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The effect of redundant contextual stimuli on autoshaping the pigeon's keypeck*

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Three experiments investigated the effect of contextual and trial stimulus lighting conditions on keypeck autoshaping in pigeons. White illumination of a response key before food presentation readily produced keypecking in a brightly lit chamber but failed to do so in a chamber without house illumination (Experiments I and III). Keypecking in a darkened cubicle progressively increased and the facilitatory effect of a houselight decreased as the keylight stimulus was varied from a color change (Experiment II) to a feature change (Experiment III). These findings support a "cue localization" hypothesis of autoshaping, according to which reinforcement signals select specific behaviors for expression and direct these behaviors toward the source of stimulation. This account was extended to superstitious and operant conditioning situations.

A particular form of behavior may develop and persist, even though reinforcers occur independently of that behavior. Skinner's 1948 paper on "superstition" in the pigeon probably provides the best known example of this phenomenon. When food was delivered every 15 sec, six out of eight hungry pigeons came to perform highly consistent, but idiosyncratic, sequences of behavior that had not previously occurred with high frequency. Skinner held that these results were due to the automatic strengthening of skeletal behaviors when they were followed by reinforcers.

Although most discussions of Skinner's study stress this operant conditioning interpretation (see Herrnstein, 1966; Sidman, 1960), Skinner also alluded to the additional possibility that the specificity of the acquired behavior might be determined by some physical detail in the environment. The behavioral sequences that Skinner observed did not occur in vacuo but were oriented and directed toward environmental features and objects. "The effect of the reinforcement was to condition the bird to respond to some aspect of the environment rather than merely to execute a series of movements [p. 169]." The possibility that directed skeletal behaviors may be educed by environmental stimuli that immediately precede reinforcement was not seriously considered by Skinner. However, the recent discovery of the autoshaping phenomenon raises the interesting possibility that the acquisition of behavioral "superstitions" may be due to Pavlovian rather than operant processes.

Brown and Jenkins (1968) pursued Skinner's analysis of superstitious behavior but focused on the problem of stimulus control. Like Skinner, these investigators presented food independently of the behavior of hungry pigeons. However, Brown and Jenkins made food conditional not upon a regular interval of time but upon the immediately prior presentation of a brief visual stimulus. This procedural modification eliminated the behavioral diversity so characteristic of Skinner's Ss. Virtually every pigeon approached and pecked a small key that was illuminated just before food delivery. The authors termed this phenomenon "autoshaping" to emphasize the progressive nature of the behavioral modification—from excited activity during the stimulus to movements oriented toward the area of the lighted key and, finally, to pecking movements directed at the keylight.

Brown and Jenkins noted that the signaling of a reinforcing event by an environmental stimulus followed the paradigm of delayed Pavlovian conditioning. Indeed, the autoshaping phenomenon may be treated as an instance of stimulus substitution (see Breland & Breland, 1966; Moore, 1971; Staddon & Simmelhag, 1971): After several keylight-food pairings, the pigeon tends to peck at the lighted key as though it were grain. However, Brown and Jenkins felt that this account was deficient in two respects. First, pecking was not the first behavior to be conditioned to the keylight. Rather, pecking developed from and depended on other motor patterns (e.g., active exploration and investigation) that bore no obvious relation to pecking at grain.[1] Second, although they did not study in detail the stimulus control of autoshaping, Brown and Jenkins suspected that the nature of the behavior conditioned was heavily dependent upon the type of signaling stimulus employed—in their case, pecking of a small, visual stimulus.

Several authors (Gardner, 1969; Staddon & Simmelhag, 1971; Williams & Williams, 1969) have noted, in addition, that the directedness of the

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autoshaped keypeck does not resemble Pavlovian conditioning phenomena of which conditioned salivation is the prototype. The pigeon's peck is directed out at the environment, whereas the dog's salivation is not (however, see Pavlov, 1934).

Two tentative conclusions concerning the stimulus control of behaviors unnecessary for reinforcer reception can be made, based upon the studies of Skinner (1948) and Brown and Jenkins (1968). First, the behaviors exhibited may be selectively related to the signaling stimulus. This conclusion follows from Brown and Jenkins's speculation concerning the environmental stimuli necessary to produce a keypeck response. If correct, this speculation might account for the marked idiosyncracy of the behaviors that Skinner observed, since "cue" selection would be individualistic in his situation. Second, the controlling environmental features may do more than "set the occasion" for behavior to be reinforced (Skinner, 1938). Such stimuli might actively orient and direct behaviors toward aspects of the experimental environment.

The present set of experiments evaluated these plausible but, thus far, little studied possibilities. What stimulus factors affect the selective and directive roles of environmental stimuli? To this end, the effect of various keylight stimulus changes (illumination, color change, feature appearance and disappearance) on the autoshaped keypecking of pigeons was studied in the context of a brightly illuminated or a continuously darkened environment.

