ATTENTION IN THE PIGEON*

ANALYSIS OF RELEVANT STIMULUS IN OPERANT DISCRIMINATION

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In general, a stimulus to which an organism responds has several aspects. If the organism's behavior would be changed by independent variation or elimination of only one aspect of the stimulus, it is possible to say that the organism attends to that aspect. This controlling relation between a response and a particular aspect of stimulus is called "attention" (cf. Skinner (6)). All of those aspects in the stimulus, however, does not necessarily control the organism equally.

Many experimental studies on attention in discrimination learning have been reported. In almost all of them, method of research is to divide the stimulus with some aspects into several physical parameters and to vary each of them independently. But it is supposed that the stimulus brings about different control over the behavior, depending on whether a simple stimulus (in which only a single aspect is included) or a compound stimulus (in which two aspects are included) is presented.

In the present experiment, differences between these two stimulus situations (simple stimulus situation and compound stimulus situation) are studied on the same subjects.

Method

The method of the experiment was similar to that of Reynolds (5), except

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that the stimulus was controlled more carefully so as to avoid involvement of extraneous factors in this experiment.

**Subjects**: Forty homing pigeons, mostly one year old, experimentally naive, were maintained at about 80% of their free-feeding body weights.

**Apparatus**: A modified Skinner-box with a single pecking key was employed as the experimental chamber. The key which was a disc of translucent optical glass was illuminated from outside of the chamber by a projector. The key was operated by a minimum effective force of 10 grams. It was connected with electric relays which permitted automatic recording and programming of reinforcements.

When subjects responded correctly, the feeder which was placed below the key came up with white light illuminant C and the subjects were given access to hemp seeds for 4 sec. All other lights were turned off during the presentation of stimulus on the key.

**Stimulus**: In a training period, either of four compound stimuli which had two aspects, color (green and red, Kodak wratten filter No. 75B & 74) and tilt (vertical line and horizontal line), was projected on the key. Those were as follows: red vertical line (RV), red horizontal line (RH), green vertical line (GV) and green horizontal line (GH). They appeared on the black background.

In an extinction period, 4 stimuli mentioned above were divided into each aspect of stimulus, i.e. green disc (G), red disc (R), white horizontal line on the black background (H) and white vertical line on the black background (V). Thus, eight stimuli, those four stimuli plus the previous four compound stimuli, were

<table>
<thead>
<tr>
<th>Training period</th>
<th>Extinction Period</th>
<th>Total number of pigeons</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>GV-RH</td>
<td>C. S. E. -S. S. E.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S. S. E. -C. S. E.</td>
</tr>
<tr>
<td>2</td>
<td>GH-RV</td>
<td>C. S. E. -S. S. E.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S. S. E. -C. S. E.</td>
</tr>
<tr>
<td>3</td>
<td>RV-GH</td>
<td>C. S. E. -S. S. E.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S. S. E. -C. S. E.</td>
</tr>
<tr>
<td>4</td>
<td>RH-GV</td>
<td>C. S. E. -S. S. E.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S. S. E. -C. S. E.</td>
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* C. S. E. : compound stimulus extinction  
S. S. E. : simple stimulus extinction

Table 1.
Intensity of light of each stimulus was determined along the spectral sensitivity curve of the pigeon, based on data of Blough (2).

Procedure: Forty pigeons were divided into the following four groups: GV-RH, GH-RV, RV-GH, and RH-GV. They are tabulated on Table 1.

Preliminary training: Each pigeon was trained by method of successive approximation to peck the key which was transilluminated by white light (illuminant C). On each of two successive days, each of 20 consecutive responses (pecking) was reinforced. The room lamp of the chamber was lighted only on the first day. If the rate of responding was too low, the same training was continued.

Original training: Following preliminary training, discrimination training which lasted at least for 8 days was carried on. Each daily session consisted of 10 presentations of positive stimulus (S+) and 10 presentations of negative one (S-). These stimuli were alternated according to Gellerman series.

Day 1. After responding to S+ was reinforced 3 times, the daily schedule was performed. Then stimulus was presented for 25 sec, during which every response to S+ was reinforced and to S- was never reinforced in this schedule.

