THE EFFECTS OF MODIFYING CONSUMMATORY BEHAVIOR ON THE TOPOGRAPHY OF THE AUTOSHAPED PECKING RESPONSE IN PIGEONS

MARK PREMACK AND WILLIAM D. KLIPEC

DRAKE UNIVERSITY

The autoshaped responses of two debeaked pigeons that had developed modified eating behavior were compared to the autoshaped responses of three control subjects that ate grain normally. The control subjects exhibited keylight responding that was judged normal by two independent raters. The debeaked subjects pecked the key and ate grain with both normal and modified responses. The results of this study demonstrate that an autoshaping procedure using grain as an appetitive stimulus may be used to establish a response that is not biologically preorganized.

Key words: autoshaping, response topography, consummatory behavior, learned release theory, stimulus substitution, pigeons

Recent experiments have demonstrated an important relationship between the reinforcer and the form of the resulting conditioned response. For example, Jenkins and Moore (1973) found that when grain was used as a reinforcer, pigeons responded to the key with a grain-pecking movement. However, when water served as the reinforcer, the pigeons responded to the key with drinking-like movements. Thus, the topography of the autoshaped response directed towards each stimulus matched the consummatory response to the particular reinforcer. Similarly, Peterson, Ackil, Frommer, and Hearst (1972) compared the conditioned responses made by two groups of rats to a retractable lever paired with either food or electrical brain stimulation. Whereas the rats gnawed and licked the lever paired with food, exploratory behavior was directed towards the lever paired with brain stimulation. In many cases this latter behavior included components of the responses that occurred when brain stimulation itself was delivered.

In the autoshaping literature, two theories have been proposed to account for these effects. The earliest, discussed by Jenkins and Moore (1973), is that of stimulus substitution. In brief, the stimulus substitution position holds that the stimulus controlling the autoshaped response comes to serve as a surrogate for the reinforcer. Jenkins and Moore illustrated this effect clearly by demonstrating that the form of the autoshaped response depended on whether food or water was used as a reinforcer. The pigeons responded to the keylight as they did to the reinforcer itself.

Recently, however, an alternative proposal has been made. Williams' "learned release" theory (see Woodruff & Williams, 1976) states that biologically preorganized (species specific) appetitive behavior patterns (e.g., pecking at grain or bowing and rooting for water in pigeons) are released by stimuli which have preceded a reinforcer.

In their experiment, Woodruff and Williams (1976) introduced water directly into a pigeon's beak. Since approach and contact to the reinforcer were eliminated, responses to the water were limited to mumbling and swallowing. However, the autoshaped response was more extensive topographically, including approach, bowing, and rooting. Woodruff and Williams' theory takes into account Jenkins and Moore's (1973) results, as well as those in which the autoshaped response is more topographically extended than the response elicited by the reinforcer. For example, Wasserman (1973), using a heat-light reinforcer with

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young chicks, found that the autoshaped response of approach, pecking, and snuggling was exhibited towards the key, even though the heat elicited generally unenergetic and undirected postures and movements. Hogan (cited in Hearst & Jenkins, 1974) has noted that approach, pecking, and snuggling towards the hen are normal heat-seeking responses of young chicks. Thus, it appears that the key elicited a more topographically extensive form of the preorganized behavior pattern than did the heat itself.

The present experiment was designed to evaluate these two hypotheses. Pigeons' beaks were surgically altered, forcing the birds to develop idiosyncratic consummatory behavior (cf., Pomeroy, 1962). By comparing the forms of the autoshaped response of pigeons with normal beaks to those with modified beaks, the merits of the two hypotheses can be examined. If the autoshaped response is biologically pre-organized, as indicated by the learned release theory, the response should resemble the normal, unmodified consummatory response in form. However, if the stimulus substitution theory is correct, the autoshaped response should resemble the modified consummatory response which is directed towards the grain during conditioning.

