

## STIMULUS CONTROL OF THE PIGEON'S ABILITY TO PECK A MOVING TARGET

RICHARD PISACRETA

FERRIS STATE COLLEGE

Two pigeons were trained to peck whichever of eight keys displayed a white field ( $S^D$ ). The other seven keys displayed a white "X" on a black background ( $S^A$ ). Each peck to  $S^D$  produced three-second access to grain, a three-second intertrial interval (ITI), and the next trial. Pecks to  $S^A$  produced a three-second timeout (TO) and the same trial. During later sessions the key displaying  $S^D$  changed every  $t$  seconds ( $t=3, 2, 1, .5, \text{ and } .25 \text{ sec}$ ), requiring the birds to track the position of the  $S^D$ . Pecks on a ninth key increased  $t$ . Several sessions employed novel stimuli to ascertain the controlling stimulus dimensions. Both birds made few errors acquiring the original discrimination. During the tracking sessions, both birds made few errors when  $t=.5 \text{ sec}$ . Only one reliably lengthened  $t$ . Data from sessions with novel stimuli indicate that color and form were important aspects of  $S^D$  and  $S^A$  respectively; movement contributed to the final performance.

*Key words:* movement discrimination, tracking behavior, stimulus control, concept learning, key pecks, pigeons

Organisms do more than detect static stimuli within their visual range. They survive by responding also to dynamic (moving) stimuli. As Hodos, Smith, and Bonbright (1976) point out:

Movement is one of the fundamental properties of visual stimuli. The detection of absolute and relative rates of movement of stimuli is crucial for the survival of all organisms that are capable of detecting patterned light. Such basic survival mechanisms as predation, avoidance of predators, food gathering in non-predators, and locomotion through the habitat are all highly dependent upon motion detection. (page 143)

Movement thresholds have been measured in humans (Brown, 1931), chimpanzees (Carpenter & Carpenter, 1958), cats (Kennedy & Smith, 1935), rats (Hawley & Munn, 1933), and pigeons (Hodos et al., 1976; Siegel, 1970, 1971). Siegel (1970, 1971) demonstrated that pigeons can discriminate between stationary (nonmoving) stimuli and stimuli presented as real or apparent movement. Hodos et al. (1976)

trained pigeons to discriminate between stationary and dynamic stimuli. Their data indicated that the movement-detection threshold for most of their birds was between 4.4 and 6.5 mm per sec. These experiments typically required the subject to peck a key if it detected movement confined within the boundaries of the key or a nearby screen. Dynamic stimuli in the natural environment, however, frequently move across spatial boundaries and must be coordinated with locomotion; e.g., predation and navigation around objects during flight. A laboratory demonstration of the pigeon's ability to peck a moving stimulus would seem appropriate.

### EXPERIMENT 1

In the first experiment, the stimulus moved across keys. The pigeons had to (1) visually locate the discriminative stimulus ( $S^D$ ) in a field with seven other stimuli ( $S^A$ s), (2) track the movement of the  $S^D$  across the keys, and (3) peck a key while it displayed  $S^D$ .

### METHOD

#### *Subjects*

Two naive White Carneaux pigeons, maintained at  $80\% \pm 15g$  of their free-feeding weights, were employed.

I wish to thank Coleman Paul for his contributions to this work; and Mrs. Nancy Myers and Mrs. Dorothy Lambert for typing various drafts. A special thanks to Evalyn F. Segal for her encouragement and skilled editing of earlier drafts. Reprints may be obtained from R. Pisacreta, Department of Psychology, Ferris State College, Big Rapids, Michigan 49307.

### Apparatus

The apparatus was a 35- by 35- by 37-cm operant chamber enclosed in a sound-attenuating hull. A 20- by 25-cm piece of one-way glass mounted on the door of the outer hull enabled observation of the entire experimental area. Figure 1 shows the intelligence panel. Except for the unusual number of pecking keys, the intelligence panel, 37 cm by 35 cm, employed standard dimensions and commercial components. Each key was 2.7 cm in diameter (BRS/LVE Model #121-16). Stimuli were rear projected onto the keys by Industrial Electronics Engineers Inline Projectors (Model #1813-44). The operating-force requirement of each key was approximately .16 N. The horizontal and vertical distances between the keys were 8.1 and 6.4 cm, respectively, center to center. A 6- by 6-cm feeder aperture was centered on the wall 10 cm above the floor.

The feeder (BRS/LVE Model #114-10) provided 3-sec access to grain. The houselight, a GE #1820 lamp, provided light before and after daily experimental sessions. During sessions, illumination was provided only by the inline projectors. Response keys 10 and 11 were never illuminated. White noise delivered

through the speaker and a ventilation fan masked extraneous noise. An E and L Instruments MMD-1 computer recorded data and controlled experimental events.

