THE CONTROL OF FEEDING BEHAVIOR BY AN IMPRINTED STIMULUS¹

HOWARD S. HOFFMAN, JAMES W. STRATTON, AND VALERIE NEWBY

PENNSYLVANIA STATE UNIVERSITY

Imprinted ducklings were trained to peck a pole using brief presentations of the imprinted stimulus as the response-contingent (reinforcing) event. Subjects' were then permitted to spend extended periods with continuous access to food and the imprinted stimulus (via a pole peck). For other (control) subjects the experimental situation was restricted to either responding for the stimulus, or feeding in the absence of the stimulus. For subjects in the control conditions, both activities occurred in cyclic fashion. When, however, there was continuous opportunity to respond for the stimulus and food was available, the tendency to respond was related to the tendency to feed. Other experiments showed that independent presentations of the stimulus could initiate feeding in imprinted ducklings with no prior pairing of the stimulus with food and with no prior pole-peck training. The most consistent control over feeding, however, was exhibited by ducklings that were imprinted and also accustomed to periodic removals of the stimulus. It is concluded that in ducklings, imprinting procedures are sufficient to endow an arbitrary stimulus with the capacity to release feeding behavior.

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Previous investigations indicate that when a duckling has been imprinted to a given stimulus it can be trained to peck a key using presentations of the imprinted stimulus as the sole response-contingent (reinforcing) event (Peterson, 1960; Hoffman, Searle, Toffee, and Kozma, 1966; Hoffman and Kozma, 1967). One phase of the earlier work from this laboratory revealed that when im-

printed and key-peck trained ducklings were subsequently permitted uninterrupted access to the imprinted stimulus by means of a key peck, responding tended to occur in bursts (Hoffman and Kozma, 1967). Although eating and drinking were not recorded, both food and water were continuously available, and informal observation suggested that the subject's tendency to peck the key was somehow related to feeding behavior. The present sequence of studies was designed to investigate this relationship in detail.

EXPERIMENT I: (A) FREE-FEEDING BEHAVIOR WITH NO ACCESS TO THE IMPRINTED STIMULUS. (B) RESPONDING FOR THE IMPRINTED STIMULUS WITH NO FOOD AVAILABLE

The first phase consisted of assessing responses for an imprinted stimulus in subjects that had not previously had access to food or

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water in the apparatus. Likewise, the free-feeding pattern of imprinted subjects with no prior history of responding was assessed for the imprinted stimulus.

METHOD

Subjects

Eight ducklings, hatched from eggs from the Wayne Duck Farm and Hatchery, Ohio, were used. When not in the apparatus, they were housed in home cages, which were 10-gal containers lined with polyethylene bags and partially filled with absorbent bedding. Food and water were continuously available in the home cages.

Apparatus

Two imprinting units, each in a separate sound-treated and temperature-controlled room, were used for all of the present work. Figure 1 illustrates the general features of the apparatus. Each was a box (183 by 76 by 76 cm) divided by a fine-mesh brass screen into two compartments, the stimulus compartment (183 by 30 by 76 cm) and the subject compartment (183 by 46 by 76 cm). The former contained a white plastic milk bottle mounted over a model train that moved back and forth the length of the compartment on HO-gauge track at approximately 30 cm per sec. Absorbent bedding was spread on the floor of the subject compartment. Lighting was provided by fluorescent bulbs in each compartment. The bulb in the subject's compartment was continuously illuminated. Under these conditions, the milk bottle was visible when the light in the stimulus compartment was illuminated but not when it was off. Presentations of the stimulus consisted of lighting the stimulus compartment and moving the bottle back and forth along the track. Stimulus with-

drawal consisted of extinguishing the light in the stimulus compartment and stopping movement of the milk bottle.

