+, with no S- presentations. These birds showed a positive peak shift, with maximum responding not at 550 $m\mu$, but displaced to 538 $m\mu$ and 544 $m\mu$. Other birds were tested with stimuli around S-, with no S+ presentations. These birds showed a negative shift, with least responding not at 574 $m\mu$, but at 586 $m\mu$. Though the first group was tested around S+ and the second around S-, total responding between groups did not differ. When retested on the other half of the continuum, however, birds that had gone from the S+ half to the S- half responded fewer times than those that had gone from the S- half to the S+ half. In a second experiment, reducing stimulus spacing from 6 $m\mu$ to 2 $m\mu$ produced flatter gradients and decreased the amount of positive shift. In a third experiment, birds were tested across the whole continuum with stimuli presented in serial order. A sequence from 538 $m\mu$ to 586 $m\mu$ produced no responding after the first part of the session; a sequence from 586 $m\mu$ to 538 $m\mu$ produced responding throughout the session.

Hanson (1959) found that successive discrimination training to a positive stimulus correlated with reinforcement (S+), and a negative stimulus correlated with non-reinforcement (S-), produced a post-discrimination gradient with a peak shifted away from the S+, in a direction opposite that of the S-. This positive peak shift has occurred only when training has involved a successive discrimination procedure (Guttman, 1959; Hanson, 1959; Honig, Thomas, and Guttman, 1959; Honig, 1962; Thomas, 1962; Terrace, 1964; Friedman and Guttman, 1965). No shift has occurred after training on a simultaneous discrimination (Honig, 1962), or after S+ training with blackouts followed by massed extinction trials to S- (Honig *et al.*, 1959; Friedman and Guttman, 1965). Even with successive discrimination training, if zero or very

few responses have occurred to the S-, no shift occurs in testing (Terrace, 1964). Unlike the usual successive procedure, this "errorless" procedure does not produce a change in the rate or latency of S+ responses opposite to the change in rate or latency of S- responses (Terrace, 1963). These results suggest that operations which fail to produce such "behavioral contrast" (Reynolds, 1961) during (S+,S-) training lead to the absence of a shift in subsequent testing. Thus, only when training operations have involved a successive (S+,S-) procedure in which S- responding and behavioral contrast occurred has a shift been observed in testing.

Given training operations sufficient to produce a peak shift, the question arises as to whether S- responding must also occur in testing. Most experiments have varied test conditions following simple S+ training without any S-. Hiss and Thomas (1963) have shown that if only one stimulus is presented to each bird during testing, the resulting group gradient is similar to gradients obtained by presenting every stimulus to each bird. But in another experiment, gradients obtained using single stimulus presentations were different from gradients obtained using multiple stimulus presentations (Kalish and Haber, 1963). However, Thomas and Barker (1964) showed that this difference is probably not due to the

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method of stimulus presentation, but to a steepening of the gradient as testing, or extinction, progresses. Furthermore, Hearst and Poppen (1965) have shown "that the opportunity for subjects to compare stimuli during testing . . . is not critical in accounting for the steepening-in-extinction effect" (p. 83). These results following simple S+ training imply that gradients following (S+,S-) training might also be independent of the method of stimulus presentation. Honig (1962) varied test conditions after simultaneous and successive (S+,S-) training as well as after simple S+ training. Following any given training condition, the peak of the gradient obtained under simultaneous test conditions occurred at the same stimulus value as the peak obtained under successive conditions. The present study further alters the test conditions, to eliminate any opportunity for S- responding or comparison of S+ and S-; it asks if a positive peak shift will occur if the S- and stimuli around it are not presented in testing.

The present study also asks if a negative shift will occur if the S+ and surrounding stimuli are not presented. A negative shift is defined as displacement of a minimum away from the S-, in the direction opposite the S+. In most peak shift experiments, there have been so few responses to the S- that a further decrease in responding to adjacent stimuli could not convincingly be observed. But in one experiment (Guttman, 1965), when responding did occur to the S- in testing, due to specific pretraining over the whole continuum and a weak discrimination training criterion, a negative shift was observed. If a negative shift were to occur in the present experiment, it would indicate that specific pretraining, a weak discrimination criterion, and the presence of the S+ in testing are not necessary to produce a negative shift.

