JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 1973, 20, 163-181 NUMBER 2 (SEPTEMBER)

THE FORM OF THE AUTO-SHAPED RESPONSE WITH FOOD OR WATER REINFORCERS[1]

H. M. JENKINS AND BRUCE R. MOORE

MCMASTER UNIVERSITY AND DALHOUSIE UNIVERSITY

The relation between the form of auto-shaped responses to the lighting of a key and the consummatory responses of pecking grain and drinking water was examined in pigeons. Responses on the key were analyzed by means of high-speed photography, recordings of the force of contact, and judges' ratings of response-form based on film and videotape recordings. The first experiment showed that food-deprived birds presented grain as a reinforcer responded on the key with a grain-pecking movement, while water-deprived birds presented water as a reinforcer responded with drinking-like movements. The second and third experiments showed that the resemblance between auto-shaped and consummatory responses does not require the dominance of the deprivational state appropriate to the reinforcer. Changing the dominant state of deprivation did not immediately change the form of the key response, and in subjects simultaneously deprived of food and water, the form of response depended on the reinforcer. In the fourth and fifth experiments, subjects simultaneously deprived of food and water received one stimulus signalling food and another signalling water in a random series. In most subjects, the response to each stimulus resembled the consummatory response to the particular reinforcer that was signalled by the stimulus. This result demonstrates the role of association between a stimulus and a reinforcer in producing a resemblance of the auto-shaped response to the consummatory response.

The procedure used in auto-shaping (Brown and Jenkins, 1968) conforms to the paradigm for classical conditioning (Pavlov, 1927). To auto-shape the pigeon's pecking response, for example, the animal is exposed to repeated temporal pairings of a lighted disc and grain. With surprising regularity, pigeons exposed to such pairings begin to peck the disc (a translucent response key). When the auto-shaping procedure is coordinated to that of classical conditioning, the grain and the pecking response that it elicits correspond to the unconditioned stimulus (UCS) and the unconditioned response (UCR); the lighted key and the response of pecking the key correspond to the conditioned stimulus (CS) and conditioned response (CR). As in classical conditioning, the auto-shaped response has no effect upon the occurrence of the reinforcer; the presentation of grain is contingent upon illumination of the key, but is not contingent upon the animal's behavior.

Standard control procedures have shown that auto-shaped pecking is not an artifact of sensitization or pseudo-conditioning (Brown and Jenkins, 1968; Brown, 1968*a*, 1968*b*). The pigeon's approach to and contact with the key depends upon the contingent pairing (association) of the stimulus and reinforcer. The parallel with classical conditioning suggests that the specific *form* of the auto-shaped behavior might also depend upon a stimulus-reinforcer association. Perhaps the pigeon *pecks* the key because pecking is the consummatory response elicited by grain.

The suggestion receives some support from experiments with other species and other reinforcers. Gardner (1969) reported that bobwhite quail, like pigeons, peck at stimuli that have been paired with grain. Squier (1969) reported that auto-shaped *tilapia* reacted to response keys with species-specific feeding movements, such as those used ordinarily in

[1]This research was supported in part by grants from the National Research Council of Canada to the first author and from the Research Development Fund of Dalhousie University to the second author. Experiments 1 to 4 were done by H. M. Jenkins. Experiment 5 was done by B. R. Moore. For convenience of exposition, Experiment 5 is reported last although it was, in fact, completed before Experiments 2 to 4 were begun. The authors are grateful to Darwin Muir for developing the deprivation and reinforcement procedures used in several of these experiments. Reprints may be obtained from H. M. Jenkins, Dept. of Psychology, McMaster University, Hamilton, Ontario, or B. R. Moore, Dept. of Psychology, Dalhousie University, Halifax, Nova Scotia.

taking algae from object surfaces; and an auto-shaped mullet reacted to the key with species-typical gobbling movements.

Further evidence that the form of the response directed toward a stimulus may be related to the form of the consummatory reaction elicited by an associated reinforcer comes from certain operant or instrumental learning experiments in which delivery of the reinforcer is dependent upon the response. Wolin (1968) found that the form of the pigeon's operant key-contact response depends on the nature of the reinforcer. The food-deprived pigeon receiving grain as the reinforcer was observed to make rapid, short, powerful pecks at the key with the beak open at the moment of contact. The movement closely resembled that used when pecking grain. On the other hand, the water-deprived pigeon receiving water as the reinforcer pushed its almost closed beak against the key in a slower motion that resembled the drinking response. Wolin also recorded the mean durations of contact responses, and found these to be consistently longer in thirsty birds receiving water as the reinforcer than in hungry birds receiving food as the reinforcer. Ferster and Skinner (1957, p. 373 *ff.*) found that the rate of response in thirsty pigeons receiving water as the reinforcer was lower than for hungry pigeons receiving grain as the reinforcer. A lower rate with water than with grain could arise from a difference in response form of the kind reported by Wolin. The well known observations of Breland and Breland (1961) on persistent, food-related action patterns directed at objects involved in food-reinforced response chains also suggest that the form of the response directed toward a stimulus object may be related to the behavior elicited by the reinforcer.

Although the observations reported by Wolin, by Ferster and Skinner, and by Breland and Breland were made in operant or instrumental-learning experiments, it is natural to suppose that the nature of the reinforcer would exert at least as much effect upon the response form in an auto-shaping experiment, since in auto-shaping there is no contingency between response and reinforcer to constrain the form of the acquired response.

There is considerable evidence to suggest that the form of the response to the signalling stimulus in the auto-shaping experiment can be influenced by the nature of the reinforcer. The purpose of the present series of experiments was to provide direct evidence of such an effect by comparing the form of the key-contact response when the reinforcer was water with its form when the reinforcer was grain. The work complements that of Wolin, but the procedure used is that of auto-shaping rather than instrumental learning, and the experiments were designed to rule out explanations based upon several non-associative factors.

EXPERIMENT 1

The purpose of Experiment 1 was to obtain and to evaluate filmed records of the key-contact movement in thirsty birds receiving water as a reinforcer and in hungry birds receiving grain as a reinforcer.

Subjects and Apparatus

Twelve adult male White King pigeons without previous experimental history were used. The apparatus consisted of a standard single-key pigeon box (model 1519C, Lehigh Valley Electronics). The response key was a translucent plastic disc, 1 in. (2.5 cm) in diameter centered on the panel 10 in. (25 cm) above the floor. The key was transilluminated with white light to provide the signal or CS. The compartment was constantly illuminated by a diffuse ceiling light. The level, as measured with an SEI photometer, was approximately 8.6 millilamberts. One wall of the box was clear glass to provide visual access for a camera and an observer. Key closures were recorded on counters and on an Esterline-Angus operations recorder. A Ralph Gerbrands Co., model B-LH, solenoid-operated dipper made water available for 4-sec periods. The bowl of the dipper was a cylinder 0.75 in. (1.9 cm) in diameter and 1 in. (2.5 cm) in depth. It held more water than could be consumed within the 4-sec period. The opening to the device was lighted while water was available. Grain, delivered by the standard LVE grain tray, was available and the tray was illuminated for 4-sec periods.

Procedure

Six birds received water as the reinforcer. The procedure for inducing thirst was as follows. Food was continuously available but

water was removed 36 hr before each experimental session. An intraperitoneal injection of 5 ml of hypertonic (9%) saline solution was administered 30 min before the session. After each session, water was freely available for three days to allow a return to normal water balance.

Six birds received grain as the reinforcer. They were maintained at 80% of free-feeding weight by restricted feeding. Water was continuously available.

After preliminary training to take the reinforcer from the delivery device, two sessions of auto-shaping were given. Water reinforced birds were run to a satiation criterion of five consecutive trials without drinking. This criterion was reached, on the average, in about 30 trials.

In both groups the key was illuminated for 8 sec. Delivery of the reinforcer was coincident with the offset of the keylight. Intervals between trials varied randomly from 30 to 90 sec with a mean of 60 sec.

A 16-mm movie camera operating at 16 frames per second was turned on 1 sec before onset of the keylight and turned off after the delivery of the reinforcer. Filming continued for 15 trials beyond the first trial of recorded key closure or for a maximum of two sessions, whichever came first.