EXPERIMENT I

This initial experiment attempted to replicate the basic findings of Brown and Jenkins, with several modifications in procedure. First, pigeons were trained for several weeks on a procedure in which keypecks in no way affected cue or reinforcement contingencies. Brown and Jenkins reported that 7 out of 12 birds trained on a fixed-trial procedure in which keypecks did not darken the keylight and deliver food (although intertrial responses did delay the presentation of the next trial) either failed to peck or evidenced very low pecking rates. Some Ss started pecking and then stopped. One pigeon began to keypeck but the location of its pecks soon moved off the key.

Second, because superstitious behavior has been said to be primarily controlled by its conjunction with the presentation of reinforcement (Skinner, 1948), the temporal distribution of pecking during the trial stimulus was recorded. According to the principles of operant conditioning, pecking should increase as the time of food delivery approaches.

Finally, in Experiment I, Ss were trained in a box that was completely dark except when the key or hopper was illuminated: Brown and Jenkins always had constant illumination provided by a houselight (HL). This modification was expected to make the keylight even more salient and, thus, facilitate the acquisition of keypecking. Training in which the only trial illumination in the chamber appears on the response key is common practice in many laboratories; it is thought to increase attention to key-projected stimuli (see Terrace, 1966).[2] Surprisingly, without house illumination, keypeck autoshaping did not occur. Further phases of this initial experiment and related follow-up experiments examined autoshaped keypecking as a function of changes in trial stimulus and contextual illumination.

Method

The Ss were six experimentally naive White Carneaux hen pigeons, 5 to 7 years old, maintained at 75% of their free-feeding weights. They were individually housed, with water always available in the home cages. Ss were run only when they were within ±10 g of their 75% weights.

A standard Grason-Stadler pigeon test chamber was used. Mounted at pigeon's eye level on the response panel were (left to right) the left key, the right key, and the HL. Centered between and below the two response keys was a solenoid-operated grain magazine. The 1.9-cm-diam transparent response keys appeared black when they were not illuminated from behind through white, red, or green jewel fixtures. A minimum peck force of 10 g was necessary to activate the response keys. When illuminated from behind, the 3.8-cm-diam HL diffused white light throughout the chamber. Keylights, HL, and food hopper were illuminated by 10-W 115-V ac General Electric bulbs. The unused right key was covered with gray tape, as was the HL when not used during a particular phase of the experiment. A ventilating fan and white noise, continuously sounded from a small loudspeaker located below the HL, masked extraneous sounds produced by the programming circuitry and recording equipment located in an adjoining room.

First, Ss were trained in a darkened box to approach quickly and eat from the lighted grain magazine. They were individually placed in the test chamber, with the food tray accessible and filled with grain. After the S had eaten for approximately 20 sec, the hopper was lowered. Thereafter, the tray was raised and lowered 20 times and the bird was permitted to eat for about 4 sec during each presentation. The feeder was activated at irregular intervals without observation of the bird's behavior.

Experimental training began the following day. Each of 60 daily trials involved illumination of the response key with white light for 8 sec followed immediately by 4 sec of access to grain. Successive keylight-grain pairings were separated by intertrial intervals (ITIs) averaging 25 sec (range: 4-46 sec). Training Days 1-7 and 15-21 were conducted with the HL unlighted and covered (HL OFF). During Days 8-14 and 22-28, the HL was continuously lighted throughout experimental sessions (HL ON). Keypecks were recorded but had no effect on the programmed cue and reinforcement contingencies.

Results

Figure 1 depicts the total number of trials with at least one peck as a function of successive days of training. Training in a dark chamber failed to produce any appreciable keypecking (the first 7 training days). Only one S (775) ever pecked the lighted key, but pecks were infrequent and never occurred on more than 7% of a day's trials.

Although these findings fail to replicate Brown and Jenkins's autoshaping effect, they do not represent a "failure of association." Periodic observations revealed that, after an initial reluctance to consume grain on the