In short, a peak shift has occurred only after successive (S+,S-) training, where S- responding was observed. The first two experiments of the present study ask if the absence of successive (S+,S-) presentations during testing affects the occurrence and amount of shift. The method involves training a successive discrimination, and then testing over only half of the continuum: the half centered around the S+ to investigate a positive shift, and the half around the S- to investigate a negative shift. Effects of spacing of test stimuli

on the amount of shift were determined by using 6 m μ spacing in one experiment, and 2 m μ spacing in the second. Since the ordering of the halves assumed importance, a third experiment involved a generalization test which simply began at either end of the continuum and worked through to the other.

METHOD

Subjects and Apparatus

Twenty-four male White Carneaux pigeons, between 1 and 2 yr of age, all experimentally naive, were maintained at approximately 75% of free-feeding weights.

The birds worked in a ventilated, light-tight aluminum box. Each bird pecked a translucent, circular, 3/4-in. response key, operated by a minimum force of 10 g. Below and to the left of this key was an aperture for food presentation via a solenoid-operated food magazine. During each 4-sec food presentation, a white, luminescent disc dimly illuminated the feeding aperture. A speaker in the box provided white masking noise.

Stimulus system. Light from a ribbon filament lamp, run on stabilized voltage at 17 amp ac, went to a motor-driven Bausch and Lomb 250-mm grating monochromator, with a band width of 13.2 m μ . The light beam then passed through an infra-red absorbing filter, two achromatic lenses, and an appropriate Wratten neutral density filter, which was placed in the beam by a motor-driven filter wheel. (The experimenter had taken brightness measurements at the response key, with a MacBeth illuminometer. Because of the similarity between human and pigeon spectral sensitivity functions (Blough, 1957), it is assumed that the corresponding filter corrections provided stimuli of approximately constant luminance for the pigeon.) Finally, with a shutter open, the beam could pass through another lens, to be projected on the back of the response key.

Control and recording. From an adjacent room, relays, timers, and tape programmers controlled presentation of stimuli and reinforcements. A cumulative recorder and counters recorded all key pecks.

Procedure

Training. All 24 birds received the same training. In session 1, each bird was magazine

trained, shaped to key peck, and given 25 reinforcements on a continuous reinforcement (CRF) schedule. The response key was continuously illuminated by 550 $m\mu$, and a house light was on during this session. In every subsequent session, the only light besides the response key was a dim feeder light which accompanied each 4-sec reinforcement. In session 2, every bird first produced 25 reinforcements on a CRF schedule in the presence of 550 $m\mu$. From this point on, a variable interval 1-min schedule (VI 1) was in effect whenever the key was illuminated by 550 $m\mu$. This last part of session 2 consisted of 60 30-sec presentations of 550 $m\mu$, and session 3 consisted of 120 presentations, all alternated with 10 sec of black-out. For all S+ presentations, the 30-sec timer stopped during each reinforcement.

Successive discrimination training began in session 4. In each discrimination session, 30-sec stimulus presentations again alternated with 10 sec of black-out but the stimulus was either 550 $m\mu$ (S+) or 574 $m\mu$ (S-). Each occurred 60 times. The S+ and S- were presented in a mixed order, with the restriction that within every block of 10 presentations, each occurred five times. Furthermore, neither stimulus could occur more than three successive times. Discrimination training stopped after four discrimination sessions (sessions 4-7) only if the following criterion had been met: no responses to S- over any two successive blocks (a total of 10 S- presentations). If the criterion had not been met by the end of session 7, training continued until it was met.

Testing

For all three experiments, conditions of extinction held during testing. As in training, 30-sec stimulus presentations alternated with 10-sec black-outs. Each experiment involved eight birds, placed into two groups of four, each group having given the same total number of responses on the last day of training.

