# ATTENTION IN THE PIGEON1

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Lashley (1938, p. 152) found that a rat that had been reinforced for jumping toward a square and punished for jumping toward a diamond did not jump consistently toward either figure if only the upper halves of the figures were presented. They did, however, jump consistently toward the square if only the lower halves of the figures were presented. This sort of relation between a particular part or aspect of the environment and a response is called attention (cf. Skinner, 1953). Lashley's rat attended only to the lower parts of the figures, which were shown experimentally to bring about the jump. In general, an organism attends to an aspect of the environment if independent variation or independent elimination of that aspect brings about variation in the organism's behavior. Thus, a gradient of generalization to tones (cps), for example, is a way of showing that the organism was attending to the frequency of the sound in whose presence responding had been reinforced, but a flat generalization function may indicate a lack of attention to the frequency of the sound (cf. Jenkins & Harrison, 1960).

The physical parameters of a visual stimulus may be independently varied, but some cannot be independently eliminated. To take specific examples, a triangle against a colored background may be varied without varying the background, and, in addition, the triangle may be eliminated without eliminating the background. The luminance of a visual stimulus may be varied without varying its position or wavelength, but it is not possible to eliminate the luminance without eliminating the entire stimulus. In both sorts of procedures, the experimental study of attention aims at the identification of the stimuli that control responding in a given situation. The present experiments use both the elimination and variation of aspects of a stimulus to study visual attention in the pigeon.

## METHOD

## Subjects

Two adult male, White Carneaux pigeons, both experimentally naive, were maintained at 80% of their free-feeding body weights.

# Apparatus

The experimental chamber was a modified picnic icebox, similar to that described by Ferster and Skinner (1957). A standard response key, 0.75 inch in diameter,

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was mounted on one wall of the chamber. The key was operated by a minimum effective force of 15 grams. Below the key was a 2-inch-square opening through which the pigeon was occasionally given access to grain for 3 seconds. The chamber was illuminated by two 6-watt lamps except during periods of access to grain. White noise masked most extraneous sounds.

A projection system<sup>2</sup> allowed transillumination of the key with either red, green, or blue light and, simultaneously, with a white triangle or a white circle. The triangle and circle appeared as white line figures against the colored background. The width of the lines composing each figure was about 0.0625 inch. The circle was 0.5 inch in diameter and the triangle, 0.5 inch high.

During the second experiment only, two Drake No. 51 pilot lights (one yellow and the other green) were mounted one above the other and 2.5 inches to the right of the key. The bulbs extended from their sockets in a plane parallel to the plane of the response key.

## **Procedures**

Both birds were trained to eat grain through the opening in the panel and to peck the response key. On each of 2 days, each of 60 consecutive responses (pecks) was reinforced (3-second access to grain). For 3 hours on each of the next 3 days, responding was reinforced on a variable-interval schedule (mean interval of 3 minutes). Throughout this training the response key was illuminated with a white triangle on a red background.

Experiment I. Each of six daily, 3-hour sessions contained 30 cycles of a two-component multiple schedule. Each cycle consisted of two 3-minute components. During the first component, the key was illuminated with a white triangle on a red background, and responding was reinforced on a VI 3-minute schedule. During the second component, the key was illuminated with a white circle on a green background, and responding was not reinforced. At the end of the sixth session, several cycles with 1-minute components were added. Changing the length of the components from 3 to 1 minute did not alter the rates of responding in the presence of each of the stimuli.

During Sessions 7 and 9, the triangle, circle, red or green light separately illuminated the key for 1 minute apiece. A different order of stimulus presentations was used in each session. A total of 52 minutes' exposure to each stimulus separately was given to one pigeon and a total of 69 minutes, to the other pigeon. No responses were reinforced. The procedure during Session 8 was the same as during the first six sessions.

<sup>2</sup>"One Plane Digital Display Unit," manufactured by Industrial Electronics Engineers, North Hollywood, California.