### Procedure

Both subjects were magazine trained. Key pecking was shaped using Key 1, illuminated with a white field ( $S^D$ ). Each bird was then allowed to produce 100 food reinforcers by pecking Key 1. All subsequent sessions terminated after 50 reinforcements.

*Phase 1—Preliminary training.* Keys 1 and 2 were illuminated on each trial. One key presented a white field ( $S^D$ ) and the other key presented a white "x" on a black field ( $S^A$ ). A peck on the white key produced a reinforcer, followed by a 3-sec intertrial interval (ITI) and the next trial. Pecks to the "x" produced a 3-sec timeout (TO) and a repeat of the same trial. During TO and ITI all visual stimuli were eliminated and the chamber was dark. Across trials, the  $S^D$  and  $S^A$  appeared equally often on each key. An irregular sequence was used that allowed a maximum of three successive trials of  $S^D$  on the same key. Each subject was trained on this two-key discrimination until there were three consecutive sessions with no errors in the last 40 trials of each session. When this criterion was satisfied, a three-key discrimination was introduced in the next experimental session. The white stimulus ( $S^D$ ) randomly appeared on Key 1, 2, or 3. The other two keys presented an "x" ( $S^A$ ). When there were three consecutive sessions with no errors in the last 40 trials by either bird, an additional  $S^A$  key was added. Keys were introduced in the sequence: 4, 6, 7, 8, and 9. This procedure was continued until each subject reliably pecked whichever key presented white ( $S^D$ ) and did not peck the seven "x"s. Key 5 was not used during this phase.

*Phase 2—Tracking  $S^D$ .* Each trial consisted of one  $S^D$  located randomly and seven  $S^A$  stimuli. If the bird did not respond to the display within  $t$  sec, the  $S^D$  changed to the next key in a clockwise direction and continued to move clockwise each  $t$  sec until a response produced TO or reinforcement. The value of  $t$  was 3 sec for three sessions, 2 sec for three sessions, 1 sec for five sessions and .5 sec for 15 sessions. Several aspects of behavior besides pecking were of interest. Did the birds shuttle across keys or wait for the  $S^D$  to reach them? If  $S^A$  was

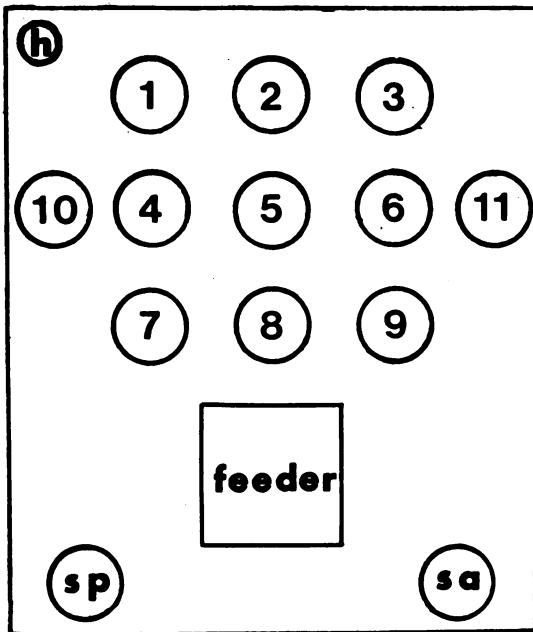


Fig. 1. The intelligence panel employed. The pecking keys are numbered 1 through 11. SP is the speaker that provided masking noise. H and SA represent the houselight and sonalert respectively.

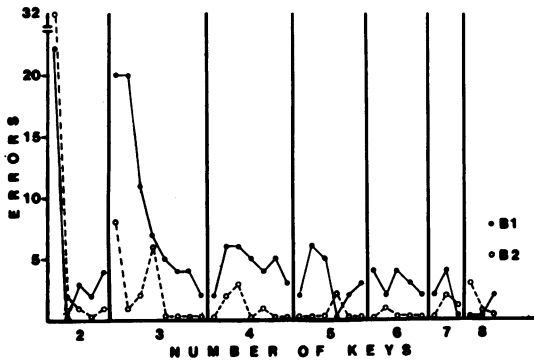


Fig. 2. Errors per condition in Phase 1—pretraining.

