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REMOVAL OF AN OBSTACLE: PROBLEM-SOLVING BEHAVIOR IN PIGEONS

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The importance of a subject's personal history in the solution of an obstruction problem was demonstrated with pigeons. Four birds were trained to peck a key located outside the chamber by poking their heads through an opening in a screen. During tests, a white block was placed in front of the opening, so that it was not possible to peck the key without removing the block. All birds failed to remove the block. However, all birds that were subsequently trained to push the white block around the chamber in the absence of the key and a few of the birds trained similarly but with a black block solved the problem by pushing the block aside and pecking the key. One bird showed the abrupt descent in the learning curve that has been considered a characteristic of "insightful" problem solving. All birds maintained their successful performance after a 1-month interval with no intervening tests.

Key words: obstruction problem, problem solving, interconnection, insight, key peck, pigeons

Among the many problems given by Köhler (1925) to his chimpanzees was an "obstruction problem," in which a lure was placed outside the grating of the animal room and a large movable object was inside the room, standing in the way of the lure, so that the animal could not get the lure directly. The task required the animal to remove the object (the obstacle) and get the lure. According to Köhler, this problem was very difficult for his chimpanzees to solve. Only 2 of 7 chimpanzees managed to solve this problem without observing the solution by other animals. Even successful animals took a long time to solve the problem.

Although Yerkes's (1927) gorilla, Congo, failed to solve an obstruction problem that was a little more intricate than Köhler's (1925), Trendelenburg and his colleagues (Drescher & Trendelenburg, 1927; Nellmann & Trendelenburg, 1926) demonstrated that the problem used in Köhler's study was easy for orangutans, rhesus monkeys, a crab-eating macaque, and a yellow baboon. Their chimpanzee, however, failed to solve the problem as well as dogs and cats did. Hertz (1926, 1928) showed that even a carrion crow and a jackdaw removed various types of obstacles, and in one experiment (Fricke, 1975), a yellowspotted triggerfish removed the covers of a glass vessel or turned a pipe, and then ate sea urchins inside.

Why do chimpanzees and gorillas fail to solve the obstruction problem? The answer may be in their evolutionary history, innate personal dispositions, personal histories, motivational states, the problem situation itself, or some combination of these variables. Before concluding that certain species cannot solve a certain kind of problem, one must strictly control these variables and examine what conditions enable or do not enable the animals to solve the problem.

Many studies indicate that a subject's personal history (experience) is an important variable in solving some problems (Bingham, 1929a; Birch, 1945a, 1945b; Epstein, 1981, 1985c, 1987b; Epstein, Kirshnit, Lanza, & Rubin, 1984; Epstein & Medalie, 1983; Jackson, 1942; Menzel, Davenport, & Rogers, 1970; Schiller, 1952; Shurcliff, Brown, & Stollnitz, 1971). We demonstrate in this article that it is also important for the obstruction problem.

In order to solve the obstruction problem, two repertoires are needed: moving the object and reaching for the lure. If these components are individually trained before the test, the

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animals may solve the problem by connecting them. Accordingly, pigeons in the present study were trained to peck at a key outside the chamber. They were also trained, in another situation, to push a block around the chamber. In the test, the block stood in the way of the key so that it was not possible to peck the key directly. The solution required was to push the block aside and peck the key.

In the present study, half of the birds were taught both pecking and pushing before the test, and the remaining birds were taught only pecking. Consequently, it was possible to examine the importance of a history of block pushing in solving the problem. Second, the effect of the color of the block on the solution was investigated by training some birds with the same color block as that used in the test and others with a different color block. Third, each bird was given 15 test trials in succession in order to obtain individual learning curves. Some researchers (e.g., Bingham, 1929b; Yerkes, 1927) have stated that an "insightful" animal can immediately solve a problem if it has been solved before, and specified "an abrupt descent in the time-curve" (Thorndike, 1898, p. 45) as a characteristic of insight. Thus, data about individual learning curves are important. Finally, subjects were tested 1 month after the last successful trial to assess maintenance of performance.

METHOD

Subjects

Eight homing pigeons served as subjects. Half of them (A32, F33, G33, and H14) were approximately 1 year old and experimentally naive. One (E32), 2 years old, had served in a three-key chaining study; the remaining birds (G11, G21, and G22) were 5 to 6 years old and had served in a peak-shift study. Because G22 frequently froze and stopped pecking during training, it was replaced by B32, which was 3 years old and had a previous experimental history involving conditional discrimination.

Prior to the experiment, all birds were food-deprived to 75% to 80% of their free-feeding body weights as established by unrestricted access to mixed grain in individual home cages. The duration of the reinforcer (hemp seeds) presentation was adjusted among subjects to between 3 and 6 s, and each bird was maintained at its own appropriate body weight (70% to 90% of its free-feeding weight). The appropriate body weight was determined for each pigeon according to its key-pecking performance; birds with low pecking rates were deprived more severely. Supplemental feedings with Indian corn were generally given only on the few days that the birds were not studied. Water and grit were continuously available in home cages.

Apparatus

All sessions were conducted in the experimental chamber shown in Figure 1. The chamber was constructed of clear acrylic side walls, a black acrylic back wall, a mesh front screen, a clear acrylic top, and a black acrylic floor. The interior dimensions of the chamber were 40 cm by 40 cm by 50 cm. The back wall had a food magazine (5 cm by 5 cm) in its center, located 9.5 cm above the floor. The magazine was illuminated from above by a 2.5-W white bulb whenever hemp seeds were made available. The mesh screen consisted of crossed iron rods 3 mm in diameter, spaced 4 cm center to center, and coated with black vinyl resin. The lower area (8 cm wide, 9.5 cm above the floor) of the center of the mesh screen was removed, providing access to the exterior of the chamber for the pigeon's head. In block-training sessions, a thin black acrylic plate (43 cm by 51 cm) was attached parallel to the mesh screen by two metal clips on the left side wall. The floor was partitioned with white lines into 16 zones, each of which was 10 cm by 10 cm. According to the experimental condition, sheets of white paper or a small-mesh copper net was laid on the floor. Each pigeon was brought into and out of the chamber through the back wall, the end of which was hinged on the left side.

One of two same-size (8 cm by 12 cm by 10 cm) and same-weight (150 g) blocks was located in the chamber, according to the condition. These blocks were made of balsa, painted white or black, and coated with clear lacquer.