Distress calls were detected by two microphones in each room and fed into specially designed voice keys, which were maximally sensitive to frequencies between 3000 and 4000 Hz, the dominant frequencies of the ducklings' distress calls (Collias and Joose, 1953). The voice keys were adjusted to respond to an intensity of at least 68 db at 3500 Hz (measured at either microphone). Since the intensity required to activate the key increased linearly for frequencies above as well as below 3500 Hz (at 2300 Hz and 5100 Hz the keys failed to respond to signals with intensities of 100 db), the arrangement prevented their response to contentment cheeps. These have frequency characteristics comparable to those of distress vocalizations, but are much less intense. Moreover, because of the limited ranges of their frequency response, other sounds, such as those produced by the moving stimulus, or those produced by the movements of the duckling also failed to activate the keys.

A balsa-wood pole (1 by 1 by 30 cm) attached to a pigeon key mounted on the wall above the center of the screen hung vertically down to the floor of the subject compartment. Responses on this pole initiated stimulus presentation for a duration determined by the setting of a timer. The peck force required to activate the stimulus was approximately 2 g.

Food and water trays, 13.5 cm apart, protruded 5 cm into the subject compartment from a side wall. Eating and drinking were separately detected by Lehigh Valley infrared photocell units placed on the wall on either side of the trays. The trays could be retracted behind sliding doors to make them inaccessible.

Responding for the stimulus, stimulus presentations, distress calls, eating, and drinking were recorded on an Esterline Angus operations recorder in conjunction with observations on a closed-circuit television system.

Procedure

Each of the eight subjects was exposed to two imprinting sessions during the first 48 hr after hatch. Each session lasted 1 hr and the interval between sessions was approximately 20 hr. The duckling was placed in the apparatus with the stimulus compartment illumi-

Fig. 1. Apparatus used for imprinting and subsequent testing. Food and water trays are on the right side. The small objects on top of them are photoelectric cells used to record feeding behavior.

nated, and the stimulus was moved back and forth along its track for the entire session. Between the fourth and tenth day after hatch, each duckling was exposed to one of two experimental conditions for one session lasting 9 to 12 hr. In the first condition, each of four ducklings was placed individually in the apparatus with food and water available, but the stimulus was not presented. Distress calls, eating, and drinking were recorded.

The four ducklings in the second group were trained by successive approximations to peck the pole for stimulus presentation. The experimenter observed the duckling and presented the stimulus for very short durations (approximately 0.5 sec) when the subject approached the pole. Once the duckling was in the vicinity of the pole, only motions that more and more closely resembled a pole peck were reinforced, until the duckling actually pecked the pole.² The first peck produced the

stimulus for about 5 sec, and as the response became stronger, this duration was increased to 15 sec. After shaping, the ducklings were left in the apparatus with continuous access to the pole, but with no food or water available. Each response produced a 15-sec stimulus presentation (*i.e.*, continuous reinforcement). Since the timer controlling the stimulus duration did not reset with additional responses after the one that initiated the stimulus presentation, time for stimulus presence did not "accumulate". As a result, the stimulus could not be kept continuously present. Pole pecks, stimulus presentations, and distress calls were recorded.

RESULTS

Figures 2 and 3 show the records from the final 8 hr for the eating and stimulus-responding subjects respectively. In Fig. 2, the bottom

chain of behavior that brought the subject to the vicinity of the pole and this greatly slowed the shaping process. The delivery of short (approx 0.5-sec) stimulus presentations was found to have three effects: (1) short presentations were sufficient to terminate ongoing distress calls, (2) subjects tended to repeat *immediately* the movement that preceded these short stimulus presentations, (3) short presentations prevented following and kept the subject in the area where these movements were made (*i.e.*, near the pole). As a result, using short presentations it was usually possible to shape the pole-peck in less than 10 min, where previously the process might have taken up to an hour.

Fig. 2. *Ad lib* eating in the apparatus when the imprinted stimulus was not present.

Fig. 3. Free operant pole-pecking for 15-sec presentations of the imprinted stimulus when food and water were not available.

line depicts distress calls, the second eating, and the top drinking. Regular eating and drinking occurred in bouts on the average of approximately one bout per hour. Since the food was dry mash, eating necessitated drinking, but most ducklings occasionally drank without eating.³ If distress calls were present, they typically were emitted after a bout. Ducklings in this condition usually remained by the water tray.