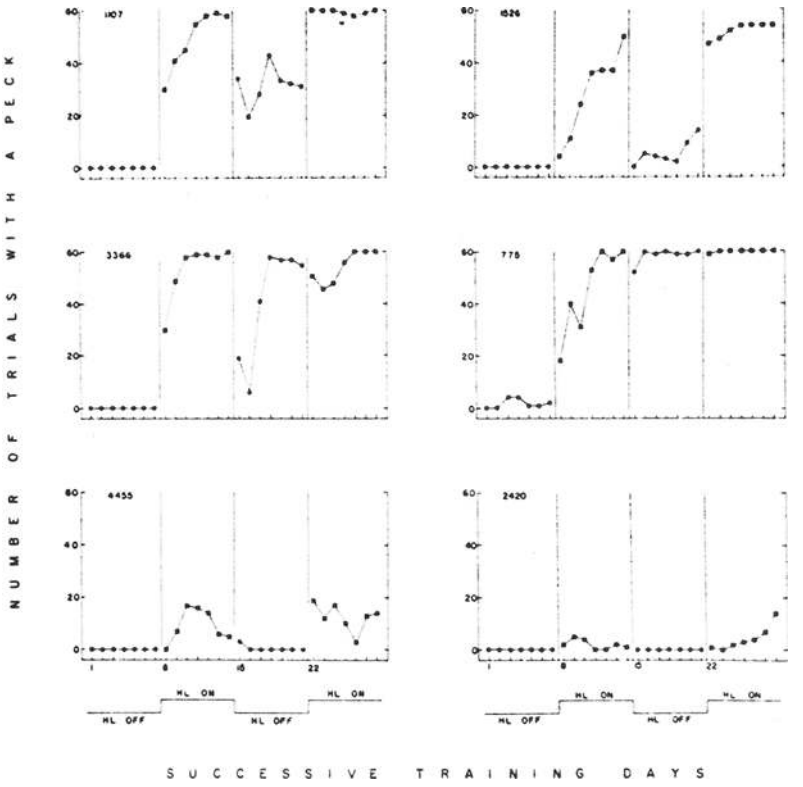

Fig. 1. Number of trials with at least one peck during successive HL-OFF, HL-ON, HL-OFF, and HL-ON phases, respectively, in Experiment I. Filled circles denote data points from HL-OFF sessions. Filled squares denote data points from HL-ON sessions. S numbers are shown in the upper left portion of each individual graph.

first training day, by Day 2 several birds had developed quite consistent behavioral patterns during key illumination. Bird 3366 would first turn toward the key but would then walk toward the masked HL, extend its neck, and "bob" its head in the upper right-hand corner of the chamber. Another S (2420) approached the keylight but did not make any pecking movements and often lowered its head toward the food hopper. Birds 4455 and 1526 directed their behaviors more explicitly toward the grain magazine. The former bird thrust and held its head in the hopper opening; whereas the latter would sway its "bowed" head from left to right across the hopper opening while emitting "cooing" sounds.

One aspect of the procedure that may have been responsible for the failure of keypecking to occur involved the fact that the entire chamber was dimly illuminated when the keylight was turned on. Indeed, all birds clearly detected the trial illumination change, despite their frequent lack of orientation toward the key; the pigeons often gave "surprise" or "alerting" reactions to keylight onset, even when their backs were to the response panel. If a necessary condition for the emergence of the keypeck is that orientation be directed toward a highly localized visual stimulus, then the absence of such a requirement might explain the failure of birds to peck the trial light when it was presented in a dark cubicle.

If the trial stimulus was not detectable by a change in ambient illumination, then an increase in keypecking should result. Continuous illumination of the chamber with a HL should minimize the possibility of control by diffuse changes. Therefore, from Days 8-14 the identical training procedure remained in force, except that the HL was illuminated continuously. Figure 1 indicates that turning on the HL led to a rise in keypecking for all Ss. Within two training sessions, each of the five pigeons that had not previously pecked the keylight did so: Pecks occurred for the first time after HL introduction on Trials 11, 14, 14, 54, and 92 for Birds 3366, 1107, 1526, 2420, and 4455, respectively. Substantial keypecking emerged and persisted except for Birds 4455 and 2420. Pigeon 4455 was observed to peck repeatedly at the lit key; however, its pecks were not recorded by the key switch because pecks struck the black plastic rim that encircled the response key. Pigeon 2420 also pecked at the key area; but its pecks stopped just short of the key surface and were, thus, unrecorded.

During the final two experimental phases, training was conducted with and without chamber illumination, respectively. Training with HL OFF during Days 15-21 produced a decrement in pecking for all Ss. Only the pecking of Birds 3366 and 775 recovered to preremoval levels. During the final phase, HL-ON training produced increased keypecking for those four Ss whose pecking had not greatly recovered during the second HL-OFF phase. Even Birds 4455 and 2420 showed a resurgence in recorded pecking, although earlier HL-ON training had given rise to many unrecorded pecks.

The temporal distributions of keypecking during trials also proved to be quite interesting and are shown in