The chamber was located on a black-painted styrene foam board. This board was 2 cm thick, and its front end had a black-painted thin wood board fitted with two metal rails. A movable black acrylic box (6 cm by 5 cm by 2.5 cm) was held by these rails. The top of the box was flush with the floor of the chamber and had a frosted glass key, 2.4 cm in diameter.

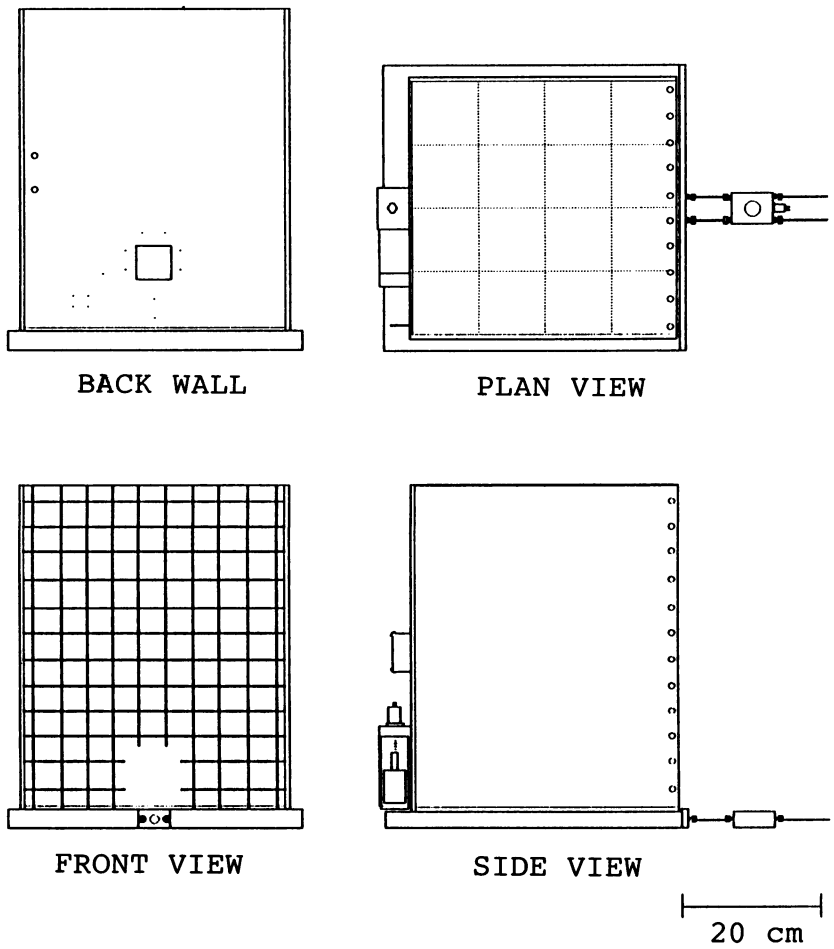

Fig. 1. The experimental chamber.

The key could be illuminated from inside by a 2.5-W white bulb; pecking at it was detected by a microswitch.

The entire apparatus described above was located in a large outer shell (88.5 cm by 51.5 cm by 89 cm). The front, back, and left side walls were gray-painted plywood, and the floor was an iron plate covered with black paper. The right wall was clear acrylic, and the top was open. A series of eight 2.5-W white bulbs, used as houselights, lined the upper part of both side walls of the shell. White noise (76 dB re scale C) was continuously presented during the sessions from a speaker mounted on the upper part of the back wall of the shell. The chamber and the shell were cleaned after each session.

The outer shell was situated at the center of the almost completely dark experimental room. The floor of the shell was 95 cm above that of the room. The behavior of the birds was recorded from above and from the right side by two Sony 8-mm CCD video cameras. Next to the left side of the shell was the control desk, at which the experimenter sat quietly during the session, observing the behavior of the birds via two visual displays. The left side wall of the shell was opaque so that the experimenter and birds could not see each other directly.

Experimental events were controlled and recorded by a Panasonic MSX 2+ microcomputer located on the control desk, using programs written in Z-80 FORTH. All controlling equipment made no easily detectable noise during the sessions.

Procedure

Magazine training. Standard magazine training lasted for at least two sessions and continued until the birds approached the hopper almost as soon as it was raised. Each bird was placed alone in the chamber with the houselights and the keylight illuminated. Whenever hemp seeds were made available and the magazine light was on, these lights were turned off.

Shaping key pecking. With the key box detached from the rails and placed at the center of the paper-covered floor and some hemp seeds scattered around and on the key box, pecking the lighted key was established by the successive approximation method. After pecking the key was shaped, the experimenter pulled a cord attached to the key box, moving it gradually toward the mesh screen. This training continued until the birds poked their heads through the opening in the screen and pecked at the key, which was now fixed by the rails with the center of the key 5 cm outside the screen. All daily sessions in this and all following phases of key-peck training began with the illumination of the houselights and the keylight and ended with the lights being extinguished.

Maintenance of key pecking. All pecks on the keys were reinforced for two sessions, one on the paper-covered floor and the other on the net-covered floor. In the sessions that followed, the birds were trained on the net-covered floor, and the schedule was changed to a variable-ratio (VR) 3, which was followed by a VR 5 schedule. For G11 and G21, the VR was increased to VR 10, but was returned to VR 5 and maintained at this value during the remaining sessions. The location of the key was 6 cm and 7.5 cm from the screen on the first two sessions and the subsequent VR 3 sessions, respectively, and 9 cm on all subsequent sessions.

Sessions ended after the 50th reinforcer, except the initial several sessions for G11 and G21, which ended following 60 reinforcers. This training phase continued for a minimum of eight sessions on the VR 5 schedule, until the rate of key pecking showed no monotonic ascending or descending trend for the last five sessions and individual-session rates were within ±15% of the five-session mean.

Introduction of the block. Once key pecking stabilized, the white block was introduced into the chamber, and the bird was trained to peck the key in its presence. The location of the block was determined pseudorandomly by the experimenter before each session: The block could be located in one of the four corners or near one of the two side walls of the chamber. Other details of training were the same as before. The criterion was the same as that described above, but with the addition that the bird not peck at the white block during the last session.

