Visual probability-learning in the monkey

Wm. A. Wilson, Jr., Marlene Oscar and M. E. Bitterman
BRYN MAWR COLLEGE

Abstract

Two rhesus monkeys were trained by the correction method in a 70:30 red-blue discrimination under conditions in which they were required to earn each opportunity for choice. In subsequent phases of the experiment, the reinforcement-ratio was changed to 50:50, then to 30:70, and again to 50:50. In the 70:30 and 30:70 phases, both monkeys maximized. In the 50:50 phases they showed non-random matching, tending on each trial to avoid the side rewarded on the preceding trials. The relation of these results to those of experiments with other species is considered.

Problem

After three experiments had yielded no evidence in monkeys of any sort of correspondence between choice-ratio and reinforcement-ratio (Wilson & Rollin, 1959; Wilson, 1960; Meyer, 1960), a fourth experiment produced matching with reinforcement-ratios of 50:50, 60:40, and 70:30 (Wilson et al., 1964). The purpose of this fifth experiment was to provide some data on visual probability-learning under conditions like those of the fourth experiment, in which the alternatives were differentiated only *spatially*. As in the fourth experiment, an automated testing situation was used instead of the WGTA, the ratio of reinforcement was controlled by a pure correction method, and S was required to earn each opportunity for choice—the initial presentation of the alternatives on each trial, and their re-presentation after each error.

Method

The Ss of the fourth experiment (two rhesus monkeys about 4-5 yr. old) were used again in this one. They were tested in a ventilated, sound-reducing chamber, one wall of which displayed three circular panels of translucent Plexiglas (2 in in diameter, 2 in apart edge-to-edge, and 14 in above the floor) and a food-cup (10 in below the center-panel). The chamber was dark at the beginning of each session. After a 7-sec. interval, the center-panel was illuminated with white light. Ten presses on the center-panel darkened it and illuminated the two side-panels, one with red and the other with blue light, the positions of the two colors varying from trial to trial in accordance with selected Gellermann orders. A correct choice (pressing the correct side-panel) delivered a piece of food to the food-cup and illuminated its aperture with white light for 3 sec., after which there was a 7-sec. intertrial interval in darkness. An incorrect choice produced a 10-sec. time-out in darkness, after which the center-panel was lighted again, and the same contingencies were in effect as before; there was no limit to the number of repetitive errors that could be made on any trial. The animals were tested in 40-trial

daily sessions, a trial being defined as a series of choices ending in a correct choice.

For the first 2400 trials, the red-blue reinforcement-ratio was 70:30; that is, red was correct on 70% of trials and blue on the remaining trials. The reinforcement-ratio was changed to 50:50 for the next 1800 trials, then to 30:70 for the next 2400 trials, and then to 50:50 for the last 2400 trials. Random series were chosen to determine which color would be correct on each trial, with the restrictions that each color be correct at least once in each block of five trials and that the reinforcement-ratio in any session be exactly equal to the prevailing ratio. All of the experimental contingencies were programmed automatically, and the responses of the animals were recorded on tape.

Results

Figure 1 shows for each animal the percentage of trials throughout the experiment on which its initial choice was red (the 70% color of the first phase). In the first and third (70:30 and 30:70) phases of the experiment, both animals maximized, but in the second and fourth (50:50) phases, their choice-ratios approximated the reinforcement-ratio.

Choice-ratios near 50:50 in a visual problem may occur solely as a result of strong position-preferences, but in the present case they do not—the percentage of response to either position exceeded 80% only in one of 42 200-trial blocks during which the reinforcement-ratio was 50:50. The animals were not, however, re-

Fig. 1. The percentage of red-choices by each animal in each phase of the experiment. The horizontal lines show the probabilities with which red-choices were reinforced. The arrow shows the point at which there was an interruption of about one week in the training of No. 20 consequent to the birth of an infant. Thereafter, mother and infant were taken together to the experimental situation.

sponding randomly with respect to position; both showed a strong tendency (as they had in the previous experiment) to avoid on any trial the rewarded position of the preceding trial. For example, in the last 1800 trials of 50:50 training (blocks 37-45), the initial choice of No. 20 was left on 85% of the trials following reward on the right as compared with 40% of trials following reward on the left. The two percentages fluctuated to some extent in the course of training—for example, in blocks 40-42 they were 80% and 25%, respectively, while in blocks 43-45 they were 95% and 55%—but the discrepancy was evident throughout. A like discrepancy appeared in the data of No. 21, which showed a substantial right-preference during most of these trials. In blocks 37-43, it went left on about 45% of the trials following a reinforcement on the right as compared with 15% of trials following reinforcement on the left. In the last two blocks, the right-preference washed out, and the values became 75% and 25%, respectively.

