

*SHAPING THE LOCATION OF A PIGEON'S PECK:  
EFFECT OF RATE AND SIZE OF SHAPING STEPS*

DAVID A. ECKERMAN, ROBERT D. HIENZ, SANDER STERN,  
AND VICKI KOWLOWITZ

UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL, JOHNS HOPKINS  
MEDICAL SCHOOL, UNIVERSITY OF ROCHESTER, AND MERCER UNIVERSITY

For several pigeons, pecking at particular locations within a ten-inch-wide response area was reinforced by grain presentations. The reinforced locations changed systematically to "shape" response location back and forth across the area. The rate and size of these shifts in reinforced locations were varied in both between-subject and within-subject comparisons to evaluate the influence of these variables on the shaping process. Larger step sizes produced larger shifts in location for all sizes inspected, with all sizes from .5 to 3.0 inches effective in shaping behavior. More rapid steps were approximately as effective as slower steps for all rates of shift inspected from 25 reinforcers to 400 reinforcers per step. These data suggest that shaping peck location proceeds most efficiently with rapid, relatively large shifts in criterion performance.

*Key words:* response differentiation, differential reinforcement, response topography, shaping, key pecking, pigeons

"Shaping" is a procedure in which behavior is changed from one predominant form to another by presenting reinforcers according to a succession of response criteria bridging the gap between current and target behavior. Two basic variables of such a succession are the difference between successive criteria (e.g., size of steps), and the rate at which criteria are changed. How might these variables affect shaping effectiveness? There seem to be two types of effectiveness: ultimate and initial. Shaping is ultimately effective to the extent that behavior conforms closely to criteria for reinforcer presentation in the long run; that is, when a high proportion of the emitted behavior meets these criteria. Shaping is initially effective when behavior quickly shifts to the new criterion behavior.

Two studies of note come to opposing conclusions regarding the influence of size and rate of criterion change on shaping effectiveness. Lane, Kopp, Shepard, Anderson, and

Carlson (1967) used penny reinforcers to shape longer or shorter durations of the phoneme /u/ spoken by undergraduates. Large steps in successive criteria were correlated with lower initial effectiveness (more trials until pennies were earned for ten successive responses) and lower ultimate effectiveness (response duration less likely to meet the new criterion). In this study, the size of steps was calibrated in standard deviation units with the standard deviation for each block of twenty responses determining the criterion for the next block of twenty responses. If the shift was small, measured in units of standard deviation, this would, almost by definition, improve initial shaping effectiveness. The conclusion reached was that small step sizes were also optimal as measured by ultimate shaping effectiveness.

Alleman and Platt (1973), on the other hand, found that shaping was optimized when large steps were taken between successive criteria. They too were shaping a temporal property of behavior—the time between successive key pecks of pigeons (interresponse times, IRTs). The criterion time was changed after each response, such that a response would be reinforced only if it terminated an IRT which exceeded  $P$  percent of the last  $m + 1$  IRTs. When  $P$  was large, therefore, the step was large; when  $P$  was small, the step was small. When shaping toward longer times, large values of  $P$  were more effective (longer IRTs were

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ultimately achieved within a fixed number of reinforcers). When shaping toward shorter times, no clear step size effect was seen. In the Alleman and Platt study, then, a small *P*-value, though it was associated with a higher initial shaping effectiveness (by definition a higher percentage of recent performance met the current criterion), produced a poorer ultimate shaping effectiveness for long IRT values. Kuch and Platt (1976) confirmed that longer key-peck IRTs were more effectively shaped when large shaping steps were used. In their study (Experiment II), they also demonstrated this influence of step size while holding rate of reinforcement constant across the step sizes.

There is an impressive number of parallels between these three studies. They all involved shaping temporal aspects of behavior, defined size of shaping steps in units of variability of responding, found better shaping of increased duration than shaping of decreased duration, and focused on ultimate shaping effectiveness of extreme durations as their measure of shaping effectiveness.

One logical difference between the studies involves the rate of criterion change—Lane *et al.* (1967) changed criterion every 20 responses, Alleman and Platt (1973) changed criterion with each response. Perhaps, then, step rate is implicated as one variable determining shaping. The present work inspects the direct and interactive effects of step rate as well as of step size. A nontemporal response dimension was chosen—location of response within a restricted spatial array. Since all possible locations could be reached with about the same ease, this dimension should have somewhat simpler metric properties than would temporal dimensions where extreme values are relatively less available to the organism.

## METHOD

### *Subjects*

Eighteen male White Carneaux pigeons (4 to 5 years old) were housed individually with free access to water and grit except during experimental sessions. All birds were experimentally naive at the start of the experiment and were maintained throughout the experiment at 75% of their free-feeding weights. Purina Wild Bird Seed (sifted through a mesh) was used during experimental sessions, and this diet was sup-

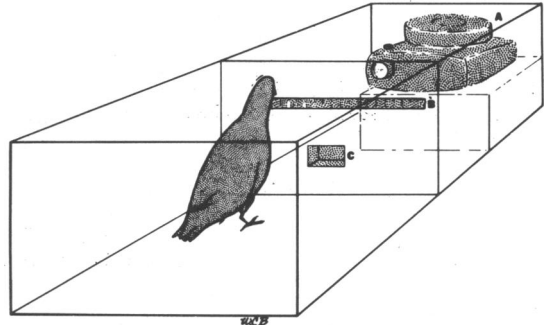


Fig. 1. Schematic diagram of the apparatus.

plemented as needed after sessions with Purina Pigeon Chow to maintain the birds' weights.