Experiment I. On test day 1, Group I received five different stimuli, ranging from 538 $m\mu$ to 562 $m\mu$ in 6 $m\mu$ steps. This range is called the "positive half," since it is centered around the S+, 550 $m\mu$. Group II received the "negative half," 562 $m\mu$ to 586 $m\mu$. On test day 2, the halves were reversed, so that Group I now received the negative half, and Group II the positive half. On test day 3, after one re-

training session, both groups received all nine stimuli. For every test day, the order of presentation was determined by reading across a stimulus array containing 10 rows, with each stimulus appearing only once in each row. The array was further arranged so that each stimulus followed itself and every other stimulus at least once.

Experiment II. The same rules of order of presentation held as in Exp I. Four more stimuli were added to each half, so that 2 $m\mu$ spacing instead of 6 $m\mu$ spacing occurred around the S+ and S-. Group I received the positive half on day 1, and Group II the negative. The halves were reversed on day 2.

Experiment III. The order of stimulus presentations was not mixed, but arranged in a successively increasing or decreasing sequence. Each stimulus was presented 10 times in a row. Starting at the positive end of the continuum, Group I received 538 $m\mu$ for 10 successive presentations, then 544 $m\mu$ for 10 presentations, then 550 $m\mu$, and so on in 6 $m\mu$ steps to 586 $m\mu$. Group II began at the negative end, with 586 $m\mu$, and worked toward the positive. On day 2, the conditions were reversed, so that Group I began with 586 $m\mu$, and Group II with 538 $m\mu$.

RESULTS and DISCUSSION

Discrimination training

By the end of session 7, 21 birds had met the discrimination criterion. Three birds, #10, #17, and #21, required 24, 10, and 59 extra blocks of stimuli before meeting criterion. Considering all 24 birds over the last 60 S+ presentations (30 sec each), total S+ responding ranged from 776 to 3683; and over the last 60 S- presentations, total S- responding ranged from 0 to 283. High S+ responding did not imply high S- responding, for the Spearman rank correlation coefficient equalled -0.01. The S+/(S+ and S-) response ratios, calculated over the last 60 S+ and the last 60 S- presentations, ranged from 0.85 to 1.00. When birds were placed into test groups, the between-group ratios did not differ. The re-training ratios for all birds ranged from 0.94 to 1.00.

Experiment I

Positive shift. On day 1 of testing, Group I received the positive half of the continuum.

The mean gradient shows a peak at 544 $m\mu$, followed by a decrease in responding through 550 $m\mu$, and out to 562 $m\mu$ (Fig. 1). A positive shift is shown by all four birds in Group I. The individual gradients are higher at both 538 $m\mu$ and 544 $m\mu$ than at 550 $m\mu$. Two gradients peak at 538 $m\mu$, and two at 544 $m\mu$. Although Group II did not receive the positive half of the continuum until day 2, its mean gradient is very similar to that of Group I (Fig. 2). All four birds in Group II show a positive peak shift; they responded more to 538 $m\mu$ and 544 $m\mu$ than to 550 $m\mu$. As with the individual gradients of Group I, two peaks occur at 538 $m\mu$ and two at 544 $m\mu$.

The above gradients obtained over only the positive half of the continuum may be compared with those of Hanson (1959), who obtained gradients over the whole continuum. The present training procedure and criterion of discrimination were adapted from Hanson's

experiment. His S+ was also 550 $m\mu$, and one of his training groups had an S- of 570 $m\mu$, only 4 $m\mu$ from the present S- of 574 $m\mu$. The main differences occurred during testing. Whereas the present groups received five stimuli spaced 6 $m\mu$ apart over only a 24 $m\mu$ range which did not include the S-, Hanson's group received 13 stimuli spaced 10 $m\mu$ apart over a 140 $m\mu$ range, which did include the S-. The gradient of Hanson's experiment peaked at 540 $m\mu$, a value not given in the present experiment, in which four peaks occurred at 538 $m\mu$ and four at 544 $m\mu$. Averaging these values gives a peak at 541 $m\mu$, very close to Hanson's 540 $m\mu$ peak. Hanson measured the amount of displacement of his gradients by determining for each subject the percent of the total number of responses emitted to stimuli to the left of the S+. These values ranged from about 48% to about 82%. In the present experiment, values ranged from 63%

Fig. 1. Percent of total responses during extinction as a function of the positive half of the test continuum on day 1 and the negative half on day 2. On day 1, response totals for Birds 1-4 were: 1564, 503, 1564, and 1087 respectively; and on day 2: 94, 1, 42, and 6.

