JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR VOLUME 9, NUMBER 6 NOVEMBER, 1966

SOME EFFECTS ON GENERALIZATION GRADIENTS OF TANDEM SCHEDULES[1]

MATTHEW YARCZOWER, JAMES F. DICKSON,[2] AND LEWIS R. GOLLUB

UNIVERSITY OF MARYLAND

The relationship between training conditions and stimulus generalization gradients was examined using tandem schedules of reinforcement. Schedules were selected so that frequency of reinforcement and rate of responding were varied somewhat independently of each other. A peak-shift in the generalization gradient was obtained when extinction had been associated with one of the stimuli. No comparable peak shift was obtained when there were equal response rates in the training stimuli even with dissimilar frequencies of reinforcement. The data imply that response rates at the end of training, rather than reinforcement frequency *per se*, determine the characteristics of the generalization gradient.

Studies of the effects of multiple schedules (two or more schedules of reinforcement each consistently associated with a different exteroceptive stimulus) of reinforcement on generalization gradients can be placed into two classes. In one class, usually called "discrimination" experiments, different rates of responding are generated in the training stimuli by different schedules of reinforcement (Guttman, 1959; Hanson, 1959). In the other class, usually called summation experiments, identical rates of responding are established in the training stimuli by using the same schedule of reinforcement in each stimulus (Kalish and Guttman, 1957, 1959).

A review of the first class suggests that when certain types of rate changes occur during discrimination training, the form of the stimulus generalization gradient also changes. The most important feature of the discrimination training is whether the response rate in the presence of the stimulus correlated with positive reinforcement (*i.e.*, the positive stimulus) is increased over some control value. This increase, when it occurs, is called "positive contrast." Reynolds (1961*a*) has defined positive contrast by reference to rate changes during multiple schedules of reinforcement. The response rate during the presentation of one stimulus may change when the schedule associated with a different stimulus is altered. "A positive contrast . . . would be an increase in the rate of responding in one component in a direction away from the rate prevailing in the other component" (Reynolds, 1961*a*, p. 115). When positive contrast occurs, the stimulus generalization gradient shows a "peak shift" (Hanson, 1959; Terrace, 1964; Friedman and Guttman, 1965). The peak shift has been defined as a difference in the distribution of responses to the several stimuli presented during the generalization test of subjects trained under a discrimination procedure, compared to those trained only with the positive stimulus (Hanson, 1959; Terrace, 1964). For example, consider stimulus generalization with wavelength stimuli. One group of subjects is given discrimination training involving a negative stimulus with a longer wavelength than that of the positive stimulus. A second group is given single stimulus training, involving only training to the same positive stimulus. The generalization gradient of the discrimination group will show a greater number of responses to stimuli of shorter wavelength than the positive stimulus compared to the gradient of the group given only single stimulus training. Conversely, when positive contrast is not observed during discrimination training, a peak-shift does not occur (Terrace, 1964). Peak-shifts have been obtained when extinction was one component of the training schedule (Hanson, 1959; Ter-

---

[1] This research was supported in part by USPHS Grants No. MH 08819-01 and MH-01604-09 from the National Institutes of Health. Reprints may be obtained from Matthew Yarczower, Dept. of Psychology, University of Maryland, College Park, Maryland 20742. The authors would like to thank Dr. Stanley S. Pliskoff for his advice and aid throughout the course of these experiments.

[2] Now at St. Olaf College.

race, 1964; Friedman and Guttman, 1965) as well as when both components involved positive reinforcement (Guttman, 1959). The present experiment investigated the effects of pairs of training schedules involving extinction as well as pairs of different positive reinforcement schedules.

There are fewer experiments in the second class but, as one example, consider Kalish and Guttman (1957). They studied the case in which identical reinforcement schedules were paired with each of the different training stimuli to produce what were probably equal rates of responding in each stimulus. The stimulus generalization gradients following this training were quite different from gradients following training with a single stimulus. However, the differences cannot be ascribed to reinforcement frequency alone, since response rates and reinforcement frequency co-varied.

It is possible to conceive of an experiment intermediate between these two classes. It could provide different frequencies of reinforcement, a characteristic of the first class of studies, but generate equal rates of responding in the presence of the two discriminative stimuli, a characteristic of the second class. Perhaps in this way we may begin to investigate the effects on generalization gradients of differential frequency of reinforcement as well as of differential response rates. The schedule chosen in an attempt to vary rate of responding and frequency of reinforcement somewhat independently of each other was a tandem (*tand*) variable interval (VI) differential reinforcement of low rates (DRL). In this schedule, reinforcement is made available at varying periods after the previous reinforcement, according to the VI schedule. When a reinforcement is available, only a response that occurs with a specified minimal interresponse time (IRT) can be reinforced. This specified minimal interresponse time is the value of the DRL schedule. In other words, the VI schedule determines the frequency of food reinforcement and the DRL schedule determines the response rate, by placing an upper limit on the rate that can be reinforced (*cf.* Ferster and Skinner, 1957; Blough, 1963).