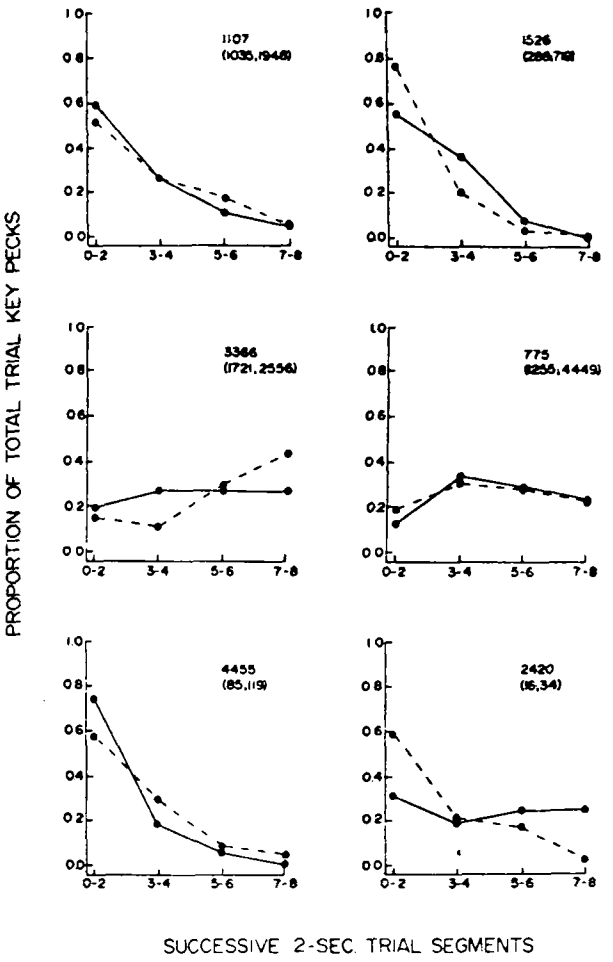

Fig. 2. Temporal response control during 8-sec trials in Experiment I. Solid line curves depict temporal response control summed across Days 8-14 (total pecks are given by the first number in parentheses), and broken line curves portray the same relationship summed across Days 22-28 (total pecks are given by the second number in parentheses). Only data from HL-ON sessions are included.

Fig. 2. This figure displays the proportion of total keypecks that were recorded in successive 2-sec trial segments during HL-ON training for each of the six Ss. The most striking finding was that four out of six Ss pecked most just after trial onset rather than toward the end of the trial stimulus (also, see the latency data of Williams & Williams, 1969). This effect emerged rapidly; responding in the terminal component was zero or near zero for three of four "onset" controlled birds during the first week of HL-ON training. During the second phase of HL-ON training, pecking during the first 2 sec of key illumination comprised 50%-80% of total trial keypecks for these four birds. Cue onset control remained relatively stable from the first to the second HL-ON phase: two Ss increased and two Ss decreased the proportion of pecks during the initial 2-sec trial interval.

Discussion

Autoshaping the pigeon's keypeck is clearly dependent upon general chamber illumination. The failure of autoshaping to occur with HL OFF was inconsistent with the cue salience hypothesis noted earlier. In the dark cubicle, lighting the key not only illuminated the key surface but also effectively illuminated the entire chamber and provided the birds with many redundant visual stimuli. Some birds appeared to be controlled by chamber features other than the keylight (e.g., corner, grain hopper). Furthermore, Ss detected the keylight without key-directed orientation. If what may be termed the "cue localization" hypothesis of autoshaping is correct, then keypecking failed to occur in a darkened chamber because several visual cues other than key surface illumination were alternative predictors of reinforcement. Presumably, the effect of the HL was to isolate key surface illumination as the best predictor of food (see Wagner, 1969; Wasserman, 1973).

Because of the discrete and punctate nature of the keylight cue, the bulk of HL-ON Ss engaged in vigorous keypecking. When general chamber changes signaled food delivery in HL-OFF training, idiosyncratic head bobbing, head thrusting, or swaying behaviors were directed at other features in the chamber. These findings, then, parallel those of Brown and Jenkins (1968) and of Skinner (1948), respectively, and support the earlier suggestion that cues that predict reinforcement may play an important role in selecting a specific behavior out of an organism's repertoire (see Staddon & Simmelhag, 1971) and directing that behavior toward the cue most predictive of appetitive reinforcement.

To date, the author is aware of only one published experiment that has successfully autoshaped the pigeon's keypeck without constant house illumination (Hitzing & Safar, 1970). In that experiment, however, complex pretraining (keylight alone, food hopper alone, and keylight and food explicitly unpaired) preceded paired keylight and grain presentations, making interpretation difficult. Perhaps more important than the pretraining procedures employed was the fact that the interior of the experimental chamber was painted flat black, whereas the cubicles used in the present set of studies were painted either glossy gray (Experiments I and II) or white (Experiment III). Chambers with dull wall surfaces probably provide far fewer redundant visual stimuli when the key is lit with HL OFF than chambers with more reflectant wall surfaces. If so, then this apparently discrepant finding of autoshaping with HL OFF may actually strongly support the "cue localization" hypothesis.

Other findings in Experiment I provide important evidence concerning the character of the autoshaped keypeck. First, the locus of the pecking response of two birds was not stable but, rather, changed over time. Two changes in peck directedness (not mutally exclusive) were observed: (1) a reduction in peck force and forward head extension, which resulted in an increase in

unrecorded "near miss" pecks that fell short of the key surface, and (2) a shift of peck location, which occasioned many unrecorded "off-key" pecks to the wall area surrounding the key (see Dunham, Mariner, & Adams, 1969; Wasserman, 1972, Experiments 7 and 8). These findings thus corroborate the observations of Brown and Jenkins (1968) concerning the relative frailty of recorded autoshaped pecking.

The notion of adventitious reinforcement provides a plausible account of the drift in peck directedness. Since there is no response-reinforcer contingency requiring pecks to the key surface, variants of the keypeck stand in an accidental relation to reinforcement and, hence, these variants may be strengthened (see Skinner, 1971). Interpretations of autoshaping based upon a Pavlovian conditioning model (Gamzu & Williams, 1971, 1973; Moore, 1971; Williams & Williams, 1969) would apparently have to invoke some additional behavioral mechanism to explain changes in peck locus.

