FAILURE TO OBTAIN POSITIVE CONTRAST WHEN PIGEONS PRESS A BAR¹

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In Experiment 1, two groups of pigeons were exposed to multiple variable-interval 1-min variable-interval 1-min schedules of reinforcement. The required response was a key peck for one group, and a foot press of a bar for the other. When the procedure was shifted to multiple variable-interval 1-min extinction, positive contrast occurred with pigeons that key pecked, whereas negative induction occurred with those that bar pressed. Moreover, the absence of contrast could not be ascribed to the lack of inhibition, since negative generalization gradients after bar press training were U-shaped in Experiment 2. The results are discussed in terms of possible relationships between positive contrast and the phenomenon of autoshaping.

Perhaps the most intensively studied interaction in multiple schedules is positive contrast, in which a change in the conditions in one component produces an increase in responding in the other (Reynolds, 1961a, b). Investigations have centered largely around the critical antecedent of the effect, in particular, whether this is a reduction in the rate of reinforcement (Reynolds, 1961a, b) or a reduction in the rate of responding (Terrace, 1966). There has, however, been little attempt in any other direction to specify the boundary conditions of the effect. For instance, almost all investigations have employed the pigeon as the subject and the key peck as the response. Exceptions are studied by Bernheim and Williams (1967) and by Pear and Wilkie (1971) both of which employed rats, the former in a running wheel, the latter in a bar-pressing situation. In both studies, positive contrast occurred in some subjects but not in others. The present experiments provide further compara-

tive data on the occurrence of positive contrast. However, instead of employing a species other than the pigeon, a response other than key pecking was used. Experiment 1 examined the occurrence of positive contrast under two conditions of responding: in the bar-press group, a foot press of a bar was the required response; in the key-peck group, a peck on an illuminated key was the required response. There were two reasons for choosing bar pressing as a response. First, it is apparently dissimilar to key pecking, and, second, it is readily instrumented.

EXPERIMENT I

METHOD

Subjects

Ten adult, male, hybrid pigeons, without prior experimental histories, were maintained at 80% of their free-feeding weights.

Apparatus

A pigeon chamber (30 by 30 by 30 cm) was used. A rat lever (8 by 4 by 0.5 cm) was attached to the stimulus panel 7 cm from the floor and 3 cm from the side wall. The lever projected into the box for 4 cm and at a slightly downward angle. The force required to operate the lever was 0.12N. On the other side of the grain hopper from the bar was a loudspeaker. A heavy duty relay mounted behind the stimulus panel provided auditory feedback for responses on the bar. A response

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key of translucent plastic, 2 cm in diameter and 20 cm above the floor, was mounted on one wall of the chamber above a grain hopper. A heavy duty relay located centrally behind the stimulus panel provided auditory feedback for responses to the key. The visual stimulus was provided by a miniature light bulb (2.5 W Vitality type x599CS) located in a housing behind the key. A thick wire mesh grid, supported by bolts (4 cm in length), covered the floor.

Stimuli

Auditory stimuli were either a tone of 1000 Hz (Advanced Electronic Signal Generator Type J2C) or a broad band white noise (Be-

havior Apparatus Type G067) both of which were maintained at 80 dB sound pressure level. Measurements were taken daily against an ambient sound pressure level of 55 to 60 dB. A houselight was mounted centrally in the roof of the chamber.

Reinforcement Scheduling

Reinforcement was 5-sec access to a tray of mixed grains. Presentation of the tray was accompanied by illumination of the magazine. During reinforcements, responses were ineffective and were not recorded, and the component time count was stopped. Reinforcements became available on the average of once every 60 sec according to a variable-interval 1-min

Fig. 1. Performance in noise (S₁) components and tone (S₂) components over the last seven sessions of Stage 1, the 21 sessions of Stage 2, and the seven sessions of Stage 3 for Bird 1705, a bar-pressing subject in Experiment I. The lower portions show responses per minute; the middle portions the time (seconds) per press; the upper portions the corrected response rate, which is the number of responses divided by the component time minus the time during which the bar was depressed.

(VI 1-min) schedule. The values of the 16 intervals used were derived from Fleshler and Hoffman (1962).

Training Procedure

Components of 30-sec duration were separated by 10-sec blackouts during which the component stimuli (houselight, auditory stimuli, and, in the key-peck group, keylight) were off and responses were ineffective. A reinforcement that was scheduled but remained uncollected by the end of a component was cancelled by the blackout. Two components alternated in an irregular sequence: in the bar press group, S_1 (noise) and S_2 (tone); in the key-peck group, the noise and tone were accompanied by the lighted key. There were no constraints on the sequencing. In practice, the longest run of either component was 10. Three such sequences alternated irregularly from day to day. There were at least six sessions per week.