A film strip was assembled to obtain judgements on the form of the contact movements. In order to acquaint the judges with normal eating and drinking patterns, the film began with two 10-sec sequences showing one pigeon drinking water from a transparent container and another eating grain. There followed a sequence of 30 trials selected from the footage taken during the experiment. Water-reinforced birds showed a clear approach and contact with the key or other object on the front panel (see below for details) on a total of only 15 trials. Every one of these trials was included in the film strip. Many more trials with approach and contact occurred in the food-reinforced group. From this larger set, 15 matching trials were selected as follows. Each water-reinforced bird that yielded one or more approach and contact trials was paired with a food-reinforced bird that gave at least as many such trials. The first n trials with approach and contact from a food-reinforced bird were selected to correspond to the n such trials from the water-reinforced bird. The trials, therefore, represented comparable stages of acquisition. Film of the resulting collection of 30 trials was spliced together in a random sequence. The film of each trial was cut before the reinforcer was delivered so that judgements could not be influenced by direct knowledge of the consummatory behavior that followed.

Ten students without first-hand experience with experiments of this type served as judges. They were instructed to watch the movements made to objects and to indicate at the end of each trial whether the movements on that trial were more like the pattern involved in eating or in drinking. At the end of the film they were asked to comment on the basis of their judgement.

Results and Discussion

Four of the six water-reinforced birds responded to the key. The first responses occurred during Trials 3, 4, 13, and 14. One bird yielded seven trials with approach and contact, one yielded four, one yielded three, and one yielded just one such trial. On four of the filmed trials, contact occurred with something other than the key; specifically, with a small piece of black tape covering a screw head located about midway between the key and the opening to the water delivery device, or with a small chromium-plate light housing located directly above the key and close to the ceiling.

Each of the six food-reinforced birds made key responses. The first responses occurred during Trials 37, 40, 77, 78, 79, and 88. Responses occurred on subsequent trials with greater frequency than for the birds receiving water as the reinforcer.

The judges correctly identified the approach and contact movements as grain related or water related on 87% of the trials. Two judges made no errors. The basis for judgement most commonly mentioned was that the eating-like movements were sharp, vigorous pecks at the key. In contrast, the drinking-like movements, it was said, involved slower, more sustained contacts with the key (or other object) and were often accompanied by swallowing movements.

The results of Experiment 1 showed that the contact movement in the pigeon shared to a remarkable degree the features of the consummatory response. The source of the re-

semblance between the consummatory response and the contact response was, however, not clear. The birds presented water were water-deprived while birds presented grain were food-deprived. It is possible that the dominance of the appropriate deprivational state was necessary to, or even entirely responsible for, the form of the contact movement. In Experiments 2 and 3, this question was examined by manipulating the conditions of deprivation and the type of reinforcer.

Method: Experiments 2, 3, and 4

Features of method common to Experiments 2, 3, and 4 are described below.

Apparatus

A two-key response panel was in place for Experiments 2, 3, and 4. However, except for Experiment 4, only the right key was used (the left key was unlighted and inoperative). The keys were translucent discs with a diameter of 1 in. (2.5 cm). When back-lighted they showed a white equilateral triangle, 0.5 in. (1.3 cm) on a side, centered in the disc. The key-centers were equidistant from the middle of the panel, were separated by 7.62 in. (19 cm), and were 10.25 in. (26 cm) from the floor. The openings to the food delivery device and to the water delivery device were each 2 by 2.5 in. (5.1 by 6.4 cm). Their closest edges were separated by 1 in. (2.5 cm). The openings were equidistant from the middle of the panel. Their lower edges were 4.5 in. (11 cm) from the floor. The opening for the water delivery device was to the right of the opening for the food delivery device. The food tray was standard LVE equipment. Water delivery was by means of a timed valve that admitted 1.2 ml into a cylindrically shaped, Teflon container, 0.5 in. (1.3 cm) in diameter and approximately 0.5 in. (1.3 cm) in depth. At the end of a 4-sec period of access, any water not consumed was forced out by a plunger, which caused the water to spill over into an inaccessible reservoir. The compartment was constantly illuminated by a diffuse ceiling light.

Procedure

Birds were first trained to consume food or water from the delivery device, according to the requirements of the experiments. The auto-shaping procedure was to light the key for a fixed duration of 8 sec, followed immediately by a 4-sec delivery of food or water. While the reinforcer was available, the opening to the delivery device was lighted. The sequence of keylight and reinforcer was unaffected by responses. Intertrial intervals varied from 20 to 78 sec with a mean of 64 sec.

When food-deprived only, the birds were maintained under restricted feeding and were at approximately 80% of their free-feeding weight at the start of each session. Water was continuously available in their home cages. When water-deprived only, food was continuously available in their home cages, but water was removed 48 hr before the start of a session. After each session, water was freely available for at least 24 hr before the next 48-hr deprivation period. When both water- and food-deprived, birds were maintained at 80% of free-feeding weight by restricted feeding and were under 48-hr water deprivation at the start of the session. They also received water freely for at least 24 hr before the next period of deprivation.

Evaluation of Recordings

Six students enrolled in an undergraduate course in the psychology of learning served as judges of video-tape recordings obtained in these experiments. They were shown the characteristic movement patterns of pigeons eating and drinking, and were also instructed about the characteristics of auto-shaped responses in a food-deprived bird receiving grain as a reinforcer and in a water-deprived bird receiving water as a reinforcer. Several filmed examples of water and food auto-shaped responses were shown. The judges were then tested for their ability to distinguish correctly between food and water auto-shaped responses. They were shown, in an irregular order, 11 trials of water auto-shaping, and 11 trials of food auto-shaping, and were required to mark one of the following alternative statements for each trial: (1) clearly eating movements, (2) probably eating movements, (3) not distinctly eating or drinking movements, (4) probably drinking movements, (5) clearly drinking movements, (B) both eating and drinking movements (*i.e.*, a mixture within the trial), (N) no rateable movements. Each judge correctly rated at least 21 of the 22 trials by marking 1 or 2 for food-reinforced trials and 4 or 5 for water-reinforced trials. The preliminary instructions and the test

served, as it were, to calibrate the judges. These steps in no way prejudiced the subsequent ratings, which were used to evaluate the effect of type of deprivation and other variables on the form of the response.

The video-tape recordings of trials for a given bird were shown in succession because it was not feasible completely to rearrange trial sequences. However, recordings of birds given different experimental treatments in Experiments 2, 3, and 4 were shown in an irregular sequence. The screen of the TV monitor was masked so that consummatory patterns were not visible.

Results on Reliability of Evaluations

Data showing the extent of agreement among the judges are presented in Table 1. These data are the ratings of a total of 272 trials by six observers from the seven birds used in Experiments 2 and 3. The ratings are on birds in several different experimental conditions, but the details are not relevant to the question of agreement among observers in the rating of movement patterns. The results in Table 1 were obtained in the following way. For each trial, the rating category used most frequently (modal category) was determined. In the case of a two-way tie, the most frequent rating was taken to be the lower one for half of the ties and the higher one for the remainder. In the case of a three-way tie, the middle category was taken as the most frequently used rating. The first row of Table 1 shows the relative frequency distribution of ratings for all trials in which the modal rating was (1), "clearly eating movements". The next row shows the same data for all trials in which the modal rating was (2), "probably eating movements", and so on. The pattern of ratings shows a high degree of consistency among observers. For example, excluding the rating (B), "both eating and drinking movements", and the rating (N), "no rateable movement", only about 5% of all ratings occur in a category more than once removed from the modal category for a given trial.

EXPERIMENT 2

The form of the auto-shaped response could be a direct reflection of the dominant deprivational state at the time of the response. If so, a change from one dominant deprivational state to another after the auto-shaped response was established would produce an immediate change in the form of the response. Experiment 2 examined the effect of such a change on the form of the auto-shaped response.