Finally, the temporal distribution of autoshaped keypecking poses a problem to currect accounts of autoshaping. Clearly contradictory to an analysis of autoshaping based on inadvertent reinforcement was the fact that, for most birds in Experiment I (and a high proportion of birds in later experiments), keypecking decreased as the time of grain delivery approached. Interpretations of autoshaping based upon Pavlovian conditioning must explain temporal distributions of responding that are opposite to those expected on the basis of "inhibition of delay" (see also Gardner, 1970; Ricci, 1973). Some other process must override any inhibitory mechanism of this kind (see Moore, 1971).

EXPERIMENT II

Experiment II sought to test further the "cue localization" hypothesis. According to this account, keypecking should increase to the extent that alternative diffuse illumination cues are made less distinctive than in Experiment I. Therefore, the key was always illuminated, except while food was presented. Food was signaled by green key illumination; otherwise, the key was colored by red light. Under these conditions, more keypecking should occur without chamber illumination than in the first experiment. To the degree, however, that a change in key color can be detected without looking directly at the key, chamber illumination might still promote autoshaping by preventing such "diffuse" detection.

Method

The same general method and apparatus were used as in Experiment I. Eight experimentally naive White Carneaux hen pigeons served as Ss.

Following a single day of hopper training, Ss were given 40 daily autoshaping trials. The key was green illuminated for 8 sec prior to 4 sec of grain availability. During ITIs, the key was illuminated with red light. For the first 8 days, half of the Ss were trained with HL ON and the other half with HL OFF.

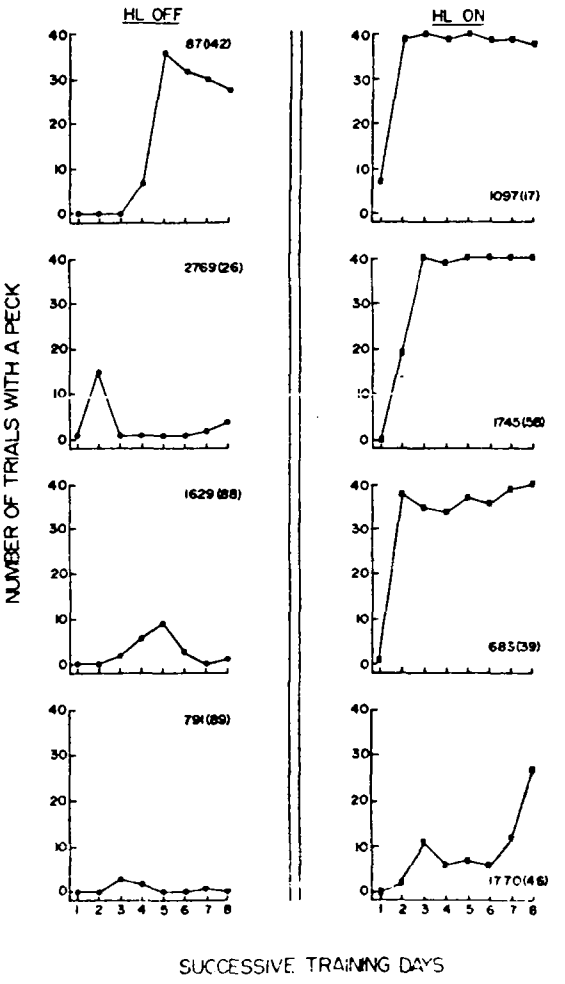

Fig. 3. Number of trials with a peck as a function of successive training days in Experiment II. Filled circles denote data points from HL-OFF sessions. Filled squares denote data points from HL-ON sessions. The numbers in parentheses to the right of the S numbers represent the trial with the first keypeck for that individual S.

During the following week, the lighting conditions for the two groups were reversed.

Results and Discussion

Figure 3 shows the results from the first 8 days of training. All birds in both groups pecked the key during trials. In contrast to the results of the first study, in which only one of six Ss initially trained with HL OFF keypecked, all four HL-OFF birds in this experiment began keypecking. However, as in the first experiment, the HL enhanced keypecking. The emergence of pecking was faster for birds trained with HL ON. The median trial with the first keypeck occurred on Trial 43 for HL-ON Ss and on Trial 89 for HL-OFF Ss. Within the first 160 trials, birds trained with HL ON pecked more frequently than HL-OFF Ss; the former Ss pecked on 19, 98, 108, and 125 trials, while the latter Ss pecked on 5, 7, 8, and 18 trials. Furthermore, HL-ON pigeons displayed maintained or increasing pecking frequencies

over the first 8 days; whereas HL-OFF birds evidenced reduced or decreasing pecking frequencies from earlier response maxima. In short, pecking was slower to develop and less persistent with HL OFF than with HL ON.