³Although quantity of food eaten is possibly an important dependent variable, its measurement is not easily accomplished. The fact that drinking is required with dry food prevents analysis of weight gains attributable to food and water separately. Measuring quantity of food and water removed from trays is inaccurate because much food and water is dropped into the subject's compartment. Another problem is that some food is transferred by the duckling from the food tray to the water tray in the course of eating. Hence, some of the approaches to the water tray may involve eating undissolved food. Moreover, although interruptions of the photocells are easily quantified, they do not necessarily reflect individual mouthfuls of food. Each approach to the food is recorded as the duckling places its head between the cells, but the jerking head movements characteristic of eating are occasionally recorded as well. As a result, the photocells are used to record the occurrence of eating and drinking rather than quantity of consumption. Food that can be counted more easily (worms, corn, *etc.*), food that can be consumed without water, or trays to catch spillage might be useful for future quantitative work.

Responding for the stimulus by subjects with no previous or concurrent access to food and water in the apparatus is shown in Fig. 3, where the bottom line depicts pole pecks, the second line stimulus presentations, and the top line distress calls. Although bursts of responding appear, there is less regularity and predictability than there is for eating cycles, and wider individual differences exist. If distress calls occurred, they typically preceded a burst of responding for the stimulus. Most of the ducklings remained by the pole during the session.

DISCUSSION

The occurrence of bursts of responses for the imprinted stimulus has been documented previously (Hoffman, *et al.*, 1966; Hoffman and Kozma, 1968). In the earlier work, however, subjects had free access to food and water at the time the recordings were obtained. The detection of these bursts in the absence of food and water imply that they are not simply a part of the behaviors that accompany eating and drinking. Bouts of feeding behavior have also been recorded previously (Shaeffer and Premack, 1961), though not for the duckling, and their occurrence here is perhaps indicative of their generality.

EXPERIMENT II: RESPONDING FOR THE IMPRINTED STIMULUS WITH FOOD AND WATER CONTINUOUSLY AVAILABLE

Having separately documented the occurrence of bursts of pole pecking and bouts of feeding behavior, the next step was to examine the relationship between responding for the stimulus and feeding behavior in a "free" situation. To do so, imprinted and pole-peck trained ducklings were permitted to remain in the apparatus over an extended period with continuous access to food and water and the imprinted stimulus (via the pole peck).

METHOD

Subjects

Twelve Peking ducklings were hatched in visual isolation from eggs from the Wayne Duck Farm and Hatchery, Ohio.

Procedure

The ducklings were exposed to the moving imprinting stimulus in two 20-min sessions during the first 24 hr after hatch, and one 45-min session on the second day after hatching. Once imprinted, the birds were shaped to peck the pole in order to view the stimulus. All ducklings were shaped sometime between the second and eighth day after hatch. After shaping, the ducklings were placed in the apparatus for extended periods of time with food and water and the stimulus available at all times. The ducklings spent an average of 30 hr in the apparatus for an average of three sessions per bird, the longest individual session being 25 hr in length. Observations were made from the eighth day after hatch to the twenty-first day. Pole pecks, stimulus presentations, distress calls, eating, and drinking were recorded.

RESULTS

When the subjects had constant access to food, water, and the imprinted stimulus, all exhibited both feeding bouts and bursts of responses for the stimulus. The occurrence of these two behaviors showed a consistent temporal relationship for each duckling, but the relationship varied somewhat between subjects. For purposes of quantitative analysis, the degree of overlap of feeding and responding for the stimulus was determined for each bird.

The record from each subject's final 11 hr in the apparatus was divided into 5-min segments and each segment was scored for whether eating occurred and whether the subject pecked for the imprinted stimulus. The data for a given subject were then tabulated to provide: (1) the probability of pecking for the imprinted stimulus (Pr) given that the subject also ate (e) within a given 5-min period (Pr,e), and (2) the probability of pecking for the imprinted stimulus given that the subject did not eat in that period ($Pr,\bar{e}$). If the tendency to peck for the imprinted stimulus was independent of that subject's eating tendencies, these two conditional probabilities would be expected to approximate one another. If, however, the tendency to peck for the imprinted stimulus was related to the subject's tendency to eat, Pr,e would be either significantly larger or significantly smaller than $Pr,\bar{e}$.