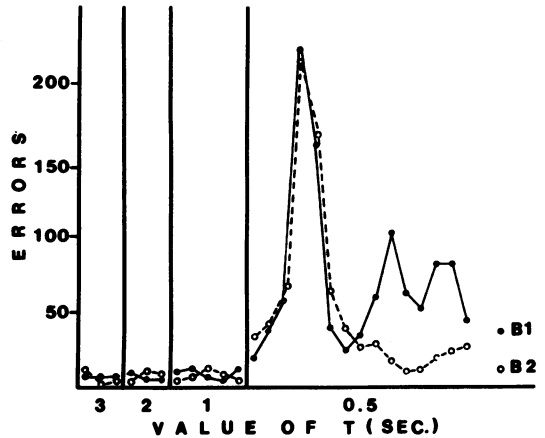


Fig. 3. Errors produced as a function of  $t$  during each session of Phase 2.

pecked, where was the  $S^D$  in relation to the  $S^A$  key pecked? Did the birds perseverate on a key(s) until reinforcement was obtained? To address these questions, each bird was observed for several minutes through one-way glass during each session. Approximately twice a week a second observer was employed for reliability checks.

### RESULTS

Figure 2 shows the errors produced during each session of Phase 1. Each bird made relatively few errors while learning the static discrimination. Furthermore, as the number of stimuli increased, errors and sessions to satisfy criterion both decreased.

Figure 3 depicts errors during the conditions of Phase 2, the dynamic discrimination. Both subjects made relatively few errors at  $t > .5$  sec, but at  $t = .5$  sec their performances deteriorated. Direct observation of both birds indicated that many errors were late pecks to a key that had been displaying  $S^D$  when the key peck began. With  $t = .5$  sec, both birds yielded an initial increase in errors followed by gradual improvement.

Analysis of all key pecks, both errors and those that were reinforced, showed that during the first six sessions both birds responded to all the available keys. In later sessions B1 responded predominantly to only three keys. B2 responded only to Keys 2 and 4. These shifts in response distributions were accompanied by a decrease in errors.

Figure 4 presents distributions of reinforced responses during Phase 2. Observation indicated that on these trials the birds oriented toward the  $S^D$  key and pecked it. With  $t = 3$  sec, responding was distributed across all keys,

but as  $t$  was decreased, key pecks became concentrated on certain keys. Direct observation revealed that both birds typically responded to the rapidly moving targets by orienting toward one of a few preferred keys and pecking the  $S^D$  as it moved by that key. With  $t = .5$  sec, pecks to Keys 6, 8, and 9 accounted for 81% of B1's reinforcements, whereas Keys 4 and 2 provided 86% of B2's reinforcements.

### DISCUSSION

Mello (1968) showed that pigeons can discriminate the direction of movement of striped patterns. Skinner (1960) demonstrated that pigeons could peck a moving target, thereby

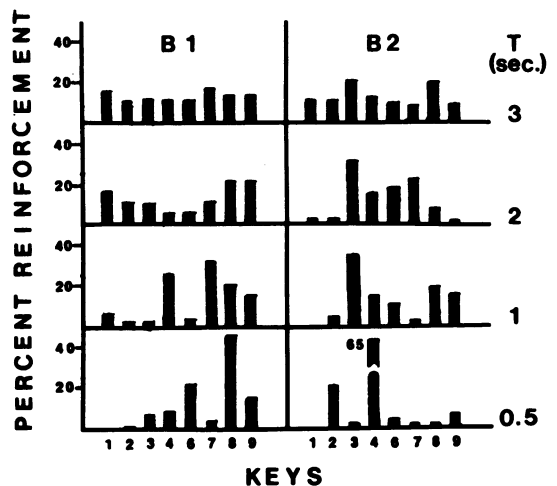


Fig. 4. The percent of reinforcement produced on each key during Phase 2.

keeping the target centered on a screen. Experiment 1 demonstrated that pigeons can track and peck a stimulus that is displayed for as little as .5 sec. The distance between the keys required the birds to track with their bodies as well as head movements. They were frequently observed to shuttle across the intelligence panel. Furthermore, the speed of movement of the  $S^D$  required the birds to initiate a peck toward a key before the  $S^D$  arrived. Both birds were observed to initiate a peck motion while the  $S^D$  was two keys away and  $S^A$  was still on the key being addressed.

Eckerman and Lanson (1969) showed that the variability of the pigeon's key peck on a 10-in. wide by .75-in. high response area decreased with training. Although their birds predominantly pecked on a narrow area of the wide key, they also pecked neighboring areas; that is, key pecks were variable in location so long as all were reinforced. The present results are similar. Although both birds shows key preferences at the shortest values of  $t$ , they did not restrict pecking exclusively to those keys. At the longer values of  $t$ , both birds distributed their responses across all the available keys.

## EXPERIMENT 2

Experiment 2 made use of Key 5, the middle key in the array. Each peck on this key increased  $t$  by .25 sec. The procedure enabled the pigeons to control the rate at which they had to track  $S^D$ , and consequently provided an opportunity for each bird to demonstrate its preferred value(s) of  $t$ . The manipulation provided several conditions under which a bird could collect reinforcement, i.e., on any of eight keys with many values of  $t$  available.