From Days 9-15, the chamber lighting conditions were reversed (not shown in Fig. 3). Three of the four birds (87, 2769, and 791) given HL-OFF training and switched to HL-ON training evidenced clear increases in keypecking. Three of the HL-ON Ss (1097, 1745, and 683) had reached quite high performance levels by Day 8. When later trained under HL-OFF conditions, all showed temporary pecking decrements, although they later showed some recovery of pecking.

These findings again support the "cue localization" hypothesis. First, because the key color change presumably involved less salient general chamber cues than in Experiment I, more keypecking resulted. Thus, under appropriate conditions, autoshaped keypecking will occur without the illumination of a chamber light. Second, the HL did have a facilitatory effect, although not as large as in the first experiment. This facilitation was presumably due to the fact that diffusely detectable changes in the color of the chamber or some part of the chamber served as redundant predictive stimuli when the HL was not continuously illuminated.

Besides providing evidence supportive of the "cue localization" hypothesis, these findings make less likely some alternative explanations of the HL effect seen in the first study. For example, explanations in terms of some unknown aversive property of sudden key illumination or in terms of inattentiveness resulting from prolonged blackout exposure seem unlikely. For birds trained with HL OFF, lighting in the ITI was provided by the red response key. Thus, the keylight cue was not an "off" to "on" change in illumination, nor were the birds ever exposed to blackout conditions.

EXPERIMENT III

This final experiment attempted to reduce more effectively than in Experiment II the detectability of redundant contextual stimuli. Here, such correlated general lighting changes with HL OFF were minimized by signaling food delivery with a key-localized feature change. For example, the response key might be illuminated during the ITI by a homogeneous white field. A few seconds prior to food delivery, three black vertical lines would be displayed on the white field. As the physical luminous energy from the two patterns were approximately equal, any discrimination of ITI and trial stimulus lighting conditions by means other than key-directed observation should be minimized. Under these circumstances, HL illumination would not be expected to greatly facilitate autoshaping because diffuse cue detectability had already been greatly reduced by the key lighting conditions. For comparison purposes, training conditions similar to those in Experiment I were included in which the keylight was darkened in the ITI. For these latter groups, the keylight change was one of illumination; a darkened key was lighted as a signal for food delivery.

Method

The Ss were 20 experimentally naive White Carneaux hen pigeons maintained under the same motivational and housing conditions as the Ss in Experiments I and II.

The center key of a three-key Lehigh Valley Electronics pigeon chamber was used to signal food delivery and to record keypecks. This 2.6-cm-diam transparent key required at least 15 g to be activated and was positioned between the grain feeder (below) and the HL (above). Stimulus variation was accomplished by a miniature display projector that could transilluminate the key with either a plain white field or a white field containing three vertical black lines when 6.3 V ac was applied to General Electric No. 44 bulbs. Both displays were initially adjusted for equal luminance and were frequently rechecked with a photometer. The HL was mounted in a chrome housing that directed light toward the ceiling and was illuminated by applying 28 V dc to a No. 313 bulb. White noise was provided from a speaker to the left of the grain hopper.

As a result of the previous difficulty with birds not readily eating from the grain magazine early in Experiment I, special care was taken here to insure that the Ss would promptly consume the food reinforcement. On the first day of hopper training, pigeons were individually placed in the darkened test chamber, with the food tray operated and filled to the brim with grain. After the S had eaten for approximately 20 sec, the tray was lowered. Thereafter, the tray was exposed for 3-sec periods at irregular intervals. If the S failed to eat from the hopper on three consecutive presentations, the tray was held in the operated position until the bird had eaten for 3 sec. This "hand" training session consisted of 20 3-sec hopper presentations from which the bird efficiently ate grain. On the following day, each bird was placed in the darkened chamber and given 40 3-sec opportunities to eat from the hopper, spaced according to the same variable-interval (VI) schedule later used in experimental training. This sequence of "hand" and VI feeder training was repeated on pretraining Days 3 and 4, respectively. Finally, on pretraining Day 5 another VI training session was given, and the birds were observed and rated according to eating performance. Four birds were dropped from the experiment at this point for failure to eat from the hopper. The remaining 16 pigeons were assigned to the four treatment conditions, which were closely matched on the basis of eating performance.

Experimental training began the following day. Four treatment conditions were created by factorially combining the type of trial stimulus (illumination, I, or feature change, F) and the illumination of the HL (ON or OFF) throughout the experimental sessions: I-ON, I-OFF, F-ON, F-OFF. The trial display for half of the birds in each group was the blank white field and for the other half it was the white field with three vertical black lines. Thus, for half of the Ss in Groups F-ON and F-OFF the feature change was line presentation and for the other half it was line removal. The effect of the trial display, blank white or lined, was not large and, therefore, will not be discussed further (see Gardner, Belson, & Smith, 1972). Training continued for 10 sessions, each composed of 40 daily trials. Trials consisted of 8 sec of key stimulus presentation followed immediately by 3 sec of access to grain. Intertrial intervals averaging 40 sec (range: 20-60 sec) separated the trials.