### *Apparatus*

The apparatus (see Figure 1) was similar to that described by Eckerman and Lanson (1969). It consisted of a 33.5- by 37- by 42-cm enclosure with a hardware cloth floor and milk Plexiglas ceiling (housetlights mounted above). A 25.4-cm-wide by 2.3-cm-high opening was centered at a height of 22.6 cm on one wall. Behind this opening, 20 .5-in. (1.2 cm) wide clear Plexiglas plates (keys) were suspended from a band of spring metal mounted above. Microswitches were mounted behind these keys such that a microswitch was closed when a peck moved a key through .1 to .3 cm with a minimum force of about 25 g (.25 *N*). The location of the peck was recorded on perforated paper tape for subsequent analysis. Characteristics of the pulse-forming circuitry limited maximum recorded rate of pecking to 5.8 pecks per sec. Although the keys were separated by a small gap (about .1 cm), adjacent keys could be activated simultaneously; such joint occurrences were treated and recorded as responses to the left member of the pair. White light was back-projected onto an etched glass screen mounted directly behind the response keys. Illumination was approximately equal across the width of the opening. The response area thus appeared as an homogeneously illuminated area behind a plane of clear plates having noticeable edges.

On the same wall as the keys, a feeder opening (5 by 6.3 cm) was centered at a height of 10 cm. The right-hand wall of the chamber was a glass plate. A television camera mounted behind this wall permitted continuous monitoring of subjects.

### Procedure

*Initial shaping.* In the first session, birds were magazine trained and then trained to peck the right inch (the two right-most keys) of the response area. During this training, only the right inch of the key was illuminated and only approaches or pecks to this location operated the feeder. The first session continued until 100 pecks to these keys had occurred or 30 min had elapsed. For four birds, more than one session was required before 100 pecks had occurred.

*Stabilizing responding at the initial location.* Twenty-four additional sessions were then given in which each of 100 pecks on the right two keys produced 2 sec access to grain. During the first four of these sessions, the left nine inches were not illuminated. Back illumination of the left nine inches was then increased during successive five-session blocks by illuminating the area through neutral density filters of the following values: 1.5, 1.0, .5 log density. During the last five sessions of this phase, the response area was evenly illuminated. In all, then, 2,500 reinforcers were earned by pecking the right two keys, the last 500 of which were pecks to the right inch of an evenly illuminated field.

*Shaping key location.* Reinforcement of pecks on the right two keys was then stopped, and pecks on other key pairs were reinforced. The step size was varied by displacing the positive keys by one, two, or three keys from the previous location. Reinforcement of pecks on these new keys continued for between 25 and 400 reinforcers until the reinforced keys again changed. The two variables, step size and step rate, were the primary variables of the study. Their manipulation will be described in separate sections.

*Varying step size, initial exposure.* Birds assigned to conditions comparing step size were given daily sessions which lasted until 100 reinforcers were earned. The pair of reinforced keys was set at the start of each session and remained unchanged throughout the session. The location of these keys, however, moved over either one key (.5 in.), two keys (1.0 in.), or three keys (1.5 in.) between sessions. For example, when the location was displaced one key (.5 in.), the reinforced keys would shift from 19, 20; to 18, 19; to 17, 18; and so forth. The location of the reinforced keys continued

to step toward the left until the left-most pair became the reinforced keys. This procedure was called one sweep. Steps were then made back toward the right until a second sweep was made. This procedure was continued until at least six sweeps were completed. This six-sweep period was considered as the initial exposure. Throughout these six sweeps, the step size was constant for a bird. Table 1 shows the conditions of the experiment for each of the nine pairs of birds studied. Evaluation of the effect of step size during initial exposure to shaping peck location was made by comparing performance on the first six sweeps for pairs 1, 2, 3, and 4.

*Varying step size, subsequent exposure.* Birds exposed to 1.0-in. or 1.5-in. steps in the initial exposure (pairs 3 and 4) were subsequently exposed to step sizes of 1.0 in., 1.5 in., and 3.0 in., as indicated in Table 1. Step rate continued at 100 reinforcers per step. This series allowed a within-subject evaluation of the effect of varying step size. Each condition of the series involved 6 to 20 sweeps.

*Varying step rate.* Different birds were initially exposed to .5-in. steps made after either 25, 50, 100, 200, or 400 reinforcers (pairs 5, 6, and 7, 1 and 2, 8, and 9, respectively). Daily sessions lasted for either 50 reinforcers or 100 reinforcers. Step rate and sessions per step were thus confounded. To unconfound these variables, some birds were exposed to conditions yielding the same number of reinforcers per step at different sessions per step (e.g., 50 reinforcers per step at .5 or 1.0 session per step, 100 reinforcers per step at either 1.0 or 2.0 sessions per step). The first six sweeps of the key strip at these step rates was considered the initial exposure to these conditions. Step rate was evaluated by comparing performance on the first six sweeps for all pairs given step sizes of .5 in.

*Varying both step size and step rate.* Four birds (pairs 6 and 7) were successively exposed to a step of .5 in. per 50 reinforcers, of 1.0 in. per 100 reinforcers, and of 3.0 in. per 300 reinforcers (see Table 1). Subsequently, the 1.0 in. per 100 reinforcer condition was repeated for pair 7. By varying both step size and step rate in this manner, the influence of step size could be unconfounded from length of training (number of reinforcers) involved in each sweep of the key. Each of these conditions was continued for 6 to 10 sweeps.