Table I

Probability of responding for the stimulus given that the duckling has eaten (Pr,e) and the probability of responding given that it has not eaten ($Pr,\bar{e}$) for each bird. The Z score is based upon the difference between Pr,e and $Pr,\bar{e}$.

Subject #	Pr,e	$Pr,\bar{e}$	Z
B-7	0.85	0.27	5.98**
B-2	0.87	0.32	5.56**
B-9	1.00	0.48	3.71**
B-12	1.00	0.67	4.13**
B-5	1.00	0.65	3.27**
B-3	1.00	0.77	2.74**
B-1	1.00	0.83	2.36*
B-8	1.00	0.87	2.17*
B-4	0.07	0.17	-1.37
B-11	0.06	0.27	-1.84
B-10	0.29	0.53	-2.42*
B-6	0.18	1.00	-9.65**

* $p < 0.05$

** $p < 0.01$

Table I shows the conditional probabilities (Pr,e and $Pr,\bar{e}$) for each subject and also the values of Z from the tests used to assess the statistical significance of the observed differences between them. In all but two cases the test yielded a significant value of Z . For eight of the birds, $Pr,e > Pr,\bar{e}$, implying that pole responses tended to occur during periods when the subject was also eating. For four of the subjects, $Pr,e < Pr,\bar{e}$, indicating that pole responses tended to be restricted to periods when the subject was not eating.

DUCKLING NO. B-7

DUCKLING NO. B-4

DUCKLING NO. B-6

Fig. 4. Patterns of feeding behavior and responding for the imprinted stimulus in a free-behavior situation in which there was continuous access to the imprinted stimulus (via a pole-peck response), and to food and water. B-7 and B-6 represent the highest positive and negative Z scores, respectively, from Table I. B-4 represents the lowest |Z| score.

Figure 4 shows the record from birds B-7, B-4, and B-6. It illustrates the response patterns that yielded the most extreme positive (B-7) and negative (B-6) values of Z, as well as the behavioral pattern that yielded the value of Z closest to zero (B-4).

For Duckling B-7, pecks for the stimulus tended to occur during the feeding bouts. For Duckling B-6, on the other hand, pecks for the stimulus tended to fill the intervals between feeding bouts. The analysis of Duckling B-4's data did not yield a significant difference between Pr_e and $Pr_{\bar{e}}$, but as seen in the record, the bird nevertheless exhibited a close temporal relationship between feeding and pecks for the stimulus, the latter being largely restricted to the periods immediately after the feeding bouts. Apparently, for this kind of behavioral pattern, the failure to attain statistical significance can be attributed to the generally low probability of pecks.

In this experiment, the ducklings were observed visually throughout most of the period during which the records were taken. Those observations confirm the impressions gained from the statistical analysis and examination of the records, namely that while each duckling exhibited a characteristic and relatively unique pattern of behavior, in all cases the tendency to peck for the stimulus was related to feeding behavior. Duckling B-4, for example, typically sat by the pole. Periodically, however, it would stand up and walk over to the food and water trays and begin a feeding bout. After the feeding bout was completed, the duckling usually returned to the pole and emitted a burst of pecks for the imprinted stimulus. After the burst of pecks, the bird usually sat beside the pole until it began its next feeding bout. The pattern for Duckling B-7 was similar except that it periodically returned to peck the pole during the feeding

bout. B-6 was similar to B-4 in that it spent most of its time at the pole and did not respond for the stimulus during the feeding bouts. In addition, B-6 began responding immediately after the feeding bout, but unlike B-4, it continued to respond until the beginning of the next bout.

DISCUSSION

Even though the patterns were variable between birds, they all are characterized by a close temporal correspondence between responding for the stimulus and the occurrence of feeding bouts. Moreover, responding for the stimulus seemed to be specific to eating rather than drinking. Drinking often occurred independently of responding for the stimulus, while eating rarely did. As noted earlier, drinking by necessity occurred with eating because the food was dry mash; the drinking responses between bouts, however, were unrelated to feeding *per se*, and their occurrence helps to eliminate the possibility that the temporal relation between feeding and responding was merely the result of the duckling's being asleep or generally inactive when it was not feeding. Although Exp. II does not identify the factors responsible for the relationships between eating, drinking, and responding for the stimulus, or the source of the large, but consistent individual differences between ducklings, the fact that strong relationships were revealed implies that certain basic processes are common to both feeding and the duckling's reaction to the imprinted stimulus.