## METHOD

### Subjects and Apparatus

Same as in Experiment 1.

### Procedure

As in Experiment 1, each of the trials consisted of one  $S^D$  and seven  $S^A$  stimuli presented for  $t$  sec on Keys 1, 2, 3, 4, 6, 7, 8, and 9. If the bird did not respond in  $t$  sec, the  $S^D$  changed to the next key in a clockwise direction. At the beginning of each trial,  $t$  had its base value. Key 5 was illuminated with yellow. Each peck on Key 5 added .25 sec to the value of  $t$ . After

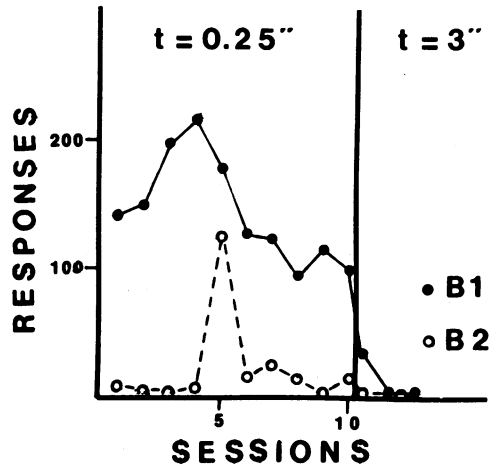


Fig. 5. Responses on Key 5 during each session.

each reinforcement, the value of  $t$  was reduced to its base value to start the next trial. Sessions ended after 50 reinforcements. The base value of  $t$  was .25 sec for ten sessions and 3 sec for three sessions.

## RESULTS

Figure 5 shows the number of pecks to Key 5 per session. During the ten sessions with a base  $t$  value of .25 sec, Subject B1 pecked Key 5, 1426 times. Only 22 (4%) of the 500 reinforcers were obtained with  $t = .25$  sec, i.e., without a peck on Key 5. Subject B2 pecked Key 5, 140 times during the same ten sessions and collected 395 (79%) of its reinforcers without pecking Key 5. During the first session that the base value of  $t$  was raised to 3 sec, Subjects B1 and B2 pecked Key 5, 32 and 3 times, respectively. Neither bird pecked Key 5 during the last two sessions of the experiment. The results indicate that pecking Key 5 was a function of the initial value of  $t$ .

Figure 6 shows the relative distribution of  $t$  values produced by each bird before collecting its reinforcers. When given the opportunity to slow the movement of the  $S^D$ , B1 produced values of  $t$  ranging from .5 to 2 sec before collecting the majority (89%) of its reinforcers. The greatest number of reinforcers, 36%, was obtained at  $t = .75$  sec. For B2, most reinforcers were obtained at  $t = .25$  sec, a few at  $t = .5$  sec and .75 sec and almost none at longer  $t$  values. The top half of Figure 7 presents the percentage distribution, across keys, of reinforced responses. Figures 6 and 7 can be read to indicate that B1 pecked Key 5 sev-

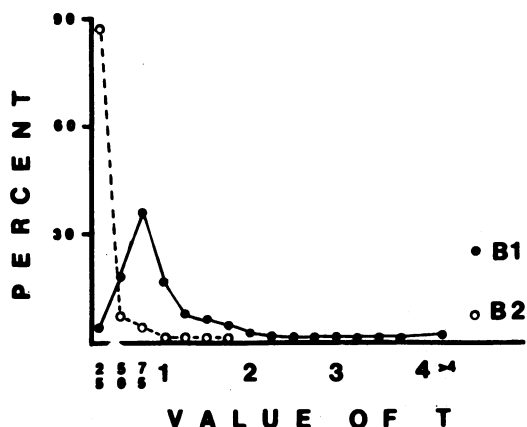


Fig. 6. Distribution of  $t$  values (percentages) produced by each subject by responding on Key 5 prior to collecting each of the 650 reinforcers.

eral times and then collected most of the reinforcers by pecking Key 3, 6, or 8. Subject B2 pecked Key 5 fewer times and showed a more pronounced preference for certain keys. B2 collected the majority of its reinforcers on Key 4, as it had at the end of Phase 2 when  $t$  was .5 sec. Direct observation revealed that on the majority of trials, B1 positioned itself in front of Key 4 and followed the movement of the  $S^D$  with orienting head movements. When the  $S^D$  was on Key 1, the bird began emitting pecking motions toward Key 4. As the  $S^D$  approached, the pecking movements more closely approached the key until one successfully depressed the key and registered as a response. When the base value of  $t$  was raised to 3 sec, both birds produced response distributions similar to those seen in Figure 4. They responded about equally across all keys.