Table 1  
Conditions of the Experiment

<i>Pair</i>	<i>Subjects</i>	<i>Condition</i>	<i>Step size</i>	<i>Reinf/step</i>	<i>Reinf/session</i>	<i>Session/step</i>
1	414, 415	1	.5	100	100	1.0
2	440, 461	1	.5	100	50	2.0
3	426, 433	1	1.0	100	100	1.0
		[2	1.5	100	100	1.0]
		[3	3.0	100	100	1.0]
		[4	1.0	100	100	1.0]
		[5	1.5	100	100	1.0]
		[6	3.0	100	100	1.0]
4	434, 435	1	1.5	100	100	1.0
		[2	3.0	100	100	1.0]
		[3	1.0	100	100	1.0]
		[4	1.5	100	100	1.0]
		[5	3.0	100	100	1.0]
5	942, 943	1	.5	25	50	.5
6	438, 439	1	.5	50	50	1.0
		[2	1.0	100	50	2.0]
		[3	3.0	300	50	6.0]
7	436, 437	1	.5	50	100	.5
		[2	1.0	100	100	1.0]
		[3	3.0	300	100	3.0]
		[4	1.0	100	100	1.0]
8	431, 432	1	.5	200	100	2.0
9	411, 412	1	.5	400	100	4.0

## RESULTS

The process of shaping key peck location may be followed through changes in the distribution of pecks across the key as shown in Figures 2 and 3. For two example birds, peck location distributions are shown for the first two sweeps at each of three shaping step sizes. For each bird, the initial condition is placed at the top. For each step, two distributions are shown—that for the first 25 reinforcers obtained in the step (this set of pecks will be taken throughout the report to indicate the performance during the initial stage of a shaping step) and that for the last 25 reinforcers for a step (this set of pecks will be taken throughout the report to indicate the ultimate performance of a shaping step).

In general, the initial distribution of pecks is broader and has a mean which has not shifted as much as that for the ultimate distribution at a step. These differences are sometimes exaggerated as the reinforced keys approach an end (note that the very top distributions in the two figures are an exception to this rule, since these represent the initial, highly trained performances). The initial performance distribution is usually broad and the

ultimate performance is often tightly distributed around the reinforced keys.

Distributions such as those shown in Figures 2 and 3 represent the basic data taken in the experiment. Since absolute rates of pecking seemed constant across the various manipulations and represented a complex intermixture of latencies and interresponse times, frequencies rather than rates of pecking at each location were taken as the basic data. Many comparisons below are between birds exposed to different experimental conditions. To improve stability of the values, the mean is typically calculated across the first six sweeps of the key under that condition. Values for the first sweeps show similar but not as clear effects.

The primary characteristic of the distributions taken to represent the shaping process is the proportion of pecks falling within the range of the reinforced keys. For both the initial and the ultimate performance, the proportion of reinforced pecks to total pecks was calculated. Increasing this proportion is the essence of shaping. The proportion is called *FINAL* when taken from the ultimate performance (the last 25 reinforcers) and *INITIAL* when taken from the initial performance (first 25 reinforcers) at a step. When the proportion