Subjects and Apparatus

Twenty Silver King pigeons, three to five years old, were maintained at approximately 75% of their free-feeding body weights throughout the experiment. The experimental chamber, made of Plexiglas except for the aluminum response panel, measured 13 in. long, 15½ in. wide, and 18½ in. high. An aluminum disc with 1½-in. circular openings into which Bausch and Lomb interference filters (44-78 series) and Kodak neutral density filters (No. 96 series) were placed, was used to program the visual stimuli. The illumination source was a GE 18a T10/2P-6v microscope illuminator bulb with a ribbon filament. The collimated monochromatic light transilluminated the translucent response key. All wavelength stimuli were equated for brightness with neutral density filters according to data on the pigeon's photopic sensitivity curve (Blough, 1957). The response panel consisted of a standard Gerbrands pigeon key below which was mounted a Lehigh Valley pigeon feeder.

Procedure

The 20 naive pigeons were divided into five groups of 3, 4, 4, 4, and 5 birds. All subjects were magazine trained on the first day and then given 50 continuous reinforcement trials on the second day with the key illuminated by a 550 nm light. The unit "nm" refers to "nanometer" which is mathematically identical to millimicron. The subsequent treatment is described in detail below, and is summarized in Table 1. The first four groups were exposed during training to a multiple schedule (Ferster and Skinner, 1957) with two stimuli, 550 nm and 570 nm, and the fifth group to only a single stimulus, 550 nm. Group 1, composed of three subjects, received between 13 and 17 days of training to the schedule, *mult* VI 30 sec EXT, in which the schedules were correlated with the 550 nm and 570 nm stimulus, respectively. In this multiple schedule, when the key was illuminated with the 550 nm light, key pecks were reinforced after varying periods of time after the previous reinforcement, with an average time of 30 sec (VI 30 sec), and when the key was illuminated with the 570 nm light, no key pecks were reinforced, *i.e.*, extinction (EXT) was scheduled. This group was used to insure that the peak shift effect could be replicated under the conditions of our apparatus and procedures, using schedules similar to those reported by other investigators.

Group 2 (four subjects) was exposed to a similar multiple schedule; 570 nm was paired with extinction, but 550 nm was paired with a *tand* VI 30 sec DRL 4 sec. As described above, this schedule provides for reinforcement of low rates (DRL) by allowing reinforcement only for interresponse times greater than 4 sec; reinforcements became available on the average of 30 sec after a preceding reinforcement (VI 30 sec). This group enabled us to see whether peak shift would occur after reinforcement on *tand* VI DRL schedules. The DRL feature of this schedule was expected to limit or prevent any rate increase (*i.e.*, positive contrast) in the presence of 550 nm. The lack of positive contrast would be most interesting if a peak shift occurred in later testing.

Group 3 (four subjects) was exposed to a multiple schedule made up of two positive reinforcement schedules, *mult* (*tand* VI 30 sec DRL 4 sec) (*tand* VI 4 DRL 8 sec). The parentheses set off the two schedules, the first paired with 550 nm and the second, with 570 nm. Comparing the second schedule to the first, it can be seen that reinforcement is scheduled only one-eighth as frequently (VI 4 *versus* VI 30 sec) and that a longer interresponse time and hence a lower response rate is required (DRL 8 sec *versus* DRL 4 sec). The purpose of establishing this training schedule was similar to that for Group 2, namely to see whether a peak shift would occur when positive contrast was not allowed in 550 nm by the *tand* VI 30 sec DRL 4 sec schedule. Another schedule, which might produce a peak shift, is, rather than extinction, a schedule with occasional but less frequent reinforcement than during the 550 nm stimulus. The selection of such a schedule was based on the study by Guttman (1959) in which it was found that a peak shift occurred when two VI training schedules differed in frequency of reinforcement.

The schedules for Group 4 (four subjects) were selected to produce equal response rates in each of the stimuli despite greatly different frequencies of food reinforcement. Using tandem VI DRL schedules in each stimulus, this effect can be produced by combining the VI schedule that provides reinforcement more frequently with the longer DRL, and the less frequently reinforcing VI schedule with the shorter DRL. The multiple schedule arbitrarily selected to produce equal rates and unequal reinforcement frequencies was *mult* (*tand* VI 30 sec DRL 4 sec) (*tand* VI 3 DRL 2 sec), paired with the 550 nm key light and the 570 nm key light, respectively.

Group 5 (five subjects) was given training only in the presence of a 550 nm key light, and was the "control" group to which all the other groups were compared. The reinforcement schedule for this single stimulus training was *tand* VI 30 sec DRL 4 sec.