The bottom half of Figure 7 shows the percentage distribution of errors across keys. B1 made 715 errors during the experiment and B2 made 3588. The error data of both birds closely match their reinforced-response distributions. B1 pecked Key 5 an average of twice per trial and made an average of one error per reinforcement. Most of B1's errors were on its preferred keys, 3, 6, or 8.

B2 pecked Key 5 on only 20% of the trials and made an average of six errors per trial. Most errors were on Key 4, its preferred key, and represented premature or late pecks on Key 4.

During the first session with  $t = .25$  sec, B1 made 255 errors. Within three sessions its errors dropped to about 35 per session as peck-

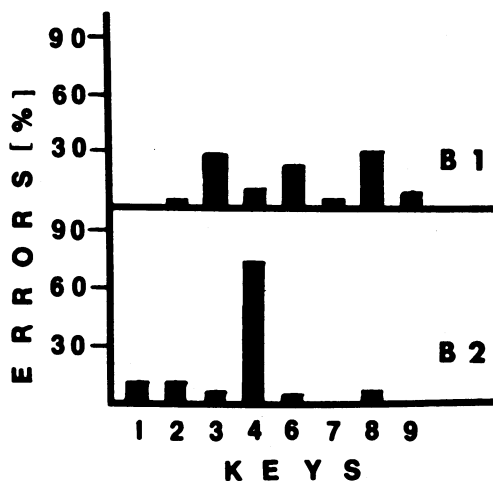
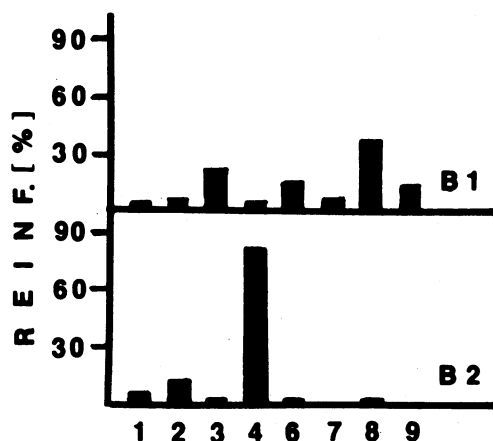


Fig. 7. Percentage distributions of reinforced responses and errors.

ing on Key 5 was established. B2 made about 200 errors in each of the first three sessions. B2's errors increased to about 350 for each of the last five sessions.

#### DISCUSSION

Although B2 made many errors, the data indicate that pigeons can successfully peck rapidly moving stimuli. Walker (1968) demonstrated that pigeons can track a dot of light in a visual display. The birds' task was to move the dot of light until it was equidistant from two other dots on a screen. The bird "moved" the dot by pecking two keys. One key moved the dot to the left and the other to the right. Although the birds were reasonably successful, initial training required over 80 sessions.

Walker speculated that less variable performance might have been obtained in less time had the dot display appeared on the pecking keys. The comparatively rapid acquisition in the present study appears to support that conclusion. Few dominant response patterns emerged relative to the several combinations of  $t$  value and key pecks possible. There were two basic response patterns for obtaining reinforcement, "body moving to the  $S^D$ " and " $S^D$  moving to the body." The pigeon could shuttle across keys or position itself in front of one key and wait for  $S^D$  to move to that key. With  $t > .5$  sec, both birds emitted the "body moving to the  $S^D$ " pattern. At  $t = .5$  sec, they shifted to the other pattern (Figure 7). This  $t$  value may be too short to enable the pigeons to locate and move to the  $S^D$  with frequent success. When Key 5 was introduced, B1 pecked it, increasing the value of  $t$  until it could effectively locate and peck  $S^D$ . B2 continued to emit the " $S^D$  moving to the body" pattern (Figure 7). During the last three sessions ( $t = 3$  sec) both birds emitted the "body moving to the  $S^D$ " pattern.

### EXPERIMENT 3

The data from the first two experiments indicate that pigeons can track reasonably well. A question remains concerning the stimulus properties that control tracking. Reynolds (1961) demonstrated stimulus control by the individual elements of a compound  $S^D$ . Pigeons were trained on a multiple schedule. In one component, pecking a key illuminated with a white triangle on a red background was reinforced on a variable-interval 3-min schedule ( $S^D$ ). The alternate extinction component presented a white circle on a green background ( $S^A$ ). After the discrimination was established, the four individual elements—triangle, circle, red, and green—were individually presented for 1-min periods. One bird pecked the triangle almost exclusively whereas the other mostly pecked red. Reynolds concluded that only one aspect of the  $S^D$  controlled responding and that aspect varied between birds.