Results and Discussion

The median trial with the first keypeck for Groups I-ON, I-OFF, F-ON, and F-OFF was 66, 400, 201, and

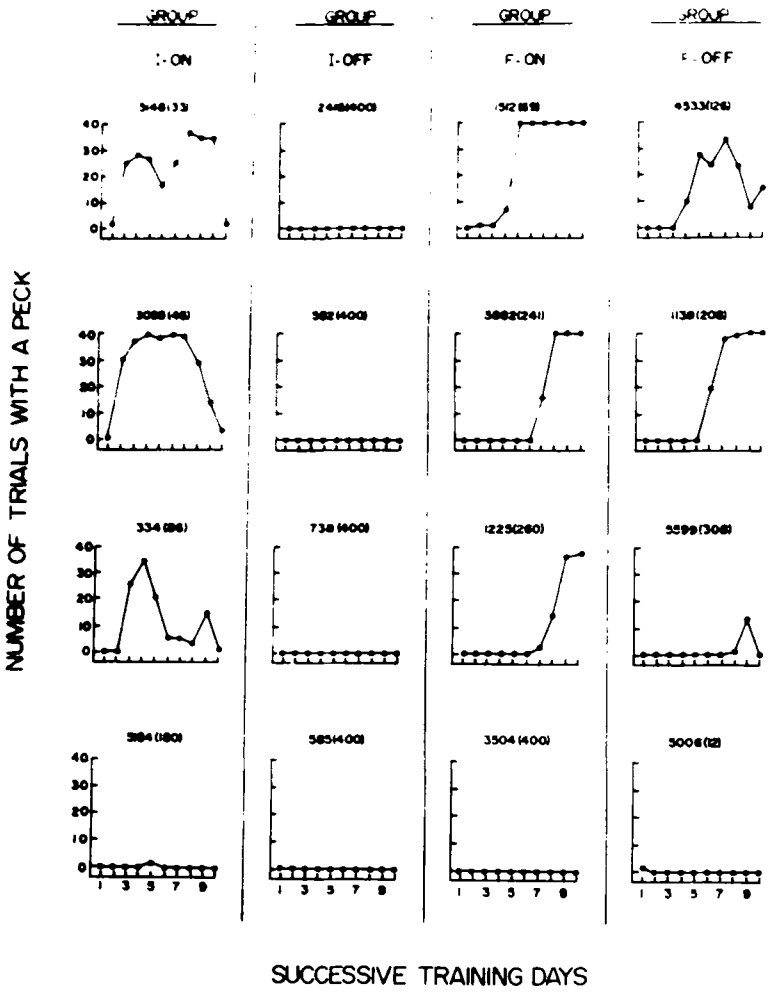

Fig. 4. Number of trials with a peck as a function of successive training days in Experiment III. Groups I-ON and I-OFF had a key *illumination* change signal food reinforcement. Groups F-ON and F-OFF had a key *feature* change signal food reinforcement. The numbers in parentheses to the right of the S numbers represent the trial with the first keypeck for that individual S.

167, respectively. Figure 4 shows the number of trials with at least one keypeck as a function of successive training days for each individual S. Comparison of Groups I-ON and I-OFF again reveals that house illumination markedly facilitated keypecking if food reinforcement was preceded by illumination of the response key. Thus, the results of Experiment I were replicated between groups of Ss in a different chamber, with different houselight and keylight placements and with different feeding training preceding experimental training. Comparison of Groups F-ON and F-OFF indicates, on the other hand, that when the keylight cue was a feature change illumination of the HL did not facilitate the emergence of keypecking.

These findings, thus, support implications derived from the "cue localization" hypothesis. Constant illumination of the HL was expected to facilitate autoshaping only if diffuse visual cues accompanied the keylight cue. Since I training presumably provided many alternative stimuli but F training provided few, if any, a large facilitatory HL effect resulted only with the former training procedure.

Two other comparisons regarding keypeck acquisition are of interest. First, keypecking occurred with HL OFF if the trial stimulus was a key feature change (F-OFF) but not if the trial stimulus was key illumination (I-OFF). Note that the similar behavior of F-ON and F-OFF Ss argues against the failure of I-OFF Ss to respond as due to keypecking being aversive when the only source of illumination in the dark chamber is the keylight. Both I-OFF and F-OFF Ss should have failed to keypeck under this logic. Second, faster autoshaping resulted when a key illumination change signaled food in a house-illuminated chamber (I-ON) than when a key feature change preceded grain presentation (Groups F-ON and F-OFF). This result is not surprising, since the trial-ITI discrimination was undoubtedly more difficult with the key feature change than with the key illumination change.

