STIMULUS GENERALIZATION AND THE RESPONSE-REINFORCEMENT CONTINGENCY

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Generalization gradients along a line-tilt continuum were obtained from groups of pigeons that had been trained to peck a key on different schedules of reinforcement. In Exp. I, gradients following training on a differential-reinforcement-of-low-rate (DRL) schedule proved to be much flatter than gradients following the usual 1-min variable interval (VI) training. In Exp. II, the value of the VI schedule itself was parametrically studied; Ss trained on long VI schedules (e.g., 4-min) produced much flatter gradients than Ss trained on short VI schedules (30-sec; 1-min). The results were interpreted mainly in terms of the relative control exerted by internal, proprioceptive cues on the different reinforcement schedules. Several implications of the results for other problems in the field of stimulus generalization are discussed.

The studies of Guttman and his colleagues (Guttman, 1956; 1963) have produced a wealth of new data on stimulus generalization and have suggested novel methods for attacking classical theoretical problems in this field. Virtually all these studies used VI schedules of food reward during the training phases prior to generalization testing. The choice of a short VI schedule is appropriate for studying many aspects of stimulus generalization because it produces a steady, high response rate during training and thus ensures a relatively great resistance to extinction during the prolonged periods of generalization testing.

It is possible, however, that the type of reinforcement schedule during training could have an important effect on the slope and form of subsequent generalization gradients. Gradients obtained after training on different interval, ratio, or rate-defined schedules might differ from each other in several important respects; from these differences, inferences might be drawn regarding the type of stimuli that control behavior on these schedules. In Exp. I of the present study, generalization gradients obtained after the usual VI training were compared with gradients obtained after

training on a differential-reinforcement-of-low-rate (DRL) schedule.

Such an investigation of gradients after VI and DRL training might also have specific theoretical implications for other problems in the area of stimulus generalization. Miller (1944; 1948; 1959) and Hearst (1962; 1964) obtained opposite results when comparing the slopes of generalization gradients following approach or avoidance training. An analysis of differences between their experimental procedures suggested that the contradictory findings might be reconciled in terms of the relative predominance of internal *vs.* exteroceptive cues in the different behavioral situations. Presumably, if internal cues constitute a comparatively large part of the stimulus complex controlling a given response, then generalization gradients along an exteroceptive dimension will prove relatively flat for that response. There is independent evidence (Miller, 1959; Hearst, 1964) to suggest that in certain approach-avoidance comparisons, internal cues are relatively more important for the avoidance response than for the approach response, whereas in other situations the opposite may be true.

One way to test these inferences would be to find out whether, within the "approach" category itself, behavior controlled primarily by internal cues exhibits flatter exteroceptive gradients than behavior which is relatively less dependent on internal cues. Direct tests of this possibility are of course difficult to devise. However, it does not seem unreasonable

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to hypothesize that DRL behavior is relatively more dependent than VI on internal, non-exteroceptive stimuli, since these kinds of stimuli are presumably involved in mediating the temporal discriminations and collateral behavior characteristic of DRL (*e.g.* Anger's (1956; 1963) discussions of DRL and Sidman-avoidance schedules). If DRL gradients along an exteroceptive dimension turn out to be considerably flatter than VI gradients, the internal cues hypothesis for approach-avoidance differences would receive valuable support. This rationale originally prompted the present study.³

In the second experiment, the effect upon generalization gradients of variations in the frequency of reinforcement during VI training were studied. Since these variations proved to have pronounced effects on gradient shape and slope, a reevaluation may be needed of the generality and applicability of prior conclusions which have been based almost exclusively on generalization gradients obtained after training on 1-min VI. In addition, the generalization results of Exp. II, considered in conjunction with those of Exp. I, suggest some interesting relationships between VI and DRL behavior.

EXPERIMENT I

Subjects

Forty-four barren White Carneaux hen pigeons, 2 to 10 years of age when obtained from the Palmetto Pigeon Plant, Sumter, S. C., were maintained at 75% of their free-feeding weights.