METHOD

Subjects

Seven homing pigeons, three to six months old, without previous experimental histories, began the experiment. Two of these were subsequently excluded after surgery because they could not obtain food in the experimental chamber. The remaining five were individually housed and maintained at 70% of their free-feeding body weights by restriction of daily food rations during autoshaping. Food was limited to racer mix with cracked corn, placed in a 12.7 by 7.6 by 1.9-cm bird-food tray located 7.6 cm above the floor of the cage. Canadian field peas were eliminated from the mix since some of the pigeons with modified beaks were able to consume large seeds by normal pecking behavior. Water and grit were continuously available in the home cage.

Apparatus

The apparatus consisted of a specially constructed single-key pigeon chamber (35.6 by

35.6 by 30.5 cm), with a wire mesh floor (Figure 1). The response key was a translucent plastic disk (5.1 cm diameter), transilluminated with white light to provide the stimulus. The key extended into the chamber at a 20° angle below the horizontal, and was mounted on a box (12.7 by 7.6 by 5.1 cm) which was centered on the right half of the panel 5.1 cm above the floor of the chamber. A .3-cm ledge surrounded the top of the box. Mounting the key in this way allowed the pigeon to contact the key with a head orientation identical to that used when contacting grain.

The chamber was constantly illuminated by a diffuse white ceiling light. The wall next to the key side of the panel was clear Plexiglas to provide visual access for a Sony videotape camera and an observer. The remaining walls and ceiling were painted flat gray to minimize reflections from the lighted key. Contingencies were controlled by electromechanical devices, and key closures during keylight presentations were recorded on electromechanical counters. Masking noise was continuously present.

The reinforcer was 15-sec access to grain in a retractable, (12.7 by 7.6 by 1.9 cm) tray centered on the left half of the panel 7.6 cm above the floor of the chamber. A 15.2- by 0.6-cm steel rod was vertically held by two screws to the center of the back of the tray. The top and bottom of the rod were attached to the back of the panel with Plexiglas mounts. A ball

Fig. 1. Photographs of the pigeon chamber used in the experiment. The picture shows the chamber with the food tray rotated to the out position.

bearing in each mount allowed the rod to rotate freely. Below the bottom of the tray the rod passed through a 5.1-cm diameter gear, which meshed with a 1.3-cm diameter gear mounted on a 20-RPM Sessions Clock motor. The motor rotated the tray through a 17.8 by 8.3-cm opening in the panel. The top and sides of the opening were framed by 1.9 cm of 1.3-cm foam rubber, which was flush with the top and sides of the tray. The motor required 6 sec to rotate the tray to a fully extended position and 6 sec to return it to a fully withdrawn position. The rotating tray was stopped when it was fully extended or withdrawn by a microswitch located under the left side of the tray behind the panel. The extended tray allowed clear observation of the pigeon's eating response and permitted consumption of grain by the debeaked pigeons, which would have been limited by a traditional hopper. The foam rubber prevented injury which might occur if a pigeon's head became caught between the rotating tray and the panel.

Procedure

Three of the five pigeons (P-1, P-2, and P-5) were debeaked. This procedure involving removing the portion of the upper beak (premaxilla) rostral to the salt gland. Figure 2 shows the extent to which the premaxilla was modified. The two remaining pigeons (P-9 and

P-10) did not have their upper beak removed.

Debeaking procedure. In preparation for surgery, food and water were removed 24 hr prior to anesthesia. The pigeons were medicated with .25 mg atropine and anesthetized with 35 mg/kg intramuscular pentobarbital sodium with a supplemental intramuscular administration of 60 mg of chloral hydrate as needed to maintain anesthetic level. When they no longer responded to beak pressure, the portion of the upper beak (premaxilla) rostral to the salt gland was removed with surgical scissors. The remaining portion of the upper beak was immediately cauterized. The pigeons were given water as soon as they regained mobility and were given food 24 hr later. Initially, the food tray in the home cage was filled to maximum depth (1.9 cm) with grain, since the pigeons were no longer able to grasp food and did not yet have an alternative, effective, eating response. As each pigeon exhibited more efficient modified eating behavior (i.e., its body weight was maintained) the depth of the grain was gradually reduced until the pigeon was maintained at 70% of its free-feeding weight. Approximately one month after debeaking, two of the three pigeons (P-1 and P-2) exhibited clearly modified eating behavior in the home cage. Subject P-5 continued to obtain food normally until three months after debeaking, at which time clearly modified eating behavior began. Autoshaaping for all subjects did not begin until about four months after debeaking, by which time the modified eating response was well established.