Addition of block-push training. Following the key-peck training described above, half of the birds were given intermixed key-peck and block-push training daily in separate sessions, spaced 30 to 60 min apart, in a pseudorandom order. The key-peck sessions were the same as in the preceding phase except that they ended after 30 reinforcers. In the block-push sessions, the black acrylic plate was attached to the screen to prevent the birds from seeing and pecking the key. The keylight was turned off during this training, and the block was placed at the center of the floor of the chamber. Under this situation, the birds' block pushing was shaped and maintained. The magazine was operated by the experimenter with a remote-control switch. Due to its weight, moving the block required a subject to tilt its head, hook the block with its beak at one of its corners near an upper edge, and rotate it slightly. Each distinct movement of the block produced reinforcement. Pushing the block with any other part of the body was never reinforced. The color of the block was white for some birds and black for others. Block-pushing sessions began with the illumination of the houselights and were terminated when 30 reinforcers had been delivered. This phase continued until the stability criterion was satisfied, the birds did not peck the white block during key-peck sessions, and it was judged by the experimenter that each bird's block pushing was skillful. For the remaining 4 birds, this phase was omitted and the problem-solving test was given immediately after the preceding phase.

Problem-solving test. All birds were tested with the white block placed on the floor of the chamber with one side (12 cm by 10 cm) just against the opening of the screen, so that the key was visible through the screen, but the birds could not peck it without removing the block. A trial began with the illumination of

Table 1

Number of sessions for each phase of training.

Phases	Birds							
	G11	A32	E32	G33	B32	F33	G21	H14
Magazine training	3	2	8	2	2	3	2	3
Shaping	3	5	4	1	2	1	3	1
CRF	2	2	2	2	2	2	2	2
VR 3	1	1	1	1	1	1	1	1
VR 5	1	—	—	—	—	—	1	—
VR 10	2	—	—	—	—	—	3	—
VR 5	21	22	31	9	8	9	20	33
Block presence	13	11	12	5	13	19	7	10
Test[a]	3F	3F	3F	3F	—	—	—	—
Mixed training	White	White	Black	Black	White	White	Black	Black
	25	50	25	36	27	11	50	37
Test[a]	15S	15S	2S + 4F	15S	15S	15S	3F	1F + 14S
Mixed training	—	—	Black	—	—	—	White	—
	—	—	1	—	—	—	22	—
Test[a]		—	3F	—	—	—	1S + 5F	—
Mixed training	—	—	Black	—	—	—	White	—
	—	—	5	—	—	—	29	—
Test[a]	—	—	3F	—	—	—	15S	—
Mixed training	—	—	White	—	—	—	—	—
	—	—	7	—	—	—	—	—
Test[a]	—	—	15S	—	—	—	—	—
Follow-up test[a]	1F + VR5[b] + 1S	3S	3S	3S	3S	3S	3S	3S

[a] Results of tests are given in terms of success (S) and failure (F) trials.
[b] For G11, key pecking was retrained on a VR 5 schedule between two follow-ups.

the houselights and the keylight as before. If the bird removed the block and pecked the key within 20 min, the magazine was operated for 15 s and the trial ended. If the bird did not peck the key within this time limit, the trial ended with all lights off. The birds received three trials per day, separated by 30 to 60 min. Birds that did not solve the problem within three trials were returned to the preceding phase and received the mixed training again. For successful birds, this test was repeated on the next day (maximum 5 days).

Follow-up test. Thirty days after the five successful test days, three trials of the same problem were again presented on a single day. The test regimen was identical to that described above.

The order and number of sessions of exposure to each training and test phase are shown for each subject in Table 1.

Behavior Observations

Several observers who had no knowledge of this experiment were enlisted to observe and score videotapes of subjects. Seven watched videos of the last session of key-peck training. Each video was viewed by at least two inde-

Table 2

Definition of behavioral categories.

Category	Type[a]	Description
Wing	C	Unfolding the wings. Usually accompanied with vigorous up and down movement (flapping) of the wings.
Preen	C	Movement in which the beak touches the feathers on the body.
Climb	C	Standing on the block. If the bird stood on one foot, the remaining foot must be off the floor.
Magazine	C	Inserting the upper part of the beak (the cere) into the magazine opening.
Back wall	D	Pecking at any part of the back wall.
Floor	D	Pecking at any part of the floor.
Block	D	Pecking at any part of the block.
Push	D	Pushing the block with beak. The block must be translocated at least slightly.
Screen	C	Approaching the screen with the upper part of the beak (the cere) within 8 cm of the screen.

[a] C = continuous behavior, D = discrete behavior.

pendent observers. All observers reported no pecking directed at the white block during these key-peck sessions.

The skill of block pushing was assessed by another two independent observers. They watched the last session of each block-push training (which had been tape recorded from a camera looking down on the chamber) and reported that all birds except G21 were good in pushing the block. The skill of G21 was poor with the black block (it pecked the block frequently, but these pecks often failed to move the block). During and after the first white-block training, however, observers reported that block pushing of this subject improved and was comparable to the skills of other birds.

Another five independent observers watched videos of the test trials and scored the occurrences of nine categories of behavior. The names and descriptions of the categories appear in Table 2. The first observer simultaneously scored "wing" and "block," the second "preen" and "climb," the third "magazine" and "screen," and the fourth "back wall" and "floor." They scored the categories by watching the videos recorded from the right side. The last observer scored "push" by watching the videos recorded from overhead.

Discrete types of behavior (back wall, floor, block, and push) were scored by pressing the appropriate keys of the computer keyboard each time an instance of the given behavior occurred. The observers scored continuous behavior (wing, preen, climb, magazine, and screen) by pressing the keys throughout the duration of an occurrence of the behavior. Some kinds of behavior could occur simultaneously. For example, when the bird pecked the block near the screen, "block" and "screen" were scored. Further, "block" was a necessary condition for "push."

The first author also described the performance of the birds in short sentences by viewing the videoscreens as they were slowed and paused by the controller. His sketches and the event records made by the observers almost always corresponded.

RESULTS

Training Phases

The results of the tests are presented in Table 1. Although the key-pecking performance did not satisfy the stability criterion in the mixed training phase for A32 and G21, this phase ended after 50 days. For A32 the rates of key pecking for the last five sessions were within ±26% of the average. For G21, the corresponding value was 19%.