Apparatus

A standard key-pecking apparatus for pigeons was used (Foringer). The response key (1 in. in diameter) was especially designed for use with projection-type miniature display units, and has been described in detail by Ferster, Holtzman, and Leckrone (1962). The digital display unit, mounted behind the key, could project eight different orientations of a white line ($\frac{3}{16}$ in. wide, $1\frac{5}{16}$ in. tall), surrounded by a black background. In the specification of stimulus values the vertical orien-

tation was designated as 0° tilt. The following orientations were also available for testing: 22.5°, 45°, 67.5°, 90° (horizontal line), 112.5°, 135°, and 157.5°, in a clockwise sequence from the vertical.

At the beginning of the experiment, the individual lamps that illuminated the eight different stimulus lines were adjusted as closely as possible for equal brightness; a Photovolt Corporation Universal Photometer (Model 210) was used in making the brightness readings. The values were recalibrated on the rare occasions when a lamp burned out and, as an additional precaution, were systematically rechecked every few weeks even if no lamp had burned out. No correlation between stimulus brightness and line orientation was ever observed. Any effects of the very small brightness differences between stimuli were therefore probably negligible.

A house light in the back of the experimental chamber provided illumination except during blackout periods, which occurred between stimulus presentations and at the end of experimental sessions. A 5-sec presentation of grain served as reinforcement, and the area of the grain magazine was illuminated when reinforcement was available. The aperture through which grain was presented was located below and to the left of the key. White noise in the experimental cubicle and an air blower in the test chamber masked extraneous sounds. In an adjacent room a system of relays, timers, and counters provided automatic control and tabulation of responses, reinforcements, and stimulus presentations. During generalization testing, the variation of stimulus values was performed manually by shifting a snap lead on the stimulus control panel; manual control permitted a greater variety of randomized stimulus orders than if just a few different orders were programmed on a stepping switch.

Procedure

All Ss followed the same 15-day schedule. Experimental sessions were scheduled five times per week, usually Monday through Friday, with the exception that a few Ss were tested Saturday rather than Friday.

Training. On days 1-3 all Ss were trained to eat from the grain magazine and then were given 100-140 regular reinforcements (CRF) for pecking the response key. During magazine

³In a personal communication Dr. Neal E. Miller independently suggested a comparison of VI and DRL gradients as a good test of the internal cues hypothesis.

training the key was covered with black friction tape; during the CRF period it was continuously illuminated with the line orientation to be used as CS for that *S*. Thirty-six *Ss* were employed—two groups of 10 (VI groups) and two groups of 8 (DRL groups). One of the VI subgroups was assigned a vertical line (0°) as the CS; the other, a horizontal line (90°). The same subdivision was followed for the DRL subgroups.

For the next 10-11 sessions (Days 4-14), 30-sec stimulus-on periods alternated with 10-sec stimulus-off periods. During stimulus-on periods the CS was projected on the key and the house light came on. During stimulus-off (blackout) periods, both the CS and the house light were turned off. Virtually no key pecking occurred during the blackout periods, which were included to give the experimenter sufficient time to vary line orientation and record data during forthcoming generalization tests. All experimental sessions lasted 50 min.

For the VI groups, a 1-min VI schedule was in effect during stimulus-on periods. For the DRL groups a 6-sec DRL schedule was in effect during stimulus-on periods. Each key peck by a DRL *S* during a stimulus-on period reset a recycling timer and was not reinforced unless at least 6 sec of no responding had elapsed since (a) the last response, (b) the beginning of the stimulus-on period, or (c) the end of the last grain reinforcement. After the 6-sec non-response contingency had been met by *S*, the next key peck in CS was always reinforced, with the exception that reinforcements which had been "set up" in one stimulus-on period did not carry over into the next stimulus-on period (*i.e.*, each new stimulus-on period restarted the DRL timer). Thus, if *S* performed perfectly on this procedure it could obtain a maximum of three reinforcements in each 30-sec stimulus-on period: (1) a 6-sec pause before key pecking after a new stimulus-on period began; (2) a 5-sec reinforcement and another 6-sec pause, followed by a response; and (3) another 5-sec reinforcement and another 6-sec pause before responding.