Eating behavior in home cage. The normal subjects (P-9 and P-10) contacted the tray in the home cage while standing directly in front of the tray with both head and body perpendicular to the length of the tray. The beak tip followed a straight path down and away from the body, and grain was pinched between the upper and lower beak. This eating response was the only one observed to be exhibited by these two subjects.

In contrast to the eating pattern of the normal subjects, two of the debeaked subjects (P-2 and P-5) contacted the tray in the home cage while positioned with both feet clasped on the ledge of the tray with the body almost parallel to the length of the tray. The head was turned to the side as much as 90° from the pigeon's normal position and curled under the body. In this inverted position, the portion of

Fig. 2. A photograph of one of the debeaked subjects showing the extent to which the premaxilla was removed rostral to the salt gland.

the upper beak that remained scooped up the grain as the beak moved in a rotary motion. The extent of the modified eating behavior varied within and between subjects. In general, Subject P-2 exhibited the most extreme modification and did so in almost all of its responses. The probability of a modified response for Subject P-5 was also high, though its responses were not as extreme.

The eating behavior of Subject P-1 was also modified, but in a slightly different manner. Like the normal pigeons, it contacted the tray in the home cage while standing directly in front of the tray, with its body perpendicular to the length of the tray. However, the head was turned as much as 90° from the front, and the portion of the upper beak that remained scooped up the grain as the beak moved in a rotary motion. This modified response was exhibited in approximately three-quarters of the pigeon's eating responses.

The relative efficiency of a pigeon's eating response may be roughly measured by the amount of food which the pigeon must be given in order for it to maintain a set weight, since less efficient responses usually result in the spilling of seed. The relative efficiency of the eating responses exhibited by the debeaked pigeons was evaluated by comparing the amount of grain required to maintain 70% of free-feeding weight to the amount necessary for the normal subjects. The two normal subjects (P-9 and P-10) required 6g and 5g daily, respectively, whereas the debeaked pigeons (P-1, P-2, and P-5) needed 30g, 10g, and 15g daily, respectively. Thus, the debeaked subjects required from 2 to 6 times as much food as the normal pigeons in order to maintain their weights.

Categorizing of subjects. The five pigeons were categorized as follows: debeaked Subjects P-1 and P-2 obtained food in the chamber with modified eating behavior and so were referred to as the Debeaked/Modified (DM) subjects. Debeaked Subject P-5 obtained food in the chamber with normal eating behavior and was called the Debeaked/Normal (DN) subject. The two normal subjects, P-9 and P-10, obtained food in the chamber with normal eating behavior and were labeled the Normal/Normal (NN) subjects.

Autoshaping procedures. The NN subjects (P-9 and P-10) were first given 10 min to acclimate to the chamber. The acclimation

period was then followed by 40 trials of keylight alone on a variable time (VT) 1-min schedule with a keylight duration of 12 sec. Following the keylight-alone condition, the autoshaping procedure was implemented. Based on the rapid approach and contact of normal pilot subjects to the extended tray, no tray training was given. Trials were presented on a VT 1-min schedule and consisted of a 12-sec keylight presentation (CS) followed by the availability of grain for 15 sec (US). The 15-sec US interval consisted of a 5-sec period during which the subject was able to obtain grain as the tray was rotated to the fully extended position, a 6-sec period during which the tray was stationary, and a 4-sec period during which the tray was rotated to the fully withdrawn position. The CS remained on until the tray began to withdraw. Each session was terminated after 50 CS-US pairings. Following Jenkins and Moore's (1973) method, the autoshaping procedure continued until the subject contacted the key with its beak during 15 to 17 CS intervals. These intervals were required to be cumulative, not necessarily consecutive. Terminating the experiment after so few CS intervals containing key contacts reflected the authors' intent to examine the initial responses directed towards the key before possible adventitious contingencies became involved. Generally, the eating response during the first and last five presentations was videotaped, as was the key response during the 15 to 17 CS intervals.