Subjects were trained either to peck the key or to press the bar. The general strategy in establishing the latter response was to train the pigeon to stand near the bar and then to reinforce movements of the head directed towards the roof of the chamber. This served two purposes: first of all, it kept directed movements of the head away from the bar and, secondly, since the animals were stretching forwards and upwards, the bar would be stood upon and food obtained. Pigeons that were observed pecking the bar at any time in the experiment were rejected. Out of 40 pigeons trained to bar press, at least five have drifted into bar pecking.

The experiment involved three stages in subjects trained to bar press, and two in subjects that key pecked. In Stage 1, which lasted for 21 sessions, the schedule was *mult* VI 1-min for both groups of pigeons. In Stage 2, the schedule was shifted to *mult* VI 1-min EXT in which responding, either bar pressing or key pecking, continued to be reinforced in

Fig. 2. Performance in noise (S_1) components and tone (S_2) components over the last seven sessions of Stage 1, the 21 sessions of Stage 2, and the seven sessions of Stage 3 for Bird 1717, a bar-pressing subject in Experiment I. The lower portions show responses per minute; the middle portions the time (seconds) per press; the upper portions the corrected response rate, which is the number of responses divided by the component time minus the time during which the bar was depressed.

Fig. 3. Performance in noise (S_1) components and tone (S_2) components over the last seven sessions of Stage 1, the 21 sessions of Stage 2, and the seven sessions of Stage 3 for Bird 1718, a bar-pressing subject in Experiment I. The lower portions show responses per minute; the middle portions the time (seconds) per press; the upper portions the correct response rate, which is the number of responses divided by the component time minus the time during which the bar was depressed.

noise components while extinction (EXT) was correlated with tone components. For pigeons that bar pressed, this lasted for 21 sessions, and for those that key pecked, 14. In Stage 3, with bar pressing, the schedule was shifted back to *mult* VI 1-min VI 1-min for seven sessions.

RESULTS

Bar-Press Response

Performance in noise and tone components over the last seven sessions of Stage 1, and all of Stages 2 and 3 is shown in Figures 1 to 5 for each subject trained to bar press.

Response rates during the stimulus correlated with VI in Stage 2 did not increase (lower portion of each figure). In none of the subjects was the highest rate in the stimulus correlated with VI reached during Stage 2 higher than the highest rate in this stimulus during Stage 1. In the case of Birds 1717 and 1722 this outcome is, perhaps, not surprising since these subjects showed little sign of the differential reinforcement contingencies. The increase in response rate in both stimuli in Stage 3 demonstrates that baseline rates are recoverable.

Fig. 4. Performance in noise (S_1) components and tone (S_2) components over the last seven sessions of Stage 1, the 21 sessions of Stage 2, and the seven sessions of Stage 3 for Bird 1721, a bar-pressing subject in Experiment I. The lower portions show responses per minute; the middle portions the time (seconds) per press; the upper portions the corrected response rate, which is the number of responses divided by the component time minus the time during which the bar was depressed.

During Stage 2, the time per press in the stimulus correlated with VI increased in every subject (middle portion of each figure). However, with the exception of Bird 1717, this was not accompanied by a decrease in the time per press in the stimulus correlated with extinction. Rather, there was also an increase in the time per press in this stimulus in each subject which was sustained throughout Stage 2. In the case of Bird 1717, this increase in the stimulus correlated with extinction was transient, extending over the first seven sessions of Stage 2. In two other pigeons, Birds 1721 and 1722, the increases in the stimulus correlated with VI were greater than the increases in the stimulus correlated with extinction. Notice, therefore, that the performances of Birds 1717 and

1722 were responsive to the differential reinforcement contingencies.

Since the time per press increased in the stimulus correlated with VI during Stage 2, it is possible that within the time still available for pressing, response rates increased. Therefore, rates were computed with the time values that were corrected for the durations that the bar was depressed. In all subjects, however, these corrected rates in the stimulus correlated with VI decreased during Stage 2 (top portion of each figure).

Key-Pecking Response

Performances in noise and tone components over the last seven sessions of Stage 1 and the 14 sessions of Stage 2 are shown in Figure 6

Fig. 5. Performance in noise (S_1) components and tone (S_2) components over the last seven sessions of Stage 1, the 21 sessions of Stage 2, and the seven sessions of Stage 3 for Bird 1722, a bar-pressing subject in Experiment I. The lower portions show responses per minute; the middle portions the time (seconds) per press; the upper portions the corrected response rate, which is the number of responses divided by the component time minus the time during which the bar was depressed.

for each subject trained to key peck. Recall that the schedule was *mult* VI 1-min VI 1-min in Stage 1 and *mult* VI 1-min EXT in Stage 2.

In all subjects during Stage 2, responding increased in the noise stimulus correlated with VI concomitantly with a decrease in responding in the tone stimulus correlated with extinction.