Subjects and Procedure

Four adult male White King pigeons were used. Two were food deprived only and received grain as the reinforcer. Auto-shaping sessions, each consisting of 30 trials, were continued until one or more pecks occurred on at least 20 of the 30 trials in a session. Every fifth trial of the session in which the criterion was met was video-taped and evaluated. The dominant deprivational state was then changed from food deprivation to water deprivation. Food and water were made freely available until the free-feeding weight was recovered. Thirst was then induced by restricting the water supply as previously described and 10 extinction trials were given. Conditions were the same as in auto-shaping except for the omission of the reinforcer and

Table 1

Distribution of Ratings of the Form of Response Arranged by Modal Rating Category

Modal Category[a]	*Relative Frequency of Ratings by Categories*						
	1	*2*	*3*	*4*	*5*	*B*	*N*
1	*0.820*	0.136	0.033	0.009	0.002	0	0
2	0.180	*0.592*	0.142	0.041	0	0.031	0.015
3	0.003	0.254	*0.463*	0.142	0.037	0.037	0.037
4	0.006	0.042	0.120	*0.503*	0.210	0.096	0.024
5	0	0.003	0.026	0.141	*0.743*	0.087	0
B	0.037	0.149	0.104	0.127	0.067	*0.522*	0
N	0.005	0.016	0.036	0.016	0	0	*0.927*

[a]Category descriptions: (1) clearly eating movements, (2) probably eating movements, (3) not distinctly eating or drinking movements, (4) probably drinking movements, (5) clearly drinking movements, (B) both eating and drinking movements, (N) no rateable movement.

the light at the opening to the delivery device. All 10 extinction trials were video-taped and evaluated. In a separate session, following extinction, the birds were given repeated opportunities to approach and drink from the water delivery device until they had approached and taken water in 30 presentations. These presentations were not signalled by lighting the key. Finally, in another separate session, 10 additional extinction trials were given as previously, and each trial was video-taped and evaluated.

Two other subjects received parallel treatments except that responses were first auto-shaped under water deprivation only, with water as the reinforcer, and were subsequently changed to food deprivation only. They received unsignalled deliveries of grain before the last 10 extinction trials.

Results and Discussion

The results for the two subjects, 31 and 26, which were first food-deprived and received food as the reinforcer are shown in Table 2. The data for Phase 1 are the judges' ratings of the form of response in the first session in which one or more key contacts occurred on at least 20 of the 30 trials. This was the fourth session for both subjects. Although the ratings show that the response form for Subject 26 was not as clearly an eating movement as for Subject 31, it is evident that the movement more closely resembled eating than drinking in each case. Data for Phase 2 are for 10 extinction trials following a change from food to water deprivation. There were small changes in the ratings on trials in which a rateable movement occurred, but the main result was that the response form remained more like grain-pecking movements than like water-drinking movements. Data for Phase 3 are for another 10 extinction trials following a session in which the birds had taken water on 30 presentations. The dominant deprivational state continued to be thirst. Again, the ratings show that the contact movement remained more like the pecking of grain than the drinking of water.

The results for Subjects 9 and 82, which were initially auto-shaped under water deprivation and later tested under food deprivation, are shown in Table 3. The criterion session for auto-shaping was the third for Subject 9 and the fifth for Subject 82. The ratings based on these sessions (Phase 1) indicate that the response form resembled drinking movements. When tested in extinction under food deprivation (Phase 2), the response form re-

Table 2

Relative frequency of response form ratings before and after a change from food to water deprivation.

	Category[a]						
	1	*2*	*3*	*4*	*5*	*B*	*N*
Subject 31							
Phase 1: auto-shaping, food reinforcer, food deprived	0.97	0.03	0	0	0	0	0
Phase 2: extinction, water deprived	0.56	0.35	0.02	0	0	0	0.06
Phase 3: extinction after drinking, water deprived	0.27	0.18	0.13	0	0	0	0.42
Subject 26							
Phase 1: auto-shaping, food reinforcer, food deprived	0	0.59	0.40	0	0	0	0
Phase 2: extinction, water deprived	0	0.33	0.27	0.03	0	0	0.38
Phase 3: extinction after drinking, water deprived	0.10	0.35	0.10	0.05	0	0.02	0.38

[a]Categories as in Table 1

Table 3

Relative frequency of response form ratings before and after a change from water to food deprivation.

	Category[a]						
	1	*2*	*3*	*4*	*5*	*B*	*N*
Subject 9							
Phase 1: auto-shaping, water reinforcer, water deprived	0	0	0	0.11	0.86	0.03	0
Phase 2: extinction, food deprived	0	0	0.02	0.30	0.53	0.15	0
Phase 3: extinction after eating, food deprived	0.05	0.17	0.13	0.03	0.08	0.47	0.07
Subject 82							
Phase 1: auto-shaping, water reinforcer, water deprived	0	0	0	0.05	0.92	0.03	0
Phase 2: extinction, food deprived	0	0	0.02	0.05	0.35	0.02	0.56
Phase 3: extinction after eating, food deprived	0	0	0	0.20	0.75	0.05	0

[a]Categories as in Table 1.

mained more like drinking than eating. After receiving grain from the tray on 30 presentations (Phase 3), the response form continued to be rated predominantly as drinking for Subject 82. For Subject 9, however, the most frequent rating was B, indicating that both eating and drinking movements occurred during the 10 trials. A greater spread of ratings across categories 1 through 5 was also evident. It would appear that the occurrence of the consummatory response altered the response form in the direction of grain-pecking movements in this subject, although we cannot be sure that this change would not have occurred simply as the result of continued testing in extinction.

The principal conclusion to be drawn from Experiment 2 is that the form of the response made in contacting the illuminated key is not determined by the type of deprivation at the time of the response. The resemblance between the form of the auto-shaped and consummatory responses persists for a substantial period despite a change in the dominant deprivational state. It is possible, however, that a dominant deprivational state appropriate to the reinforcer is necessary for the initial appearance of the reinforcer-related response form; this was examined in Experiment 3.

EXPERIMENT 3

If, in subjects that are both food- and water-deprived, the form of the auto-shaped response depends on whether food or water is the reinforcer, we can be sure that the dominance of the deprivational state appropriate to the reinforcer is not a necessary condition of the resemblance between the consummatory response and the auto-shaped response. Further, if dominance of one deprivational state is not necessary it might be possible to alter the response form within a subject by changing from one reinforcer to the other without altering the prevailing conditions of deprivation.

Subjects and Procedure

Four male White King pigeons were deprived of both food and water according to the procedure previously described. They were trained to take food and water presented in the same session. Two birds then experienced auto-shaping with the food reinforcer only until they met the criterion of one or more key closures on at least 20 of the 30 trials of a session. Every fifth trial of the session in which they met criterion was video-taped and evaluated. They then received, in a separate session, 10 extinction trials, all of which were

taped and evaluated. In the next session auto-shaping was resumed, but the reinforcer was changed from food to water. One subject received 10 sessions of auto-shaping with the new reinforcer whereas the other received three such sessions. Every fifth trial of these sessions was video-taped and evaluated. A third bird received a parallel series of treatments except that the reinforcer was water in the first phase and was subsequently changed to food for 10 sessions. A fourth bird was started on water auto-shaping but was discontinued after nine sessions in which no contacts were made with the key.

Results and Discussion

The results for subjects initially auto-shaped with food are shown in Table 4. Subject 21 reached criterion in the fifth and Subject 40 in the second session of auto-shaping. The response form in the criterion session (Phase 1) strongly resembled grain pecking. The response form remained predominately grain pecking during extinction (Phase 2). The response ratings after the change to water as reinforcer are shown as Phase 3, early and late. In the case of Subject 40, Phase 3, early, is based on the first session with water as the reinforcer, whereas Phase 3, late, is based on Sessions 8, 9, and 10 (the last three sessions) with water as the reinforcer. In the case of Subject 21, Phase 3, early, is based on the first two sessions with water as the reinforcer, whereas Phase 3, late, is based on the third and last session with water as the reinforcer. Sessions or groups of sessions were selected for homogeneity of ratings. In each case there was progressive and gradual change from a predominant rating of drinking movements to one of pecking movements.

The results for Subject 30, initially auto-shaped with water, are shown in Table 5. The criterion was met in the second session, although, as it turned out, on half the sampled trials no rateable movement occurred. The rateable movements that did occur, however, resembled drinking (Phase 1) and continued to do so during the extinction trials (Phase 2). Ratings for the first two sessions after the change to the food reinforcer and for the last five sessions with food are shown in Phase 3, early and late. Again, a progressive change occurred to a new response form resembling grain pecking more than drinking.

The results of Experiment 3 show clearly that the form of the contact movement is dependent upon the reinforcer (food or water) in birds that are both food- and water-deprived. The dominance of a deprivational state appropriate to the reinforcer is not necessary

Table 4

Relative frequency of response form ratings in food-and water-deprived subjects changed from a food to a water reinforcer.