In a replication of Reynolds' (1961) study, Wilkie and Masson (1976) found that each of their six birds pecked almost exclusively in the presence of the color previously associated with reinforcement. The birds were then re-

warded for pecking the key in the presence of the forms. Pecking the form formerly associated with reinforcement was acquired more rapidly than pecking the form formerly associated with extinction. The authors concluded that responding to one aspect of a compound stimulus need not imply selective attention because even though one dimension of a stimulus appears to control behavior, the other dimensions may contribute to the overall performance. Blough (1972), Butter (1963), and Wolf (1963), among others, have demonstrated joint control of behavior by several stimulus dimensions. In the present study, pigeons reliably pecked a white disc presented simultaneously with seven "x"s. Several aspects of the stimuli could have contributed to the overall performance, viz., color, form, brightness differences between  $S^D$  and  $S^A$ , as well as movement. Experiment 3 consisted of several attempts to ascertain which stimulus dimensions controlled discriminative performances in the first two experiments.

### METHOD

#### *Subjects and Apparatus*

The same pigeons and equipment as in the first two experiments.

#### *Procedure*

Each daily session terminated after 50 reinforcements. The procedure involved exposing the birds to novel stimulus conditions followed by a session with the original discrimination to recover the original performance. As before, each trial presented one  $S^D$  and seven  $S^A$ s. A peck to  $S^D$  produced a reinforcer, ITI, and the next trial. Errors produced a TO and a repeat of the same trial. The first 14 sessions presented novel stationary discriminations, the next ten sessions introduced novel dynamic discriminations, and the last 12 sessions employed both stationary and dynamic stimuli. Further details are given with the results.

### RESULTS

Figure 8 shows the number of errors made by each bird during each session of Experiment 3. (Because the same subjects were employed throughout all three experiments, the session numbers are continued from the first two experiments.) Sessions 78 to 80 inclusive