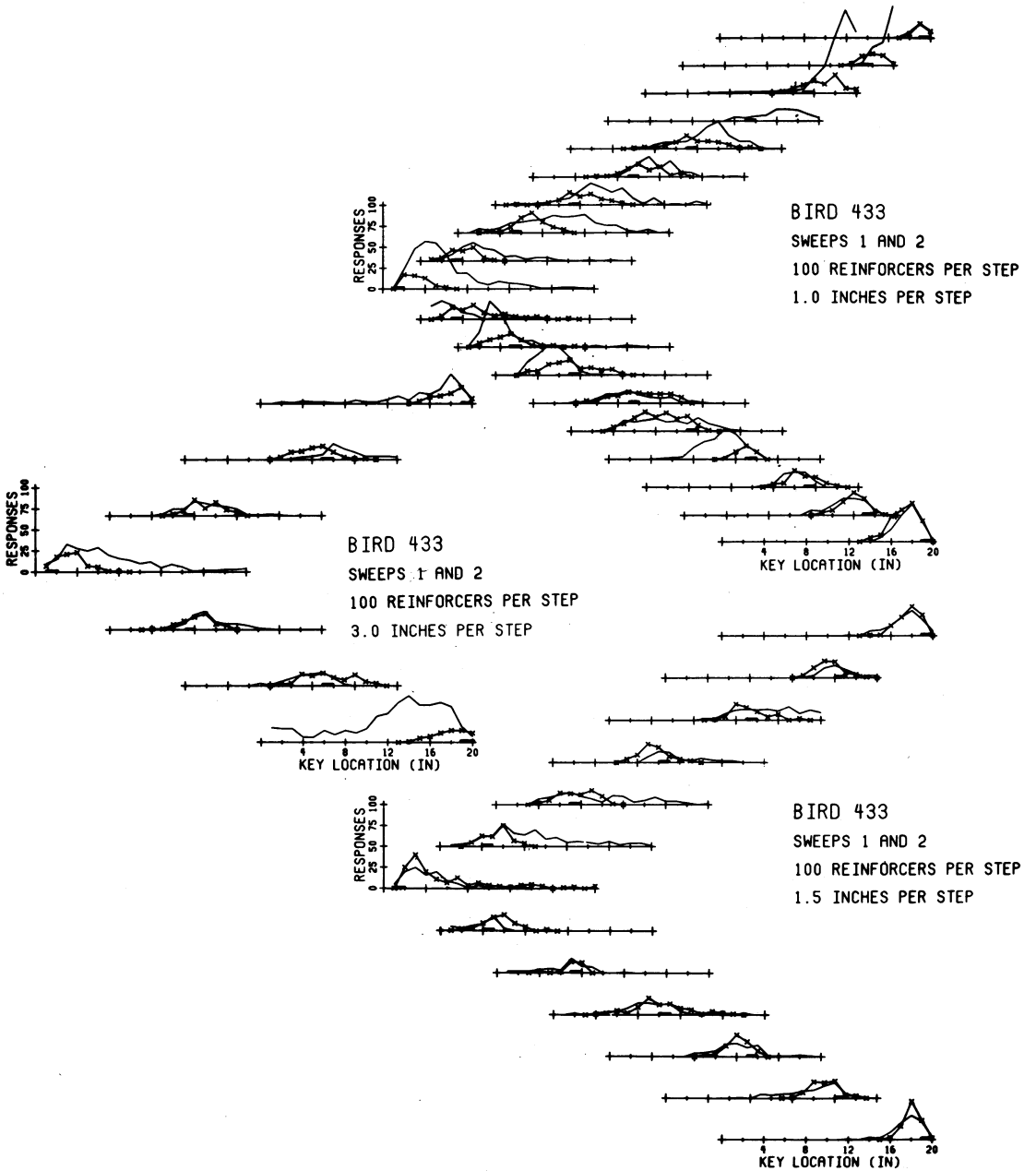


Fig. 2. For Bird 433, frequency of pecking each key location in the first and second sweeps under three different shaping step sizes. The first presented condition is at the upper right. The reinforced key locations are shown as a dark bar along the abscissa. The distribution for pecks emitted prior to the 25th reinforcer at a location are shown as a frequency polygon without Xs. The distribution for pecks during the last 25 reinforcers at a location are shown as a frequency polygon with data points indicated as Xs. This last-25 distribution is unavailable for the fourth step at 1.0 inch per step.

is high, performance is relatively clustered at the reinforced locations. In addition, the proportion of pecks falling on the next-to-be-

reinforced keys was calculated for the last 25 reinforcers at each step. This measure, called PRE, represents a baseline against which INITIAL

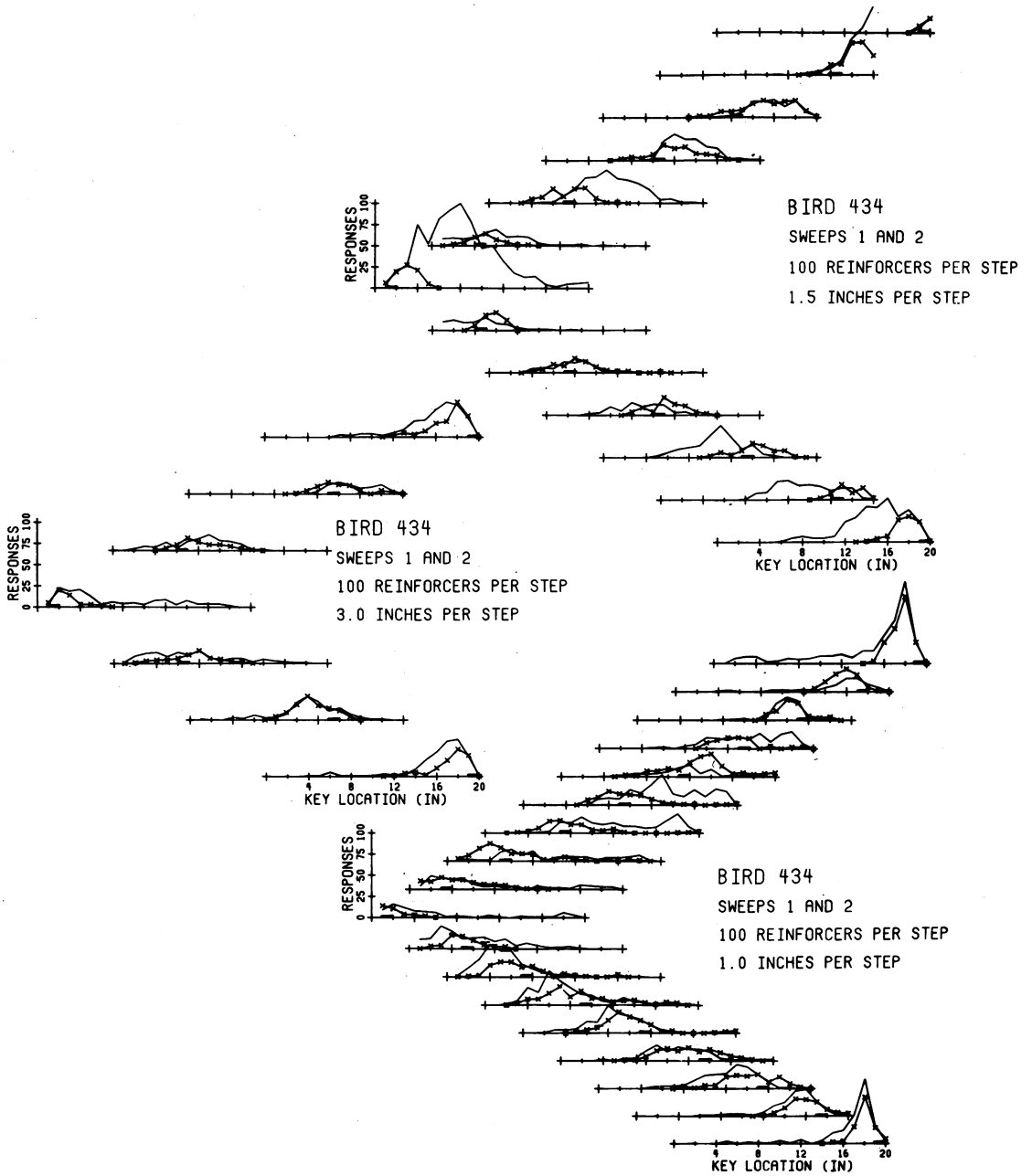


Fig. 3. For bird 434, frequency of pecking each key location in the first and second sweeps under three different shaping step sizes. Format same as that for Figure 2.

can be compared. The influence of step size and step rate will be judged from these three measures: FINAL, INITIAL, and PRE.

*Effect of Step Size*

The three measures were averaged over the first six sweeps and are shown in Figure 4

for the birds that were initially exposed to different step sizes but the same step rate (pairs 1, 2, 3, and 4 in Table 1). Similar data are shown in Figure 5 for the two pairs that were subsequently exposed to three different step sizes in the within-subject comparison. The data presented in Figures 4 and 5 were taken

only from key locations common to all step sizes considered. That is, keys 1 and 2, 7 and 8, 13 and 14, and 19 and 20, which were reinforced keys for the 3.0-in. step size and were also reinforced for all smaller steps. The data presented below are for responding at these common steps and are not, therefore, biased by different representation of steps near the ends versus near the middle of the key strip. Conclusions are not, however, changed when data from all steps are considered.

