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PIGEON CONCEPT FORMATION: SUCCESSIVE AND SIMULTANEOUS ACQUISITION[1]

R. K. SIEGEL AND W. K. HONIG

DALHOUSIE UNIVERSITY

Pigeons were trained to discriminate the presence of one or more human forms in displays projected on a panel above the response key. This task was mastered, although imperfectly, with successive and with simultaneous presentations of positive and negative instances. The course of acquisition of the discrimination was similar for the two training procedures. Animals were able to transfer the discrimination from the successive to the simultaneous situation. Various tests were carried out to control for artifactual cues on which the discrimination might have been based. The discrimination was maintained when new displays were presented, when reinforcement was omitted, and when displays were inverted 180°. Animals were also able to discriminate between pairs of displays that were identical, except that one member of the pair contained a human form. The research extends the techniques used by Herrnstein and Loveland (1964), and confirms their finding that pigeons can master the concept of "person-present" in a visual display.

Herrnstein and Loveland (1964) studied the complex visual concept of "human being" in the pigeon, and concluded that the pigeon "readily forms a broad and complex concept when placed in a situation that demands one". In their procedure, pigeons learned to discriminate between the presence and absence of human forms in successively presented visual displays that represented "real scenes". The positive and negative instances varied on a large number of visual dimensions. Groundbreaking and unusual research of this kind invites extension and replication. Since there is some reason to believe that concept attainment is facilitated through simultaneous presentation (Cahill and Hovland, 1960; Hovland and Weiss, 1953), we investigated successive and simultaneous presentation of visual displays, both in training and testing. The method provided a discrimination ratio based on response rates, which made it possible to compare performance in the two training and testing procedures. While Herrnstein and Loveland showed convincingly that response rates were faster to positive instances of the concept at the end of training, their data were not presented in terms of common measures of discrimination performance, in which response rates to positive and negative trials are compared for each session. Nor did they present the course of acquisition of the discrimination; the data illustrated in their paper were restricted to two selected sessions presumably obtained after discrimination performance had stabilized.

METHOD

Subjects

Eight naive loft-reared homing pigeons were maintained at 70% of their free-feeding weights.

Apparatus

The chamber was equipped with two 2 in. by 3 in. (51 mm by 76 mm) screens, one on each side of a centrally positioned food magazine. The screens were angled in towards the bird at an angle that approximated the lateral placement of the eyes in the bird's head. Each screen could be transilluminated by a Kodak Carousel slide projector. Response keys were below each screen. Scheduling equipment was in a separate room.

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Procedure

Successive discrimination group. Four animals were trained to discriminate between the presence and absence of human forms in daily sessions of 40 successively presented slides (one screen illuminated). Slides were selected from a wide variety including landscapes, animals, humans, and inanimate objects. The slides containing human forms included people of various races, ages, and sizes. They were dressed in a variety of ways, were displayed in various attitudes, and occupied different positions in and portions of the displays. Positive slides contained at least one human form or part thereof. Responses in their presence were reinforced on a schedule that provided grain reinforcement at irregular intervals averaging 37.5 sec. Negative slides without human forms were presented while extinction was in effect.[2] Each session consisted of 20 positive and 20 negative trials, randomly alternated, and 60 sec long. Each trial was followed by a timeout interval of 10 sec. The slides presented during a session all differed from each other, and different sets of slides were presented in each session. Slides were randomly selected for presentation during specific sessions. The slide library was sufficient to arrange about seven sessions (280 slides) without repetition. Since 36 training sessions were given before the first test, each individual slide was repeated about five times. Only one panel was illuminated during this stage of training.

After 36 sessions, all birds were given three tests with slides presented successively. For all of these tests, "new" slides were used that had not been presented during training (20 positive and 20 negative instances), but reinforcement was never available. At least three regular training sessions intervened between tests in order to counteract extinction of the response or disruption of the concept incurred in testing. The first test ("successive test") was simply carried out with a set of new slides. In the second test ("180° test"), the pictures were inverted by rotating the slides by 180°. In the third test ("focus test"), the slides were presented out of focus to such a degree that, for the human observer, the contours of the figures dissolved into the background, although the main patches of color retained their distribution in the picture.