The procedure followed for the debeaked subjects was similar to that followed for normal subjects with two exceptions. Since the consummatory response was more complex for the debeaked subjects, each pigeon was given tray training until it would reliably consume grain from the tray. This training was carried out prior to the keylight-alone trials. In addition, although the US presentation for the DN subject was identical to that used for the two NN subjects, the amount of time the tray remained stationary in the chamber was increased to 9 sec for the DM subjects. This extended period allowed for their lower response rate, thus holding the amount of time spent consuming grain roughly constant across all subjects.

Recording procedures. Videotapes of responses to the tray and the key were rated by the first author and a trained observer familiar

with both normal and modified pigeon eating behavior. The tape of each trial was replayed as often as requested and, modifying Jenkins and Moore's (1973) recording procedure, the two raters independently recorded frequencies of normal and modified responses during every interval. A response began with a downward movement of the beak while the head was over the tray or the key box, and ended with either a contact with the tray or the key or with an upward movement. No contact was required between the beak and the surface because it was difficult to tell from the videotape which responses were actually contacting a surface and which ones stopped short of the surface. A normal response was defined as a response in which the head was at an angle less than 45° from the front, and the beak tip followed a straight line downward. A modified response was defined as a response in which the head was at a 45° angle or greater and/or the beak tip followed any part of a clockwise circular path moving downward as viewed from the right side. This description is typical of the modified eating response. Figure 3 illustrates the form of the normal and modified key response.

Data analysis. The response frequencies during the CS and US were recorded in one of three categories: (a) The number of responses recorded as normal by both raters in an interval was designated "normal"; (b) the number of responses recorded as modified by both rat-

ers in an interval was designated "modified"; and (c) the number of responses in each interval on which the raters disagreed (i.e., the number of responses judged normal by one rater and modified by the other) were designated "indeterminate."

RESULTS

Acclimation and Keylight-Alone Behavior

None of the subjects contacted the key during the 10-min acclimation period, and only Subject P-9 contacted the key with its beak in the keylight-alone condition. This contact occurred during the seventh keylight presentation and did not recur for the remainder of the condition. Contact between the foot and the key occurred frequently for Subjects P-2, P-9, and P-10 during the keylight-alone condition, but tended to occur whether or not the keylight was present. It occurred when the subject occasionally perched or jumped onto the key box.

Consummatory Behavior in the Chamber

Although consummatory behavior during US presentations was recorded during the first and last five trials, the body position of most subjects often blocked a clear view of their heads. For Subject P-9, one of the last five trials was unscorable. For Subject P-10 the first five trials were not scorable; consequently consummatory behavior was recorded for the last 10 trials. Rating consummatory behavior for the DM subjects during all but the first three and the first five trials was impossible for Subjects P-1 and P-2, respectively.

Figure 4 shows the cumulative consummatory responses, per trial, which were classified as normal, modified, or indeterminate, for each subject. In the intervals rated, the two NN subjects, P-9 and P-10, exhibited only normal responses (325 and 281, respectively). The DN subject made 314 normal responses and one modified response. Both DM subjects, P-1 and P-2, exhibited both modified, normal, and indeterminate responses. The normal responses that occurred were generally confined to the period during which the tray was rotating into the chamber. Subject P-1 made 9 normal, 41 modified, and 5 indeterminate responses during the three US intervals that could be scored. Subject P-2 exhibited 16 normal, 30 modified, and 32 indeterminate responses during the first five trials. The modified responses ex-

Fig. 3. A drawing representing the topography of the normal and modified key response in front and side view. The arrows trace the path that the tip of the beak followed.