Table 1 contains a summary of the design. All groups given training to two wavelength stimuli had either extinction (Groups 1 and 2) or less frequent reinforcement (Groups 3 and 4) in the presence of the 570 nm light. The column labeled "rft. ratio 570 nm/550 nm" shows the ratio of reinforcement frequencies in the presence of the two stimuli. The response rate in the presence of 570 nm relative to the rate in the presence of 550 nm is shown for each group in the right column. The extinction schedule for Groups 1 and 2 was expected to reduce responding to zero in the presence of 570 nm, whereas the selection of *tand* VI DRL schedules for Groups 3 and 4 was expected to produce lower and equal response rates, respectively. The terms in parentheses roughly summarize the results of training, and indicate the extent to which the design was met. We are in a position to evaluate, independently, the effects on stimulus generalization of response rates and rein-

Table 1

Summary of schedules of reinforcement and expected reinforcement and response ratios.

Group		*Rft. ratio 570 nm/550 nm*	*Resp. rate 570 nm/550 nm*
1	*mult* VI 30″—EXT	0	0
2	*mult tand* VI 30″ DRL 4″—EXT	0	0
3	*mult tand* VI 30″ DRL 4″—tand VI 4 DRL 8″	.20 (.20)*	<1 (<1)
4	*mult tand* VI 30″ DRL 4″—tand VI 3 DRL 2″	.20 (.33)	1 (>1)
5	*tand* VI 30″ DRL 4″	—	—

*obtained data are in the parentheses.

forcement frequencies that were associated with training.

Other details of the training and testing procedure were as follows. The presentation of stimuli in training was alternated in a fashion similar to that of Guttman (1959). Two 4-min trials of 550 nm alternated with two 4-min trials of 570 nm. Each 4-min trial was separated by a 10-sec time-out period (TO) during which the box was dark and no reinforcements were given. Each session consisted of 20 4-min trials, 10 at each stimulus value. The group receiving only single-stimulus training received 10 4-min trials.

On the day of testing, the four discrimination training groups were given four 4-min trials under the appropriate schedules, two trials at each stimulus value. The group given only single-stimulus training received two 4-min trials under the appropriate schedule. Generalization testing followed immediately and consisted of random presentations of seven test stimuli for 30 sec with a 10-sec time-out. There was a total of 56 test trials, eight presentations of the seven test stimuli (520 to 580 nm in 10 nm steps). No reinforcements were available during tests.

RESULTS

The response rates in the presence of 550 nm and 570 nm, and numbers of reinforcements in each session are presented for the individual birds in Fig. 1, 2, and 3. The left column of Fig. 1 shows that relatively high rates of responding were maintained in the presence of the 550 nm key light (VI 30 sec schedule), and near-zero rates in the presence