Testing. On Day 15, generalization tests were given to all *Ss*. A 10-min preliminary period preceded generalization testing; during this period the same reinforcement and stimulus conditions as on Days 4-14 were in effect. Then the generalization test began and was conducted under extinction conditions. Eight

different orientations of the stimulus line were presented. There were 10 presentations of each orientation during the test for a total of 80 stimulus-on periods. These 80 presentations were arranged in 10 blocks, each of which included the eight different stimuli in a randomized order. As before, stimulus-on periods lasted 30 sec and alternated with 10-sec stimulus-off periods. The number of key pecks in each 30-sec stimulus-on period was recorded.

RESULTS

Figure 1 presents a group comparison of generalization gradients after VI and DRL training. Relative generalization (on the ordinate) was scaled by assigning the value of 1.00 to the peak of each gradient, the line orientation to which the largest number of responses occurred; all other response frequencies were expressed as decimal fractions of this maximum value. In terms of "Degrees from CS" (on the abscissa) the stimulus line that was 157.5° from the CS in a clockwise direction is indicated as -22.5° , the line that was 135° from the CS is indicated as -45° , *etc.* Since a line $+157.5^\circ$ from CS is physically as close to the CS as a line $+22.5^\circ$ from the CS, both these values were plotted at the same absolute

Fig. 1. Gradients of relative generalization for the VI and DRL groups. Each group was composed of two subgroups, one trained with a vertical line as the CS (0°) and the other with a horizontal line as the CS (90°).

distance from CS, in a positive or negative direction. For purposes of symmetry the same response measure was plotted at $+90^\circ$ and -90° .

Both VI gradients were peaked at their respective CS's and showed a sharp diminution in responding as the line orientation was varied more and more from the CS. Both DRL gradients were relatively flat in comparison to the VI gradients.

Since a DRL schedule specifically reinforces low rates of responding, it was no surprise that DRL Ss emitted many fewer responses during the generalization test than did VI Ss. Figure 2 displays the absolute response frequencies from which the relative gradients of Fig. 1 were derived. The total output of VI Ss during the generalization test was approximately four to seven times greater than that for the DRL Ss. However, this does not mean that the DRL Ss extinguished more rapidly than the VI Ss during generalization testing; inspection of cumulative records showed that DRL Ss usually responded at a low rate throughout the test period and did not quickly reach a zero rate of responding.

Fig. 2. Gradients of absolute generalization for the VI and DRL groups of Fig. 1.

Figures 3 and 4 show the relative generalization gradients for all individual Ss in this experiment. The gradients for the VI and DRL Ss can be compared with regard to their slope and the location of their peak. Hiss and Thomas (1963) used the per cent of total generalization test responses occurring to the CS (i.e., CS Responses/Total Responses to all

eight stimuli) as an index of gradient slope; values of this index (to be abbreviated CSP) above 20% may be taken as an indication of sharp gradients, whereas values of approximately 12.5% indicate relatively flat gradients. The individual CSP values are given as percentages on each gradient in Fig. 3 and 4. Only one of the 16 DRL Ss had a CSP above 20%, whereas 12 of the 20 VI Ss did. In addition to this marked difference in the slope of the VI and DRL individual gradients, Fig. 3 and 4 indicate that there was considerable variation in the location of the gradient peak among the DRL Ss and almost no variation in the peak location for the VI Ss. Only three of the 16 DRL Ss had their peak at the CS, whereas 18 out of the 20 VI Ss did. It is noteworthy that the averaged (group) DRL gradients in Fig. 1 showed a peak at the CS, even though very few of the individual DRL gradients actually had their peak at the CS.

One way of testing the statistical significance of the slope differences between VI and DRL gradients is through a comparison of the CSP's of individual Ss in the two groups. When these values were subjected to a Mann-Whitney *U* Test, an analysis of VI and DRL Ss with the CS at 0° yielded slope differences significant at beyond the .01 level ($U = 10$, one-tailed test). Differences between VI and DRL Ss with the CS at 90° were even more significant ($U = 7$).

The DRL Ss received an average of 68 reinforcements per session (range of individual means: 20 to 113) during the last four training sessions before generalization testing, whereas VI Ss received an average of 32 reinforcements per session (range: 29 to 35). The best performers in the DRL group did so well that they received more reinforcements than were necessary to maintain their 75% weights. Despite underfeeding of these Ss on weekends, two of the 16 Ss were between 80% and 86% of their *ad lib* weight by the time the generalization test occurred. However, these overweight Ss showed no systematic differences from the other DRL birds either in the number of extinction responses or in the shape and slope of generalization gradients.