Figures 4 and 5 show that both across-subject and within-subject comparisons produce similar effects. First, there was little effect of step size on ultimate performance (FINAL) even though the consistent differences in the PRE measure show that only a small proportion of pecks met the new criterion at larger step sizes. Second, the INITIAL measure did show a slight change across the step size variable. Larger steps lead to more pecks being emitted before the first 25 reinforcers of the step were obtained. This slight decline in the INITIAL measure approached conventional statistical reliability for the between-subjects comparison ( $p = .057$  with a Mann-Whitney U-test comparison of the ranks for the 2 pairs with the .5-in. steps versus the 2 pairs with larger steps) and was statistically reliable for the within-subject comparison (a Friedman analysis of variance with ranks for these four subjects shows  $p < .005$ ). Third, there was considerable shift between the PRE and INITIAL performance at all step sizes, demonstrating a rapid shift to the new reinforced locations. For each pair of birds in the first six sweeps (Figure 4), a substantial amount of the change from PRE to FINAL was accomplished during the first 25 reinforcers (INITIAL) regardless of step size. For subsequent exposures (Figure 5), a growing difference was seen between PRE and INITIAL performance as step size increased. These data imply, then, that larger step sizes were as effective as or even more effective than smaller step sizes in shifting behavior from PRE to FINAL performance.

A source of possible confusion in the comparison of step size is length of training. One sweep of the key at .5 in. per step and 100 reinforcers per step involved 1,900 reinforcers (and 19 sessions) whereas a sweep at 3.0 in. per step and 100 reinforcers per step involved 400 reinforcers (and 4 sessions). The six-sweep period considered in the data summarized in

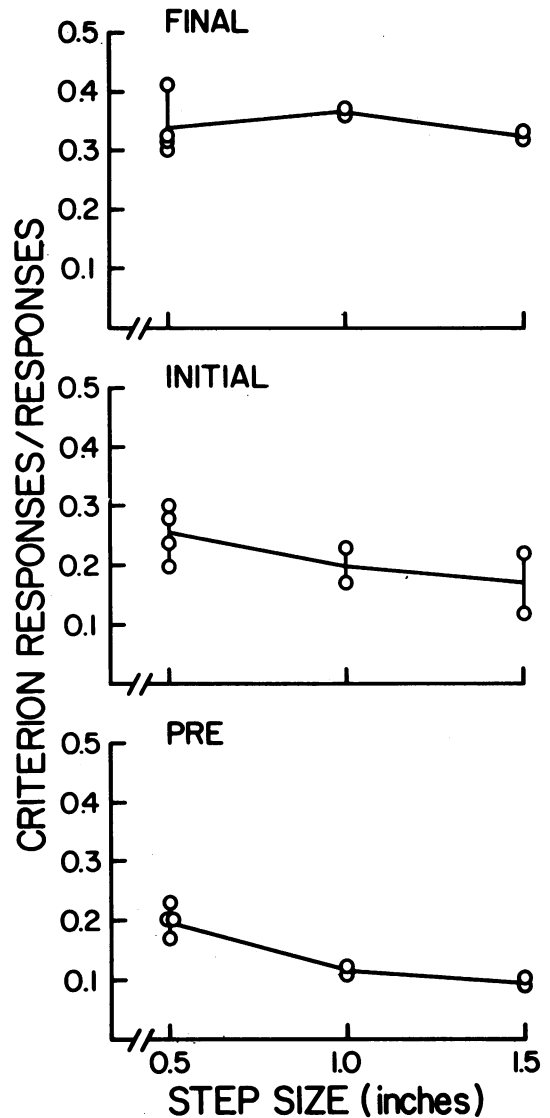


Fig. 4. Mean proportion of pecks meeting the reinforcement criterion for the first six sweeps for (a) the last 25 reinforcers of shaping steps (FINAL, top panel), (b) the first 25 reinforcers of shaping steps (INITIAL, middle panel), and (c) the next-to-be-reinforced keys during the last 25 reinforcers of shaping steps (PRE, bottom panel). Each data point represents the data for one bird, from three shaping steps each sweep—those steps present for a shaping step size of 3.0 inches.

Figures 4 and 5 thus represent different numbers of reinforcers and different numbers of sessions for the various step sizes. Since performance improved somewhat across training, step size and training duration are confounded variables. This confound would be more of a concern if we needed to account for large