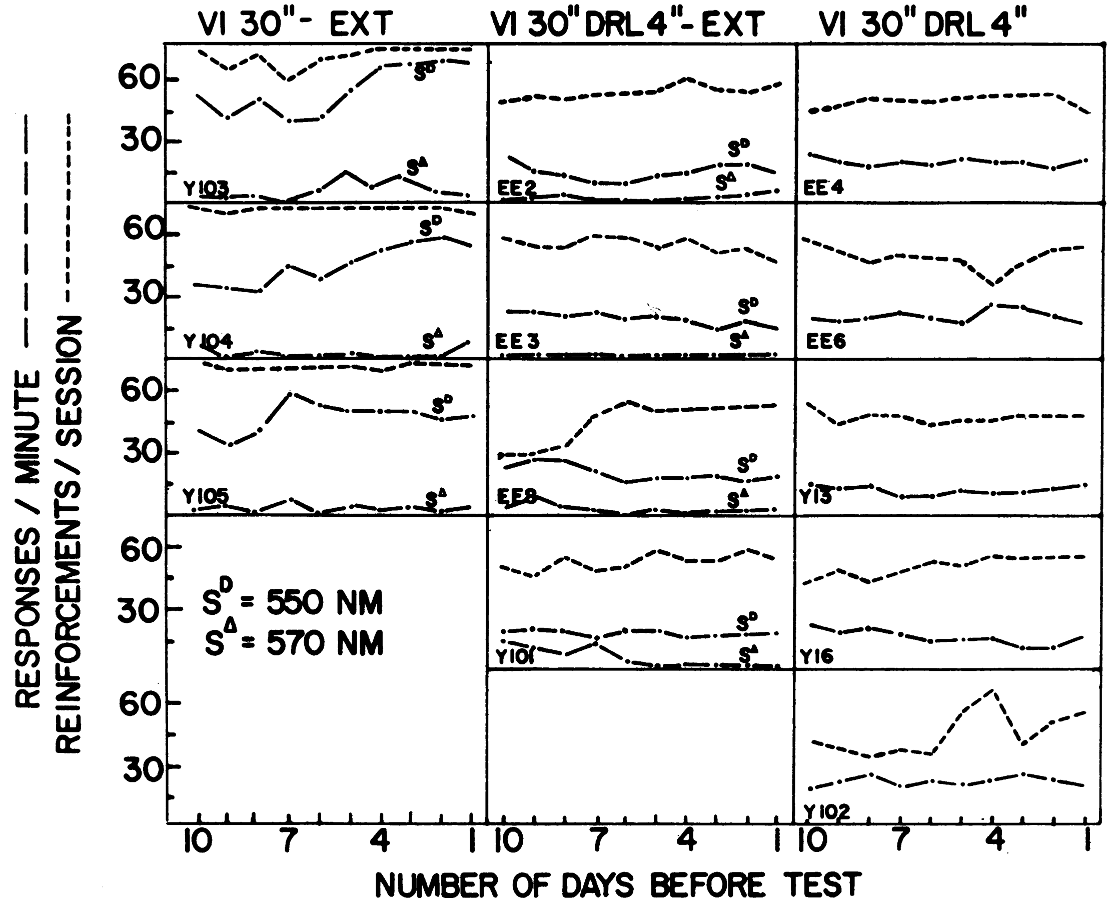

Fig. 1. Mean rates of responding and numbers of reinforcements for each of the last 10 sessions before generalization test for every subject in Groups 1 (*mult* VI 30"—EXT), 2 (*mult tand* VI 30" DRL 4"—EXT) and 5 (*tand* VI 30" DRL 4"). Response rates are shown by the long-dash curves and numbers of reinforcements per session, by the short-dash curve. The unit nm refers to nanometer which is mathematically identical to millimicron.

of the 570 nm key light (extinction). About 70 reinforcements were delivered each session. As shown in the middle column of Fig. 1, when extinction (570 nm key light) was alternated with *tand* VI 30 sec DRL 4 sec (550 nm light), the response rate in the presence of 550 nm was much lower, decreasing from a mean of about 55 responses per min, for responding under VI 30 sec, to about 17 responses per min, for responding under *tand* VI 30 sec DRL 4 sec. (The reinforcement rate also declined in the presence of the 550 nm key light, from about 70 per session to about 52.) The response rate in the presence of 550 nm was the same under *tand* VI 30 sec DRL 4 sec, whether or not this schedule was alternated with extinction and a 570 nm key light. Comparison of the rates for individual subjects shown in the middle and right columns of Fig. 1 shows near equivalence of both response rates and reinforcement frequencies in the presence of the 550 nm key light. Since these two groups have one schedule in common, *tand* VI 30 sec DRL 4 sec, this comparison shows that extinction, alternated with the tandem schedule for one of the groups, produces no difference in response rate. Behavioral contrast, tested here in terms of a difference in response rates for two groups of subjects, did not occur.[3]

The response rate data of the *mult tand* VI 30 sec DRL 4 sec—*tand* VI 4 DRL 8 sec birds are shown in the left column of Fig. 2 and the reinforcement data in the right column. The extent to which the data of these subjects met the objective of being comparable to the data of Guttman (1959) can be evaluated. We attempted to obtain comparable differences in response rate as a function of differences in the frequencies of reinforcement of two schedules. If one calculates the number of reinforcements earned per session in the presence of 550 and 570 nm, the ratio of reinforcements in those respective stimuli is 5:1, the same as in Guttman's study which used a *mult* VI 1 VI 5. The difference in response rates, shown in the left column of Fig. 2, was not as great as in Guttman's study. The present schedules yielded only a 20% difference in total percent of responding (60% in 550 nm, 40% in 570 nm) while Guttman's data show a 35% difference in total percent responses to each stimulus. Note also that the rates of responding in the presence of the 550 nm key light are comparable to the rates of the two groups shown in Fig. 1 trained under a *tand* VI 30 sec DRL 4 sec schedule. In other words, the alternation of this schedule with one providing less frequent reinforcement does not produce behavioral contrast.

The response rates and reinforcement data for the individual birds exposed to the *mult tand* VI 30 sec DRL 4 sec—*tand* VI 3 DRL 2 sec are presented in Fig. 3. The response rate data are shown in the left column and the reinforcement data in the right. Two of the subjects, Y2 and Y7, had overlapping response rates, despite large differences in reinforcement frequency, whereas the other two subjects, Y8 and EE7, had slightly higher response

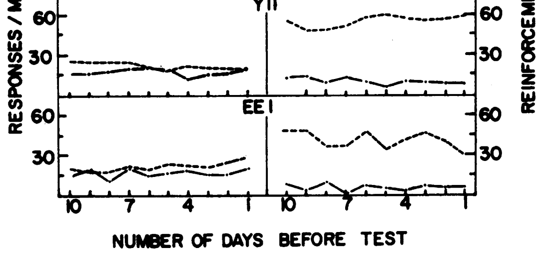

Fig. 2. Mean rates of responding, in the left column, and numbers of reinforcements, in the right column, in each stimulus for the last 10 sessions before generalization test for every subject in Group 3. The two-component schedules of the multiple schedule were *tand* VI 30" DRL 4" and *tand* VI 4 DRL 8", with the key lit by 550 nm and 570 nm lights, respectively. The unit nm refers to nanometer which is mathematically identical to millimicron.

