Backward association in pigeons¹

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After three pigeons learned two paired-associate color sequences, they were tested with the colors in each sequence reversed. These tests showed that the pigeons had formed a backward association, and that the forward association was stronger than the backward association, but not significantly so.

In a recent paper on human verbal learning, Asch & Ebenholtz (1963) conclude that forward (a-b) and backward (b-a) associations are of equal strength. They argue that the reason most studies do not support this conclusion is that the b-terms are more "available" to recall than the a-terms by virtue of training procedures (Asch & Ebenholtz, 1963, Experiment 1).

It would be of interest to compare man with lower animals in associative symmetry (or asymmetry) and to examine the role of availability in sub-human species. The prerequisite to such a study is the demonstration that lower animals are capable of forming a backward association. To the best of my knowledge, backward association has never been demonstrated in birds. Thus, the present experiment examines the ability of birds (pigeons) to form a backward association.

Procedure

Three pigeons were taught two color sequences. They were then tested for backward association with the colors in each sequence reversed. The paradigm was $A \rightarrow X$ and $B \rightarrow Y$ in training and $X \rightarrow A$ and $Y \rightarrow B$ in backward testing, where A and B represent stimulus (S) colors and X and Y response (R) colors. A, B, X, and Y were selected from the colors red, green, blue and yellow. In training, pigeons were presented with A or B followed by X and Y. In backward testing, X or Y was followed by A and B.

Pigeons I and II (II died) were randomly assigned to the color combinations red $\rightarrow$ green, blue $\rightarrow$ yellow, and pigeons III and IV to the reverse combination (G $\rightarrow$ R, Y $\rightarrow$ B). They pecked lighted buttons arranged in a triangle with one stimulus-button on the bottom and two response-buttons on top. The steps in the training procedure were as follows: (1) S-light came on. (2) Pigeon pecked it. (3) S-light went off and the two R-lights came on. (4) If pigeon pecked the correct response-light, food was delivered in 50% of the trials. The other 50% were unreinforced. (5) If pigeon pecked an incorrect R-light, an overhead light went off, leaving the bird in darkness for about 10 sec. (6) Back to step (1). A training session, one per day, consisted of 56 trials, 7 blocks of 8 trials. The eight possible combinations of stimulus colors (A or B), response-light positions (X on right, Y on left or vice-versa), and

reinforcement or nonreinforcement appeared in random order in each block.

The initial plan was to train all birds to a criterion of 90% correct for two sessions in a row, under a system where total pecks (56) were constant and total correct pecks varied. But after 100 sessions, since pigeons III and IV had learned very little, the criterion was changed to 75% for two sessions in a row, under a system where the number of correct pecks (56) was constant and total pecks were permitted to vary.

After a bird reached criterion, it was tested: first in the backward direction ($X \rightarrow A$, $Y \rightarrow B$), then forward (in training order), then backward again. The test trials were unreinforced; however, incorrect responses caused the overhead lights to go off for 10 sec. In backward testing, one of the previous response colors (X or Y) appeared in the bottom button and the two previous stimulus colors (A and B) appeared in the top buttons. The pigeon first pecked the bottom color, previously a response color but now in the stimulus position, and then had a choice between two colors in the response positions that had previously been stimulus colors. Each test was given on the day after the criterion had been reached and consisted of 28 trials. Between tests, each pigeon was retrained to criterion.

Results

Table 1 shows the test scores, i.e. the number of correct responses in 28 backward association trials and the p value as compared to chance performance. Pigeons I and III showed reliable evidence of having formed a backward association. Although pigeon IV did relatively poorly on the backward association tests, when the data from the three pigeons are combined, the proportion of correct responses in the backward tests is greater than chance. The poor performance

Table 1.
Number of Correct Pecks in 28 Trials in Each of Three Tests

	Pigeon			
	I	III	IV	Combined
No. training sessions	53	123	155	
1st test, backward	18	17	14	$p > .10$
2nd test, forward	25	23	16	$p < .01$
3rd test, backward	18	19	18	$p < .05$
Both backward tests	$p < .05$	$p < .05$	$p > .10$	$p < .02$
Difference	$p > .10$	$p > .10$	$p > .10$	$p > .10$

Note: The p values are for the null hypothesis that the probability of pecking correctly was .50 on each trial, except in the bottom row, where p is for the null hypothesis that the difference is zero between proportion of correct backward and forward test trials. In the "combined" column, p was obtained from the entries in the other three columns by the formula $-2 \sum \ln p \cdot x^2(6)$.

of pigeon IV may have been caused by erratic behavior which was exhibited throughout the experiment.

Discussion

Three things may be concluded from the data: first, that pigeons are capable of forming associations between colors; second, that these pigeons formed a backward association; and third, that the forward association was not significantly stronger than the backward association.

It is likely that these results are related to the manner of training; specifically, requiring the pigeon to peck at the stimulus color before pecking at the response color. In terms of the Asch-Ebenholtz studies, this procedure may help to equalize the "availability" of the S- and R-colors as contrasted to a procedure which requires pecking at R only. The present procedure was adopted in the belief that it would enhance the likelihood that the pigeons would pay attention to the S-color. Using a procedure which requires pecking the R-color only might result in the backward association being significantly weaker than the forward association.

It could be argued that the blackout after an incorrect response in backward testing strengthened the backward association. If the blackout explanation is correct, then the number of correct responses in the last half of the tests should be greater than those in the first half. This explanation is not supported by the data; the total number of correct pecks in the first 14 testing trials

over all pigeons equaled the total correct in the last 14 trials. The same result was also true for the first versus the last 10 trials, as well as for the first versus the last 5 trials. Therefore, it would appear that the blackout during testing did not strengthen the backward association.

It should be noted that the results of this study are based upon intra-individual performance and not upon comparisons between pigeons. Therefore, the loss of pigeon II and the erratic behavior of pigeon IV do not destroy the conclusion drawn from the experiment.

The capacity to form backward associations may be used to evaluate differences in intelligence or learning ability, in much the same way that Bitterman (1965) has used the tasks of habit reversal and probability learning for evolutionary comparisons of learning ability.

References

- Asch, S., & Ebenholtz, S. The principle of associative symmetry. *Proc. Amer. Phil. Soc.*, 1962, 106, 135-163.
Bitterman, M. E. Phyletic differences in learning. *Amer. Psychol.*, 1965, 20, 396-410.

Note

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Reply to David J. Barker by Allan L. Jacobson

Barker is correct in concluding that by "predominant choice," we meant the alternative chosen 13 or more times on the 25 test trials. We did not intend to suggest anything else, and in fact, we pointed out in the text that "absolute preferences were on the whole small."

As for the statistical test; the approximate number of Ss and the way we would treat the data were decided in advance. We did not expect to obtain strong preferences,

even if our results were positive, since (among other reasons) recipient rats were never rewarded during testing; thus we chose a "sensitive" criterion of preference. Perhaps in so doing, we inadvertently capitalized on the vagaries of χ^2 . If so, Dr. Barker is indeed justified in considering our conclusion too strongly stated. We hope at some future time to resolve this question more satisfactorily in the laboratory.

For Comment on Jacobson et al see page 314.