EXPERIMENT I, GROUP II

Fig. 2. Percent of total responses during extinction as a function of the negative half of the test continuum on day 1 and the positive half on day 2. On day 1, response totals for Birds 5-8 were: 1265, 783, 1430, and 296 respectively; and on day 2: 1185, 1268, 643, and 397.

to 87% for all eight birds, showing considerable overlap with Hanson's values. That is, the combined operations of reducing the range, number, and spacing of test stimuli, and omitting the S- did not noticeably affect the amount of shift.

Thus, not only do simultaneous *vs* successive presentations of test stimuli have little effect on the post-discrimination gradient (Honig, 1962), but so also does presence *vs* absence of the S- in testing. Just as "active comparison" of stimuli is not necessary to produce a simple generalization gradient (Hiss and Thomas, 1963), neither is "active comparison" of S+ and S- necessary to produce a post-discrimination gradient. It therefore seems that production of a peak shift depends largely on training, rather than testing, operations.

Negative shift. When only the negative half of the continuum was presented on the first

test day, the overall responding to it was much higher than if the whole continuum had been presented (*e.g.*, Hanson, 1959). This allows investigation of a negative shift following the usual (S+, S-) training. The gradient of Group II on day 1 shows an orderly decrease in percent total responses, from 562 mμ to 586 mμ (Fig. 2). Thus, although in training every bird had met the criterion of no responding over 10 S- presentations, in testing when the S- was also presented 10 times, minimum responding was displaced away from the S-, in the direction opposite the S+. All four birds in Group II show this negative shift, as well as an orderly decrease from 562 mμ to 586 mμ. When Group I received the negative half on day 2, three birds show a maximum at 562 mμ (Fig. 1). However, nothing can be said of a shift, since few or no responses were given to each stimulus beyond 562 mμ.

Responding to 562 mμ. Figures 1 and 2

show that when 562 $m\mu$ occurred in the positive half it received fewest responses; and when it occurred in the negative half, it received most responses (with one exception in Group I, day 2). If a typical gradient over the whole continuum were taken and split at 562 $m\mu$, the above would also hold. Thus, results regarding both the positive shift and responding to 562 $m\mu$ indicate that relative responding over a given half of the continuum is predictable from relative responding over the whole continuum.

What is not directly predictable from a gradient obtained over the whole continuum is the absolute number of responses to 562 $m\mu$ when it appeared in each half. On day 1, the total number of responses to 562 $m\mu$ by each bird in the positive group (Group I) was 1, 32, 39, and 46; on the same day, the responses to 562 $m\mu$ by each bird in the negative group (Group II) were 216, 355, 503, and 659. That is, more absolute responses were given to 562 $m\mu$ when it was presented with the negative half than with the positive half.

Positive shift after retraining. After retrain-

ing, both groups were tested with all test stimuli. The gradients of the groups are very similar (Fig. 3); both show a peak at 544 $m\mu$, and an orderly decrease to 586 $m\mu$. A comparison with days 1 and 2 shows that the four birds which had previously peaked at 538 $m\mu$ now peaked at either 544 $m\mu$ or 550 $m\mu$. The four which had previously peaked at 544 $m\mu$ still peak here, but the second highest number of responses occurs at 550 $m\mu$ rather than at 538 $m\mu$. It would be important to determine how much of this decrease in amount of shift is due to retesting, over the whole continuum after only half, and how much to retraining. The amount of shift increases with amount of training given before all test stimuli are presented (Thomas, 1962); and the amount of shift decreases with repeated testing in a "multivalued S- situation" where the S+ is still correlated with reinforcement (Pierrel and Sherman, 1962). It might be that the training before testing (Thomas, 1962) affects the shift one way, and training during testing (Pierrel and Sherman, 1962) or after testing (the present experiment) affects it another way.