Experiment II. The key was illuminated with either of four stimuli: a white triangle on red or on blue, or a white circle on red or on blue. Each of the four stimuli was presented for 3 minutes in this order: triangle on red, circle on red, triangle on blue, circle on blue, triangle on red, triangle on blue, circle on red, circle on blue. This sequence of eight stimuli (a cycle) was repeated six times during each daily session. During Cycles 1, 3, and 5, the yellow side-lamp (cf. Apparatus) was lighted. During Cycles 2, 4, and 6, the green side-lamp was lighted. Thus, the stimulus at a given moment in this procedure consisted of one lighted side-lamp plus a white figure and a background color on the key.

The schedule of reinforcement correlated with each stimulus was either a fixed interval of 3 minutes (no limited hold) or extinction. Which reinforcement schedule was in effect at a particular time depended upon both the side-lamp and the key illuminations. When the yellow side-lamp was lighted, responding was reinforced in the presence of key stimuli containing red. When the green side-lamp was lighted, responding was reinforced in the presence of stimuli containing a triangle. Each bird was exposed to this procedure for about 100 hours over a 2-month period.

After a stable pattern of responding had developed, several modifications of the procedure were introduced for one or two sessions each. Between modifications, the birds were returned to the original procedure for at least two sessions. Responding was never reinforced during a modified procedure.

The modifications of the procedure were:

- (1) Extinction: Responding was extinguished in the presence of the usual pattern of side lamp and key illuminations.
- (2) Both side-lamps were lighted together, and no responses were reinforced.
- (3) No side-lamps were lighted, and no responses were reinforced.
- (4) The yellow side-lamp was lighted during Cycles 1, 3, and 5, and responding was reinforced appropriately during the presentation of stimuli containing red. *No* side-lamp was lighted during Cycles 2, 4, and 6, and no responses were reinforced.
- (5) The green side-lamp was lighted during Cycles 2, 4, and 6, and responding was reinforced appropriately during the presentation of stimuli containing the triangle. No side-lamp was lighted during Cycles 1, 3, and 5, and no responses were reinforced.
- (6) The positions of the original yellow and green sidelamps were reversed, and no responses were reinforced.
- (7) A lighted *red* side-lamp replaced the green side-lamp during Cycles 2, 4, and 6 only, and no responses were reinforced.
- (8) A lighted *white* side-lamp replaced the yellow side-lamp during Cycles 1, 3, and 5 only, and no responses were reinforced.
- (9) The yellow side-lamp was *dimmed* (by increasing the distance between the bulb and the jewel) during Cycles 1, 3, and 5, and no responses were reinforced.

### RESULTS

# Experiment I

When responding was reinforced (VI 3 minutes) in the presence of a triangle on red and extinguished in the presence of a circle on green, both birds came to respond predominantly in the presence of the triangle on red. The discriminative control acquired by these stimuli is shown in the control (Cont.) histograms in Fig. 1, which present the average rates of responding for three sessions in the presence of each of the two stimuli (abscissa).

The results of presenting each stimulus—triangle, circle, red, and green—separately are shown in the experimental (Exp.) histograms in Fig. 1. Pigeon 105 responded (in extinction) at a rate exceeding 20 responses per minute in the presence of the triangle and at a rate of 0.5 response per minute in the presence of a red key (52 minutes in each stimulus). Pigeon 107, however, responded at a rate exceeding 20 responses per minute in the presence of a red key and at a rate less than 0.5 response per minute in the presence of a triangle (69 minutes in each stimulus). Even though each pigeon was reinforced in the presence of a triangle superimposed on a red background, the responding of each bird was brought under the control of only one of the two aspects of the discriminative stimulus.

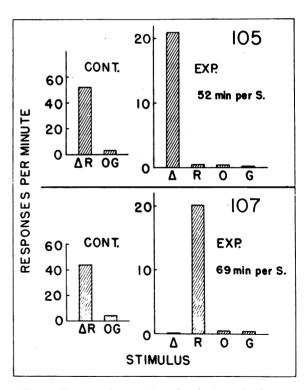


Fig. 1. The rate of responding of each pigeon in the presence of each of the key illuminations in the control and experimental phases of Experiment I.