In the next phase of training, the pigeons were prepared for simultaneous testing. While only one screen was illuminated at a time during training sessions, its position alternated in a random fashion from trial to trial. The second phase of testing consisted of three tests in which a negative and a positive slide were simultaneously presented on each trial. Four regular training sessions intervened between tests. The first test ("simultaneous test") involved 40 pairs of "new" slides not presented before. The members of each pair differed in the many ways distinguishing the positive and negative slides presented in successive training and testing. In the second test ("matched pairs test"), pairs of slides were shown. Each pair consisted of two photographs of the same scene that differed only in that one or more human forms were present in one picture and absent in the other. The third test ("mannequin pairs test") consisted of matched pairs of slides in which mannequins ("Barbi-Dolls") were used instead of real people. The use of mannequins permitted greater flexibility in the composition of the slides, and control over such photographic factors as lighting and contrast.

Simultaneous discrimination group. Four birds were trained in 37 sessions with simultaneous presentation of one positive and one negative slide on each screen. The general procedure differed from that described above in the following ways: (1) Each trial ended with one reinforcement scheduled on a VI 37.5-sec schedule. This made it impossible for the pigeon to use the occurrence of a reinforced response as a cue. (2) An error-delay following each incorrect response made reinforcement unavailable for 5 sec. The length of each trial was therefore determined by the interreinforcement interval, but it could be extended if the pigeon made errors less than 5 sec before reinforcement was due. (3) Only simultaneous tests were given. Each test trial lasted for 60 sec, followed by a 10-sec intertrial interval. The first test involved unmatched pairs of "new" positive and negative slides, and was identical to the "simultaneous test" presented to the successively trained group. The second test, which followed four regular train-

[2]The authors are indebted to the Nova Scotia Tourist Bureau for providing some hundreds of slides, and to friends and colleagues for the use of their personal slide libraries. Readers who desire a more detailed account of the slides used should write to either of the authors.

ing sessions, was identical to the "mannequin pairs test" described above. The birds were then given seven training sessions in which positive slides contained a mannequin or part thereof, instead of the usual human being. Negative displays were of the usual variety, and were not matched with the positive slides in any way. Animals were then tested for the third time with a new set of matched pairs of mannequin slides ("mannequin pairs 2").

RESULTS

Successive training group. The acquisition of the discrimination by the successive group is illustrated in Fig. 1. The daily performance of each subject was summarized as a discrimination ratio, which is the proportion of total responses made during positive trials in the course of a session. Mean discrimination ratios are presented for blocks of five sessions. Individual data are also shown for one typical subject. Initial performance was near 0.50, and the discrimination appeared to develop progressively, although slowly. While the graph suggests that further improvement might be obtained with additional training, this was not actually found in the training sessions carried out between tests with the successive group.

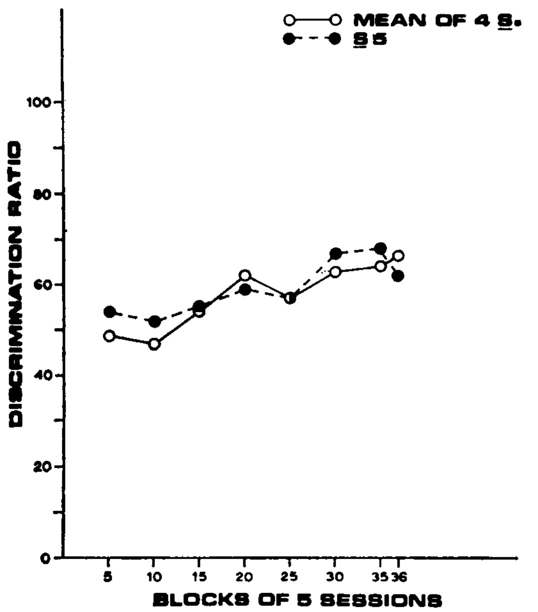

Fig. 1. Discrimination ratios obtained from pigeons trained on the successive discrimination. The data from one typical animal are shown together with the mean data for the group.

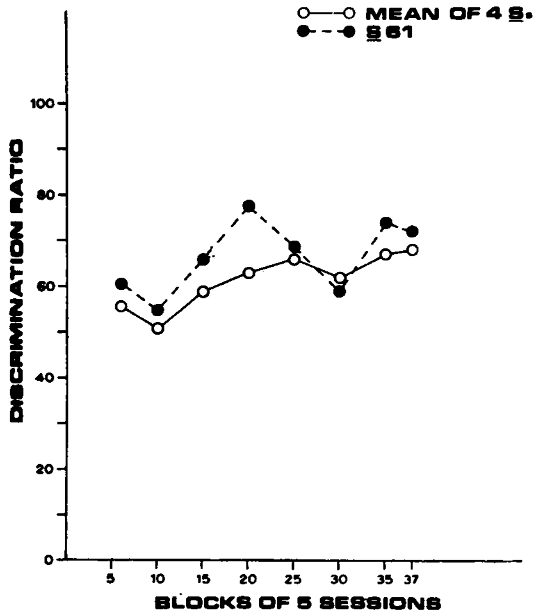

Fig. 2. Discrimination ratios obtained from pigeons trained on the simultaneous discrimination. The data from one typical animal are shown together with the mean data for the group.