EXPERIMENT I, Day 3

Fig. 3. Percent of total responses during extinction following one day of retraining. Response totals for Birds 1-4 were: 1427, 602, 377, and 702 respectively; and for Birds 5-8: 2184, 1115, 1251, and 403.

Experiment II

Positive shift. With only 2 $m\mu$ spacing, the mean gradient for Group I on day 1 shows a positive shift, with a peak at 544 $m\mu$, and an orderly decrease to a minimum at 562 $m\mu$ (Fig. 4). Similarly, the individual curves for Group I show fairly orderly gradients and a peak shift, in spite of difficult conditions for a discrimination. That is, stimuli were spaced only 2 $m\mu$ apart, equated for brightness, presented successively, and accompanied by no differential reinforcement.

The additional stimuli did affect the amount of shift. In Exp I, two birds in Group I peaked at 538 $m\mu$, and two at 544 $m\mu$. If the amount of shift is independent of the test series, then when 546 $m\mu$ and 548 $m\mu$ are added, some birds should still peak at 538 $m\mu$. Instead, two birds peaked at 544 $m\mu$ and two at 546 $m\mu$. Furthermore, the amount of dis-

placement, as measured by percent of total responses to stimuli to the left of the S+, is smaller for all birds in Group I of Exp II (a range of 55%-61%) than for all birds in Group I of Exp I (63%-77%). The mean gradient for Group II when it received the positive half shows an orderly increase to 546 $m\mu$, followed by a decrease out to 562 $m\mu$, with one deviant point at 552 $m\mu$ (Fig. 5). Individual gradients do not differ from those of Group I with respect to peak location or amount of displacement. A comparison between Fig. 1 and 4 indicates that the gradient flattens when more stimuli are added around the S+. Indeed, relative responding to the left of the S+ is less in Exp II than in Exp I. That is, for Group I on day 1 of each experiment, responding to 538 $m\mu$ divided by responding to 550 $m\mu$ was less for all four birds in Exp II than for all four in Exp I. This also holds for relative responding to 544 $m\mu$. On the other

EXPERIMENT II, GROUP I

Fig. 4. Percent of total responses during extinction as a function of the positive half of the test continuum on day 1 and the negative half on day 2. On day 1, response totals for Birds 9-12 were: 465, 1598, 718, and 985 respectively; and on day 2: 19, 9, 6, and 31.

EXPERIMENT II, GROUP II

Fig. 5. Percent of total responses during extinction as a function of the negative half of the test continuum on day 1 and the positive half on day 2. On day 1, response totals for Birds 13-16 were: 692, 2355, 1025, and 1395 respectively; and on day 2: 1149, 1442, 22, and 1945.

side of the S+, relative responding to 556 $m\mu$ and 562 $m\mu$ did not differ between experiments.

Thus, with a 6 $m\mu$ to 2 $m\mu$ reduction in spacing, the amount of positive shift decreased and the gradient flattened. Comparing the 6 $m\mu$ gradient taken over a small range with Hanson's 10 $m\mu$ gradient taken over a large range showed no such change in amount of shift. Furthermore, when Friedman (1961) tested over 5, 10, and 20 $m\mu$ spacing, with the smallest range occurring with 5 $m\mu$ spacing, he found no differences in slopes of resulting gradients. It is therefore possible that a change in relative responding occurs only with extremely small spacing, and/or with the range held constant. When spacing was decreased with the range held constant, it was necessary to add more stimuli, and the amount of extinction increased. However, it is unlikely that simply increasing the amount of extinction would cause a flattening (Thomas and Bar-

ker, 1964; Hearst and Poppin, 1965). A series of experiments would be required to determine whether adding more stimuli or decreasing spacing is the important variable in changing relative responding.