The rates of responding in the presence of the two aspects of the stimulus correlated with extinction, a circle and a green key, were typically low for both birds.

## Experiment II

When a yellow side-lamp was lighted, responding in the presence of key illuminations containing red was reinforced (FI 3 minutes). When a green side-lamp was lighted, responding in the presence of key illuminations containing a triangle was reinforced. Figure 2 shows cumulative records of responding from a complete session for each bird. The record was reset to the base line at the end of each cycle of eight 3-minute stimulus presentations. The color of the side lamp during each cycle and the key illumination have been indicated on the records, which have been telescoped (Ferster & Skinner, 1957). A filled circle has been placed above the labels on stimuli during which responding was reinforced (FI 3 minutes). When the side lamp was yellow, responding occurred predominantly in the presence of stimuli containing red. When the side lamp was green, responding occurred predominantly in the presence of stimuli containing a triangle. The rate of responding during the key stimulus, a triangle on blue, for example, is high when the side light is green and low when it is yellow. Almost no responses occurred

during a circle on blue, in whose presence responding was never reinforced. A high rate of responding occurred during a triangle on red with both yellow and green side-lamps. An acceleration of responding through each interval is noticeable, but not well-developed.

The rate of responding in the presence of each sidelamp and each key illumination is summarized in the Control graph of Fig. 3. The ordinate is rate of responding, and the abscissa is a nominal scale of stimuli. The solid lines show the responding of Pigeon 105, the dotted lines, the responding of Pigeon 107. Stimuli in whose presence responding was reinforced are indicated by filled circles on the abscissa. The graph shows the same data as the cumulative records: The rate of responding was high only during stimuli in whose presence responding was reinforced.

The graph labeled Extinction in Fig. 3 shows the pattern of responding when the side lamp and key illuminations are maintained as in the control session but no responses are reinforced. The pattern or ordinal arrangement of the rates of responding in the presence of each side-lamp was not altered by extinction alone.

Figures 4 and 5 show the results of the changes in procedure, which were designed to demonstrate the stimuli to which the organisms were attending. Stimuli correlated with reinforcement are indicated by filled

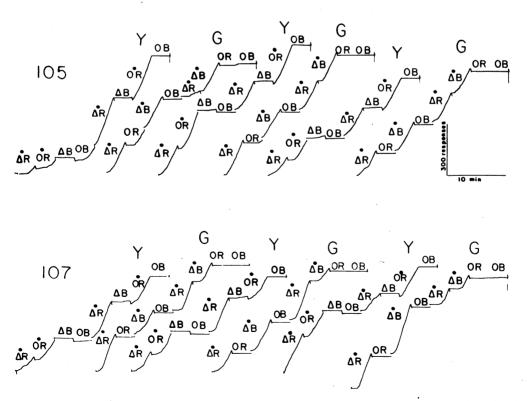


Fig. 2. Telescoped cumulative records of the responding of each pigeon during one complete control session in Experiment II. Filled circles appear above key stimuli during which responding was reinforced (FI 3 minutes).

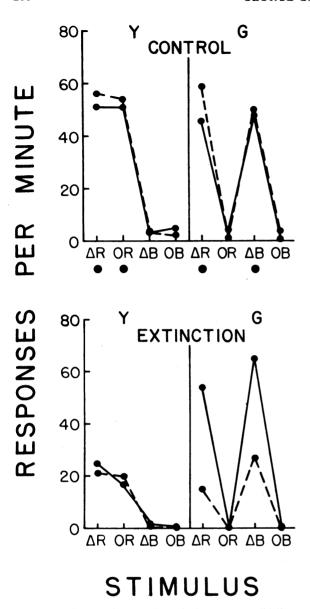


Fig. 3. The rate of responding of Pigeon 105 (solid lines) and Pigeon 107 (dashed lines) in the presence of each of the stimuli on the key during yellow and green side-lamp illuminations. Filled circles along the abscissa designate stimuli in whose presence responding was reinforced.