When the white block was introduced into the key-peck training, only 1 bird (E32) pecked at the block, and only once; the other birds never pecked the block during this phase. During the mixed training phase, some birds pecked at the white block in the key-peck sessions. However, pecks at the white block in the key-peck sessions were negligible for most birds, and even the birds that tended to peck it seldom pushed it.

Testing

Figure 2 presents solution times for each subject during test trials. Birds tested before mixed training including block pushing (G11, A32, E32 and G33, displayed in the top four panels in Figure 2) never solved the problem within 20 min. After their first orientation toward the screen, all birds flapped hard and ran around the chamber for some time; they all also brought their heads near the white block and the screen repeatedly. G11 and G33 sometimes stretched their necks toward the key through the screen mesh. All 4 birds sometimes pecked at the upper side or corners of the white block, but the block did not move because of the inappropriate direction and weakness of the pecking. The birds showed many other activities during the first trial: preening, pecking the back wall and the floor, poking their heads into the magazine opening, scratching their head with their feet, head bobbing, walking, and turning. The event records of the performances in the first trial of E32 and G33 are shown in the first panels of Figures 3 and 4, respectively.

In the second and the third trials, all birds except G33 gradually decreased all active behavior and increased the time spent crouching at the center of the chamber against the right wall. Subject G33 developed side-to-side pendulum-like movements, bobbing up and down against the right wall while stepping from side to side.

After the mixed training, some birds solved the problem for five consecutive test days, but others failed. On the first trial, 5 birds (A32, E32, G33, B32 and H14) oriented toward the screen and then ran around while flapping hard (see, e.g., the second recording in Figures

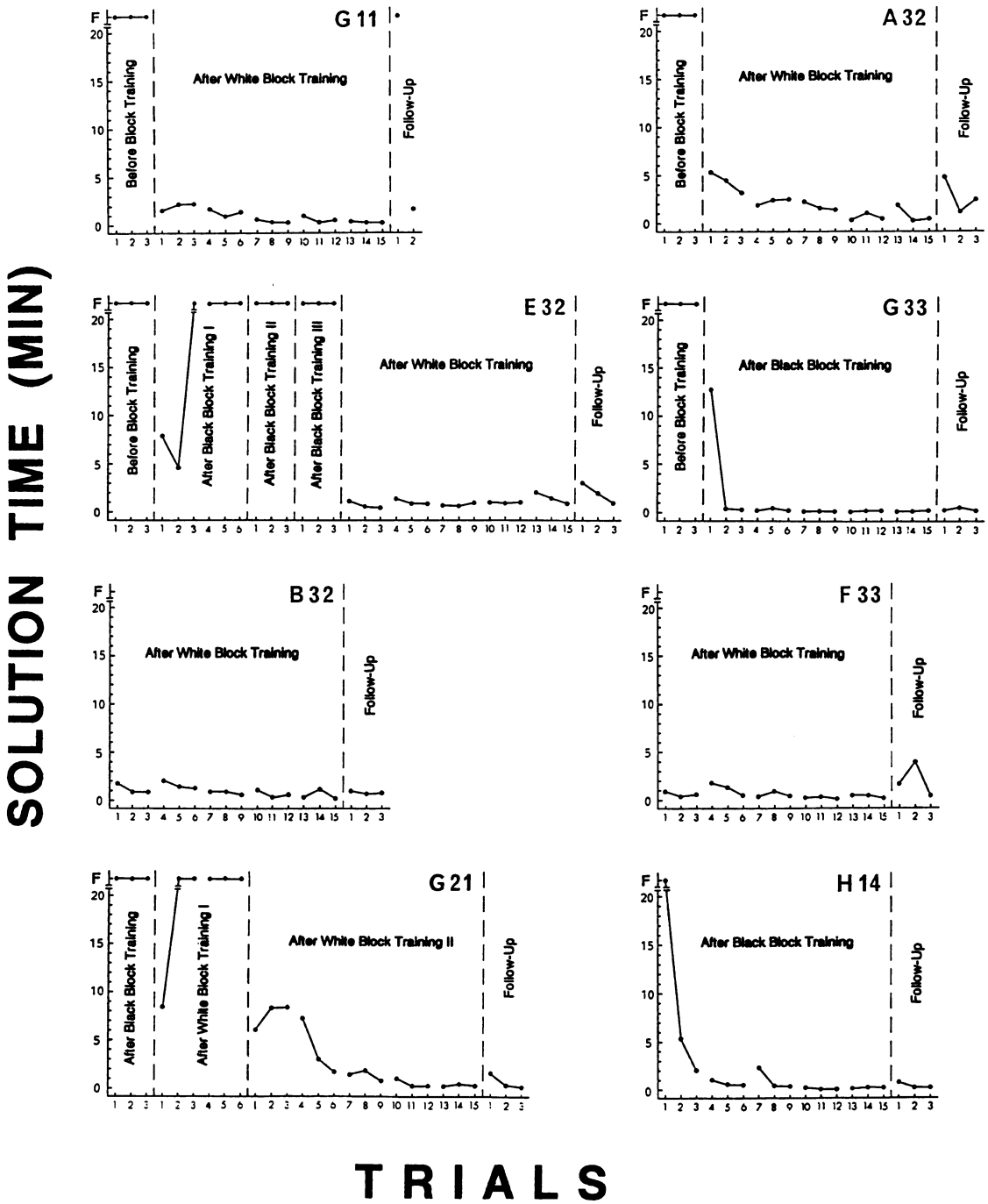

Fig. 2. Time to solution (F = a failure trial on which the bird failed to solve the problem within 20 min).

3 and 4). They also produced various activities as described above. Subjects A32, E32, G33, and B32 then began to push the block aside and pecked the key.