Fig. 4. Cumulative number of consummatory responses across trials which were rated normal (unfilled triangles), modified (unfilled circles), or indeterminate (filled circles) for each subject.

hibited by Subject P-2 were typically less extreme than those which occurred in the home cage. For example, whereas Subject P-2 usually perched on the tray while eating in the home cage, it perched on the tray during only one interval in the chamber. However, the modified responses of both DM subjects consistently included a circular movement of the beak while the head was at a 45° angle or more from the front. It is important to note from Figure 4 that while Subjects P-5, P-9, and P-10 exhibited virtually only normal responses, Subjects P-1 and P-2 showed both modified and normals.

The relative efficiency of the subjects' eating responses was described above as the amount of food required daily in the home cage. In the chamber, it may be roughly measured by comparing the amount of weight gained by each pigeon during a typical session. The NN subjects gained between approximately 30 and 60g, while Subject P-5 (DN) gained between 10 and 30g. Subjects P-1 and P-2 (DM) only gained between 0 and 10g during a session.

Key Contact Behavior during Autoshaping

Figure 5 shows the cumulative normal, modified, and indeterminate key responses across trials for each subject. All pigeons contacted the key with their beaks while the keylight was on, and there were no consistent differences

in the number of trials to the first contact, or in the total number of trials until the criterion for terminating the autoshaping procedure (contacting the key during 15 to 17 CS intervals) was met. The first trial with a response and total trials for Subjects P-1 and P-2 (DM) were 4 and 172, and 86 and 149, respectively. For Subject P-5 (DN) they were 255 and 272. For Subjects P-9 and P-10 (NN) they were 255 and 272. For Subjects P-9 and P-10 (NN) they were trials 3 and 66, and 228 and 251, respectively.

Both observers agreed that the NN subjects exhibited normal responding almost exclusively. Subjects P-9 and P-10 made 109 and 125 normal responses, respectively. During one interval, a single response made by Subject P-10 was indeterminate. The DN subject made 87 normal responses, whereas four responses were indeterminate.

The responses of the two DM subjects fell into all three categories. About half of the intervals scored included both normal and

Fig. 5. Cumulative number of key responses across trials which were rated normal (unfilled triangles), modified (unfilled circles), or indeterminate (filled circles) for each subject.

modified responses. One interval for each subject contained exclusively modified responses, whereas a similar number of intervals included only normal responses. Subject P-1 made 85 normal responses, 27 modified responses, and 19 indeterminate responses. The corresponding totals for Subject P-2 were 16, 18, and 15. The modified responses directed to the key were much less extreme than those directed to the tray, consisting almost exclusively of a rotary movement of the beak in its downward path.

The response rates for each of the five subjects were relatively stable over the last five trials. During the last ten trials, the rate of agreed normal responses for Subject P-1 (DM) increased sharply relative to the rates of the other types of responses. Such an increase did not occur in the case of Subject P-2 (DM).

DISCUSSION

The results demonstrated that a pigeon's normal eating response can be modified by de-beaking, and that a less extreme form of this modified response is directed to a keylight which is paired with grain availability. Though the relative frequencies of normal, modified, and indeterminate responses were not identical between tray and key intervals for the DM subjects, the high occurrence of responses in the latter two categories directed towards both grain and the CS represents a considerable difference between the responses observed in these pigeons, and those exhibited by the DN and NN subjects. Such results are not predictable, nor can they be solely explained, by a theory of either biological preorganization (Woodruff & Williams, 1976) or of stimulus substitution (Jenkins & Moore, 1973). The former theory predicts that the DM subjects should contact the key with only normal responses, even though the modified responses are directed to the food, since a normal response is the biologically preorganized one. The subjects' 3- to 6-month histories of normal responding demonstrate that this biological preorganization existed, and it could not have been affected by debeaking. Despite this history, both DM subjects exhibited keylight responses which were not rated as normal. Contrary to predictions of the stimulus substitution theory, however, these pigeons did not respond to the keylight as they

did to the grain, in that neither subject ever exhibited a keylight response which was topographically as extreme as the modified eating behavior in the chamber.