EXPERIMENT III: INITIATION OF FEEDING BY INDEPENDENT PRESENTATIONS OF THE IMPRINTED STIMULUS, (A) WITH ACCESS TO THE STIMULUS VIA POLE-PECK, (B) WITH THE POLE REMOVED, AND (C) SCHEDULE VARIATIONS WITH THE POLE REMOVED

The presentations of the stimulus in Exp. II were determined exclusively by the duckling's pecking behavior. Although the tendency to peck for the stimulus seemed to be in part controlled by the duckling's eating cycles, it also seemed possible that some type of reciprocal influence existed where the presence or absence of the stimulus may have in

turn controlled feeding behavior. Study of this possibility involved experimenter-controlled presentations of the stimulus when food was available.

The first portion of the research examined the effects of presenting the stimulus independently of the subject's behavior when the subject also had access to the stimulus by means of a pole-peck response. Two additional procedures were then used to assess the effects of different schedules of independent presentations when self-initiated access to the stimulus was prevented by removal of the pole.

Subjects

All of the ducklings from Exp. II served.

Procedure

Phase I. Ducklings B3, B5, and B10 were exposed to a 10-hr test session in which the stimulus was presented for 5 min every 40 min independently of the bird's behavior. Otherwise, the experimental situation was the same as in Exp. II where the duckling had free access to food and water as well as to the imprinted stimulus via the pole-peck response.

Phase II. Ducklings B1, B4, B6, B7, B8, and B12 were exposed to a 10-hr session in which the schedule of independent presentations was 5 min of presence for every 20 min of stimulus absence. However, the pole was removed so that the duckling no longer had control over presentations of the stimulus.

Phase III. Using Ducklings B2, B9, and B11, this procedure consisted of 5-min presentations of the stimulus with variable withdrawn periods. Each subject was exposed to the following withdrawn intervals: 25, 40, 60, 120, and 25 min, in that order. Each schedule was in effect for about 5 hr so that the session was roughly 25 hr long. Here, as with the second procedure, the pole was removed.

RESULTS

Figure 5 shows examples from the test session in which subjects had access to the stimulus via a pole peck (Phase I). Although independent stimulus presentations often induced responding for the stimulus, it is clear that the presentations also served to initiate eating and drinking, even though the duckling had continuous access to the stimulus by means of the pole-peck response, and food and water were always available.

Fig. 5. The effects of response-independent stimulus presentations on pole-pecking and feeding behavior. Independent presentations are identified by upward deflections of the stimulus line with no corresponding deflections in the pole-peck line.

Figure 6 shows a typical operations recorder record from the second procedure in which the pole was removed and the stimulus presented for 5 min every 20 min (Phase II). Few distress calls were emitted, and eating and drinking occurred mainly during stimulus presence. The relationship between feeding and stimulus presentation is summarized in the bottom section of Fig. 6, which represents the data from both sessions of the second procedure for all birds. This histogram shows the relative frequency of eating in each of the five 5-min periods that comprised one cycle of 5 min of stimulus presence and 20 min of stimulus absence. The abscissa represents successive 5-min segments of the complete cycle and the ordinate represents the relative probability of eating in the several 5-min intervals. The latter was calculated by determining the proportion of times the ducklings ate in each 5-min segment of the 25-min cycle across both sessions. Thus, the relative probabilities sum to 1.0. Inspection of the histogram makes it clear that most of the eating was during stimu-

lus presence. Chi-square was used to evaluate the statistical significance of the trend seen in Fig. 6. It compared the observed distribution with the flat function expected if eating were equally probable in each 5-min segment of the 25-min cycle. The test yielded $X^2 = 383.64$, d.f. = 4, $p < 0.001$.