---

[3] It is possible that behavioral contrast is less likely to occur when both S+ and S— stimuli are alternated at the very beginning of training. Reynolds and Catania (1961) found contrast in a *mult* DRL-EXT schedule when EXT was introduced after base-line data had been obtained on a mult DRL 21"-DRL 21". Also, three months after the present study birds EE1, EE2, EE7, EE8, and Y101 were exposed to a *tand* VI 30" DRL 4" in the presence of 550 nm and when the rates were again stable a *mult tand* VI 30" DRL 4"—EXT was introduced. All birds showed significant rate increases in the presence of the positive stimulus *i.e.*, behavioral contrast.

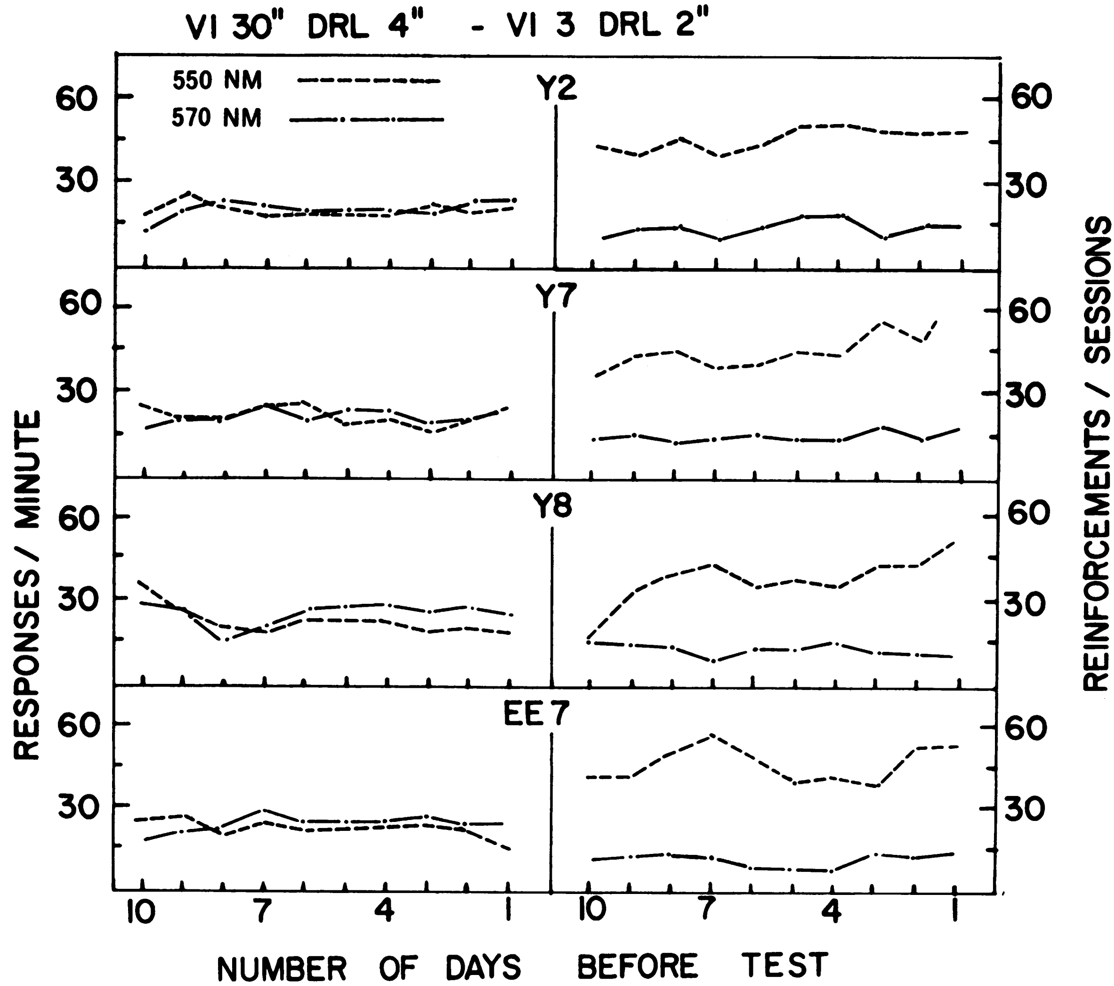

Fig. 3. Mean rates of responding, in the left column, and numbers of reinforcements, in the right column, in each stimulus for the last 10 sessions before generalization test for every subject in Group 4. The two-component schedules of the multiple schedule were *tand* VI 30″ DRL 4″ and *tand* VI 3 DRL 2″, with the key lit by 550 nm and 570 nm lights, respectively. The unit nm refers to nanometer which is mathematically identical to millimicron.