A detailed analysis of G33's performance on the first test after block-push training is shown in Figure 5. When the lights came on, the bird's head was oriented toward the screen (Frame A, 0 s). It immediately brought its head near the screen from the left side of the block

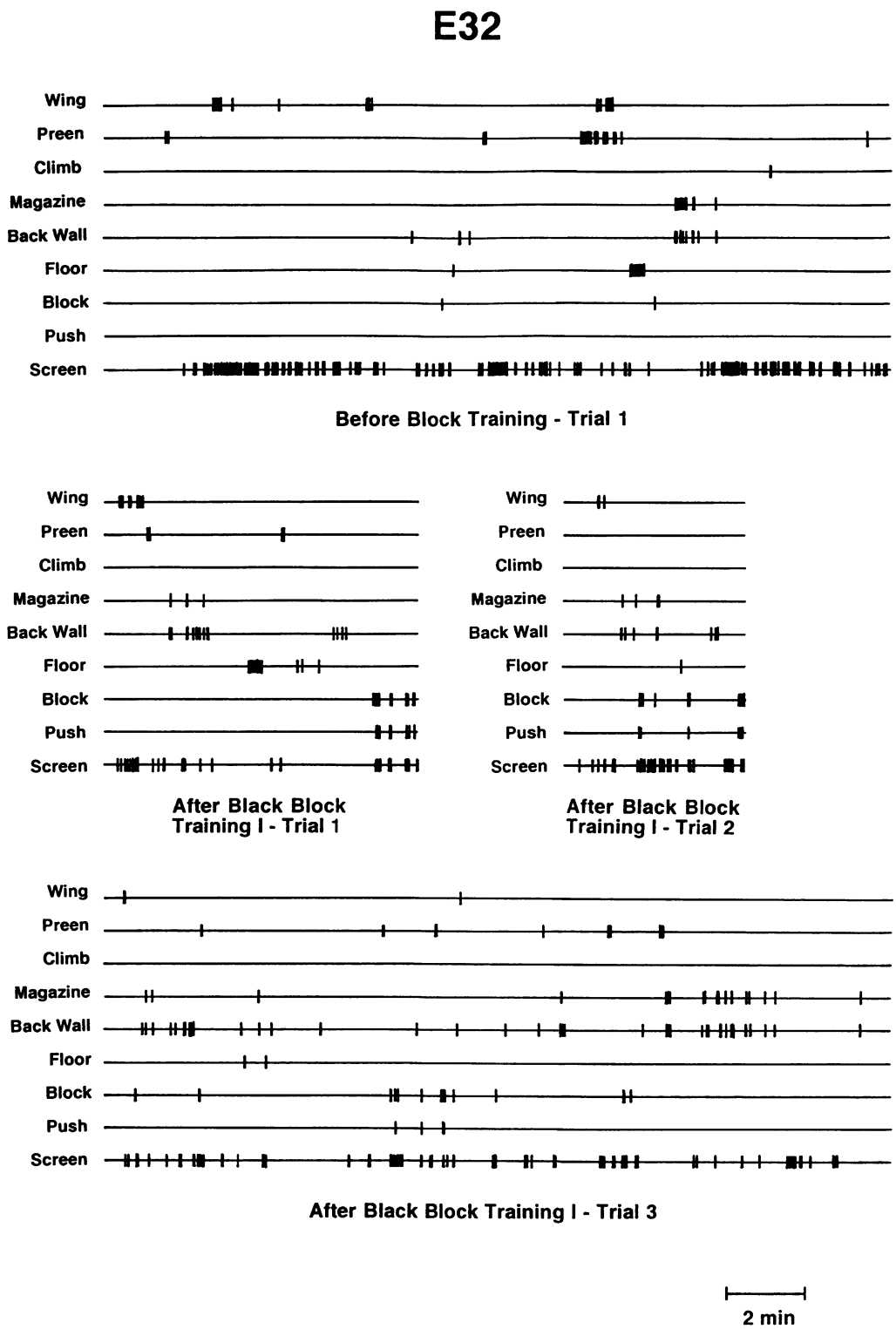

Fig. 3. Event records of the performance of E32. See Table 2 for a description of each behavior recorded.

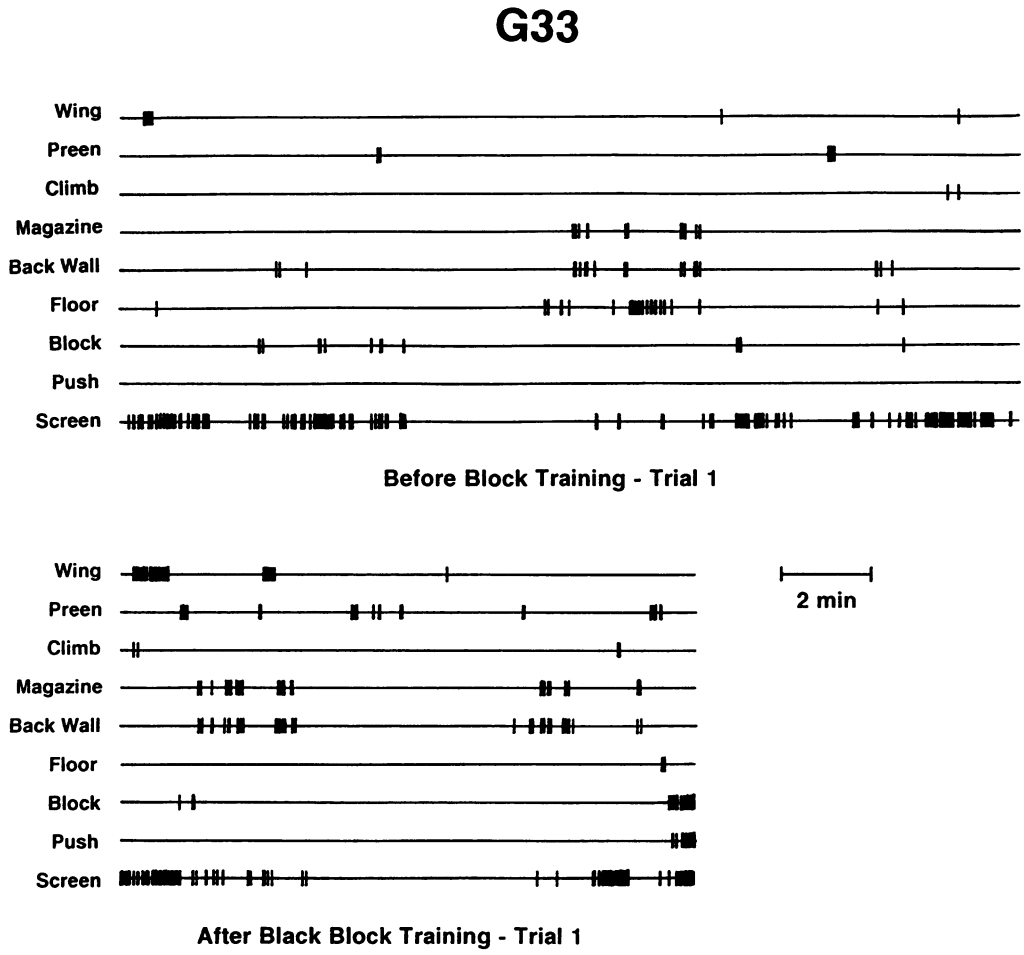

Fig. 4. Event records of the performance of G33.