	Category[a]						
Phase	*1*	*2*	*3*	*4*	*5*	*B*	*N*
Subject 21							
(1) auto-shaping, food reinforcer	0.83	0.14	0.03	0	0	0	0
(2) extinction	0.78	0.15	0.03	0	0	0	0.03
(3) auto-shaping, water reinforcer (early)	0.40	0.26	0.06	0.04	0.05	0.04	0.15
(3) auto-shaping, water reinforcer (late)	0.03	0.17	0.17	0.25	0.08	0.06	0.25
Subject 40							
(1) auto-shaping, food reinforcer	0.92	0.08	0	0	0	0	0
(2) extinction	0.90	0.10	0	0	0	0	0
(3) auto-shaping, water reinforcer (early)	0.61	0.19	0.06	0.11	0.03	0	0
(3) auto-shaping, water reinforcer (late)	0	0.02	0.04	0.15	0.46	0.10	0.24

[a]Categories as in Table 1.

Table 5

Relative frequency of response form ratings on a food- and water-deprived subject changed from a water to a food reinforcer.

Phase	Category[a] 1	2	3	4	5	B	N
Subject 30							
(1) auto-shaping, water reinforcer	0	0	0.06	0.28	0.17	0	0.50
(2) extinction	0	0	0.08	0.50	0.40	0	0.02
(3) auto-shaping, food reinforcer (early)	0.01	0.14	0.29	0.26	0.21	0.08	0
(3) auto-shaping, food reinforcer (late)	0.34	0.45	0.19	0.01	0	0.01	0

[a]Categories as in Table 1.

for the auto-shaped response to take on characteristics of the consummatory response. This conclusion is further supported by the finding that a change of reinforcer produces a corresponding change of response form when the prevailing conditions of food and water deprivation are unchanged.

EXPERIMENT 4

The previous experiments showed that the resemblance between the consummatory response and the response to the signalling stimulus could not be explained by the dominance of a deprivational state appropriate to the reinforcer. However, it has not yet been shown that the resemblance was the result of the contingent temporal pairing between the stimulus and the reinforcer. There are two other sources that could account for the resemblance. First, there is the possibility of generalization from the light at the delivery site of the reinforcer to the keylight. The availability of food or water was accompanied by a light at the delivery site, which could have provided a basis for generalization to the lighting of the key. Second, it is possible that the repeated activation of a consummatory response of one type exerted a direct influence on the form of the response to the lighted key. The consummatory response might be potentiated by repeated activation.

Experiments 4 and 5 were designed to show that the pairing of stimulus with reinforcer is sufficient to lead to an auto-shaped response resembling the consummatory response even when stimulus generalization, the potentiation of one consummatory pattern, and the dominance of a deprivational state are not available as possible sources for the resemblance. The plan of the experiments was to present to a water- and food-deprived subject one stimulus, S_1, before the food reinforcer and another stimulus, S_2, before the water reinforcer. The two stimuli were presented in an entirely random sequence from the outset of conditioning. In this arrangement, a resemblance between responses to the stimuli and responses to the reinforcers that the stimuli signalled could not be due to stimulus generalization. If S_1 and S_2 were equally similar (or dissimilar) to the stimuli directly associated with the delivery of the two reinforcers, generalization could not produce one form of response to S_1 and another to S_2. The potentiation of consummatory patterns by prior activation could also be ruled out because in a random sequence, pecking and drinking would be activated equally often before trials on which S_1 signals food or S_2 signals water. The dominance of one deprivational state is obviously ruled out as a source of different response-forms to S_1 and S_2 by this within-subject design.

Procedure

A single male, White King pigeon, simultaneously food- and water-deprived, was used. After training to take food and water from the delivery devices, auto-shaping with the two stimulus-reinforcer pairs was begun. The lighting of the left key preceded the delivery of water, which was made available from the right opening. The lighting of the right key preceded the delivery of food in the left opening. The only difference between the stimulus

preceding food delivery and the stimulus preceding water delivery was the position of the lighted key; *i.e.*, on the left or right side. Each key showed a white triangle when lighted. Each session consisted of 30 trials in which food was presented and 30 trials in which water was presented. Food and water trials were presented in a random order. In all other respects the auto-shaping procedure was as previously described. There were nine sessions. Every fifth water-reinforced trial and every fifth food-reinforced trial of the last three sessions was video-taped and evaluated.

RESULTS

The ratings of response form during Sessions 7 to 9 (last three sessions) are shown in Table 6. The trials were shown to the judges in the same random order in which they occurred. The profile of ratings shows a clear

Table 6

Relative frequency of response form ratings on a subject receiving signalled food and signalled water.

	Category[a]						
Trial Type	*1*	*2*	*3*	*4*	*5*	*B*	*N*
Food trials:	0.69	0.12	0.06	0.03	0.01	0.03	0.05
Water trials:	0.04	0.26	0.15	0.31	0.19	0	0.06

[a]Categories as in Table 1.

difference in the response forms on food and water trials. Ratings on food trials show the response form to resemble grain pecking with few exceptions. On water trials, a mixture of response forms occurred. The ratings of "clearly", or "probably drinking movements" (categories 4 and 5) were, however, more frequent than the ratings of "clearly" or "probably eating movements" (categories 1 and 2). It is evident that each stimulus evoked features of the consummatory pattern appropriate to the specific reinforcer that it signalled.

EXPERIMENT 5

In this experiment, randomly intermixed food and water trials were again used to investigate the importance of stimulus-reinforcer pairings in producing the resemblance of auto-shaped to consummatory responses. Instead of judges' ratings, the force characteristics of responses auto-shaped with food and water reinforcement were recorded. To reduce generalization between the food and water keys, the visual stimuli were made less similar. Finally, high-speed photography was used to reveal further details of response form.

Subjects

Six White Carneaux pigeons, about 1 yr old and without previous experimental training, were maintained at 85% of their normal weights, and water intake was limited to 18 ml per day. Individual subjects were pre-fed 10, 15, or 20 g of mixed grain 10 min before each session. The exact amounts were adjusted during pretraining to try to ensure that each animal would react quickly to both food and water presentations. On days when no training session was held, enough grain was provided to bring the subject to the 85% weight level, and the animal was then given its ration of water.

Apparatus

The experimental chamber contained a Lehigh Valley two-key response panel, modified to permit the use of water reinforcement and to allow measurement of response forces. The water receptacle, which was taken from a Lehigh Valley model 1577 liquid feeder, protruded into the experimental chamber 0.5 in. (1.3 cm) above the food magazine. A small indicator lamp, mounted 1 in. (2.5 cm) above the receptacle, was illuminated for 3 sec whenever water was delivered.

The force transducing keys are described in detail elsewhere (Moore, 1971). Briefly, 4-in. (10-cm) long Plexiglas keys were hinged on 0.008-in. (0.02-cm) brass shim stock. Movement of the key compressed a coil spring, and was monitored by a Hewlett Packard/Sanborn model 7DCDT-100-B11 displacement transducer. Above a 5 gf (0.05 N) threshold, the transducer's output voltage was proportional to static force applied to the key. This system was used in place of rigid force transducers because pecks that land upon unyielding keys sometimes cause beak injury and cessation of responding (Hefferline, Birch, and Gentry, 1961; but *cf.* Rilling, Kramer, and Askew, 1970).

Photographs were made after the experiment was completed. For high-speed motion pictures, a telephoto lens was used and the camera and photographer were hidden behind a screen 5 ft (1.5 m) from the subject. The

chamber was illuminated by a single 500-W photoflood lamp. The lamp was aligned with the edge of the response panel so that it would not shine directly upon the keys. For still photographs, a box containing normal Lehigh Valley response keys was utilized. A Nikon-F camera was set on "bulb", and an electronic flash was switched by the response key itself, thus catching the subject at approximately the moment of key contact (*cf.* Smith, 1967).

Recording was done on a Techni-rite model TR-711 oscillograph. The experiment was controlled by a LINC-8 digital computer.