Figure 7 is the record of a representative duckling (B11) from the third procedure in which the pole was removed and different intervals of stimulus absence were interposed between successive stimulus presentations. From top to bottom, Fig. 7 shows the 25, 40, 60, 120, and final 25-min intervals respectively. The control over feeding behavior is quite powerful up to 1 hr. At 2 hr the control "breaks down" but is reinstated when the interval is reduced to 20 min.

DISCUSSION

Each procedure demonstrated stimulus control over feeding behavior. The first two procedures showed that the control was highly reliable, while the third procedure showed

Fig. 6. Control of feeding behavior by independent presentations of the stimulus when the pole was removed in ducklings that had been previously pole-peck trained. The lower portion shows a histogram summarizing the tendency (across six subjects) to eat in different portions of the cycle of stimulus presentations and withdrawals. See text for explanation.

that this control was not the mere fortuitous synchronization of the stimulus presentations with natural eating periods. The control did seem limited, however, to stimulus-withdrawn intervals which did not greatly exceed the normal *ad lib* eating cycles. It is interesting to note that except for the 2-hr interval, there were few distress calls throughout the session, a finding that contrasts with the usual results of response-independent presentations of the stimulus or of extinction procedures (Hoffman *et al.* 1966).

EXPERIMENT IV: INITIATION OF EATING AFTER IMPRINTING ONLY

Although the initiation of eating by the imprinted stimulus is a powerful phenomenon, the above experiment does not specify the necessary conditions for its occurrence. If the stimulus releases feeding behavior, then early exposure (imprinting) alone might be a sufficient condition for its occurrence. Experiment IV was conducted to determine if a schedule of response-independent stimulus

presentations could control the feeding behavior of ducklings that are imprinted but that have not been trained to peck the pole.

Subjects

Six ducklings were hatched from eggs from the Wayne Duck Farm and Hatchery.

Procedure

All of the ducklings were imprinted individually on the first two days after hatch. During imprinting and during all subsequent procedures, the pole was removed. The ducklings, after having been imprinted, were left individually in the apparatus for approximately 8 hr between the third and fifth days with food and water continuously available. The stimulus was never present during this period. This phase was conducted to insure that the animal was accustomed to eating in the apparatus before testing was begun. The tests were run in the same fashion as in Exp. III with 5 min of stimulus presence for every 20 min of absence. The ducklings were tested between the sixth and tenth days after hatch

DUCKLING NO. B-II

Fig. 7. The effects on eating behavior of varying the interval between experimenter controlled stimulus presentations. From top to bottom the intervals are 25, 40, 60, 120, and 25 min respectively. All records are from a single duckling and were obtained in the order shown.

in two sessions for an average of 10 hr per session.

RESULTS

Figure 8 summarizes the results of Exp. IV. Inspection of the histogram in Fig. 9, constructed in the same fashion as in Exp. III, shows that the stimulus control over eating was not very strong. Although the chi-square was significant ($X^2 = 23.74$, $df = 4$, $p < 0.001$), there was nearly as much eating in the 5 min after stimulus presence as there was during stimulus presence. Inspection of the individual operation recorder records confirms the conclusions from the analysis of the group results.

No ducklings, except C4, demonstrated the kind of strong control over feeding behavior evidenced in Exp. III. Even C4 showed strong control for only a few hours. More typical is the top record (C2). Here there are many distress calls and there is relatively little eating during stimulus presence as compared with Exp. III. Very often these animals followed the stimulus instead of eating in its presence.

DISCUSSION

Although the group results show a significant trend toward feeding during stimulus presence and during the 5 min immediately afterward, the control exhibited was not as

Fig. 8. Control of feeding behavior by independent presentations of the stimulus in ducklings that had not had pole-pecking experience. The histogram summarizes the tendency (across six subjects) to eat in different portions of the cycle of stimulus presentations and withdrawals. See text for explanation.

impressive as for the animals in Exp. III. Even so, the behavior of C4, the duckling that did demonstrate strong stimulus control, implies that imprinting alone can be a sufficient condition for the stimulus to exert control over feeding. On the other hand, the behavior of the majority of the subjects studied implies that other conditions have to be met before strong control is consistently observed.