circles on the abscissa of each graph. Note that reinforcement was never programmed when the side-lamp illumination was altered. The solid lines show the responding of Pigeon 105, and the dotted lines, the responding of Pigeon 107. The legend for each pair of curves indicates the side-lamp illumination: Y + G means that both side-lamps were lighted; None, that neither side-lamp was lighted; and Y, that only yellow was lighted, etc. The graphs show the responding of

each bird on the usual sequence of stimuli under the side-lamp illumination in the legend. The left half of each graph shows the rate of responding in Cycles 1, 3, and 5; and the right half, that in Cycles 2, 4, and 6.

The graphs in Fig. 4 show generally an invariance in the ordinal arrangement (or pattern) of the rates of responding in the presence of the key illuminations under two changes in the side-lamp illumination. When no side-lamp was lighted (indicated by None in Graphs 2, 3, and 4), the pattern of rates usually resembled the pattern when only the green side-lamp was lighted. This may be seen by comparing the pattern of responding under None in Graphs 2 and 3 of Fig. 4 with the pattern under G in the control graph in Fig. 3 or with the pattern under G in Graph 4, Fig. 4. The occasional, very low rates of responding in Cycles 2, 4, and 6, as in the right half of Graph 2 (Fig. 4), result from rapid extinction, which affects the responding in

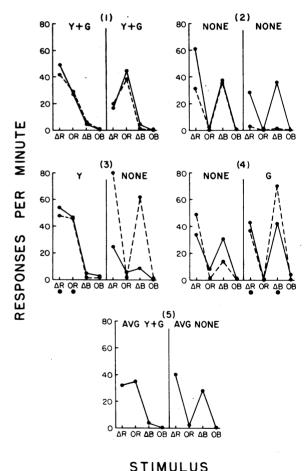


Fig. 4. The rate of responding of Pigeon 105 (solid lines) and Pigeon 107 (dashed lines) in the presence of each of the stimuli on the key during the modifications of the side-lamp illumination that are given by the labels of the graphs.

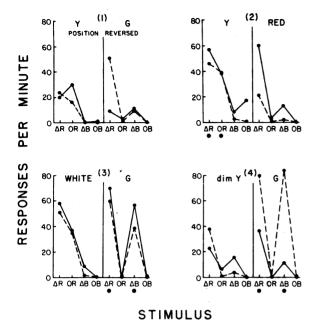


Fig. 5. The rate of responding of Pigeon 105 (solid lines) and Pigeon 107 (dashed lines) in the presence of each of the stimuli on the key during the modifications of the side-lamp illumination that are given by the labels of the graphs.

the later cycles more than in Cycles 1, 3, and 5 (left half of the graph). When both side-lamps were lighted (indicated by Y + G in Graph 1, Fig. 4), the pattern of responding resembled the pattern when only the yellow side-lamp was lighted (compare with Y in control graph, Fig. 3, and in Graph 3, Fig. 4). These results of lighting both or none of the side lamps are summarized in Graph 5 of Fig. 4. The left half of Graph 5 shows the average rates of responding of both pigeons in the presence of the key stimuli when both side-lamps were lighted. The right half shows the average rates of responding of both pigeons in the presence of the key stimuli when no side-lamp was lighted. The patterns of responding in Graph 5 closely resemble the patterns in the control graph, Fig. 3. To summarize, both lamps produce responding as if only yellow were lighted, and no lamp produces responding as if only green were lighted. It thus appears that responding was controlled by the presence or absence of the yellow lamp.