Table 1 presents the discrimination ratios obtained from each pigeon for each test session, and on the three training sessions immediately preceding each test. All birds provided very consistent pre-test ratios, which were, of course, obtained under very similar conditions. The ratio obtained on the first successive test is higher for each bird than the corresponding pre-test ratio, perhaps because the positive slides were selected to provide human forms that were easily detectable. While the discrimination was remarkably well maintained during the test with inverted slides, the presentation of the visual material out of focus resulted in a marked reduction of the discrimination for three of the four birds. The first test with simultaneous positive and negative slides provided a very high discrimination performance for all four birds. Results from the first matched pairs test were not quite as good, but the second test of this kind (involving mannequins) provided better discrimination ratios.

Simultaneous training group. The mean discrimination ratios are presented in Fig. 2, with the data from one bird again presented separately. Again, the increase in performance is very gradual. For this group, discrimination performance improved between tests, as seen

Table 1

Mean Pre-Test and Test Discrimination Ratios for the Successive Discrimination Group

Bird	Pre-Test	Successive Test	Pre-Test	180° Test	Pre-Test	Focus Test	Pre-Test	Simultaneous Test	Pre-Test	Matched Pairs Test	Pre-Test	Mannequin Pairs Test
B5	0.66	0.83	0.65	0.68	0.62	0.46	0.64	0.89	0.62	0.65	0.64	0.85
B41	0.71	0.86	0.70	0.75	0.68	0.58	0.76	0.96	0.75	0.88	0.70	0.75
B56	0.61	0.65	0.61	0.63	0.61	0.52	0.60	0.98	0.66	0.70	0.63	0.88
B59	0.61	0.68	0.60	0.60	0.57	0.60	0.62	0.95	0.65	0.73	0.61	0.81
Mean	0.65	0.76	0.64	0.67	0.62	0.54	0.66	0.95	0.67	0.74	0.65	0.82

in Table 2. This improvement is found for all pigeons. It should be noted, however, that the last pre-test sessions were carried out with mannequin slides as the positive instances.

The performance on the first test is practically the same as that on the pre-test sessions, reflecting the similarity between training and test conditions in this case. For the remaining tests, performance was lower than during the preceding training, probably because these tests involved matched pairs of stimuli. (Since the training sessions preceding the last test involved mannequin slides, it cannot be argued that the deterioration in performance was due to the shift from real people to mannequins in the positive instances of the concept.)

DISCUSSION

By the usual criteria for concept attainment, the pigeons in this experiment acquired the concept of "person-present" in the positive displays. They learned the discrimination on the basis of a variety of positive and negative instances, they transferred the discrimination to a set of instances not previously presented, and they maintained the discrimination in the face of more than one change in testing conditions. On the other hand, during the "focus test", the discrimination was largely disrupted with the change of an essential feature that removed a cue critical to the discrimination.

With an unusual task of the kind demanded here, we should ask whether there were any artifacts that could account for the level of discrimination achieved. It is unlikely that the birds used the occurrence of a reinforcement as a cue for the positive instances. In simultaneous training, this was not possible, since each period ended with a reinforcement. Following successive training, the discrimination was maintained during testing in the absence of any reinforcement and was transferred to simultaneous presentation of stimuli at a very high level.

With regard to the displays themselves, we may consider whether any feature of the stimuli correlated with the presence of human forms provided a spurious basis for the discrimination. The positive slides may have been on the average more complex; there may have been more blue sky in the negative slides, which tended to be landscapes; human forms tend to be located in the foreground, and thus in the lower part of a display, and so forth. It is of interest to note that the discrimination was maintained even when the pictures were inverted, which would control for some of these factors, such as the latter. But blurring of the contours which made the forms difficult to identify (for the human observer at least), but maintained the distribution of colors in each slide, reduced the level of accuracy in three of the four pigeons in Exp. 1.