With regard to the persistence of autoshaped keypecking, only 4 out of 11 birds that began to keypeck failed to evidence marked declines in keypecking. Of these birds, three were in Group F-ON. These conditions probably required the most key-directed observation because: (a) the key feature change was more difficult to detect than the key illumination change, and (b) the HL could serve to reduce the detectability of any global stimulus changes

Table 1
Mean Percentage of Trials With a Keypeck Over the Last 4 Days of Initial Training

House Illumination Condition	Key Illumination Change		Key Color Change	Key Feature Change
	Experiment I	Experiment III	Experiment II	Experiment III
OFF	.01*	.00	.23	.39
ON	.63†	.34	.81	.60

**Phase 1 of Experiment I* *†Phase 2 of Experiment I*

(a possible cue being the brief "blink" that occurred when the ITI display was turned off and the trial display was illuminated in Group F-OFF). However, since those Group F-ON birds that did keypeck were very slow to begin pecking, they were not trained long enough to make a firm statement about the permanence of keypecking.

The behaviors of Birds 3095 and 334 in Group I-ON provide some insight into the interrelation between temporal response control and topographic drift previously discussed in Experiment I. Although both birds once pecked on more than 85% of a day's trials, keypecking later fell to near zero levels. Accompanying this absolute pecking decrement was a tendency for proportionately more pecking to occur just after trial onset. Keypecking was most likely to occur when the key was first lighted; thereafter, pecking movements became either less effortful (Bird 334) or ceased altogether (Bird 3095) as the pigeon lowered its head to the food hopper. Both the decrease in peck force and the supplementation of keypecking by other behaviors more compatible with the consumption of grain from the hopper are not unusual (see Moore, 1971; Skinner, 1971) and may be responsible for the "inverted scallops" seen in Experiment I.

One further point deserves mention. Pecking in the present study was somewhat slower and less likely to emerge, as well as somewhat less persistent, under favorable key- and houselighting conditions than in the first two studies. This may have been due to the extensive feeding training administered prior to experimental training. Unsignaled food deliveries have previously been found to proactively interfere with keypeck autoshaping (Engberg, Hansen, Welker, & Thomas, 1972; Smith & Wilkes, 1971; Wasserman, 1972, Experiment 6). A similar proactive interference effect occurs after uncorrelated or negatively correlated keylight and food presentations (Gamzu & Williams, 1971; Wasserman, Franklin, & Hearst, 1973).

GENERAL DISCUSSION

The three experiments can be organized in a sequence of potentially redundant contextual stimuli accompanying different kinds of trial stimulus change. Trial stimulus changes of illumination, color, and feature alteration probably involve progressively fewer generally detectable stimuli to compete for control with stimulus variation on the key surface. Table 1 depicts the mean percentage of trials with a keypeck during the last 4 days on a particular procedure in each of the three studies under HL-ON and HL-OFF conditions. These results indicate that with HL OFF progressively greater keypecking occurred as trial stimuli were varied from illumination, to color, to feature changes. The different trial stimuli had little consistent effect upon response frequencies with HL ON. In addition, the difference in keypecking frequencies between HL-ON and HL-OFF conditions generally declined across trial stimulus changes from illumination, to color, and to feature variations (with the exception of the key illumination change in Experiment III).

Taken together, the results of these experiments suggest that the emergence of the pigeon's keypeck with the autoshaping procedure is dependent upon the highly localized nature of the visual cue involved. Should more widespread visual changes predict food reinforcement as well as key-localized cues, then stereotyped approach and pecking movements will not be exhibited nor directed toward the response key. The keylight cue would appear to have a special status in evoking the pigeon's peck and directing that response toward a signal of appetitive reinforcement.[3] Stimulus localizability may then be importantly involved in influencing conditioned response direction, which appears to be an important difference between autoshaped and classically conditioned behaviors (see Moore, 1971). The potential involvement of the physical characteristics of signaling and reinforcing stimuli in modulating the topographies of conditioned behaviors should, thus, be more seriously considered by investigators than previously.

If conditioned stimuli are viewed as playing an active role in selecting specific skeletal behaviors and orienting these behaviors toward spatially isolated stimuli (Wasserman, in press), then the provisional explanation of superstitious sequences entertained earlier may also pertain to the acquisition of many so-called "operant" behaviors as well. Ss might learn to approach and contact conventional experimental manipulanda not because of any "operant strengthening" of these behaviors, but because these localized stimulus features have been differentially correlated (either temporally or spatially) with reinforcer presentation (see Birch & Bitterman, 1949, p. 306).

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NOTES

1. This sequence of conditioned response development is apparently the reverse of that noted previously by Culler (1938), in which a "replica" of the unconditioned response was the first behavior to be evoked by the CS.

2. Thomas, Ernst, and Andry (1971) have shown that generalization gradients for line-tilt stimuli projected on the key are steeper if training is conducted without, rather than with, a HL.

3. Were various different signaling stimuli to be employed, then other behaviors appropriate to these conditioned stimuli would probably be expressed (see Bindra, 1969; Hefferline, Bruno, & Davidowitz, 1971). When auditory stimuli signal food delivery, pigeons rarely peck the sound source, although they do approach it and engage in vigorous "listening" movements (Farthing, 1971; Wasserman, 1972, Experiment 5).

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