Negative shift. Group II received the negative half on day I. The resulting gradient was also less steep than in Exp I (Fig. 2 and 5). Responding to both 562 $m\mu$ and 568 $m\mu$, relative to S-, was less in Exp II than in Exp I. No change in relative responding occurred to stimuli to the right of S-. The gradient for Group II on day 1 shows a decrease in responding from 562 $m\mu$, through the former S-, and out to 586 $m\mu$ (Fig. 5). Gradients for three of the birds are similar to the mean gradient. The other bird, #16, shows a general decline, but it is not orderly. With Group I on day 2, two birds show a maximum at 562 $m\mu$, but the other two had stopped responding before 562 $m\mu$ was presented (Fig. 4).

Responding to 562 $m\mu$. Responding to 562

m_μ relative to a given half is again predictable from gradients taken over the whole continuum. When 562 m_μ appeared in the positive half, seven birds gave the lowest number of responses to this stimulus. When 562 m_μ appeared in the negative half, the two birds in Group I that responded over more than the first few stimulus presentations, and all birds in Group II responded most to it (Fig. 4 and 5). As in Exp I, the absolute number of responses to 562 m_μ was less when 562 m_μ appeared in the positive half than in the negative half. On day 1, the total number of responses to 562 m_μ when in the positive half was only 3, 4, 4, and 48 for each bird; on day 1 the total number to 562 m_μ when in the negative half was 187, 233, 295, and 579.

Experiment III

In this experiment, the test stimuli were presented in either a successively increasing or decreasing order, so that each group started at one end of the continuum and then proceeded in 6 m_μ steps to the other end. Group I went

from the positive to the negative end on day I. As shown in Fig. 6, three birds peaked at 538 m_μ , and one at 544 m_μ . This apparent peak shift may be an extinction effect, since 550 m_μ was presented later in the session than 538 m_μ and 544 m_μ . All birds showed an orderly decrease to the right of the peak. However, responding did not continue past the first half of the session. Two birds did not respond after 556 m_μ , and two did not after 562 m_μ . Similarly, an abrupt cut-off in responding occurred with Group II on day 2, with no responses after 544 m_μ for one bird, and none after 556 m_μ for three birds (Fig. 7).

This abrupt stop did not occur with Group II on day 1, when it went from the negative to the positive end of the continuum (Fig. 7). For all four birds, responding continued throughout day 1, and even increased from 586 m_μ through the former S—. One gradient peaks at 574 m_μ (the third stimulus presented), two peak at 568 m_μ (the fourth), and one peaks at 556 m_μ (the fifth). Later in the session, effects of extinction take over; the group curve

EXPERIMENT III, GROUP I

Fig. 6. Percent of total responses during extinction as a function of positive to negative ordering on day 1 and negative to positive ordering on day 2. On day 1, response totals for Birds 17-20 were: 983, 1278, 992, and 316 respectively; and on day 2: 15, 518, 316, and 104.

reaches a maximum at 568 $m\mu$, and then decreases. On day 2, when Group I began at 586 $m\mu$ and went to 538 $m\mu$, the peak is even further to the left with a group peak at 550 $m\mu$ (Fig. 6). Taken individually, two birds peak here, one at 544 $m\mu$, and one at 538 $m\mu$, the last stimulus presented. In addition to this change in peak location during a second test session, the percent of total responses for stimuli over the last part of the session indicates more relative responding later in the session for Group I, day 2 than for Group II, day 1. That is, the combined percents of total responses to the last three stimuli presented (550 $m\mu$, 544 $m\mu$, and 538 $m\mu$) are greater for each bird in Group I than for each bird in Group II.

Response totals, Exp I, II, and III

Within each experiment, birds went either from the positive to the negative half of the continuum, or from the negative to the positive. In Exp I and II, Group I received the positive half on day 1 and then the negative

on day 2, while Group II received the reverse. Experiment III differed in that stimulus presentations were ordered along the continuum, and each group received the two halves within the first session.