Procedure

The stimuli that were paired with the two reinforcers differed in form, color, and position. For half of the animals, an $^{11}/_{16}$-in. (1.75-cm) diameter red disc projected onto the left key signalled water, while three white, vertical stripes projected onto the right key signalled food. The reinforcement assignments were reversed for the remaining animals. The stimulus duration was 6 sec. The reinforcements were a 3-sec presentation of grain, or 0.10 ml of tap water. Each animal was studied for 10 sessions, spaced at 48-hr intervals. Each session contained 30 food and 30 water trials, intermixed in random order. The sequences were generated by the computer, using an additive pseudo-random number generating. The mean intertrial interval was 60 sec.

The response-force records selected for reproduction were chosen by a random sampling technique. The training period was partitioned into five two-session (120-trial) blocks. Blank records were excluded, and a table of random numbers was used to select one food and one water record for each subject from each block of trials.

Results

All subjects responded to both stimuli. The first recorded response to the food key appeared after a mean of 23 food reinforcements (range: 7 to 70); responses to the water key emerged after a mean of 29 reinforcements (range: 13 to 68). Acquisition curves for individual subjects and a mean curve are shown in Figure 1.

Most responses were of appropriate consummatory form. There were two exceptions: Subject 218 made frequent drinking reactions to the food key during the first training session, and Subject 305 made many responses of mixed or indeterminate topography throughout the experiment. The remaining animals, however, made few or no responses of other than reinforcement-appropriate consummatory form. The typical topographies are shown in Figure 2. On food trials, the pigeon's beak was usually opened wide at the moment of contact with the key; on water trials, the beak was ordinarily closed, *or almost so.* The reaction to the water key often included the slow, rhythmic low-amplitude opening and closing of the beak characteristic of the species' drinking reflex. Both visual observation and motion pictures revealed that a licking response was sometimes co-ordinated with these movements. At least three of the experimental animals, and one pilot subject, were seen to lick the key, or lick toward it, as shown in Figure 3. The filmed sequence shows almost two complete cycles of drinking movements. As the beak begins to open, the tongue is raised and can be seen between the mandibles. By the time of the next exposure (16 msec later) the tongue has been extended toward the key. It is then retracted, the beak is closed, and the cycle is repeated.

The pecks evoked by the food key were typically brief, forceful reactions. Most were of roughly 10 to 70 msec duration, and therefore appear as spikes in the response-force records shown in Figure 4. Most reached 50 to 200 g force (0.5-2.0 N). Responses on the water key were occasionally of longer duration, and consistently of lower force. Examination of Figure 4 reveals that the mean response force to the food key exceeded the mean force to the water key in at least 26 of the 28 pairs of records. The pattern held true for all six subjects. The chance probability that all six would tend in the expected direction is less than 0.02.

Altogether, the force differences, the judges, ratings, the photographic evidence, and the experimenters' observations indicate that reactions to the food and water keys were distinctly different, and that each showed a remarkable resemblance to the consummatory pattern elicited by the reinforcer that it signalled.

GENERAL DISCUSSION

The principal conclusion from this series of experiments is that exposure to contingent

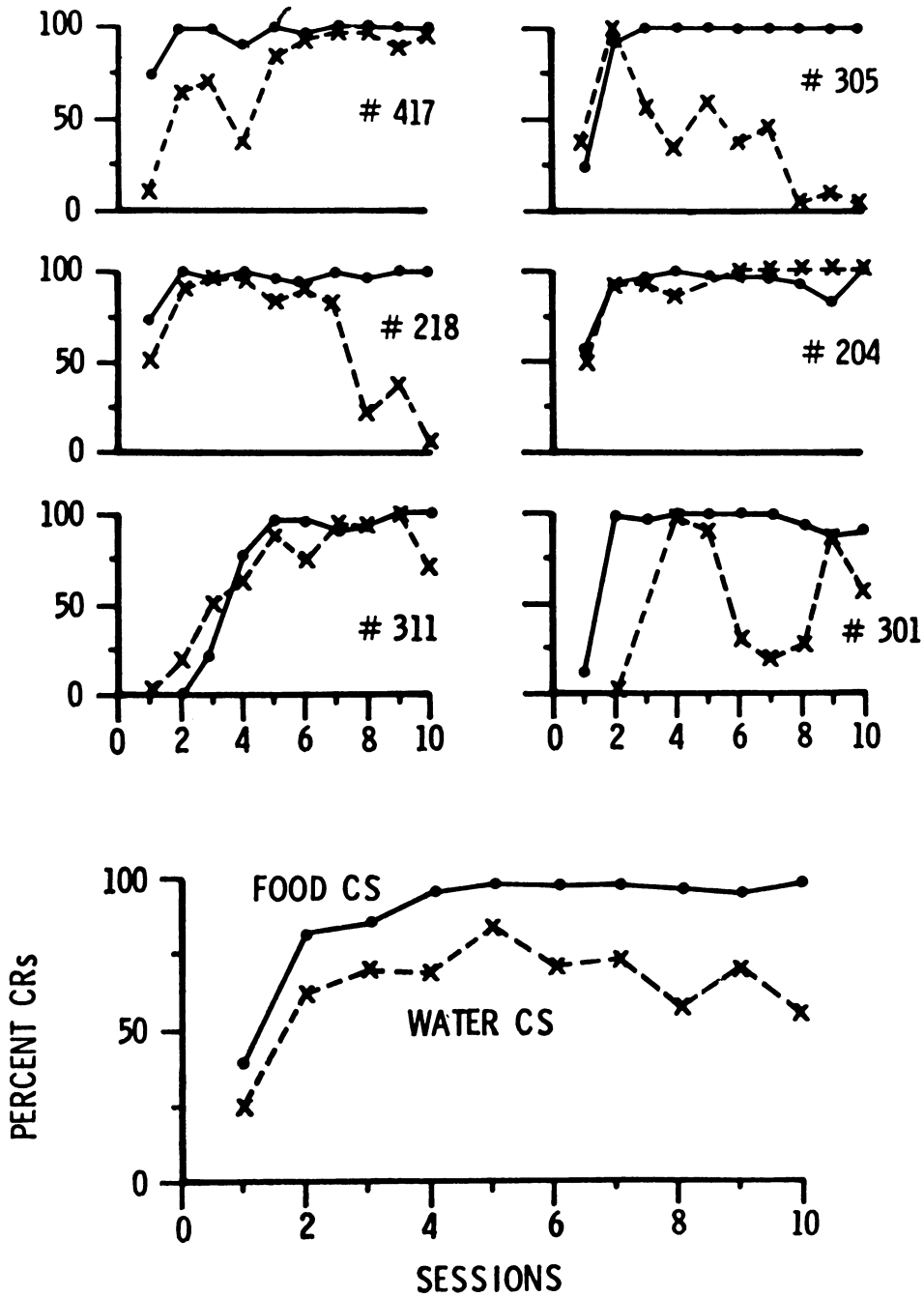

Fig. 1. Acquisition curves for individual subjects (above) and the mean curve (below). The curves show the proportion of trials during which one or more responses were recorded. The low water-key response rates shown briefly by Subjects 218 and 305 were due to reinforcement-delivery or deprivation-balance problems not experienced by other subjects.

pairings of a stimulus and reinforcer may cause the pigeon to approach the stimulus, and to respond to it, in a way that resembles the consummatory reaction evoked by the reinforcer. The resemblance of the response to the signalling stimulus and the response to the reinforcer cannot be explained in terms of mere potentiation of a consummatory pattern