As a further check on the generality of the DRL results, an additional experiment was performed in which eight new Ss were placed on a 10-sec DRL schedule. The CS was 0° for all these Ss; apparatus and procedure were

Fig. 3. Individual gradients of relative generalization for all the VI subjects. Indicated at the top of each gradient is the bird's number and its CS during training (either 0° or 90°). The CSP value is given as a per cent on each curve.

otherwise exactly the same as for the 6-sec DRL Ss. Because of the longer DRL requirement, no S in this new group received so many reinforcements that it was overweight by the time of the generalization test. The Ss averaged 26 reinforcements per session (range: 6

to 82) during the final four days of training. The gradient secured from these Ss (Fig. 5) was at least as flat as the gradients of the other DRL groups shown in Fig. 1 and 2. Only one of the eight new Ss had a CSP over 20% and only two had a gradient peak at the CS.

The slope of the DRL gradients thus was not dependent on the number of reinforcements obtained during training. DRL gradients were characteristically flatter than VI gradients, even though some DRL Ss obtained a smaller, and some Ss a much greater, average number of reinforcements than the Ss in the VI group.

DISCUSSION

This experiment demonstrated that generalization gradients following training on a 1-min VI schedule are much steeper than gradients following DRL training. The gradients of the individual DRL Ss, besides being rela-

tively flat, seldom had their peak at the CS value. Apparently DRL training reduces the control exerted by certain exteroceptive features of the behavioral situation.⁴ Thus, the reinforcement contingency during training has a powerful influence on the slope and form of subsequent generalization gradients.

As has also been observed by many others (e.g., Wilson and Keller, 1953; Bruner and Revusky, 1961; Hodos, Ross, and Brady,

⁴At the Conference on Stimulus Generalization (Boston University, 1963) Dr. Donald Blough reported extremely flat gradients along a light intensity continuum after DRL training, which supports the results described here for a line-tilt continuum.

Fig. 4. Individual gradients of relative generalization for all the DRL subjects.

1962), we noticed that idiosyncratic, stereotyped behavior (often called "collateral" or "mediating" behavior) developed in most DRL Ss during the intervals between occurrences of the experimentally-defined response; the most common form of this behavior observed was a stereotyped circling of the experimental chamber between key-pecking responses. The occurrence of such collateral behavior is probably of considerable importance in explaining the flat generalization gradients obtained from the DRL Ss.

Fig. 5. Relative generalization gradient for the 10-sec DRL group. All Ss were trained with CS of 0°.

Collateral behavior could have influenced the gradients in at least two ways: (1) Since the DRL Ss spent so much time away from the response key while they engaged in collateral behavior, they presumably did not have as much "exposure to the CS" as did the VI Ss, which were almost always observed to stand directly in front of the key. A difference in amount of exposure to the CS may have contributed to the results, but previous studies of instrumental learning (*e.g.* Mednick and Freedman, 1960) have usually not shown steeper gradients with greater and greater amounts of training—which ought to be the case if this explanation of the VI *vs.* DRL differences were correct. (2) Since key pecking was smoothly linked to the preceding collat-

eral responses, it may have become so powerfully controlled by movement-produced stimuli derived from the collateral behavior that the physical properties of the key did not gain very much control over key pecking. This explanation postulates that the stimulus control of key pecking in the DRL situation is primarily proprioceptive in nature; if this is true, then variations in an exteroceptive dimension like line-tilt ought to be more or less irrelevant for the key-pecking DRL response. In contrast, in the VI situation there appear to be fewer different kinds of stimuli (especially internal-proprioceptive) associated with the key-pecking response; therefore, the visual properties of the key may constitute a proportionately larger part of the conditioned stimulus compound than is the case in the DRL situation—and thus lead to steeper visual gradients for VI. Such an interpretation, which is an application of the internal-cues hypothesis to the present situation, seems the most reasonable explanation of the extremely flat DRL gradients. Blough's discussion (1963) of the control exerted by "response" variables in studies of stimulus generalization presents a very similar argument.