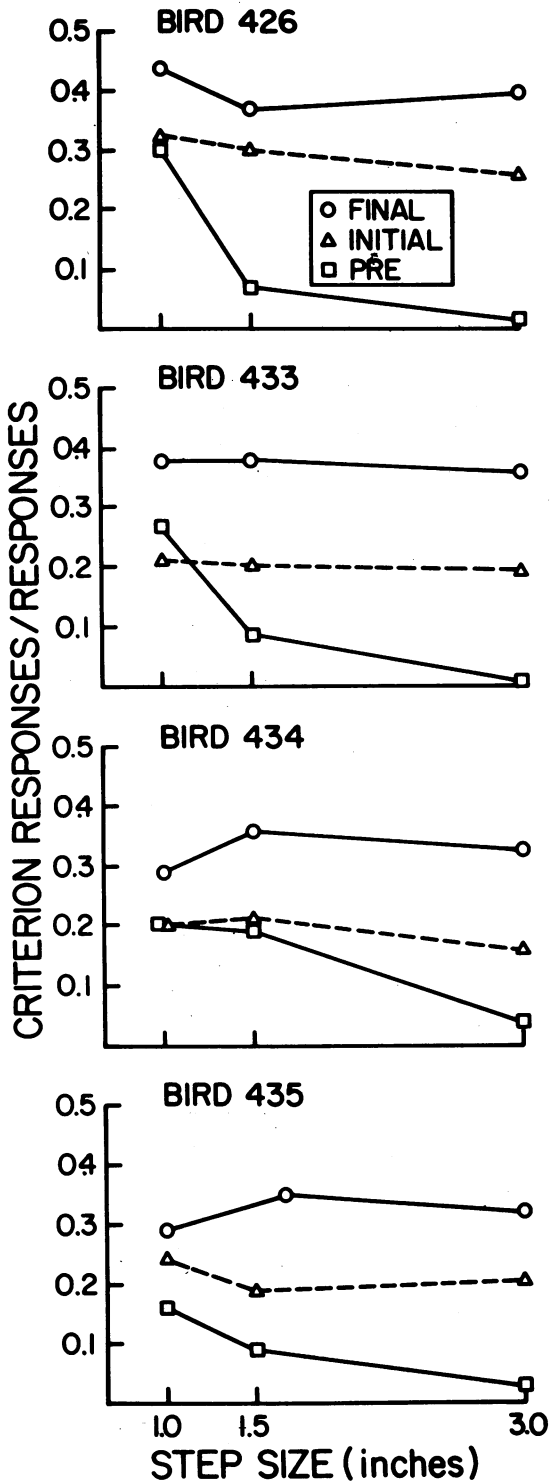


Fig. 5. Mean proportion of pecks meeting the reinforcement criterion for the first six sweeps at the three different step sizes arranged for each of these four birds. The proportion is shown (a) for the last 25 rein-

differences on the basis of step size—especially if smaller sizes were judged more effective. Instead, however, only small differences were found and these favored the larger step size, which shifted behavior farther with fewer reinforcers and less training. That the within-subject and across-subject comparisons are similar for the small differences in initial performance also suggests that this training confound is not crucial. The within-subject data were obtained after long training and yet show the same effects. The confound may, however, add somewhat to the effect in the across-subject comparison.

*Effect of Step Rate*

Several birds were initially exposed to the same step size (.5 in.) but different step rates (25, 50, 100, 200, and 400 reinforcers per step). Figure 6 shows that the step rate manipulation affected both FINAL and PRE measures but had surprisingly little effect on the INITIAL measure. Final performance included a higher proportion of reinforced pecks when step rate was slow (a Mann-Whitney U-test comparing the 2 pairs with 50 reinforcers per step to the 4 pairs with 100 or more reinforcers per step shows  $p = .036$ ). Birds with 25 reinforcers per step were not included in this comparison since FINAL and INITIAL measures were taken from the same data. Since the step size is .5 in., one of the keys in the next-to-be-reinforced pair was also in the currently reinforced pair. The increase in PRE may thus represent a clustering at a reinforced location just as does an increase in FINAL. That clustering increased with continued training at a step is reflected by the observation (see Figure 6) that for the birds at 400 reinforcers per step the PRE measure after 200 reinforcers was below that after 400 reinforcers and was comparable to the PRE measure for the two birds given 200 reinforcers per sweep. A Mann-Whitney U-test shows PRE was reliably higher for the 4 pairs with 100

forcers at the steps (FINAL), (b) for the first 25 reinforcers at the steps (INITIAL), and (c) for the next-to-be-reinforced keys during the last 25 reinforcers of the steps. Each data point represents the data for exposures to these shaping steps following the initial shaping condition (data from the initial condition are included in Figure 5). Data were included for three shaping steps each sweep—those steps present for a shaping step size of 3.0 inches.



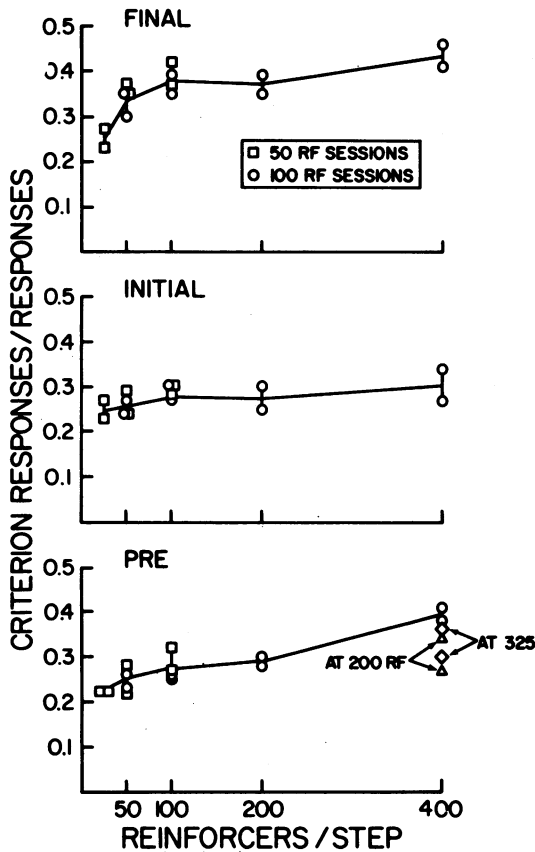


Fig. 6. Mean proportion of pecks meeting the reinforcement criterion for the first six sweeps for (a) the last 25 reinforcers per step (FINAL, top panel), (b) the first 25 reinforcers per step (INITIAL, middle panel), and (c) the next-to-be-reinforced keys during the last 25 reinforcers of shaping steps (PRE, bottom panel). Each data point represents the data for one bird, from all shaping steps of the first six sweeps of the key. Values for birds given 50 reinforcer sessions are shown as squares; values for birds given 100 reinforcer sessions are shown as circles. Additionally, the PRE measure is shown for the two birds given 400 reinforcers per step for the 175th to 200th reinforcer per step (triangles) and for the 300th to 325th reinforcer per step (diamonds).

or more reinforcers per step when compared to the 3 pairs with 25 or 50 reinforcers per step ( $p = .01$ ).