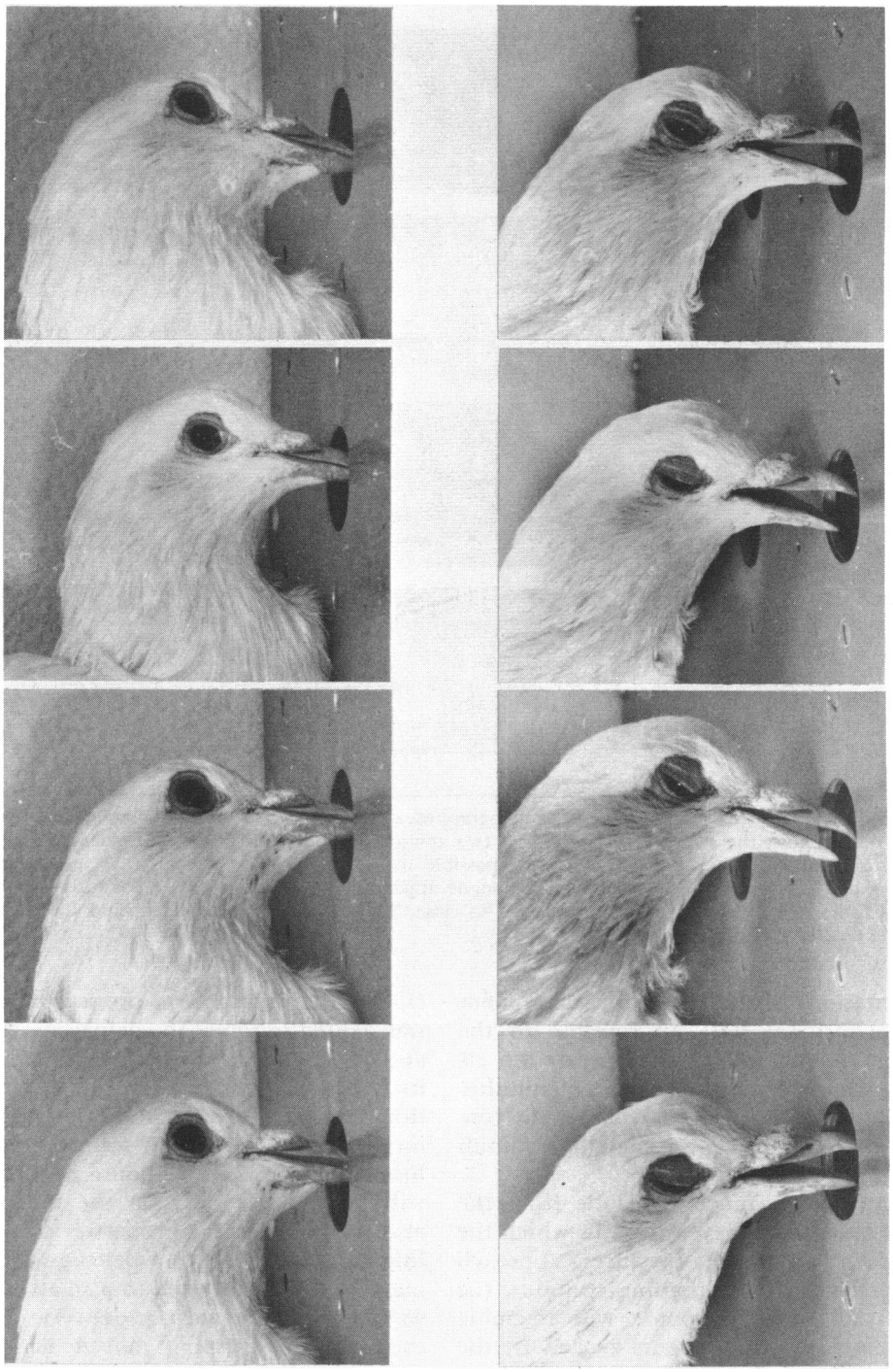

Fig. 2. Typical food and water auto-shaped responses as they appear at the moment of key contact. The photographs show the contact responses of Subject 204 during eight consecutive trials. Photographs on the left show responses to the left key, which was paired with water; those on the right show responses to the right key, which was paired with food.

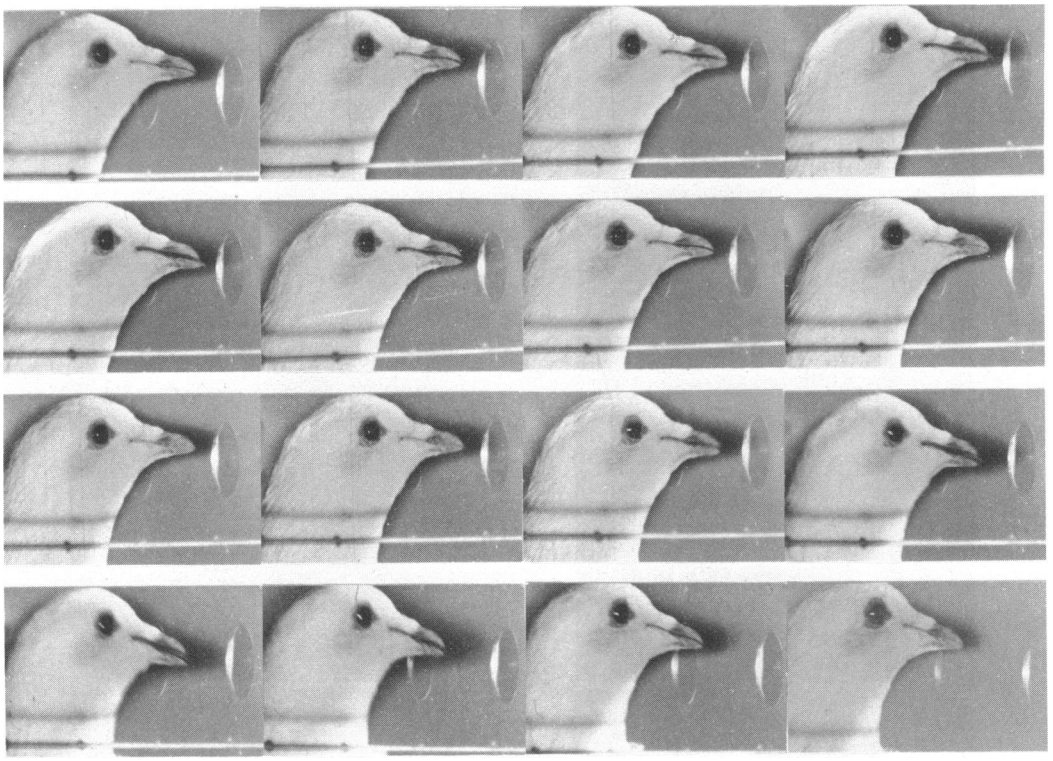

Fig. 3. Auto-shaped drinking movements, photographed at 64 frames per second. Viewed from left to right beginning on top row, the sequence shows almost two complete cycles of drinking movements. The beak does not in this case touch the key, and it is therefore possible to see the licking response that is coordinated with the opening and closing of the mandibles. The tongue appears in the third frame and is fully extended in the fourth and fifth; it is retracted as the beak begins to close. The cycle is then repeated, and the tongue is seen again in the twelfth and thirteenth frames.

by presentations of the reinforcer, dominance of a deprivational state appropriate to the reinforcer, or generalization between the reinforcing stimulus and the signalling stimulus. The resemblance is a consequence of the contingent relation between the signalling stimuli and the reinforcers.

One cannot, of course, conclude from the present results that in every case in which the auto-shaping procedure produces approach and contact with the signalling stimulus, the form of the contact response will resemble the consummatory movements evoked by the reinforcer. In fact, Sidman and Fletcher (1968), and Rachlin (1969) obtained contact movements in auto-shaping experiments that were not obviously related to movements evoked by the reinforcer.

In the experiment by Sidman and Fletcher (1968), rhesus monkeys pressed a panel that was lighted to signal the delivery of food. The authors reported: "Although the monkey used its fingers to press the key and to pick up the [food] pellet, the topography of these behaviors is quite different." It seems likely that the form of the contact response in auto-shaping will depend not only on the reinforcer but also on the physical properties of the signalling stimulus. Perhaps a pellet-grasping movement would be directed to a small object that was lighted to signal the delivery of a pellet, even though grasping movements were not made to the panels used by Sidman and Fletcher.