rates in the presence of the 570 nm key light which had the lower reinforcement frequency. The attempt to eliminate the positive correlation between response rate and reinforcements per session was successful. If anything, responding under the schedule giving fewer reinforcements was higher than responding under the schedule giving more reinforcements per session. The attempt to achieve the 5:1 reinforcement ratio, the same difference as for Group 3 (Table 1), was not successful. The approximate ratio of reinforcements in the presence of 550 and 570 nm was 3:1. The mean rate of responding in the presence of 550 nm for these subjects was higher than the mean response rate of the group given only single-stimulus training (Group 5). Thus, discrimination training produced an increase in responding in the presence of 550 nm. This increase in responding is, however, more appropriately called induction rather than contrast (Reynolds, 1961*a*). Induction refers to a change in rate in one component in a direction *toward* the rate prevailing in the other component. Since the rate in 570 nm was, if anything, higher than that in 550 nm it appears more appropriate to label the rate increase in 550 nm, induction.

The generalization gradients are shown in Fig. 4. The five curves divide themselves into two types: the groups of pigeons trained on *mult* VI 30 sec—EXT and *mult tand* VI 30 sec

DRL 4 sec—EXT both show a peak-shift, with more responding to wavelengths shorter than 550 nm and less responding to wavelengths longer than 550 nm. It should be noted that the *mult tand* VI 30 sec DRL 4 sec—EXT group did not show behavioral contrast during training. Nevertheless, a peak-shift in the generalization gradients was obtained. The other three groups have curves rather similar in appearance. The gradient for the birds given *mult tand* VI 30 sec DRL 4 sec—*tand* VI 4 DRL 8 sec differs markedly from gradients produced by birds trained with extinction as one component in the multiple schedule. The gradient does not in fact differ markedly from the gradient (Group 5) obtained after single-stimulus training ($p = .112$, Mann-Whitney U test). It thus appears that the generalization gradient is not necessarily affected by discrimination training in which the training stimuli are associated with different frequencies of reinforcement.

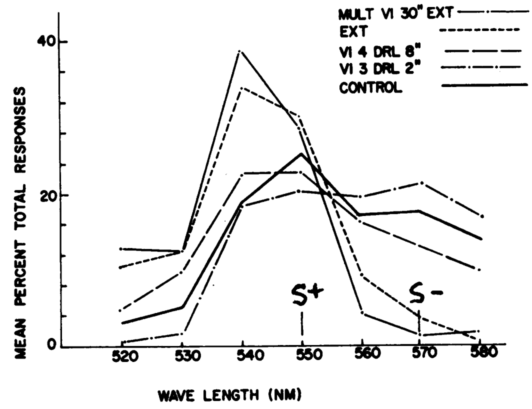

Fig. 4. Stimulus generalization gradients of all subjects. The mean relative response rate for each group (percent of total responses) is plotted against each of the stimuli in the generalization test (wavelength of light on response key, nm). All five groups are represented, and the curves for each are labeled in the following way: Group 1, after *mult* VI 30″—EXT: mult VI 30″ EXT; Group 2, after *mult tand* VI 30″ DRL 4″—EXT: EXT; Group 3, after *mult tand* VI 30″ DRL 4″—*tand* VI 4 DRL 8″: VI 4 DRL 8″; Group 4, after *mult tand* VI 30″ DRL 4″—*tand* VI 3 DRL 2″: VI 3 DRL 2″; and Group 5, after *tand* VI 30″ DRL 4″: CONTROL. In other words, the groups (2-4) trained with *tand* VI 30″ DRL 4″ in the 550 nm key light are designated by an abbrevation of the schedule that had been presented in the 570 nm stimulus; Group 5, with no prior exposure to 570 nm is designated CONTROL, and Group 1, not trained under tandem schedules, is labeled in full, *mult* VI 30″ EXT. The unit nm refers to nanometer which is mathematically identical to millimicron.

One interesting comparison is between the data of the birds trained under a *mult tand* VI 30 sec DRL 4 sec—*tand* VI 3 DRL 2 sec with the data of those trained under a *mult tand* VI 30 sec DRL 4 sec—*tand* VI 4 DRL 8 sec. Both schedules provided less frequent reinforcement in 570 nm, but the first schedule produced equal, or slightly lower rates in 550 nm compared to 570 nm, whereas the second produced slightly higher rates in 550 nm. All birds trained under the first schedule emitted a greater percentage of responses in the presence of stimuli associated with less frequent reinforcement and a slightly higher rate. These data suggest that response rates before generalization tests are an important factor affecting gradient shape. This suggestion has been made by Migler (1964) in a slightly different context. Migler suggested that generalization gradients may be ". . . an artifact of averaging . . . different behaviors" (p. 307). An implicit assumption in Migler's argument is that the differential behaviors or, in the present case, the different response rates, maintained during discrimination training contribute more to the characteristics of the generalization gradient than do the differential reinforcement contingencies that produced the different behaviors.