While the effects on FINAL and PRE measures are noticeable in Figure 6, little effect can be seen on INITIAL performance. The slight difference in INITIAL performance for the 3 pairs with 25 or 50 reinforcers per step compared to the 4 pairs with 100 to 400 reinforcers per step is, however, statistically reliable (Mann-

Whitney U-test shows  $p = .025$ ): more reinforcers per step produced a slight improvement in INITIAL performance. Since the difference between PRE and INITIAL performance did not increase for slower step rates, however, we cannot conclude that shaping was affected. Increasing the number of reinforcers increased stereotypy and therefore increased FINAL, INITIAL, and PRE performances in a comparable manner.

It appears odd that in Figure 6 the INITIAL measure for the 400 reinforcers-per-step birds falls somewhat below the PRE measure. A confound, however, accounts for this difference—INITIAL is taken from the first 25 reinforcers of a session while PRE is taken from the last 25 reinforcers of a session. If PRE is taken instead from the first 25 reinforcers of the last session of a step (called "at 325 RF" in Figure 6), the INITIAL and PRE measures are comparable. That is, when within-session warm-up is taken into account, INITIAL and PRE measures are similar. For birds with less than 400 reinforcers per step, INITIAL performance contained more pecks at the reinforced locations than did the PRE performance, even without this correction for within-session effects, showing that INITIAL performance had rapidly shifted from PRE performance—as implied by the notion of shaping.

There is a confound in the comparison of the influence of step rate, since the number of sessions per step varied as the number of reinforcers per step was manipulated. To partially unconfound these two variables, one pair of birds was given 50 reinforcement sessions and another pair was given 100 reinforcement sessions at both 50 and 100 reinforcers per step, allowing direct comparison of .5 to 1.0 sessions at 100 reinforcers per step and of 1.0 to 2.0 sessions at 50 reinforcers per step (see Figure 6). No apparent differences were produced by the differing number of sessions per step, suggesting that this variable was not crucial.

The step rate manipulation did not appear to affect shaping, even though there was a tendency for slower steps to produce slightly higher INITIAL performance. Since slower steps led to a greater stereotypy and greater efficiency in FINAL performance, and since a .5-in. step includes one of the previously reinforced keys, the increased stereotypy brought more pecking

onto the next-to-be-reinforced keys (PRE) and increased the INITIAL performance as well. Shaping effectiveness as indicated by INITIAL-PRE appeared unaffected by step rate.

#### *Effect of Step Rate and Step Size Jointly Varied*

For two pairs of birds, a within-subject comparison was arranged between conditions in which step rate and step size were jointly varied (pairs 6 and 7 in Table 1). The conditions were arranged in such a way that the same number of reinforcers were given per sweep for each condition. The conditions involved .5-in. steps each 50 reinforcers, 1.0-in. steps each 100 reinforcers, and 3.0-in. steps each 300 reinforcers. Figure 7 shows the effects of these conditions on the FINAL, INITIAL, and PRE performance measures. The effect was very much like that seen for step size: as step size increased, fewer pecks were seen at next-to-be-reinforced locations (PRE), but the ultimate performance was little affected (FINAL), and the initial performance was reliably, but only slightly, affected (INITIAL). The effects were similar to those seen in Figure 5, where step sizes of 1.0, 1.5, and 3.0 were evaluated with a constant rate of 100 reinforcers per step. Since step rate was manipulated over a sixfold range here (50 to 300 reinforcers per step) and yet the effect of step size was comparable to that when step rate was constant, step rate does not seem to be a strongly controlling variable in this process.

### DISCUSSION

It is reasonable to expect an optimal size and rate to be found for the shifts in reinforcement criterion comprising a shaping procedure. Shifts smaller than some value ( $S_1$ ) or occurring more slowly than some rate ( $R_1$ ) will expend more time and/or reinforcers-per-unit change in behavior and perhaps even render the behavior more resistant to change. Shifts larger than some value ( $S_2$ ) or occurring more rapidly than some rate ( $R_2$ ) will move the criterion away from the behavior so fast that reinforcement rate is insufficient to maintain the performance. Effective shaping involves keeping shifts within the limits  $S_1$ - $S_2$  and  $R_1$ - $R_2$ .

These ranges are likely to differ from re-

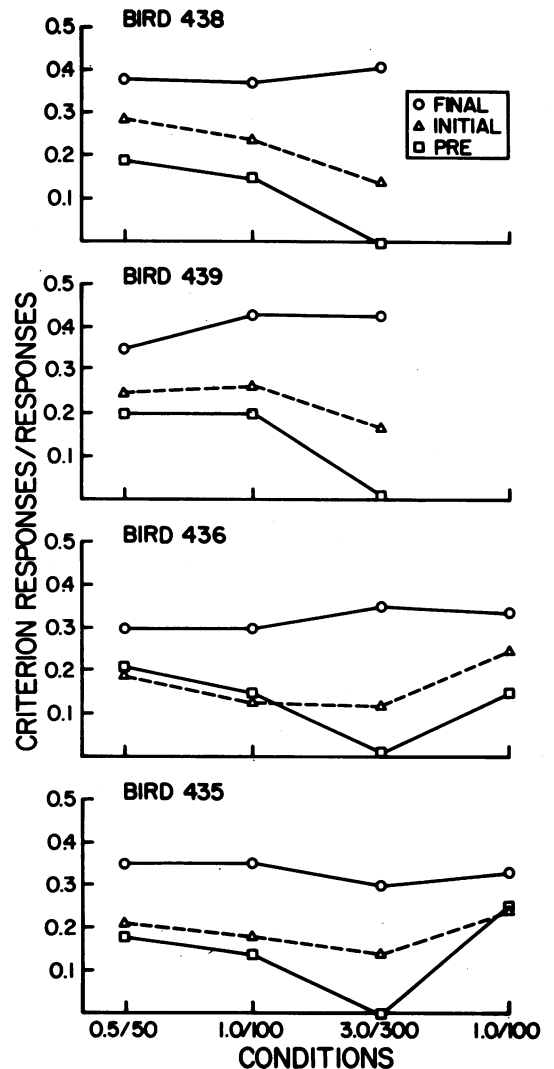


Fig. 7. Mean proportion of pecks meeting the reinforcement criterion for the first six sweeps at the three different step rate-size conditions arranged for each of these four birds. The proportion is shown for (a) the last 25 reinforcers of each shaping step (FINAL), (b) the first 25 reinforcers of each shaping step (INITIAL), and (c) the next-to-be-reinforced keys during the last 25 reinforcers of each shaping step (PRE). Data were included for three shaping steps each sweep—those present for shaping step size of 3.0 inches.