Besides the internal-cues interpretation, there is another possibly fruitful way of viewing the differences between VI and DRL. Azrin (1961) has pointed out that certain schedules of positive reinforcement may have aversive properties, as evidenced by the fact that Ss, if permitted, will frequently terminate stimuli associated with these schedules, even though termination removes the possibility of positive reinforcement. Guttman's (1959) finding that a stimulus accompanying a long VI schedule (5-min VI) has inhibitory properties analogous to those of an extinction-correlated stimulus, provides additional evidence that some schedules of positive reinforcement can simultaneously have negative characteristics. DRL is usually considered to be one of these "semi-aversive" schedules, and therefore its negative properties might interact with its positive properties to affect the peak and slope of generalization gradients. The fact that only five of the 24 DRL Ss had a gradient peak at the CS lends some weight to the notion that DRL possesses inhibitory effects. Such a mixture of positive and negative properties could produce unexpected effects on stimulus generalization.

Since the appetitive DRL schedule, like a Sidman shock-avoidance schedule (Hearst, 1962), produces characteristically flatter gradients than 1-min VI, it seems clear that no simple distinction can be made between "approach" and "avoidance" (as normally defined) in terms of the slope of their respective generalization gradients. Gradient steepness appears to be critically dependent on factors that cross the boundaries of these two types of behavior. Therefore, the suggestion of Miller (1944; 1959) and Hearst (1960) that fundamental differences may exist between generalization gradients for approach and avoidance appears untenable. Rather than to search for basic relationships between stimulus generalization and "approach *vs.* avoidance," it would appear more profitable to first determine what kind of conditions produce flat gradients and what kind of conditions produce sharp gradients.

EXPERIMENT II

Experiment I demonstrated that generalization gradients after 1-min VI are markedly different from gradients obtained after training on a 6- or 10-sec DRL schedule. However, since there was no attempt to equate VI and DRL Ss with regard to overall response rate during training, the possibility remains that the results of Exp. I were primarily due to differences between the groups in response output, rather than to the unique contingencies of VI and DRL. In other words, perhaps slow responders during training yield flat gradients and fast responders yield sharp gradients, regardless of the reinforcement schedules involved. Guttman (1956), however, reported no such relationship between response rate and gradient slope among his 1-min VI Ss. An analysis of the individual VI Ss in Exp. I of this report also revealed no significant positive correlation between average response rate during training and gradient slope (CSP).

These variations in VI response rate in the Guttman experiments and those of Exp. I were merely a result of individual differences among Ss; all Ss were trained on 1-min VI and therefore differences in response output during training were not attributable to any experimentally-manipulated variable. In Exp. II, we attempted to manipulate response rate experimentally by training different groups of

Ss on different frequencies of VI reinforcement. It is a well-confirmed finding (*e.g.*, Ferster and Skinner, 1957; Clark, 1958) that VI schedules with relatively long mean interreinforcement intervals produce lower response rates than VI schedules with relatively short interreinforcement intervals. In contrast to correlations based on individual differences within one VI group, this new procedure was expected to provide a more direct test of the possibility that differences in response output were critically involved in producing the gradient differences of Exp. I.

Subjects and Procedure

Forty-four new pigeons of the same type as in Exp. I were tested under deprivation conditions and general treatment identical to those of the first experiment. The same apparatus and schedules of training and testing were also used.

The only difference between this experiment and Exp. I lay in the different VI schedules used. All Ss in Exp. II were trained with the vertical line (0°) as the CS.

In addition to 1-min VI, four new VI schedules (30-sec, 2-min, 3-min and 4-min) were tested. The minimum and maximum interreinforcement intervals on each VI tape were as follows: 30-sec VI: 9 sec and 62 sec; 1-min VI: 8 sec and 220 sec; 2-min VI: 9 sec and 444 sec; 3-min VI: 10 sec and 354 sec; 4-min VI: 19 sec and 541 sec. The mean value that specifies each schedule (30 sec, 1-min, *etc.*) was the arithmetic average of all the interreinforcement intervals on that schedule.

There were *N*'s of 10 in the 30-sec, 2-min, and 3-min groups and an *N* of 12 in the 4-min group. Also, two more Ss were tested on 1-min VI, which increased the *N* in that group to 12, counting the 10 Ss from Exp. I at the 0° CS.