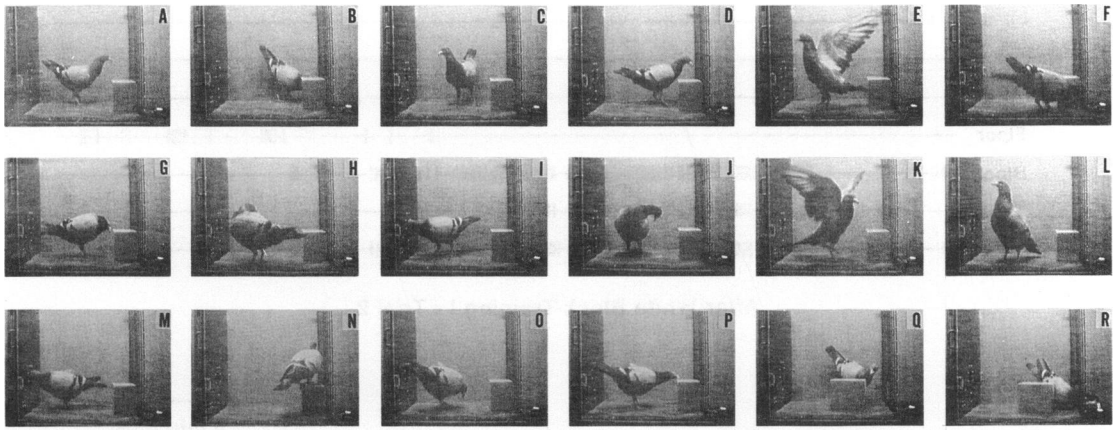

Fig. 5. Videotape frames showing the performance of G33 on the first trial after black-block training. An Epson CD-2000 video printer was used to print frames. See text for description.

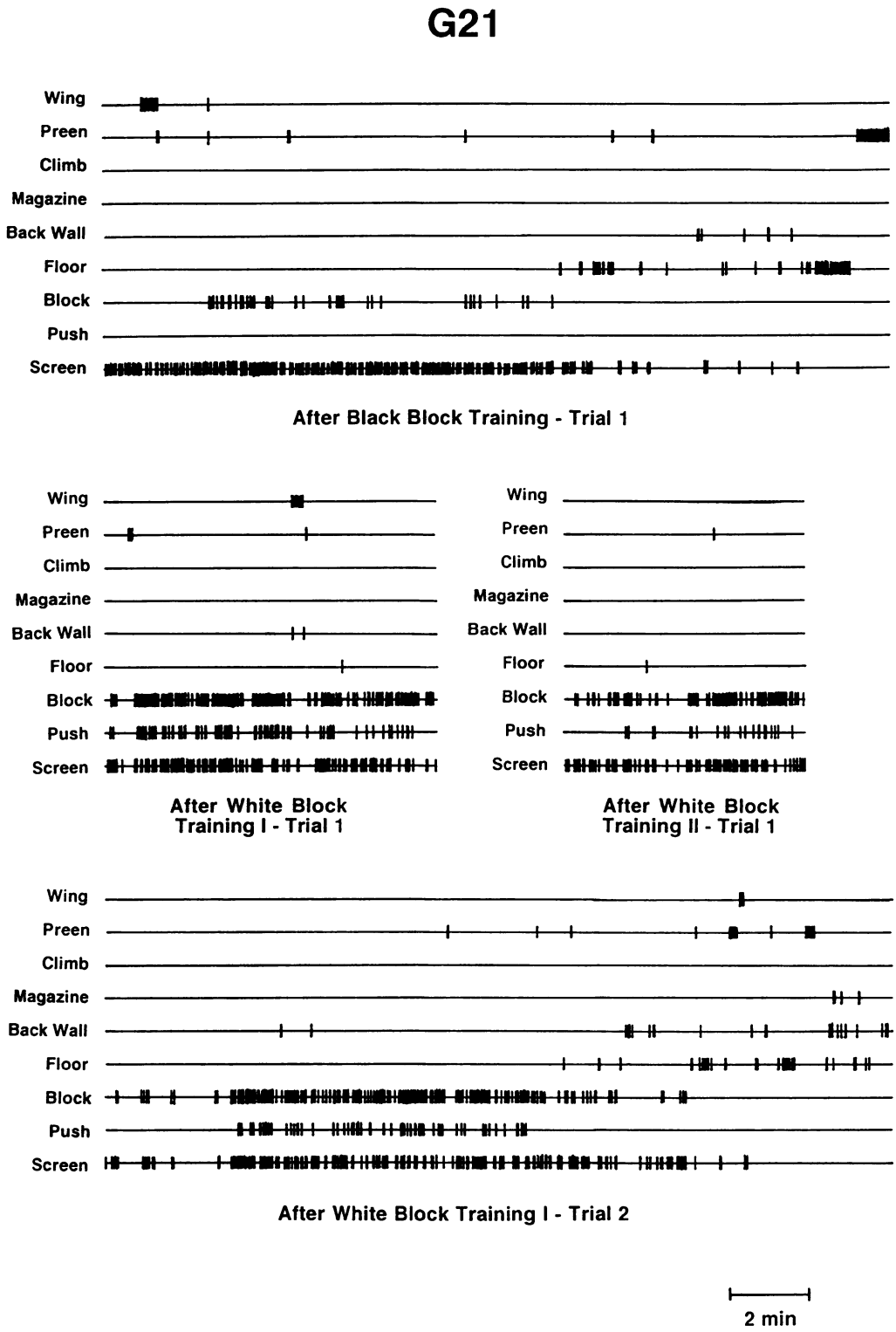

Fig. 6. Event records of the performance of G21.