Four other modifications of the side-lamp illumination were studied in order to identify further the effective stimulus. The results are shown in Fig. 5. Reversing the positions of the yellow and green lamps did not alter the pattern of responding (Graph 1, Fig. 5). A lighted red side-lamp (Graph 2), replacing the green lamp, produced a pattern of responding that was ordinally similar to the pattern produced by the absence of the yellow lamp. The functions produced by red may be compared with those produced by green in Fig. 3 and in Graph 4, Fig. 5. A lighted white side-lamp (Graph 3),

replacing the yellow lamp, produced a pattern of responding similar to the pattern produced by the yellow side-lamp (compare with Graph 2, Fig. 5). A dimmed yellow lamp (Graph 4), however, produced a pattern of responding more similar to the pattern produced by the complete absence of the yellow lamp than to the pattern produced by the presence of the original yellow lamp. The intensity, rather than the wavelength or position, of the side lamps appears to be the effective stimulus.

### DISCUSSION AND SUMMARY

In each of the present experiments, the responding of a single pigeon was affected by only one of several aspects of a compound discriminative stimulus. other aspects of the discriminative stimulus apparently did not control responding and therefore were not discriminative stimuli for the pigeon. In the first experiment, the responding of each bird was reinforced (VI 3 minutes) in the presence of a white triangle with a red background on the response key and extinguished with a white circle on a green background. Subsequently, in extinction, the triangle, circle, red, and green lights were presented separately. Only the presentations of the triangle for Pigeon 105, and only the presentations of a red key for Pigeon 107, resulted in respond-Both aspects of the stimulus correlated with extinction, the circle and the green light, produced typical, low rates of responding.

In the second experiment, reinforcement (FI 3 minutes) or extinction in the presence of stimuli on the key depended upon the color of a side lamp. When the side lamp was yellow, any stimulus on the key containing red was correlated with reinforcement; when it was green, any key stimulus containing a triangle was correlated with reinforcement. Responding appropriate to the reinforcement dependencies developed (Fig. 2). Changes in the procedure (Fig. 4 and 5) revealed that if both side-lamps were lighted, the pattern of responding in the presence of the key stimuli was as though only the yellow side-lamp were lighted. If none of the side lamps was lighted, the pattern of responding was as though only the green side-lamp were lighted. Only the presence or absence of the yellow light affected the pattern of responding to the stimuli on the key. The discriminative behavior of neither pigeon was based upon the different colors of the side lamps. Reversing the position of the side lamps also did not alter the patterns of responding in the presence of the stimuli on the key.

The results of the additional modifications of the side-lamp illumination suggest that the complex discrimination shown in Fig. 2 was based predominantly on the intensity, rather than the wavelength or position, of the side lamps. During the presentation of a *red* side-lamp, about as bright as the green lamp, the key stimuli controlled a pattern of responding similar to the pattern that they controlled during green. During the presentation of a *white* side-lamp, brighter than the yellow, the

key stimuli controlled a pattern similar to the pattern that they controlled during yellow. Intensity is further implicated as the effective stimulus since the pattern of responding with a dimmed yellow side-lamp turned out to be more similar to the pattern produced by green than to the pattern produced by the original yellow. These results suggest that although pigeons usually can easily discriminate these wavelength bands, these birds were instead responding to the intensity of the stimuli. The present discrimination was certainly not, however, based upon the relative intensity of the yellow lamp and the dimmer green lamp, since Graph 4, Fig. 4, shows that both a green lamp and the dimmer no-lamp condition produced very similar patterns of responding during the same experimental session. Possibly, the effective stimulus was the difference in the effects of the high and low side-lamp intensities upon the form and color combinations as they appeared on the response key.

The present results show that a pigeon may attend to only one of several aspects of a discriminative stimulus. Every part of the environment that is present when a reinforced response occurs may not subsequently be an occasion for the emission of that response. In the present usage, attention refers to the controlling relation between a stimulus and responding. An organism attends to a stimulus when its responding is under the

control of that stimulus. In the first experiment, one pigeon attended to the red key and the other to the triangle, even though the responding of each had been reinforced in the presence of the triangle superimposed on the red key. On the other hand, both parts of a compound stimulus correlated with extinction separately produced the low rate of responding typical of extinction. In the second experiment, neither pigeon attended to the color of the side lamp. Their responding was controlled only by the presence or absence of the yellow side-lamp, or, under further analysis, by the intensity of the side-lamp illumination.

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