Because testing was restricted to the use of one experimental chamber, only eight or nine new Ss could be run during each repetition of the 15-day experiment until the total *N* of 44 was achieved. Subjects from different VI groups were included in every repetition of the experiment, *i.e.*, the current group of eight or nine Ss was divided into two or three different VI subgroups.

Results

Figure 6 shows relative generalization gradients obtained after training on each of the

five different VI schedules. Gradients for the shortest VI schedules (30-sec and 1-min) displayed the steepest slopes, whereas the gradients for the longest schedule (4-min) were quite flat. Results for the intermediate groups (2-min and 3-min) fell in between those for the extreme groups.

Gradients based on absolute response frequencies are plotted in Fig. 7. The major differences between the five gradients in Fig. 7 occurred in the area close to the CS; at values relatively far from the CS systematic differences among the gradients disappeared.

As in Exp. I, slope indices (CSP) and peak locations were determined for the individual gradients of all Ss. A Kruskal-Wallis one-way analysis of variance by ranks (Siegel, 1956) revealed that CSP differences among the five VI groups were significant at beyond the .01 level ($H = 14.13$, $df = 4$). This result provides statistical support for the inverse relationship between gradient slope and VI mean interval evident in Fig. 6 and 7.

With regard to location of the gradient peak, 70% of the 30-sec VI Ss had their peak at the CS, 83% of the 1-min Ss, 50% of the 2-min and 3-min Ss, and 42% of the 4-min Ss. It will be recalled that of the 24 DRL Ss in Exp. I, only five (*i.e.*, 21%) displayed a peak at the CS.

Fig. 6. Gradients of relative generalization for the five different VI groups. The CS was a vertical line (0°) for all Ss.

Fig. 7. Gradients of absolute generalization for the five different VI groups.

Another measure of peak location also proved revealing. This was the per cent of Ss in each group that had their gradient peak either at the CS or at the line orientation closest to the CS ($\pm 22.5^\circ$). Over 80% of the Ss in each of the five VI groups fell into this category. On the other hand, of the 24 DRL Ss in Exp. I only 12 (50%) had their gradient peak either at the CS or at the $\pm 22.5^\circ$ values. It appears that gradient peaks following DRL training are much more likely to be displaced to stimulus values relatively far from the CS than are peaks for a wide variety of VI schedules.

As outlined above, the variations in frequency of VI reinforcement were expected to produce different response rates during training for the different VI groups. In general, the present experiment did confirm prior findings that VI mean interreinforcement interval and response rate are inversely related. Mean response rates on the last four days of training were calculated after subtracting consummatory time (total time the grain reinforcements were available) from the total stimulus-on time. Values obtained through this subtraction method were slightly inaccurate because the 5-sec grain reinforcements sometimes began in the final seconds of a stimulus-on period and therefore extended into the first few seconds of stimulus-off periods. Nevertheless, the obtained differences were much greater than could possibly be attributed to this small source of error. Mean response rates of 65 rpm were obtained for

both the 30-sec and 1-min VI groups, 49 rpm for the 2-min group, 34 rpm for the 3-min group, and 41 rpm for the 4-min VI group. A Kruskal-Wallis test disclosed that these group differences were significant at beyond the .001 level ($H = 22.75$, $df = 4$). It will be noted in Fig. 7 that the same rank order of groups occurred in response output to the CS.

Although group differences in response rate during training were highly significant, the total number of responses emitted during generalization (extinction) tests did not differ significantly among the five VI groups ($H = 5.99$, $df = 4$, $P = .20$). The absence of a difference in this measure is presumably due to the interaction between gradient slope and conditioned response strength; VI groups that had the highest response rates during training and, in like manner, responded most frequently to the CS during generalization testing, often responded less frequently during testing to stimulus values far from the CS than did the other VI groups (See Fig. 7).

Within the separate VI groups, correlation coefficients (Spearman "rho"; see Siegel, 1956) were determined between several different response measures. Correlations between CSP and mean response rate on the last four days of training were low and insignificant among the individuals in every VI group. Also insignificant were correlations between CSP and total generalization test responses. However, rhos between training response rates and total generalization test responses were positive and significant at beyond the .05 level in all five of the VI groups; as would be expected, within a given VI group the Ss that had higher rates during training also tended to emit more responses during generalization (extinction) tests.