DISCUSSION

The present data will be analyzed with a view to specifying the necessary and sufficient conditions for the peak-shift in generalization gradients. First, it seems that positive contrast during training is not a necessary condition for a peak-shift. A peak-shift was found even though positive contrast had not occurred during training (Group 2 *versus* Group 5). Friedman and Guttman (1965) have also suggested that positive contrast during wavelength discrimination is not a necessary prerequisite for a shift in the gradient of wavelength stimuli. Is a rate increase a sufficient condition? The group trained under a *mult tand* VI 30 sec DRL 4 sec—*tand* VI 3 DRL 2 sec (Group 4) had a rate increase in the presence of one training stimulus, although we interpreted this increase as induction rather than positive contrast. In the generalization test, however, there was no shift in the distribution of responses away from the stimulus associated with less frequent reinforcements. There was, in fact, a shift towards the stimulus associated with less frequent reinforcement and higher response rates. Friedman and Guttman also suggest that "some effect of discrimination training in addition to S+ rate increase is involved in the shifted gradient . . . " (1965, p. 266).

Kalish (1965, p. 73) has suggested that "the nature of S− and the conditions for its presentation appear to be substantial variables in determining the form of the postdiscrimination gradient." It would appear that one necessary condition for a peak-shift is that responding in the presence of the "negative" stimulus be reduced in frequency during training. The key word is "reduced." Blough and Millward (1965, p. 72) also suggest that " 'Inhibitory' phenomena seem . . . to arise when the subject responds to a stimulus but this responding is not reinforced enough to be maintained at its initial level." Terrace (1964) has shown that if almost no measured responses are ever made to the negative stimulus then the peak-shift does not occur. The present data can also be interpreted in this manner. That is, if responding in the presence of a stimulus (570 nm) associated with less frequent reinforcement is maintained at a relatively high level, compared with responding in the presence of a stimulus (550 nm) associated with more frequent reinforcement, then the peak-shift does not occur. Kalish (1965, p. 72) has also suggested that, "the ratio of responses to S+ and S− required to produce the post-discrimination changes is, of course, a ripe subject for investigation." The reduction in responding in the presence of the negative stimulus need not occur during discrimination training in which the negative and positive stimuli are presented alternately. Responding in the presence of the negative stimulus can be reduced by a separate extinction session in which exposure to only the negative stimulus is given after previous sessions of exposure to only the positive stimulus. Friedman and Guttman (1965) have shown that if a separate extinction session is given in which only the negative stimulus is presented, then a peak-shift occurs with no further training involving the positive stimulus. Honig, Thomas, and Guttman (1959) and Hearst and Poppen (1965), however, had previously reported experiments in which a separate session of extinction in the presence of the negative stimulus did not produce a peak shift. The important difference between these studies is that Friedman and Guttman (1965) had, before the separate extinction session, obtained a rate increase in the presence of the positive stimulus, whereas Honig *et al.* (1959) and Hearst and Poppen (1965) did not report any such rate increase. The rate increase to the positive stimulus in the Friedman and Guttman study (1965) resulted from discrimination training involving a wavelength stimulus that illuminated the entire pigeon key (the positive stimulus) and a cross of the same wavelength. There was a peak shift.

What if positive contrast does not occur? What further conditions are necessary to obtain a shift in the generalization gradient? The present data suggest that a peak-shift will occur even though positive contrast has not been observed during discrimination training if the positive and negative stimuli are alternated in some fashion during discrimination training and if there is a reduction in responding to the negative stimulus. It also appears that if responding in the presence of the negative stimulus is reduced and a rate increase in the positive stimulus is obtained during discrimination training, then a shift in the generalization gradient occurs even though the negative stimulus was presented in a separate extinction session. Friedman and Guttman (1965, Experiment 3) appear to contradict this latter suggestion. In that experiment, a wavelength stimulus (550 nm) was presented in random alternation with a time out stimulus, each stimulus condition of 60 sec duration. After this discrimination training, a separate extinction session with a different wavelength stimulus (570 nm) did not produce a shift in the gradient, although they report that positive contrast occurred during discrimination training. A closer analysis of their discrimination data suggests that the increase in response rate to the positive stimulus (550 nm) may have been a consequence only of the added number of reinforcements given during the discrimination training and not of discrimination training with a time-out stimulus. The authors state that "the rate to 550 mμ did not increase during the first training period" (p. 262). The data presented in their Fig. 1 show that the response rate in the presence of 550 nm was increasing steadily over the five days of training before the time out stimulus was introduced. Perhaps if training had been continued without the 60-sec time out stimulus, the rate increase in the presence of 550 nm would nevertheless have resulted. Further support for this suggestion is present in their Table 1 (p. 258) which shows that the terminal rate to the positive stimulus (550 nm) for two groups given discrimination training with 550 nm and a 60-sec time out stimulus was lower than the terminal rates for two groups given discrimination training involving 550 nm on the entire key and a 550 nm cross on the key. If these interpretations are correct, namely that no increase due to time out occurred in their experiments, then their data are not inconsistent with our hypothesis. That is, under the specific conditions in which responding is decreased in the presence of a negative stimulus by a separate extinction session, a peak-shift will not occur unless positive contrast had occurred.