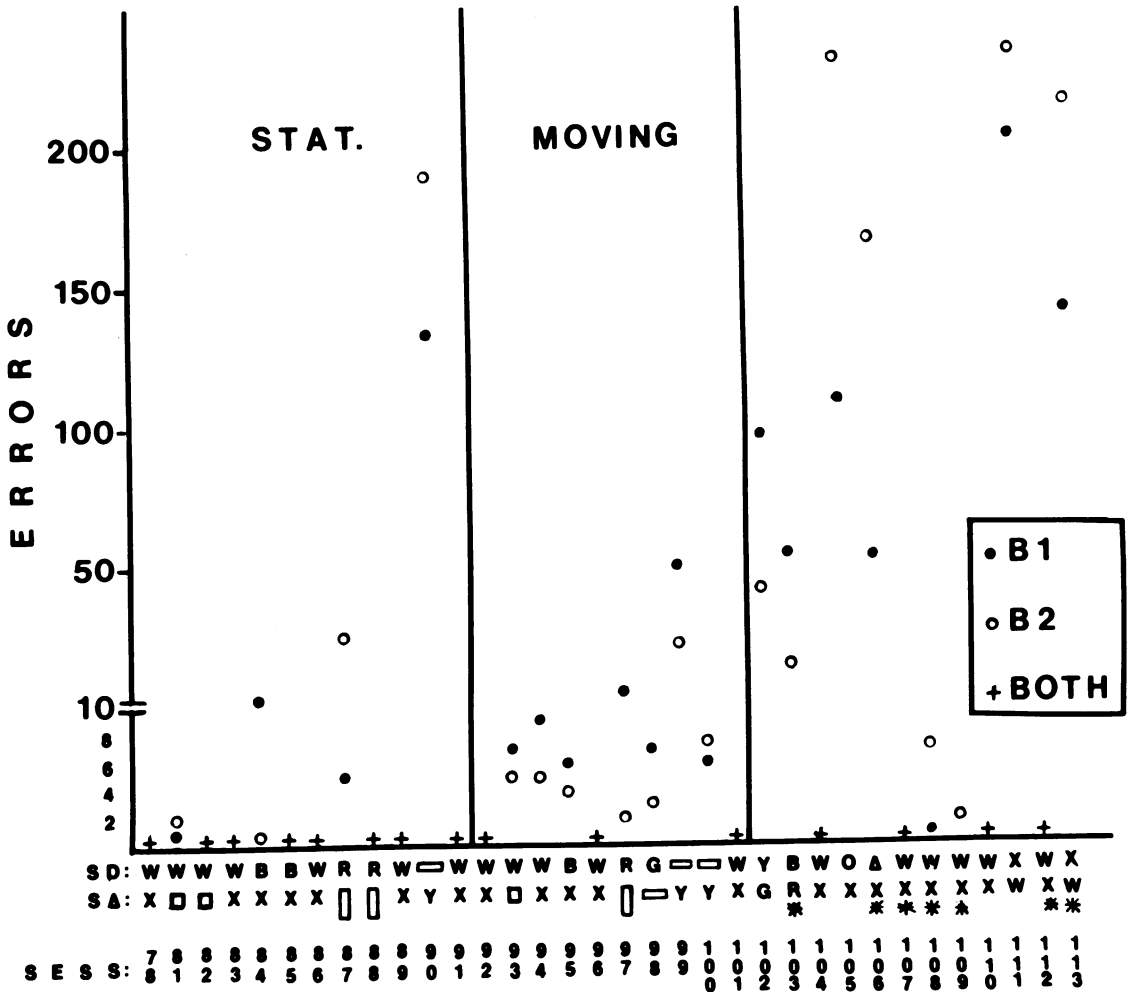


Fig. 8. Errors produced during each session. The novel stimuli were presented as stat(ionary) discriminations during the first 14 sessions and dynamic (moving) discriminations during the next 10 sessions. Dynamic discriminations during the last 12 sessions are denoted by an asterisk (\*).

demonstrated that the original stationary discrimination was intact for both subjects, i.e., neither bird made any errors. During Sessions 81 and 82, a white square on a black background replaced the "x" as S<sup>A</sup>. Both birds made few errors, indicating that they were not avoiding "x" specifically. During Sessions 84 and 85 a blue key replaced white as S<sup>D</sup>. B1 made a few errors, Subject B2 made none. Sessions 87 and 88 simultaneously provided a novel S<sup>D</sup> (red) and a novel S<sup>A</sup> (white vertical line on a black background). Both birds made few errors, indicating that the birds were not specifically pecking white only. Until this point in the experiments, S<sup>D</sup> had always been

a blank key whereas S<sup>A</sup> had always been a form. Session 90 presented another novel pair of stimuli. This time a form (horizontal white line on a black background) served as S<sup>D</sup> and a blank yellow key served as S<sup>A</sup>. Both subjects made many more errors than in the earlier sessions with novel stimuli.

The next ten sessions presented the same stimulus pairs under dynamic-discrimination conditions. S<sup>D</sup> moved clockwise every 3 sec. Session 92 indicated that the original tracking discrimination was intact for both subjects. Sessions 93 and 95 replicated the results produced with the same stimuli under stationary conditions (in Sessions 81, 82, and 84, 85 re-

spectively). That is, the birds were not avoiding "x" specifically nor was "moving white" the specific  $S^D$ . Sessions 97 and 98 provided evidence of maintained stimulus control when both  $S^D$  and  $S^A$  were novel. Sessions 99 and 100 confirmed the results obtained in Session 90, with a blank key  $S^A$  and a form  $S^D$ . Both birds, however, made fewer errors with a moving  $S^D$  than with the same stimuli under stationary conditions. Practice effects, however, could account for the fewer errors made by B1 during Session 95 relative to 84 and by both birds during Sessions 99 and 100 compared to 90. Practice effects could not account for Session 98 in which green ( $S^D$ ) with horizontal line ( $S^A$ ) were introduced.

Session 102 provided a two-color stationary discrimination. Subjects B1 and B2 emitted 97 and 41 errors, respectively. These data indicate that form was an important element of  $S^A$  in the earlier discrimination.

Session 103 provided two colors as a dynamic discrimination. Both subjects emitted slightly fewer errors in this session than in Session 102, the two-color stationary discrimination. This suggests that movement may have been an important element of the  $S^D$ . Practice with two colors may also have contributed.

Sessions 105 and 106 were two-form discriminations, the original  $S^A$  with a novel form as  $S^D$ . The data were similar to those obtained with two colors. Session 105 indicates that absence of form was an element of  $S^D$ , whereas session 106 shows that movement was also an important element of  $S^D$ .

Sessions 108 and 109 presented the original discrimination, white =  $S^D$ , x =  $S^A$ , with novel direction of movement. In Session 108, the  $S^D$  moved counter-clockwise. During Session 109, the  $S^D$  moved across the keys in horizontal rows; i.e., 1, 2, 3, 4, 6, 7, 8, 9. The few errors produced with these conditions indicated that direction of movement was irrelevant. Session 111 presented the original stationary discrimination reversed. X was  $S^D$  and white was  $S^A$ . During the first trial, Subjects B1 and B2 emitted 205 errors and 234 errors respectively, and then both birds stopped responding. The session was terminated after each bird had not responded for an hour. This reverse discrimination was presented again in Session 113. The x, however, moved clockwise every two seconds. Both birds made fewer errors in Ses-

sion 113 relative to the first trial of Session 111 and finished their respective sessions.