Discussion

In this experiment, generalization gradients for line orientation became steeper as the VI mean interval during training was shortened. This result supports the findings of Haber and Kalish (1963) who examined three VI schedules ranging from 15-sec to 4-min and obtained steeper visual wavelength gradients following training on the shorter VI schedules. It seems clear, then, that generalization gradients are markedly influenced by the type of VI schedule that prevailed during training.

When the VI schedule is studied as a parameter of stimulus generalization, as was done in the present experiment, eventual differences in the shape and slope of generalization gradients may be attributed either (a) to the unequal number of reinforcements necessarily given to the different groups during training or (b) to the particular properties of the behavior (different response rates and patterns, *etc.*) that develops as a result of the different schedules. If (a) were the critical factor, then studies of operant behavior which examined the effect of increases in the amount of training (or in the "number of reinforcements") on a single schedule of reinforcement ought also to have obtained a systematic steepening of generalization gradients. This does not seem to be the case, since the studies of this type summarized in Mednick and Freedman (1960) have usually found that both absolute and relative generalization increase as a function of number of reinforced training trials—the opposite conclusion from that demanded above. Also, it will be recalled that Exp. I revealed no systematic effects of number-of-reinforcements within the DRL situation. There is, therefore, very little evidence in support of alternative (a) above.

More reasonable is alternative (b) which proposes that frequency of reinforcement affects generalization indirectly, through its own effects on response rate and pattern. This argument would suggest that the various appetitive reinforcement contingencies (*e.g.*, DRL and long VI schedules) which produce comparatively low response rates during training, along with a large amount of pausing and a relatively frequent occurrence of stereotyped response chains, are more likely to yield flat generalization gradients than contingencies which produce high, steady rates during training. In this connection, visual observation of the Ss in Exp. II did indicate that stereotyped "mediating" response chains were much more likely to develop on long VI schedules than on short VI schedules; presumably, on short VI schedules, rates of key pecking are so high that there is little opportunity for other behavior to emerge and gain in strength through adventitious reinforcement.

In Exp. I we favored an explanation that attributes the relative flatness of DRL gradients to the greater variety of conditioned stimuli and the proportionately larger control ex-

erted by proprioceptive and other internal stimuli in the DRL situation. Since, as suggested above, long VI schedules seem to produce response rates and patterns somewhat like those of DRL, it is possible to interpret the generalization effects of Exp. II in a similar fashion. One would expect less control by the exteroceptive properties of the response key on longer VI schedules and therefore flatter generalization gradients along a dimension such as line orientation on the key stimulus.

Since Guttman (1959) showed that long VI schedules (5-min) may have inhibitory properties similar to those of an extinction schedule, an explanation that postulates some interaction between the positive and negative aspects of relatively long VI schedules may prove to be another fruitful way of viewing the Exp. II results. Arguments of this sort were discussed in Exp. I.

Experiment II was originally undertaken to find out whether Ss with low rates due to infrequent VI reinforcement would show generalization gradients similar to those of DRL Ss, which also respond at comparatively low rates. The affirmative answer that was obtained does not mean, however, that a low rate is a necessary condition for flat generalization gradients. Within a single VI group, Ss with relatively low rates were no more likely to show flat gradients than Ss with relatively high rates. And in prior work (Hearst: 1962, 1964), Ss on Sidman shock-avoidance schedules responded at extremely high rates and still yielded very flat gradients. Rate *per se* is apparently not the critical factor but, rather, the pattern of responding and the relative amount and kind of mediating behavior that emerges on these different appetitive and avoidance schedules.

Taken together, the results of Exp. I and Exp. II clearly indicate that the behavioral baseline during training is a crucial factor in determining the slope and form of subsequent generalization gradients; manipulation of the stimulus during generalization testing will not necessarily produce a sharp response gradient if the response has been conditioned according to certain contingencies of reinforcement. This fact raises the question of how profitable it is to derive systematic laws of generalization (e.g., summation, peak shift, etc.), or to engage in tests of the inverse hypothesis (Guttman, 1963), from data based almost exclusively on

gradients obtained after 1-min VI. In this regard, Blough's (1964) warning that an understanding of "response rate" and its determinants is needed before one can make strong conclusions about operant generalization is definitely supported by the results and viewpoint presented here.

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