The present analysis tends to subordinate the role of the differential reinforcement contingencies in the positive and negative stimuli to the role of the differential behaviors in the stimuli (as independent variables) in affecting the peak-shift. It is possible that although differential reinforcement contingencies establish different behaviors during discrimination training, the characteristics of the different behaviors have a more major role in generalization tests than the reinforcement contingencies that produced the different behaviors. The present emphasis on the behaviors established in the presence of each stimulus during training resembles the position taken by Migler (1964).

This analysis would lead to the following, unusual, experimental prediction. If key pecks were reinforced with food in the presence of one stimulus, *e.g.*, 550 nm, on VI 30 sec, and, in the presence of another stimulus, *e.g.*, 570 nm, non-key pecking behavior were reinforced with food with the same frequency of occurrence (a DRO, *i.e.*, differential reinforcement of other behavior schedule), a peak shift should result! Responses in the presence of the stimulus associated with DRO schedule (*e.g.*, 570 nm) would be reduced to some level; positive contrast in the presence of the stimulus associated with the VI 30 sec schedule (*e.g.*, 550 nm) presumably would not occur (Reynolds, 1961*b*) but since 550 and 570 nm would be alternated, all the conditions previously found necessary for the peak-shift would have been met.

REFERENCES

Blough, D. S. Spectral sensitivity in the pigeon. *J. Opt. Soc. Am.*, 1957, **47**, 827-833.

Blough, D. S. Interresponse time as a function of continuous variables: a new method and some data. *J. exp. Anal. Behav.*, 1963, **6**, 237-246.

Blough, D. S. and Millward, R. B. Learning: Operant conditioning and verbal learning. In *Annual Rev. Psychol.*, 63-94. (Farnsworth, P. R., Ed., Annual Reviews Inc., Palo Alto, Calif., 571 pp., 1965).

Ferster, C. B. and Skinner, B. F. *Schedules of reinforcement.* New York, Appleton-Century-Crofts, 1957.

Friedman, H. and Guttman, N. Further analysis of the various effects of discrimination training on stimulus generalization gradients. In *Stimulus generalization*, 255-267. (Mostofsky, D. I., Ed., Stanford Univ. Press, Stanford, Calif., 389 pp., 1965).

Guttman, N. Generalization gradients around stimuli associated with different reinforcement schedules. *J. exp. Psychol.*, 1959, **58**, 335-340.

Hanson, H. M. Effects of discrimination training on stimulus generalization. *J. exp. Psychol.*, 1959, **4**, 321-334.

Hearst, E. and Poppen, R. Steepened generalization gradients after massed extinction to the CS. *Psychon. Sci.*, 1965, **2**, 83-84.

Honig, W. K., Thomas, D. R., and Guttman, N. Differential effects of continuous extinction and discrimination training on the generalization gradient. *J. exp. Psychol.*, 1959, **58**, 145-152.

Kalish, H. I. Stimulus generalization. (Pre-publication draft of copy to appear in *Learning processes.* (Marx, M., Ed., The Macmillan Company)

Kalish, H. I. and Guttman, N. Stimulus generalization after equal training on two stimuli. *J. exp. Psychol.*, 1957, **53**, 139-144.

Kalish, H. I. and Guttman, N. Stimulus generalization after training on three stimuli: A test of the summation hypothesis. *J. exp. Psychol.*, 1959, **57**, 268-272.

Migler, B. Effects of averaging data during stimulus generalization. *J. exp. Anal. Behav.*, 1964, **7**, 303-307.

Reynolds, G. S. An analysis of interactions in a multiple schedule. *J. exp. Anal. Behav.*, 1961*a*, **4**, 107-117.

Reynolds, G. S. Behavioral contrast. *J. exp. Anal. Behav.*, 1961*b*, **4**, 57-71.

Reynolds, G. S. and Catania, A. C. Behavioral contrast with fixed-interval and low-rate reinforcement. *J. exp. Anal. Behav.*, 1961, **4**, 387-391.

Terrace, H. S. Wavelength generalization after discrimination training with and without errors. *Science*, 1964, **144**, 78-80.

Received August 4, 1965