(Frame B, 2 s). After orienting its head toward the magazine (Frame C, 4 s), it again oriented toward the screen from the top left side of the block (Frame D, 10 s). Then it turned to the right wall, and began to flap its wings. This flapping continued for 50 s, during which time it repeatedly shuttled between the screen and the back wall (Frame E, 40 s). It next approached the screen from the right side of the block (Frame F, 74 s) and pecked at the left top corner of the block once (Frame G, 79 s). It went to the back wall and preened (Frame H, 85 s), and returned to the screen to peck the left top corner of the block nine times. However, pecking did not move the block. The bird then approached and explored the magazine (Frame I, 104 s). It repeatedly turned and walked around the chamber, poked its head into the magazine, preened (Frame J, 185 s), and ran around the chamber with vigorous flapping (Frame K, 196 s). After flapping stopped, it again examined the magazine. Then it stood for approximately 5 min against the right wall and only moved its head (Frame L, 460 s). Sometimes it pecked at the hinge on the wall and preened. After that, it pecked at the magazine and poked its head inside (Frame M, 560 s), then turned and brought its head near the screen from the left side of the block. It climbed the block once (Frame N, 663 s). After some additional preening, it pecked the floor repeatedly (Frame O, 722 s), and the orientation of pecking then switched to the upper left corner of the block (Frame P, 729 s). Now the block was moved for the first time. The bird moved the block to the center of the chamber (Frame Q, 765 s), and then immediately poked its head into the opening of the screen and pecked the key (Frame R, 766 s). It suddenly solved the problem after 12 min from the onset of the first trial. In the subsequent trials, it immediately approached the screen, pushed the block aside, and pecked the key. This resulted in an abrupt descent in the solution time (see Figure 2).

Subject E32 also succeeded in the second trial (the third panel of Figure 3), but failed in the third (the fourth panel of Figure 3). In the second trial, it pushed the block after 2 min from the onset, but many activities interrupted this behavior: It went to the back wall many times, poked its head into the magazine, and pecked the back wall and the floor. Even when the block was moved aside and it was possible to peck the key, E32 continued these activities. Although E32 sometimes pushed the block in the middle of the third trial, the movements of the block were very small. It also failed in three trials of the next day, and repeating key-peck training and black-block training did not produce a successful performance. After mixed training including white-block pushing, however, E32 solved the problem. This time the successful performance continued for 5 days.

On the first trial after mixed training including black-block pushing, G21 walked around the chamber while cooing. Sometimes it pecked the block lightly, but no peck strong enough to push it was observed. The event records of this performance are shown in the first panel of Figure 6. After repeating mixed training (in this case, the block used in the block-push training was white), G21 solved the problem for the first time. The second panel of Figure 6 shows performance during this trial. Although G21 pushed the block immediately and many times, it often stopped pushing and walked around the chamber. Preening, pecking the back wall and the floor, and hard wing flapping were observed. In the second trial, it failed to peck the key (the fourth panel of Figure 6). Although the block was pushed many times during the middle portion of this trial, the movement produced by each push was small and the direction of pushing varied widely, such that the net effect was insufficient to allow the bird access to the key. After repeating the mixed training again, G21 solved the problem with few interrupting activities (see the third panel of Figure 6), and this time successful performance continued for 5 days.

On the first trial, H14 pushed the block several times, but the movements of the block were small, and finally it stopped pecking the block. On the second trial, the force of the pecks was strong enough to move the block aside, and H14 solved the problem in spite of some interrupting activities. Performance on these trials is shown in Figure 7. This performance continued during the subsequent test trials.

Solutions of the remaining 2 birds (G11 and F33) were swift, occurring on the very first trial. On the first trial, G11 oriented toward the screen, and approached the magazine and the right wall. Then it began to push the block,

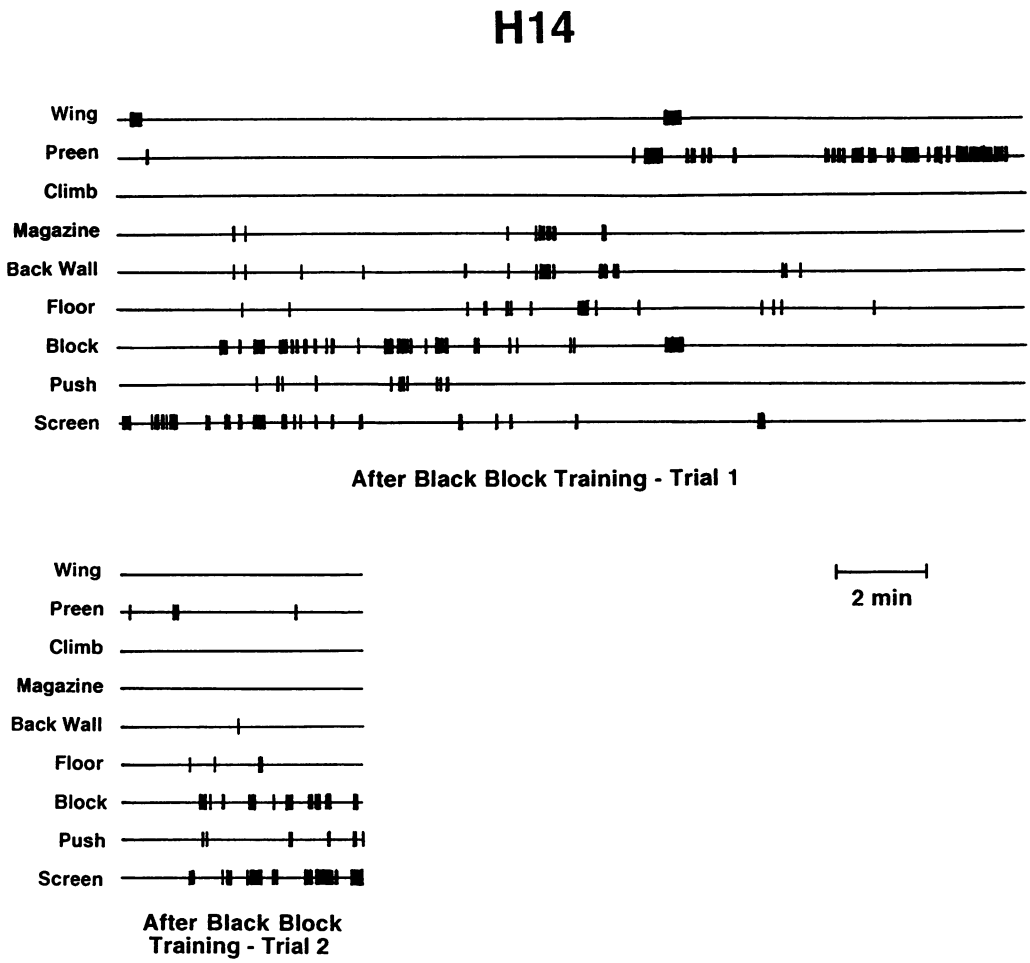

Fig. 7. Event records of the performance of H14.

and finally it pecked at the key. Immediately after the onset of the first trial, F33 approached the screen and removed the block. No other activity was observed.