Rachlin (1969) used the cessation of shock as a reinforcer with pigeons in an experiment that might be viewed as auto-shaping. A series of shocks was begun, and 77 sec later the key

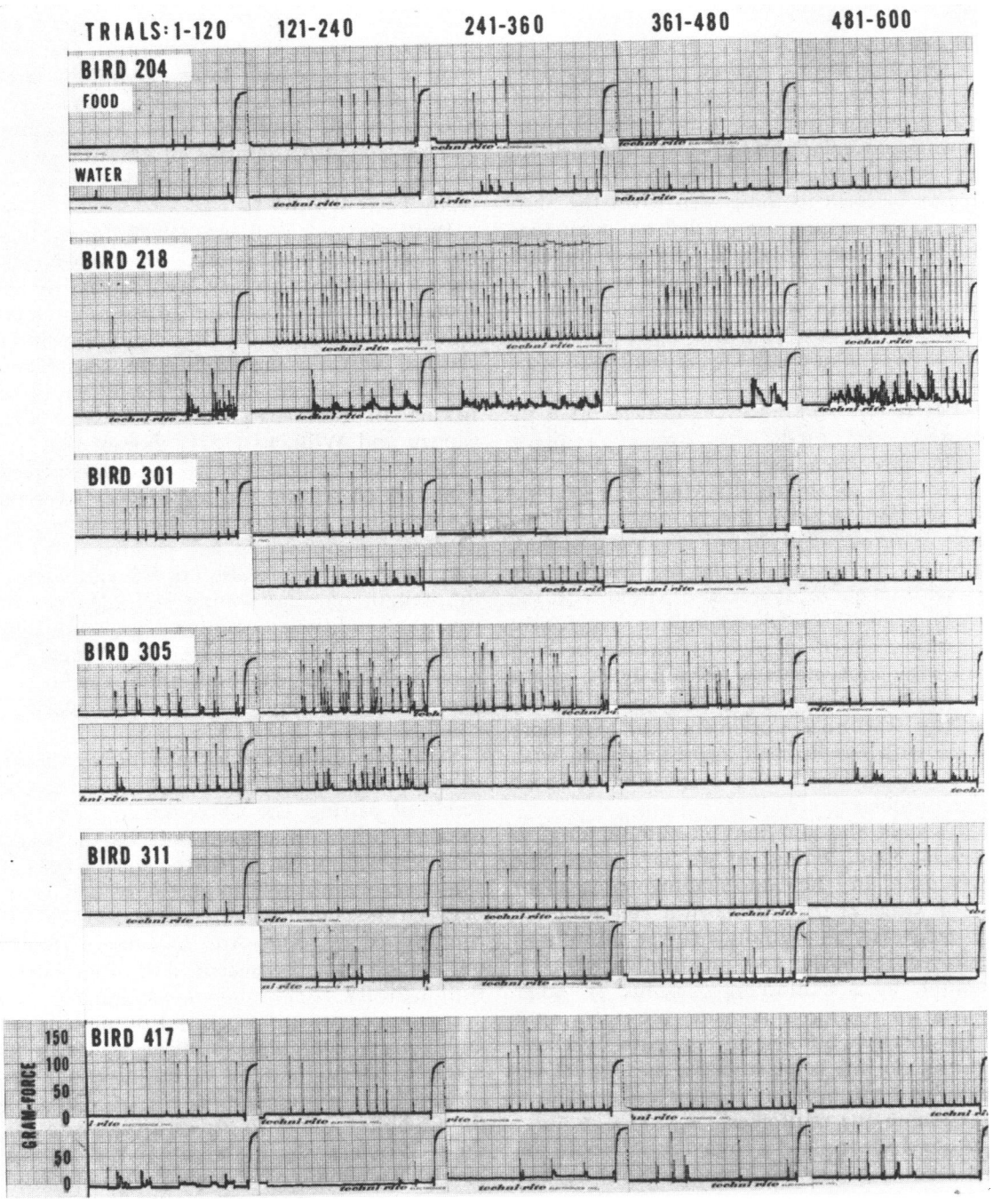

Fig. 4. Response-force recordings from randomly selected food and water auto-shaping trials. The five records at top of page show that Subject 204 responded to the food key with pecks that often reached 100-g force (1.0 N). The subject's water-trial records, immediately below, show responses of far lower force. The next subject, 218, typically struck the food key with more than twenty 175-gf (1.7 N) pecks, but touched the water key lightly, with responses of considerable duration. Consistent force differences, and occasional duration differences, can be seen in the records of Subjects 301, 311, and 417. Differentiation is poor in the early records of 305. *Scale:* Stylus returns to center of chart to demarcate end of each 6-sec trial. Force scale as shown.

was lighted. If no response occurred, it went off after 7 sec coincident with cessation of shock. An escape contingency was also in effect, since a response within the 7-sec period turned off the light and the shock immediately. The procedure resulted in pecks at the lighted key and in wing movements, which also depressed the key. Rachlin stressed that the key pecks were similar in form to those seen when the auto-shaping procedure was carried out with food as the reinforcer. Since in the aversive case, pecks were not evoked by the cessation of shock, Rachlin's result appears to be an example of an auto-shaped contact movement whose form is unrelated to movements evoked by the reinforcer.

The results are, however, open to other interpretations. First, the contact response might have been shaped by the escape contingency. If so, the results would not bear on the relation between the reinforcer and the form of *auto-shaped* contact responses. Second, although the lighting of the key preceded the cessation of shock, it was also paired with the presence of shock. Shock-induced aggressive responses, which in pigeons include pecking and wing movements of certain types, might be directed to the key as the result of this pairing. Rachlin's experiment may have more to do with conditioned aggression than with auto-shaping based on the cessation of shock as a reinforcer.

What is the relation of auto-shaping to classical conditioning? As we have noted, the procedure in the auto-shaping experiment is the same as that in classical conditioning. In each case, an initially neutral stimulus is followed regularly, and independently of responses, by a reinforcing stimulus. In other words, the reinforcer is made contingent on a prior stimulus but not on responses. We have referred to this prior stimulus as a signalling stimulus because of its contingent, predictive relation to the reinforcer.

Auto-shaping differs from the reference experiments in classical conditioning in one obvious way. The reference experiments were concerned with the conditioning of relatively local, specific responses of certain muscles or glands. In auto-shaping, on the other hand, the conditioned behavior of interest involves skeletal movement directed toward the signalling stimulus. We do not yet know the significance of this difference.

Is the conditioning process in auto-shaping the same as the one involved in accepted examples of classical conditioning? The answer to that question must depend in large part upon the extent to which the same variables have the same effects on auto-shaping and on accepted examples of classical conditioning. Some interesting parallels have already been shown.

Williams and Williams (1969) found that the auto-shaped key-peck response in the pigeon tended to persist even when the response resulted in omission of the reinforcer. A similar phenomenon has been shown in classical salivary conditioning in dogs (Sheffield, 1965) and in classical conditioning of licking in rats (Patten and Rudy, 1967). Gamzu and Williams (1971) showed that the delivery of unsignalled reinforcers between trials, which reduces the contingency between the signalling stimulus and the reinforcer, reduces the frequency of key pecking in auto-shaping. A parallel relation of S-S contingency to strength of conditioning has been shown with the conditioned emotional response (Rescorla, 1968). The auto-shaped key-contact response shares to an impressive extent the properties of accepted examples of classical conditioning.

Stimulus substitution is the orthodox theory of classical conditioning. It holds that as the result of pairing, the CS comes to evoke the response originally evoked only by the UCS. The observation on which the theory rests is the close resemblance found in certain cases between the conditioned response and the unconditioned response. Are the present results on auto-shaping consistent with the substitution theory of classical conditioning?

It is important to recognize that there is an ambiguity in concept of substitution. It can be taken to mean that the CS acquires the response-eliciting properties of the UCS, or that the CS-object comes to act as a surrogate for the UCS-object. The ambiguity in the concept of substitution becomes apparent in the context of the auto-shaping experiment precisely because the behavior of interest is skeletal movement directed toward stimulus objects, rather than a directionless reflex.

Consider that the UCS is the delivery of grain, the UCR is approach and eating from the grain tray, and the CS is the lighting of the response key. Substitution in the sense of

response elicitation implies that the CS will come to elicit the response that the US elicits, namely approach to, and pecking at or near, the grain tray. On the other hand, substitution in the sense of the CS-object as a surrogate for the US-object implies that it is the keylight that will be approached and pecked at as though it were the grain. The results of the present experiment were, of course, consistent with the latter meaning of substitution.

What was Pavlov's concept of substitution at the behavioral level? Consider the following quotations:

> Let us take any natural phenomenon that has never had any relation either to food motion or to food secretion. If this phenomenon precedes the act of eating, once or several times, it will later provoke a food reaction; it will become, so to speak, a surrogate for food—the animal moves toward it and may even take it into its mouth, if the object is tangible.
> —Pavlov, 1930, p. 209. Also, 1941, p. 47.