Table 2

Mean Pre-Test and Test Discrimination Ratios for the Simultaneous Discrimination Group

Bird	Pre-Test	Simultaneous Test	Pre-Test	Mannequin Pairs Test 1	Pre-Test	Mannequin Pairs Test 2
B15	0.66	0.70	0.78	0.64	0.78	0.69
B17	0.71	0.78	0.76	0.74	0.89	0.63
B61	0.69	0.65	0.77	0.70	0.96	0.62
B62	0.54	0.52	0.56	0.54	0.73	0.62
Mean	0.65	0.66	0.72	0.66	0.84	0.64

The strongest argument in favor of a "true" discrimination based on the presence of a human form is the positive outcome of the matched pairs tests. These tests provide as careful a control for spuriously correlated visual factors as the experimental situation will permit. While the performances were not always outstanding on these tests, there is no question but that the discrimination was maintained. Actually, the slides presented in such tests may be confusing to the bird, since so many elements in the two matched displays are identical. In any ordinary discrimination task one would expect poorer performance with very similar displays, and this is precisely what we obtained in the matched pairs tests. If training were carried out with matched pairs, the final level of test performance might approach that obtained with unmatched pairs.

Training and test ratios, while consistently above 0.50, did not reach the high levels normally obtained with pigeons on simple visual discriminations of form, color, *etc.* Before the first test, the mean discrimination ratio was 0.65 in both experiments. While this ratio actually reflects a considerable difference in response rates to the positive and negative stimuli (about 2:1 for 0.65), it does not approach the level of 10% errors that is frequently set for pigeons as a criterion for visual discrimination problems.

Since the birds responded very consistently to the positive stimuli, the discrimination ratios reflect imperfect extinction to the negative instances. There may be several reasons for this, and they need not be the same for both training conditions. The variety of negative instances may have prevented reliable suppression of responding. In most discrimination training, the negative stimulus is a specific constant stimulus pattern, but in the current work, it changed from trial to trial. Very little is known about the attainment of discriminations involving multiple negative instances, and it is therefore difficult to relate this hypothesis to "standard" discrimination experiments.

A second possibility is that the birds responded to negative slides because of the overlap in visual content between the positive and negative instances. The slides containing the human form also had many features in common with the negative slides, such as trees, buildings, sky, and so forth. Recent work on the "feature positive effect" (Jenkins and Sainsbury, 1969) indicates that discrimination learning in pigeons is markedly affected by common features present in positive and negative displays. Our "common" features were, of course, not the identical stimulus elements used by Jenkins and Sainsbury, but represented members of the same class of objects that appear in varying forms in the pictures. Nevertheless, it is possible that if the pigeons recognize objects in the slides without special training (as Herrnstein and Loveland suggest) they will respond on the basis of the presence, say, of a tree in the picture, which would, of course, be found in positive as well as negative slides.

Very few direct comparisons of simultaneous and successive training procedures can be found in the operant discrimination literature. Honig (1962) compared the acquisition of a spectral discrimination between 550 nm positive and 560 nm negative. The simultaneous problem was mastered with many fewer errors than the successive, and discrimination ratios were much higher for the former, although all birds eventually achieved extinction to the negative stimulus on both problems. In the present study, the simultaneous birds did not learn the problem more rapidly, nor did they achieve a notably higher level of training, except for the training sessions preceding the last test. These sessions involved mannequin slides as positive instances, and may have provided an easier set of stimuli for that reason.

To explain his results, Honig argues that "true" extinction to the negative stimulus was required and achieved only in the successive case. In simultaneous training, the pigeons could use the negative stimulus as a cue to switch to the positive stimulus. This interpretation was in part based on tests that showed that the successive discrimination transferred perfectly to the simultaneous case, while the reverse was not true. The present failure to obtain superior performance in simultaneous training can be understood if we assume that the subjects need to have a consistent stimulus both for extinction in the absolute sense (successive condition) and as a cue to switch to the positive stimulus (simultaneous condition). It is interesting that when the successive birds were given simultaneous tests, their performance improved markedly. In this condition, inhibition of responding is not required, since the positive stimulus is concurrently available. Unfortunately, the simultaneous birds were not given a successive test, but it is unlikely that they would have shown any great improvement over their simultaneous performance.

The research reported here does not exhaust the conditions under which a concept of the kind required can be attained. Other training procedures may well result in very high levels of discrimination. It might be possible, for example, to teach pigeons a few positive and negative instances to a very high degree of performance, and then to enlarge the classes gradually, *cf.* Lehr (1967). Perhaps the ultimate performance would reach a high level if matched pairs were used throughout training, forcing the animals to isolate the specific features that differentiate positive from negative slides. Such questions are intriguing and should be the subject of further research efforts. The kind of result reported here is certainly of interest and value to psychologists who concern themselves with bridging the gap between the highly specific and controlled sets of stimuli used in most research on stimulus control, and the complex and varying objects that govern the behavior of many animals in real life.

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