The normal responding of the NN subjects shows that the type of tray and key used had no effect on the form of the response typically observed in pigeons. The keylight responses exhibited by the DN subject indicate that modified responses directed to the CS were controlled by the response to grain paired with the CS, rather than simply having been de-beaked or having contacted grain with modified behavior in another environment (i.e., the home cage). In addition, the increase in the frequency of normal responses during the later CS intervals of Subject P-1, and the normal responses rated for the DN subject, suggest that the frequency of modified responses in de-beaked subjects was not produced by any aversive consequences of pecking with a modified beak.

The DM subjects made fewer responses per interval than did the NN or DN subjects, primarily because it took a longer period of time to make a modified response. During modified responses the pigeon's beak traveled a greater distance than in a peck. There was a systematic difference in the number of responses which were indeterminate. This rating occurred almost exclusively with the DM subjects. Two factors may explain this difference. First, the DM subjects contacted the tray and the key with a wide variety of body orientations, which occasionally made it difficult for the observers to rate responses accurately. Secondly, the majority of indeterminate ratings reflected responses which, though different from normal pecks, did not unequivocally meet the stringent definition of a modified response. This problem might be overcome in future experiments by employing film rather than videotape. Since a film record is more amenable to slow motion, stop action, and frame-by-frame analysis, it would facilitate a more molecular analysis of individual responses instead of gross categorical frequencies and allow more precise measurement of beak movement. In addition, filming from two camera angles would be advisable to minimize instances when the response is not visible because of the bird's body orientation.

The key employed in this study permitted comparison between the manner in which the

head was oriented to the key and the manner in which it was oriented to the tray. The food-delivery device allowed the opportunity for modified eating responses to occur and for most eating behavior to be clearly observed. However, there were problems with the key and tray design. The subjects often perched or jumped on the key box, and the resulting foot to key contacts had to be isolated from beak to key contacts. The rotation of the tray may have limited the extreme nature of Subject P-2's eating response, since standing on the tray had the consequence of rotating the bird into the panel as the tray withdrew from the chamber. In addition, though 15-sec access to grain was provided to all subjects, there were marked differences in the amount of grain actually consumed (as measured in weight gained per session) by the subjects. Nevertheless, there were no consistent differences between NN, DN, or DM subjects in the rate of acquisition, as measured in the number of trials to the first beak-key contact, or the rate of conditioning, as measured in the number of trials from the first beak-key contact.

The occurrence of normal key responses in the DM subjects is not inconsistent with a stimulus substitution theory of autoshaping since normal as well as modified responses were directed toward the grain. However, the finding that most of Subject P-1's responses were normal during the last 10 trials argues against a stimulus substitution interpretation of these data. Learned-release theory fails to predict the occurrence of modified responses in both DM subjects. Moreover, although learned-release theory would predict the disproportionately high rate of normal responding occurring in Subject P-1, it fails to explain why normal responses were not released on the early trials.

Although the present data do not unequivocally support either stimulus substitution or

learned-release theory, the data do show clearly that the generality of autoshaping transcends the constraint of learned-release theory which restricts autoshaping to that class of responses which are biologically preorganized. This finding greatly increases the theoretical and applied significance of the autoshaping phenomenon. Further experimentation in this area is necessary before all the variables which control the form of the autoshaped response can be determined. These variables must account for the results of the present study as well as those of Woodruff and Williams (1976) and Wasserman (1973). Debeaking may be a particularly useful procedure in such experiments since it results in a learned eating response which may be directly compared to the biologically preorganized eating behavior of normal subjects.

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