> The first reaction elicited by the established conditioned stimulus usually consists in a movement towards the stimulus, *i.e.*, the animal turns to the place where the stimulus is to be found. If the stimulus is within reach, the animal even tries to come in touch with it, namely, by means of its mouth. Thus if the conditioned stimulus is the switching on of a lamp, the dog licks the lamp; if the conditioned stimulus is a sound, the dog will even snap in the air (in case of very heightened food excitability). In this way the conditioned stimulus actually stands for the animal in place of food.
> —Pavlov, 1934, p. 187.

In these, and in several similar passages, Pavlov was describing an object-substitution principle. It seems clear that the present observations on auto-shaping would have been regarded by Pavlov as conforming to his view of the substitution principle in classical conditioning.

Other authors have taken the position that action directed toward a localized CS does not conform to a substitution principle of classical conditioning. Zener (1937) described conditioned movement toward a CS (a bell mounted to the side of the food pan), as well as conditioned movements directed toward the food pan itself. He argued that neither of these actions was in keeping with a substitution theory of classical conditioning. Williams and Williams (1969) also took the position that the directed property of the pigeon's key peck in auto-shaping does not conform to a substitution theory of classical conditioning. Staddon and Simmelhag (1971) expressed similar reservations. It would appear that each of these authors is rejecting the concept of the CS as a substitute for the response-eliciting property of the UCS. Whether they would also reject the concept of the CS-object as a substitute for the UCS-object is a moot point.

Bindra (1972), on the other hand, offered an interpretation of auto-shaping that is more similar to the one that we believe is clearly implied by the previous quotations from Pavlov. Bindra refers to the UCS as an unconditioned incentive stimulus and to the CS as a conditioned incentive stimulus. In auto-shaping, according to Bindra, the CS becomes a surrogate of the UCS and acquires some of its incentive properties. Approach to and contact with the CS is taken to be a direct result of this process.

To recapitulate, the procedures in auto-shaping and classical conditioning are formally identical, a number of variables have been shown to affect auto-shaped responses and accepted examples of classically conditioned responses in similar ways, and the present results on auto-shaping are consistent with one interpretation of the substitution theory of classical conditioning. What is the significance of these relations for an understanding of auto-shaping?

What might be called the object-substitution principle of classical conditioning (CS as a surrogate of the UCS) is little more than a shorthand description of the correspondence between the behaviors directed toward the conditioned and unconditioned stimuli. Neither the correspondence nor the description is perfect. The form of a classically conditioned response often depends not only upon the nature of the reinforcer but also upon other factors including the physical properties of the conditioned stimulus. Such multiple determination undoubtedly occurs also in auto-shap-

ing (*cf.* Sidman and Fletcher, 1968). Further, it is quite possible that unscheduled response-reinforcement relations will prove important in at least some auto-shaping situations. Because so little that is fundamental is presently known about conditioning, the further analysis of auto-shaping may tell us more about how the distinction between operant and classical conditioning should be drawn than our current conceptions of this distinction can tell us about auto-shaping (Bindra, 1972; Moore, 1973).

The evidence that auto-shaping and accepted examples of classically conditioned responses are affected by certain manipulations in similar way (Williams and Williams, 1969; Gamzu and Williams, 1971) is of considerable interest. It suggests that other variables known to affect classical conditioning should be explored in the context of auto-shaping. But, evidence of this form cannot by itself distinguish between kinds of learning processes. Until the appropriate experimental comparisons are made, we must entertain the possibility that operantly shaped behavior that is, like auto-shaping, under close stimulus control will be affected by these manipulations in a way that parallels the results on auto-shaped responses (Jenkins, 1973).

REFERENCES

Bindra, D. A unified account of classical conditioning and operant training. In A. H. Black and W. F. Prokasy (Eds.), *Classical conditioning II*, New York: Appleton-Century-Crofts, 1972. Pp. 453-481.

Breland, K. and Breland, M. The misbehavior of organisms. *American Psychologist*, 1961, **16**, 681-684.

Brown, P. L. *Some effects of unconditional reinforcement in the pigeon.* Unpublished doctoral dissertation, McMaster University, 1968. (*a*)

Brown, P. L. Auto-shaping and observing responses (R_o) in the pigeon. *Proceedings, 76th Annual Convention, American Psychological Association*, 1968, 139-140. (*b*)

Brown, P. L. and Jenkins, H. M. Auto-shaping of the pigeon's key peck. *Journal of the Experimental Analysis of Behavior*, 1968, **11**, 1-8.

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

Gamzu, E. and Williams, D. R. Classical conditioning of a complex skeletal response. *Science*, 1971, **171**, 923-925.

Gardner, W. M. Auto-shaping in bobwhite quail. *Journal of the Experimental Analysis of Behavior*, 1969, **12**, 279-281.

Hefferline, R. F., Birch, J. D., and Gentry, T. Simple transducers to detect or record operant amplitude. *Journal of the Experimental Analysis of Behavior*, 1961, **4**, 257-261.

Jenkins, H. M. Effects of the stimulus-reinforcer relation on selected and unselected responses. In R. A. and J. S. Hinde (Eds.), *Constraints on learning.* London: Academic Press, 1973

Moore, B. R. *On directed respondents.* Unpublished doctoral dissertation, Stanford University, 1971.

Moore, B. R. The role of directed Pavlovian reactions in simple instrumental learning in the pigeon. In R. A. and J. S. Hinde (Eds.), *Constraints on learning.* London: Academic Press, 1973

Patten, R. L. and Rudy, J. W. The Sheffield omission training procedure applied to the conditioning of the licking response in rats. *Psychonomic Science*, 1967, **8**, 463-464.

Pavlov, I. P. *Conditioned reflexes.* (Translated by G. V. Anrep) London: Oxford University Press, 1927.

Pavlov, I. P. A brief outline of the higher nervous activity. In C. Murchison (Ed.), *Psychologies of 1930.* Worcester, Mass.: Clark University Press, 1930. Pp. 207-220.

Pavlov, I. P. An attempt at a physiological interpretation of obsessional neurosis and paranoia. *Journal of Mental Science*, 1934, **80**, 187-197.

Pavlov, I. P. *Lectures on conditioned reflexes* (Volume 2) *Conditioned reflexes and psychiatry.* (Translated by W. H. Gantt) New York: International, 1941.

Rachlin, H. Autoshaping of key pecking in pigeons with negative reinforcement. *Journal of the Experimental Analysis of Behavior*, 1969, **12**, 521-531.

Rescorla, R. A. Probability of shock in the presence and absence of CS in fear conditioning. *Journal of Comparative and Physiological Psychology*, 1968, **66**, 1-5.

Rilling, M., Kramer, T. J., and Askew, H. R. The preliminary analysis of the dynamics of the pecking response in pigeons. *Journal of the Experimental Analysis of Behavior*, 1970, **13**, 267-278.

Sheffield, F. D. Relation between classical conditioning and instrumental conditioning. In W. F. Prokasy (Ed.) *Classical conditioning*, New York: Appleton-Century-Crofts, 1965. Pp. 208-225

Sidman, M. and Fletcher, F. G. A demonstration of auto-shaping in the monkey. *Journal of the Experimental Analysis of Behavior*, 1968, **11**, 307-309.

Smith, R. F. *Behavioral events other than key striking which are counted as responses during pigeon pecking.* Unpublished doctoral dissertation, Indiana University, 1967.

Squier, L. H. Autoshaping key responses with fish. *Psychonomic Science*, 1969, **17**, 177-178.

Staddon, J. E. R. and Simmelhag, V. L. The "superstition" experiment. *Psychological Review*, 1971, **78**, 3-43.

Williams, D. R. and Williams, H. Auto-maintenance in the pigeon: sustained pecking despite contingent non-reinforcement. *Journal of the Experimental Analysis of Behavior*, 1969, **12**, 511-520.

Wolin, B. R. Difference in manner of pecking a key between pigeons reinforced with food and with water. Paper read at Conference on the Experimental Analysis of Behavior, 1948. Reprinted in A. C. Catania (Ed.), *Contemporary research in operant behavior*. Glenview, Ill.: Scott, Foresman, 1968. p. 286

Zener, K. The significance of behavior accompanying conditioned salivary secretion for theories of the conditioned response. *American Journal of Psychology*, 1937, **50**, 384-403.

Received 22 May 1972.
(*Final Acceptance 19 April 1973.*)