sponse dimension to response dimension as well as individual to individual and are likely to depend on other factors as well (e.g., reinforcement history, reinforcer effectiveness, concurrent reinforcement and punishment contingencies, etc.). What general rules might there be regarding these ranges? From Alleman and Platt (1973), Kuch and Platt (1976),

and the present study, there seems an emerging theme: large, rapid, shaping steps are recommended to maximize shaping. This rule contradicts what is often heard in the clinic and classroom: take small steps and minimize errors (e.g., Redd, Porterfield, & Anderson, 1979, pp. 45-46). The rule also contradicts the literature on the fading of stimulus control, which recommends small steps (e.g., Sidman & Stoddard, 1967). We may characterize the apparent contradiction as follows: the three laboratory studies imply that the values of  $S_1$  and  $R_1$  are higher than common sense would suggest, and that the values of  $S_2$  and  $R_2$  are higher than expected and need not limit the shaper. The clinic and classroom wisdom, however, emphasizes that these values are all lower than common sense would suggest to the therapist or teacher and that the danger is in shifting criterion too far and too fast. It is important to note that this disagreement is quantitative and not qualitative—it is a disagreement over where the  $S_1$ - $S_2$  and  $R_1$ - $R_2$  ranges will fall with respect to an expected starting point of the shaper. Shaping in the clinic typically involves changing behavior along more dimensions and less easily characterized dimensions than in the laboratory studies. These are differences in complexity. There may also, however, be differences in kind between dimensions along which behavior is shaped in the clinic and the dimensions of shaping in these three laboratory studies. Below we evaluate one difference between the typical clinical situation and that of the present study which may account for the different suggested step sizes.

An important determinant of shaping would seem to be the alignment between the change in behavior attempted by the shaping procedure and that produced by extinction or insufficient reinforcement. Extinction and shaping may produce changes in the same direction, in opposite directions, or may affect independent, noninteractive dimensions. Alleman and Platt (1973) and Kuch and Platt (1976) found large, rapid steps to be more effective when shaping long IRTs—a change in behavior which also results during extinction. We found large, rapid steps to be as effective (or even more effective) when shaping the horizontal location of key-pecking. Because extinction increases variability in response location (Eckerman & Lanson, 1969), shaping should be aided by changes in peck location

produced by extinction. In the clinic and classroom, it is more common to be shaping changes which are opposite those produced by insufficient reinforcement for the target behavior. Increased time-on-task, increased skillful coordination of action, decreased “fooling around”—these all express changes opposite those encouraged by the absence of the therapist's reinforcers. Perhaps large steps are recommended when extinction aids shaping and small steps are recommended when extinction opposes shaping.

This line of reasoning is supported in that Lane et al. (1967) were shaping changes which opposed the effects of extinction when they reached a conclusion opposite that of the present study. Lane et al. found that shaping longer durations of /u/ was more often successful when small shaping steps were taken. They calibrated their steps by standard deviation units and found that shaping steps of 1.5 or 2 units were too large to be effective in shaping behavior. Assuming a normal distribution of durations, this suggestion translates to recommending against  $P$ -values of .90 to .96. On the other hand, Alleman and Platt (1973) found these were the most effective  $P$ -values to use in shaping longer IRTs. In the present study, we found that shaping steps of six standard deviation units were effective in shaping response location (measuring the 3.0-in. steps in terms of the standard deviation of response location during the last 25 reinforcers of the prior shaping step). While both a spoken /u/ and the IRT for key pecks were biased toward short durations at the outset of training, the spoken /u/ had short duration because of prior social contingencies and physiological limitations while IRTs were short because of reinforcement of key pecking by food. Assuming that the absence of reinforcement from the experimenter (extinction) would yield a change toward baseline, the spoken /u/ should shorten and the IRT should lengthen during extinction. The difference between the Lane et al. (1967) study and the other laboratory studies might well, then, be the manner in which the shaping aligns with the effects of extinction.

There is another difference between the Alleman and Platt and Lane et al. procedures that may also contribute to the difference in result. While Alleman and Platt adjusted the criterion for reinforcement following each re-

sponse (a high rate of shifts), Lane *et al.* adjusted the criterion following every 20 responses (a low rate of shifts). Such a difference meant that if responding did not shift, Alleman and Platt adjusted their criterion immediately (though only by a small amount, as the last several IRTs were considered in setting the criterion); the slower rate of adjustment in the Lane *et al.* procedure meant that the probability of reinforcement could fall precipitously if performance shifted outside the reinforced range. The more rapid adjustment in the Alleman and Platt procedure would work to render the probability of reinforcement more constant. Though differences in the types of operants and situations preclude close comparison across these studies, Lane *et al.* might have achieved more shaping had they adjusted their criterion more often. We varied step rate in the present study and saw no clear effect on shaping. The step rate comparisons were made, however, only at the smallest step size. At larger step sizes, we might have found an effect of step rate. Perhaps optimal step size and step rate will interact. The present message, however, seems to be that where extinction changes behavior in the same direction

as that being shaped, large shaping steps are to be encouraged.

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