During the 5 days with successful solutions, the birds that had previously exhibited some interrupting activities ceased them and began to move the block immediately after the onset of the trial. For all birds except E32 and G33, the topography changed from a "punctilious" one (removing the block fully and then poking the head into the screen opening) to a "lazy" one (moving the block a little and then squeezing the head into the opening). For E32 and G33, the punctilious topography was observed during all tests.

Follow-Up

On the follow-up trials 30 days later, all birds except G11 solved the problem on the first trial and subsequent trials. Subject G11 failed to solve the problem on the first follow-up test. During this trial, it stayed crouching almost motionless at the center of the floor. Then, 38 min later, its key pecking was reinforced on a VR 5 schedule until 30 reinforcers were delivered. There was no peck on the white block in this retraining session. On the second follow-up test, given 31 min after the retraining session, G11 solved the obstruction problem. Because of a procedural error by the experimenter, these follow-ups were

done with G11 25 days rather than 30 days after the original successful test.

DISCUSSION

Birds trained only to peck a key did not deal successfully with the problem presented when a white block obstructed access to the key. However, birds that received training of key pecking mixed with block pushing solved the obstruction problem. The fact that the birds succeeded only after mixed training indicates that solutions were not simply derived from effects incidental to nonreinforcement, such as an increase in general activity (e.g., Amsel, 1958; Hughes & Dachowski, 1973) or the enhancement of variability in response topography (e.g., Antonitis, 1951; Eckerman & Lanson, 1969). Block-push training was a necessary condition for the solution of this problem.

The results of the present experiment suggest that block-push training with the same (white) block as that used in the test was more effective in prompting a solution than training with a different color (black) block. All 4 birds (G11, A32, B32 and F33) trained with the white block solved the problem within 6 min in the first trial. On the other hand, only 2 bird (E32 and G33) succeeded in the first trial after the training with the black block, and the solution time for these birds was longer than that of the birds described above. However, the results of the 1 bird (G21) initially trained with the black block who failed in the first trial are difficult to interpret, because the skill of block-pushing was poor in this subject. Hence the failure might as easily be ascribed to the poor skill level of pushing as to the color of the block used in training. A definitive answer to this question awaits further experimentation.

The primary purpose of the present study was to demonstrate the importance of personal history on the solution of the obstruction problem. We also were interested in the performance of each bird on the trials following the first solution. Subjects that frequently engaged in activities other than "block" and "push" during tests tended to fail on subsequent trials. If many other activities occurred while the birds were engaging in block pushing, reinforcement was delayed. Moreover, these interrupting activities may have obscured the contingency between block pushing and reinforcement. These conditions do not favor the repetition of the solution on subsequent trials. In contrast, G33's performance suggests that solving the problem without any interrupting activity facilitated a swift solution on subsequent trials.

All birds except G11 succeeded in the follow-up test, despite the 1-month gap after the original successful test. Although G11 failed on the first follow-up trial, it had maintained the block-pushing repertoire, because it solved the problem after key-pecking retraining.

A moment-to-moment account of insightful performance in pigeons, like that provided by Epstein (1985a, 1985c, 1987b; Epstein & Medalie, 1983; Epstein et al., 1984), could be given for the results of this experiment. After the onset of the first test trial, the birds began to orient to and approach the screen and brought their heads near the screen. This apparent attempt to peck the key was never reinforced because of the obstruction by the white block. This nonreinforcement produced various activities. Many of them seemed emotional, but the most conspicuous one consisted of running around the chamber with hard wing flapping. However, for the birds that had been exposed to reinforcement for pushing the block, extinction of approaching the key also induced block pushing (an "extinction-induced resurgence" of a previously reinforced behavior; Epstein, 1983, 1985b). The color of the block was important at this point, because it determined the extent of the generalization between the training and the test: The same block facilitated generalization, but the different-colored block sometimes made it difficult. Pushing the block aside created a clear opening to the screen. Because this was the situation under which key pecking was reinforced, it made this behavior more likely. This is the process of "automatic chaining" (Epstein, 1985a).

Many authors have described the criteria or the characteristics of insightful performance (e.g., Bingham, 1929b; Hartmann, 1931; Köhler, 1925; Pechstein & Brown, 1939; Tolman, 1928; Wyatt, 1926; Yerkes, 1927). Some features of the performances of the birds in the present study seem to satisfy these conditions, but this does not imply that they solved the problem by a "process" of insight. The fea-

tures that have been considered to be manifestations of insight may be derived from other sources. For instance, G33 suddenly produced a smooth continuous course of solution on the first trial, and further showed an abrupt descent in the learning curve. Traditionally, these two features have been considered to be derived from the process of insight. But, as described above, the latter may be the result of the former: Smooth solution may facilitate swift solution in subsequent trials. Epstein (1981, 1984a, 1984b, 1985a, 1986, 1987a; Epstein & Koerner, 1986) asserted that animals' performances should be accounted for in terms of empirical principles and that this was also true for creative and/or complex types of behavior. Our attempt to account for insightful performance accords with this view.

The results of the present study demonstrate the importance of personal history in the solution of the obstruction problem, and the generality of the effect across birds was validated to a certain extent. But we observed some individual differences among birds that had been treated similarly. What produced these differences? Many factors affect performance on the tests. Even some trivial factors can have profound effects. For example, Epstein (1987b) indicated that "a turn of the head radically changes the visual field and hence may increase the probability of inappropriate behaviors" (p. 200). We cannot yet state which of many possible factors produced the individual differences observed in the present study. The answer to this question may be found in future research that controls these variables. A well-controlled study with chimpanzees and gorillas is also needed for the elucidation of the factors responsible for failure to solve the obstruction problem by these animals.

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