There is some evidence that No. 21 was influenced by color during the 50:50 training: it showed a moderate over-all preference for blue in the fourth phase of the experiment which turned out upon analysis to be due primarily to a low probability (about 20%) of response to red following reinforcement of red-on-the-right. This color-position interaction washed out in the last two blocks (44-45), along with the right position-preference to which reference has already been made. There is no evidence that No. 20 was influenced by color during the 50:50 training.

It may be well to emphasize that all the data here presented are for the initial choices of each trial. Having had considerable previous experience with correction, the animals actually made rather few repetitive errors. The median daily number of repetitive errors was only 6 for No. 20 and 2 for No. 21 in the first block of trials; the frequency of these errors decreased throughout the experiment and the corresponding values for the last block were 0 and 1, respectively.

Discussion

Experiments on probability-learning in animals have yielded three main effects. *Maximizing* has appeared under certain conditions in all species tested. Rat and monkey have shown what may be called *non-random matching*. The term signifies that an animal's choice-ratio approximates the reinforcement-ratio, but that evidence of sequential dependency appears in its choices. For example, the animal may tend strongly to prefer (Overall & Brown, 1959; Hickson, 1961) or to avoid (Wilson et al., 1964) on any trial the reinforced alternative of the preceding trial. Simpler organisms, such as

fish (Bitterman et al., 1958; Behrend & Bitterman, 1961), pigeon (Bullock & Bitterman, 1962; Graf et al., 1964), and cockroach (Longo, 1964), have shown what may be called *random matching* in the sense that evidence of sequential dependency is lacking. Random matching has been found also in decorticated rats (Gonzalez et al., 1964).

As we ascend the phyletic scale, random matching drops out first, and non-random matching appears first, in spatial as compared with visual problems. The fish has shown random matching in visual and in spatial problems, but the pigeon (as well as the decorticated rat) has shown random matching only in visual problems. The non-random matching found in the normal rat and in the monkey has reflected strategies of a predominantly spatial kind and has appeared only where there has been no differential reinforcement for response to visual properties. In the monkeys of the present experiment, a 70:30 visual problem produced only maximizing, although a 70:30 spatial problem previously had produced non-random matching.

References

- BEHREND, E. R., & BITTERMAN, M. E. Probability-matching in the fish. *Amer. J. Psychol.*, 1961, 74, 542-551.
- BITTERMAN, M. E., WODINSKY, J., & CANDLAND, D. K. Some comparative psychology. *Amer. J. Psychol.*, 1958, 71, 94-110.
- BULLOCK, D. H., & BITTERMAN, M. E. Probability-matching in the pigeon. *Amer. J. Psychol.*, 1962, 75, 634-639.
- GONZALEZ, R. C., ROBERTS, W. A., & BITTERMAN, M. E. Learning in adult rats with extensive cortical lesions made in infancy. *Amer. J. Psychol.*, 1964, 77, in press.
- GRAF, V., BULLOCK, D. H., & BITTERMAN, M. E. Further experiments on probability-matching in the pigeon. *J. exp. Anal. Beh.*, 1964, 7, in press.
- HICKSON, R. H. Response-probability in a two-choice learning situation with varying probability of reinforcement. *J. exp. Psychol.*, 1961, 62, 138-144.
- LONGO, N. Probability-learning and habit-reversal in the cockroach. *Amer. J. Psychol.*, 1964, 77, in press.
- MEYER, D. R. The effects of differential probabilities of reinforcement on discrimination learning by monkeys. *J. comp. physiol. Psychol.*, 1960, 53, 173-175.
- OVERALL, J. E., & BROWN, W. L. A comparison of the decision-behavior of rats and of human subjects. *Amer. J. Psychol.*, 1959, 72, 258-261.
- WILSON, W. A., JR. Supplementary report: Two-choice behavior of monkeys. *J. exp. Psychol.*, 1960, 59, 207-208.
- WILSON, W. A., JR., & ROLLIN, A. R. Two-choice behavior of rhesus monkeys in a noncontingent situation. *J. exp. Psychol.*, 1959, 58, 174-180.
- WILSON, W. A., JR., OSCAR, M., & BITTERMAN, M. E. Probability-learning in the monkey. *Quart. J. exp. Psychol.*, 1964, 16, in press.

Note

1. This research was supported by Contract Nonr 2829(01) with the Office of Naval Research and by Grant MH-04472 from the Public Health Service.