Response totals in Exp I, where stimuli were mixed, did not differ from those in Exp III, where stimuli were ordered. That is, a comparison of Groups I over their first-presented positive half (538 $m\mu$ - 562 $m\mu$) shows 503, 1087, 1564, and 1564 responses for each bird in Exp I; and 316, 983, 992, and 1278 responses for each bird in Exp III. A comparison of Groups II over their first-presented negative half (586 $m\mu$ - 562 $m\mu$) shows 296, 783, 1265, and 1430 responses for each bird in Exp I; and 393, 1146, 1189, and 1957 responses for each bird in Exp III. Thus, over the restricted range of 24 $m\mu$ (i.e., 538 $m\mu$ - 562 $m\mu$ or 586 $m\mu$ - 562 $m\mu$), ordered *vs* mixed stimulus presentations did not differentially affect total responding.

Within each experiment, one might ask if the group getting the positive half responded

Fig. 7. Percent of total responses during extinction as a function of negative to positive ordering on day 1 and positive to negative ordering on day 2. On day 1, response totals for Birds 21-24 were: 1842, 2903, 840, and 1633 respectively; and on day 2: 140, 164, 24, and 88.

more than the group getting the negative half, and furthermore if this difference held when the halves were reversed for each group. In order to decrease individual differences in response totals, each bird's total over a given half was weighted by its total (or rate, since time was constant) for the final training session. (Hearst, Koresko, and Poppin [1964], have shown that there is a positive correlation between response rate during VI training and total responses during generalization testing.) Figure 8 presents these weighted totals taken over each half, and over the halves combined. Points are connected simply to join the data for any given bird. The first set of points in each graph represents the first half presented; for Group I, it was the positive half, and for Group II the negative. Within any of the three experiments, the two groups do not differ. The second set of points represents the second half presented. In each experiment, the groups do differ, with each bird in the group now receiving the positive half (Group II) giving more weighted responses than the group (Group I) now receiving the negative half. This difference is reflected in the totals over both halves, with Group II, which went from negative to positive giving more than Group I, which went from positive to negative.

It is puzzling that the positive half of the continuum did not produce more responding on the first test day than did the negative half. On day 1, the range of absolute responses in Exp I for the positive half was 503 for the lowest bird to 1564 for the highest bird *vs* 296 to 1430 for birds getting the negative half; in Exp II for the positive half (465-1598) *vs* (692-2355) for the negative half; and in Exp III for the ordered positive half (316-1278) *vs* (393-1957) for the ordered negative half. Yet on day 2, the range of absolute responses in Exp I for the positive half was (397-1268) *vs* only (1-94) for the negative half; in Exp II for the positive half (22-1945) *vs* (6-31) for the negative half; and in Exp III for the ordered positive half following the ordered negative half on day 1 (654-1391) *vs* (0-6) for the ordered negative half following the ordered positive half on day 1.

The concept of behavioral contrast (Reynolds, 1961) comes closest to handling this lack of difference in response totals, followed by a difference. Contrast experiments suggest that responding to stimuli associated with different frequencies of reinforcement would become more different if these stimuli were presented to the same subject, rather than to different subjects. That is, if responses to the positive and negative half did not differ when

Fig. 8. Weighted response totals for each bird. Open circles represent birds tested on the positive half during day 1 (Exp I and II) or during the first half of the session (Exp III), and on the negative half during day 2 or during the second half of the session. Filled circles represent birds tested on the negative half on day 1 and the positive half on day 2.

each group received only one half, responses would be expected to differ when each group had received both halves. The present results do show that following no difference between birds tested with the positive half and birds tested with the negative half, when the second half was presented, birds going from the positive to negative half responded far less often than birds going from negative to positive. However, this is an extended application of behavioral contrast. In previous contrast experiments, both positive and negative stimulus presentations alternated within a session; here they did not. Usually, at least one of the stimuli was correlated with a reinforcement schedule; here, one of the stimuli *had been* correlated with a reinforcement schedule. Hopefully, further investigation will show how useful it is to extend contrast to the present context.

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