EXPERIMENT II

The main outcome of Experiment I was that responding in the VI component during *mult* VI EXT differed depending on whether the response was a key peck or a bar press. Positive contrast occurred with key pecking but not with bar pressing. However, in view of

the lack of stimulus control over response rate in some of the subjects that bar pressed, *e.g.*, Birds 1717 and 1722, the absence of positive contrast was, perhaps, not surprising. More specifically, the failure of positive contrast to occur could have been due to the failure of the stimulus correlated with extinction to acquire "inhibitory" properties. It has been proposed that as a condition for positive contrast to occur, responses must be inhibited in one of the components of the multiple schedule (*e.g.*, Halliday and Boakes, 1972) or that the stimulus correlated with reinforcement must alternate with an inhibitory stimulus (Terrace, 1972). Evidence for these proposals derives from studies showing that positive contrast does not occur in a multiple schedule

Fig. 6. Responses per minute of each subject that key pecked in Experiment I in noise (S_1) components and tone (S_2) components over the last seven sessions of Stage 1 and the 14 sessions of Stage 2.

in which responding is reduced in one of the components by a variable-time schedule (Halliday and Boakes, 1971) nor in an errorless discrimination procedure (Terrace, 1966).

Experiment II examined the possibility that the absence of positive contrast was due to a lack of "inhibitory" control by providing a

negative generalization test after bar press discrimination training.

METHOD

Subjects

Five, adult, male hybrid pigeons without prior experimental histories, served.

Apparatus and Training Procedure

The apparatus and training procedure were as described in Experiment I, and all pigeons were trained to bar press.

The experiment involved three stages. In Stage 1, which lasted for 21 sessions, the schedule was *mult* VI 1-min VI 1-min. In Stage 2, the schedule was shifted to *mult* VI 1-min EXT in which bar pressing continued to be reinforced in S_1 (noise) while extinction was correlated with S_2 (1000-Hz tone). In Stage 3, a generalization test was administered.

Test Procedure

The test consisted of the presentation of 10 different auditory stimuli: tones of 50, 250, 500, 750, 1000, 1250, 1500, 1750, 2000 Hz, and the noise, each maintained at approximately 80 dB sound pressure level. The test session consisted of 140 components. There were 14 blocks, each of which contained the 10 stimuli. The order of stimuli within each of the blocks was irregular. Reinforcements were arranged according to the VI 1-min schedule, and were non-differential with respect to all test stimuli.

The Use of Reinforcement During Test

A recurrent problem with negative generalization tests has been the small amount of

responding that occurs. Besley and Hearst (reported in Hearst, Besley, and Farthing, 1970) argued that (a) scheduling reinforcement non-differentially should result in a substantial amount of responding at all values and (b) if a stimulus is an inhibitor, then responding should take longer to develop in its presence. They presented some data to substantiate their arguments. In view of this precedent and also of pilot studies using extinction in which little or no responding occurred, the "Resistance-to-Reinforcement" technique was used here.

RESULTS

Presses per minute over the last seven days of Stage 1 and the 14 days of Stage 2, along with the number of presses emitted in each of the test stimuli, are shown for each subject in Figures 7 to 11. Time spent pressing was not recorded because this experiment was conducted before Experiment 1.

Discrimination Performance

By the end of Stage 2, response rates during the stimulus correlated with VI for each subject were higher than during the stimulus correlated with extinction. The decrease in rate in the stimulus correlated with VI replicates the decrease observed in Experiment I.

Fig. 7. Responses per minute in Experiment II for Bird 1664 over the last seven sessions of Stage 1 and the 14 sessions of Stage 2 along with the number of responses emitted to the test stimuli.

Fig. 8. Responses per minute in Experiment II for Bird 1667 over the last seven sessions of Stage 1 and the 14 sessions of Stage 2 along with the number of responses emitted to the test stimuli.

Test Performance

There was considerable between-subject variability in the amount of responding, from

Bird 1664, which emitted approximately 900 responses, to Bird 1674, which did not respond at all on the test. There was also a considerable variability in the shape of the generalization

Fig. 9. Responses per minute in Experiment II for Bird 1668 over the last seven sessions of Stage 1 and the 14 sessions of Stage 2 along with the number of responses emitted to the test stimuli.

Fig. 10. Responses per minute in Experiment II for Bird 1674 over the last seven sessions of Stage 1 and the 14 sessions of Stage 2 along with the number of responses emitted to the test stimuli.

function. Birds 1664, 1667, and, to a lesser extent, Bird 1676 produced a U-shaped function with the minimum at or near the stimulus that had been correlated with extinction. The function for Bird 1668 had a shallow, rather irregular shape. Bird 1674, which had not responded on the first day, was administered a second test on the following day, and a shallow but U-shaped gradient appeared with a mini-

mum in the region of the stimulus that had been correlated with extinction.