In seeking to identify these conditions, the factors that differentiated subjects in Exp. III and IV, were re-examined. Although there are many such factors (including differences in age at the time of testing), it seemed likely that the critical factor might be whether subjects had previously pecked the pole for the imprinted stimulus. For example, it seemed possible that the pairing of food and the imprinted stimulus, albeit by the duckling itself,

bestowed the stimulus with an enhanced capacity to initiate feeding behavior.

Another possibility was that the history of pecking for the stimulus (independently of its pairing with food) modified the duckling's reaction to it, and in this fashion enhanced its capacity to control feeding behavior. For example, when the subject had unlimited access to the stimulus (via a pole peck) it had, in one sense, control over its own environment. In general, imprinted ducklings give distress calls in the absence of the stimulus, but one of the salient characteristics of birds that have control over presentations of the stimulus is a lack of distress calls during relatively long periods of stimulus absence. It seemed possible that this kind of "individual control" might have generated an insulating effect, so that during later tests (when stimulus presentation was controlled by the experimenter) subjects

could better tolerate stimulus withdrawal. An effect of this sort could, in principle, account for the observed differences in distress vocalization in Exp. III and IV, and accordingly it might also account for the observed differences in the degree to which the stimulus influenced feeding behavior. However, an explanation of this sort is relatively unpalatable, largely because the dimensions of "individual control" are left undefined.

Accordingly, we cast about for an alternative explanation to account for the low incidence of distress calls in an effort to avoid the assumption that a history of "individual control" was the critical factor. One possibility was that when pole pecks yielded stimulus presentation, the subject was (through its own performance) exposed to a schedule of stimulus presentation and withdrawal through which it gradually developed a tolerance for stimulus removal. An earlier study (Hoffman and Stratton, 1968), indicated that a subject's tendency to emit distress calls is in part determined by the schedule of stimulus presentation and withdrawal. On this basis it seemed possible that the schedule of stimulus presentation generated by the subject's performance had gradually inured the subject to longer and longer periods of stimulus absence.

EXPERIMENT V: INITIATION OF EATING AFTER IMPRINTING AND TRAINING TO TOLERATE STIMULUS ABSENCE

Experiment V was designed to determine if the development of tolerance for the removal of the stimulus by some means other than a history of "individual control" would subsequently permit independent presentations of the stimulus to control feeding behavior. If previous "individual control" by the duckling is a necessary precondition for the stimulus to influence subsequent eating, and tolerance is merely a by-product of this control, then the duckling's feeding behavior should not be strongly affected by the stimulus even if tolerance is developed by some other means. On the other hand, if "individual control" over the stimulus presentations represents only one method of developing tolerance, assuming this is a crucial factor, then it should be possible to demonstrate strong stimulus effects on eat-

ing by an experimental history other than pole-peck training.

METHOD

Subjects

Six ducklings were hatched from eggs from the Wayne Duck Farm and Hatchery.

Procedure

The ducklings were placed individually in the apparatus approximately 20 hr after hatch, and the stimulus was presented in cycles of 5 min stimulus presence and 5 min stimulus absence for a 4-hr session. From the second to fifth day after hatch, the stimulus absence period was gradually increased to 20 min, while the stimulus presence remained at 5 min, as in the testing situation in Exp. III and IV, except that no food or water was available. On the sixth day, the animals spent a 12-hr session in which food and water were available, but the stimulus was not presented. On the seventh day after hatch, testing for stimulus control was begun. The testing situation was the first time that the stimulus was presented when food and water were available. The tests were run in two 10-hr sessions and consisted of 20 min stimulus absence for every 5 min of response-independent stimulus presentation. Stimulus presentation, distress calls, eating, and drinking were recorded.

RESULTS

Figure 9 includes a typical record from the operations recorder, and shows the histogram for both sessions for all animals. Clearly, stimulus control was well developed in these subjects ($X^2 = 126.97$, $df = 4$, $p < 0.001$). In addition, there were few distress calls during the testing sessions. For four of the six ducklings, the first stimulus presentation initiated eating while the remaining ducklings began eating on the second 5-min presentation in the first session.