Day 2. After responding to S+ was reinforced once, the daily schedule was performed. Respondings to S+ were reinforced on a fixed interval (FI)-10 sec schedule and respondings to S- never reinforced.

Day 3—Day 8. After responding to S+ was reinforced once, the daily schedule was performed. Respondings to S+ were reinforced on a variable interval (VI)-25 sec schedule and respondings to S- never reinforced. Between presentations of each stimulus, there was 5 sec of blackout during the experimental sessions. Discrimination training was carried out until the 8th day. After the 8th day, when ratio of correct response, that is, number of correct responses/total number of responses reached to 0.95 (10 reinforcements a day), original training finished. If subjects did not reach this criterion, the same training was continued.

Day 9. Extinction. Following completion of discrimination training, two kinds of extinction procedure were performed separably; in one of them, compound stimulus was used and in the other, simple stimulus was used. Order of two different kinds of extinction was inverted, depending on which group was used (see Table 1). Extinction trials consisted of 12 presentations of each stimulus and were replicated four times. No responses were reinforced.

Day 10. Re-training. The same training as the 3rd day of original training was performed. When the ratio of correct response reached to the above
mentioned figure, re-training finished.

Day 11. Extinction. The procedure was the same manner as that of the 9th day, but the order of simple extinction (S. S. E.) and compound stimulus extinction (C. S. E.) was inverted.

Results

In the course of experiment one pigeon died because of illness and another pigeon was found to be hard to train in original training. Thus, the results for 38 pigeons are shown here.

In original training, all but three subjects responded correctly on the second day. The remaining three responded correctly on the third day. Their correct responses were observed uninterruptedly until the eighth day.

In re-training the subjects were trained in the same manner as original training until they had reached the same level of original training. All subjects reached 100 % correct responses on the first day of re-training.

In the extinction, the following five different types of responses were observed. They are illustrated in Fig. 1 and 2.

Type I. In simple stimulus extinction (S. S. E.) either color or tilt (vertical line and horizontal line) exceeds the other significantly in the rate of responding, whereas in compound stimulus extinction (C. S. E.), the rate of responding to two stimuli which involved an exceeding aspect of the same color or tilt as a positive value in discrimination training were not different. It would be considered that only one aspect of stimulus (either color or tilt) was a cue in this discrimination. Three pigeons showed this sort of response (2, in C. S. E. -S. S. E. and 1, S. S. E. -C. S. E.) as seen in Fig. 1. The same result was found in REYNOLDS’ experiment (5).

Type II. In S. S. E., the rate of responding to either color or tilt was higher than the other one, similar to that of Type I and REYNOLDS’ case. In C. S. E., however, the rate of responding to the positive stimulus
Illustrates 5 types which were schematized from the result.

<table>
<thead>
<tr>
<th>Type</th>
<th>Responding</th>
<th>Extinction Order</th>
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<tbody>
<tr>
<td>I</td>
<td>S.S.E.</td>
<td>C.S.E.</td>
</tr>
<tr>
<td></td>
<td>Pc, Nc, Pt, Nt</td>
<td>C.S.E. - S.S.E.</td>
</tr>
<tr>
<td></td>
<td>PePt, PeNt, NcPt, NcNt</td>
<td>S.S.E. - C.S.E.</td>
</tr>
<tr>
<td>II</td>
<td></td>
<td>2*</td>
</tr>
<tr>
<td></td>
<td>PePt, NcPt, NcNt</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>PePt, PeNt, NcPt, NcNt</td>
<td>11</td>
</tr>
<tr>
<td>III</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Pe, Nc, Pt, Nt</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>PePt, PeNt, NcPt, NcNt</td>
<td>4</td>
</tr>
<tr>
<td>IV</td>
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<td>PePt, PeNt, NcPt, NcNt</td>
<td>2</td>
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<tr>
<td>V</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Pe, Nc, Pt, Nt</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>PePt, PeNt, NcPt, NcNt</td>
<td>0</td>
</tr>
</tbody>
</table>

Illustrates 5 types which were schematized from the result.

ordinate: number of responding
abscissa: stimulus
Pc  positive color
Pt  positive tilt
Nc  negative color
Nt  negative tilt

Fig. 1. Types of responding in extinction.
in original training was distinctivly higher than the others. It means that the responding would be influenced by both aspects of stimulus (color and tilt). As found in Fig. 1, twenty-four pigeons showed this type of reponse (13, in C. S. E. -S. S. E. and 11, S. S. E. -C. S. E.).