DISCUSSION

This experiment demonstrates two major points. First, auditory stimulus control of bar pressing can be established in pigeons, with substantial reductions in responding in the

Fig. 11. Responses per minute in Experiment II for Bird 1676 over the last seven sessions of Stage 1 and the 14 sessions of Stage 2 along with the number of responses emitted to the test stimuli.

stimulus correlated with extinction. Second, the occurrence of U-shaped gradients indicates that the reduction of bar pressing in the extinction stimulus during *mult VI EXT* was accompanied by that stimulus' acquisition of inhibitory properties. This means that the absence of positive contrast cannot be ascribed in any simple way to an absence of inhibition.

However, an inhibitory view of positive contrast of the sort proposed by Halliday and Boakes (1972) or Terrace (1972) could be modified to encompass the present results by supposing that inhibitory after-effects are not necessarily specific to the response being suppressed but, rather, affect the response that has the highest probability of emission in the situation. Typically, of course, these responses are the same. However, pecking behaviors have such a high probability of occurrence in a situation where food is available (*cf.* Staddon and Simmelhag, 1971) that those behaviors, instead of bar pressing, could have received the impact of the inhibitory after effects.

Implicit in such a view, however, is the notion that the failure to observe positive contrast is a peculiarity of bar pressing. An alternative approach to the present data would be that positive contrast is peculiar to key pecking. A certain amount of evidence suggests a special status to the pecking behaviors of hungry pigeons in a situation where food is available (*e.g.*, Brown and Jenkins, 1968; Williams and Williams, 1969; Staddon and Simmelhag, 1971). Gamzu and Schwartz (1973) have outlined an account of positive contrast that refers to this status. They propose that a transition from *mult VI VI* to *mult VI EXT* involves the introduction of a stimulus-reinforcer contingency. The effect of this contingency is to channel onto the key the "reflexive" pecks which, during baseline, have been occurring off the key. The effect of this change is to enhance the output of key closures. They further speculate that stimulus-reinforcer contingencies might appear and, thereby, positive contrast, whenever the stimuli are associated with different conditions of reinforcement, for example, *mult VI DRL* (Terrace, 1968) or *mult VI VI + shock* (Brethower and Reynolds, 1962).

Although this account encompasses the present results, there are at least two objections to it. The first is the implicit assumption that reflexive pecks are occurring off the key during

mult VI VI where the contingent response is key pecking. There are at least two reasons why this should not be so. First, multiple schedules that separate the components with blackouts provide the basis for the development of stimulus-reinforcer contingencies even during *mult VI VI*. Second, the correlation between an operant response on the key and reinforcement permits a stimulus-reinforcer correlation to emerge that comprises the components of the peck, the auditory consequences of the peck and the key.

The second objection to their account is that it assumes that a sufficient condition for the occurrence of positive contrast is that the components signal different conditions of reinforcement. This implies that positive contrast would occur when a transition is made from *mult VI VI* to *mult VI VT* (variable-time schedule) when, in fact, it does not (Halliday and Boakes, 1971).

This finding and the present results suggest an alternative account of positive contrast. It requires that two conditions be met for positive contrast to appear. The first is, like Gamzu and Schwartz's view, that the "reflexive" behaviors occurring in the situation resemble topographically the operant response required by the contingencies, for example, key closures. Although the term "reflexive" is vague, it can be made less so by defining it as a set of responses that have a high probability of occurrence even when the operant contingencies require that they do not occur, for example, pecking in a negative automaintenance schedule (Williams and Williams, 1969). The second condition is that these reflexive behaviors be inhibited in one of the components of the multiple schedule. Further, these behaviors need not be occurring on the key. The effect of their inhibition is the augmentation of the reflexive behaviors already occurring on the key in the reinforced component.

This view accommodates the effect of the transition from *mult VI VI* to *mult VI VT* since, it is assumed, response-independent food presentation does not involve the inhibition of reflexive pecks. It predicts positive contrast in a transition from *mult VI VT* to *mult VI EXT* even where no responses have occurred on the key in either the VT component or the EXT component. This condition might be obtained by alternating a lit key (VI component) and a dark key (VT changing to EXT component).

Also, of course, this view permits the absence of positive contrast on bar pressing since, it is assumed, the response of bar pressing does not comprise both operant and criterially similar "reflexive" components.

A final implication of the present view concerns variable-time schedules and is worth mentioning because it emphasizes the separation of positive contrast and the inhibition of operant responding. The present view asserts that contrast does not occur in a *mult* VI VT schedule because a VT schedule does not involve the inhibition of "reflexive" behaviors. However, the reduction in operant responding that occurs in the VT component of such a schedule could be accompanied by the development of an inhibitory process. This means that it would be possible to "disinhibit" such responding (*cf.* Brimer, 1972) and also to obtain U-shaped gradients after such training without, of course, the prior occurrence of contrast.

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