DISCUSSION

Since sufficient conditions have been met here to reveal reliable stimulus control over feeding behavior, it would seem that a duckling's ability to tolerate removals of an imprinted stimulus is an important factor in allowing the stimulus to exert its control over

Fig. 9. Control of feeding behavior by independent presentations of the stimulus in ducklings that had not had pole-peck training but which have been exposed to various cycles of stimulus presentation and withdrawal before testing with food present. The histogram summarizes the tendency (across six subjects) to eat in different portions of the cycle of independent presentations and withdrawals. See text for explanation.

eating. Moreover, since for most subjects eating commenced with the first stimulus presentation, it can be concluded that, given appropriate conditions, an imprinted stimulus can act as a releaser for feeding behavior. At present, the available evidence suggests that the necessary conditions are that the duckling has had enough experience with the removal of the stimulus such that its withdrawal, during testing, does not induce an aversive state of affairs (as determined by the duckling's distress calls).

GENERAL DISCUSSION

The present sequence of experiments has revealed basic interactions between the duckling's feeding behavior and the control exerted by the imprinted stimulus. When the experimental situation is restricted to either responding for the stimulus or eating in the absence of the stimulus, both activities occur in cyclic fashion, although responding for the stimulus has less regularity than eating (Exp. I). When there is continuous access to both the stimulus (via pole-peck response) and food and water, responding and eating occur in

temporal proximity (Exp. II). Experiments III, IV, and V revealed that independent presentations of the stimulus could initiate eating in imprinted ducklings, but the most consistent control was exhibited by ducklings accustomed to periodic removals of the stimulus.

While interactions between the imprinted stimulus and eating are probably present throughout the various free-behavior situations, perhaps the strongest interactions are seen when the experimenter employs the stimulus to initiate eating. The phenomenon seems closely related to social facilitation of eating (*e.g.*, Ross and Ross, 1949). Typically, experimenters have induced additional eating in satiated animals by allowing other deprived animals of the same species to eat in the presence of the satiated one. In general, however, the various mechanisms hypothesized to account for the phenomenon do not seem applicable to the results of Exp. III, IV, and V.

Explanations that require the pairing of eating with the social stimulus, as in classical conditioning (*e.g.*, Harlow, 1933), are inadequate because food and the imprinted stimulus were never simultaneously present until

testing in Exp. IV and V. In addition, since control was usually exhibited immediately in the testing sequence, this control cannot be attributed to an association made during testing. Other hypotheses, such as imitation or local enhancement of cues, also seem of limited value in the present context. The possibility that presentation of the stimulus merely exerts a general arousing function that activates the duckling to move about the apparatus, and hence, brings the subject near the food, is not tenable. This explanation would not account for the fact that withdrawal of the stimulus terminated eating, nor could it account for the finding that drinking often occurred between eating bouts (e.g., Fig. 6) which means that the duckling was often near the food but did not necessarily eat.

While the present findings indicate that prior imprinting is a sufficient condition for the stimulus subsequently to exert control over eating, and while the above considerations make it clear that the effect is not due to either simple arousal effects or to associations formed in the subject's history, they do not in themselves indicate whether prior imprinting is also a necessary condition for the effect to occur. Previous investigations, however, found that ducklings that are not exposed to the imprinting stimulus within the first 48 hr from hatch exhibit flight behavior, accompanied by distress calls, when they are subsequently exposed to it (Hoffman, 1968). Moreover, for such ducklings, stimulus presentation is not reinforcing (Hoffman *et al.*, 1966). On this basis, it seems safe to conclude that a necessary precondition for a stimulus to control eating is that subjects have previously been imprinted to it.

Finally, it is noteworthy that, although experimenter controlled presentations of the

stimulus can induce eating, a more subtle form of interaction probably exists between the stimulus presentations and eating when the duckling has control over the stimulus. It was suggested in Exp. II that responding for the stimulus may in part be guided by the *ad lib* eating cycles. On the other hand, the exposures of the imprinted stimulus (produced by pole pecks) may also affect these cycles by initiating and/or sustaining eating.

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