Type III. In S. S. E., the number of responding to color or tilt were in equal level, whereas in C. S. E., the rate of responding to positive stimulus in original trainig exceeds the others significantly. This sort of response was found in eight pigeons (4, in C. S. E.-S. S. E. and 4, S. S. E.-C. S. E.).

Type IV. In S. S. E., the rate of responding to color was equal to that to tilt. In C. S. E., the rate of responding to positive stimulus was also equal to that in S. S. E.

This type of response was found in two pigeons (2 in S. S. E.-C. S. E.). It means that the influence of both color and tilt would be found, similar to that of Type III.

Fig. 2. Examples in 4 types of responding in extinction.
Type V. One pigeon responded only to the same positive stimulus as that in original training. It seems that this pigeon would discriminate the stimulus, based on Gestalt dictum.

As far as these results were concerned, no difference between orders of extinction trials (order: C. S. E. - S. S. E. or S. S. E. - C. S. E.) could be found.

It is noticed that not only one aspect of stimulus but also both aspects of it (color and tilt) influence to response as a cue of discrimination except Type I and V, which only four subjects show.

Discussion

In original training, it was found that almost all subjects reached 100% correct responses within three days. This indicates that all subjects have received overtraining after the third day.

Many hypotheses about attention have been presented; some of them seem to explain the responses observed in the present experiment. According to Trabasso & Bower (9), they are as follows: the pattern-component transfer hypothesis (Atkinson & Estes (1), Friedman (3)), cue additivity hypothesis (Warren (10)), configural hypothesis (Trabasso & Bower (9)), cue-dominance hypothesis (Lashley (4)), hypothesis of multiple analyzer (Sutherland & Mackintosh (8)) and habit-distribution hypothesis (Spence (7)). Type V, which only one pigeon showed, seems to be explained by configural hypothesis, because of its Gestalt dictum. Following this hypothesis, the presentation of a separated cue constitutes a new pattern. Expectation from cue additivity hypothesis would be fulfilled in Type III. Since compound relevant cue increased correct response in testing, when the relevant cue was given separately in training. Type III, however, could be explained by habit-distribution hypothesis. According to this hypothesis, a subject is expected to show an intermediate degree of transfer to each relevant cue tested singly, but the two cues will not necessarily show equal transfer. Pattern-component hypothesis supposes that a
subject responds first to the conditioning of the entire pattern and the elements of the stimulus separately are conditioned to the same response. This could be found in Type II, Type III and type IV.

The hypothesis of multiple analyzer explains that each analyzer works separately by itself and the response of each trial is consisted by a pattern which is made by the work of the analyzer. If this pattern is not a single one, this hypothesis may explain the results of the present experiment. However, those hypotheses may be useful in the analysis of each part of the results, they must be combined systematically for the explanation of whole result.

In REYNOLDS’ experiment, only one aspect of stimulus was concluded to be a cue in discrimination learning in which the stimulus has two aspects. This may support cue-dominant hypothesis. This hypothesis assumes that the subject’s attention is restricted to one aspect at a time and whenever the subject eventually finds one relevant aspect to solve the problem, he does not seek for any aspects further.

Nevertheless, in the present experiment it was shown that both aspects of a stimulus worked together and the function of an irrelevant cue (such as “tilt” dimension in this experiment) could not be ignored.

Summary

Pigeons were trained to respond to a stimulus that contains two aspects in itself and were tested on attention in extinction trials. In the experiment of REYNOLDS, one single aspect became a cue to discriminate the stimulus. In the present experiment, however, it was found that both of two aspects worked effectively and the irrelevant cue also had a noticable effect.
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References


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