## DISCUSSION

Experiment 3 indicates that the final performance was a product of the stimulus control exerted by properties of both  $S^D$  (color) and  $S^A$  (form). Movement may also have been an  $S^D$  dimension. Discrimination accuracy was maintained throughout most of the sessions with novel stimuli. Some degree of concept formation is implied. Conceptual behavior involves generalization within classes of stimuli and discrimination between stimulus classes (Keller & Schoenfeld, 1950, p. 155). In the present study, a key illuminated by white light (Experiments 1 and 2) or by light of several different colors (Experiment 3) functioned as the  $S^D$  property, whereas the class of forms on the keys functioned as the  $S^A$  property. Accuracy of discrimination when exposed to novel stimuli has been taken as evidence of conceptual behavior (Herrnstein & Loveland, 1964; Lubow, 1974; Siegel, 1970; Siegel & Honig, 1970). The data suggest that the concept "homogenous field present," viz., a color, was in evidence. The largest number of errors occurred when two forms or two colors were presented as  $S^D$  and  $S^A$ , and when a form and a color served as  $S^D$  and  $S^A$  respectively. This suggests that the concept "nonhomogenous field," viz., a form, usually employed as  $S^A$ , may have contributed to the overall performance.

Siegel (1970) demonstrated that pigeons can learn a movement concept. The inverse relationship between the values of  $t$  and the number of keys pecked, and the use of Key 5 to slow the movement of the  $S^D$ , may satisfy Lubow's (1974) concept-formation criteria. In the present case, the varying dimension could be the value of  $t$ . Improved performance with the moving stimuli in Experiment 3 might reflect the importance of movement as a controlling stimulus. Unfortunately, during some sessions, it might also reflect increased practice with the set of stimuli.

## REFERENCES

- Blough, D. S. Recognition by the pigeon of stimuli varying in two dimensions. *Journal of the Experimental Analysis of Behavior*, 1972, 18, 345-367.



- Brown, J. F. The thresholds for visual movement. *Psychologische Forschung*, 1931, 14, 249-268.
- Butter, C. M. Stimulus generalization along one and two dimensions in pigeons. *Journal of Experimental Psychology*, 1963, 65, 339-346.
- Carpenter, B., & Carpenter, J. T. The perception of movement by young chimpanzees and human children. *Journal of Comparative and Physiological Psychology*, 1958, 51, 782-784.
- Eckerman, D. A., & Lanson, R. N. Variability of response location for pigeons responding under continuous reinforcement, intermittent reinforcement, and extinction. *Journal of the Experimental Analysis of Behavior*, 1969, 12, 73-80.
- Hawley, J. M., & Munn, N. L. Visual discrimination of movement by white rats. *Journal of Comparative Psychology*, 1933, 16, 137-141.
- Herrnstein, R. J., & Loveland, D. H. Complex visual concept in the pigeon. *Science*, 1964, 146, 549-550.
- Hodos, W., Smith, L., & Bonbright, J. C. Detection of the velocity of movement of visual stimuli by pigeons. *Journal of the Experimental Analysis of Behavior*, 1976, 25, 143-156.
- Keller, F. S., & Schoenfeld, W. N. *Principles of psychology*. New York: Appleton-Century-Crofts, 1950.
- Kennedy, J. L., & Smith, K. U. Visual thresholds of real movement in the cat. *Journal of Genetic Psychology*, 1935, 46, 470-475.
- Lubow, R. E. High-order concept formation in the pigeon. *Journal of the Experimental Analysis of Behavior*, 1974, 21, 475-483.
- Mello, N. K. Interhemispheric transfer of a discrimination of moving patterns in pigeons. *Brain Research*, 1968, 7, 390-398.
- Reynolds, G. S. Attention in the pigeon. *Journal of the Experimental Analysis of Behavior*, 1961, 4, 203-208.
- Skinner, B. F. Pigeons in a pelican. *American Psychologist*, 1960, 15, 28-37.
- Siegel, R. K. Apparent movement detection in the pigeon. *Journal of the Experimental Analysis of Behavior*, 1970, 14, 93-97.
- Siegel, R. K. Apparent movement and real movement detection in the pigeon: Stimulus generalization. *Journal of the Experimental Analysis of Behavior*, 1971, 16, 189-192.
- Siegel, R. K., & Honig, W. K. Pigeon concept formation: Successive and simultaneous acquisition. *Journal of the Experimental Analysis of Behavior*, 1970, 13, 385-390.
- Walker, J. K. The bisection of a spatial interval by the pigeon. *Journal of the Experimental Analysis of Behavior*, 1968, 11, 99-105.
- Wilkie, D. M., & Masson, M. E. Attention in the pigeon: A reevaluation. *Journal of the Experimental Analysis of Behavior*, 1976, 26, 207-212.
- Wolf, M. M. Some effect of combined S<sup>P</sup>s. *Journal of the Experimental Analysis of Behavior*, 1963, 6, 343-347.

Received March 23, 1981

Final acceptance September 17, 1981