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Long-delay visual discrimination learning in monkeys (*Cebus apella*)

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The position and arm preferences of four cebus monkeys were assessed before they were trained on a simple visual discrimination between the black and striped arms of a T-maze. Only the animal for which the preferred arm served as S+ "learned" the visual discrimination. Extensive preextinction sessions given to one animal failed to abolish a left-turn preference, which reemerged and increased during visual discriminative training. The methodological significance of preexisting and concurrently formed stimulus and response preferences in long-delay learning was discussed.

We have recently shown that cebus monkeys rapidly acquire a cue-correlated spatial discrimination in a T-maze with a 30-min reinforcement delay if the animals spend the delay interval in their home cages and if they do not have a strong initial preference for S– (D'Amato, Buckiewicz, & Puopolo, 1981). In contrast, animals that enter spatial discrimination training with a strong preference for S– fail to acquire the discrimination, even after prolonged training. Most likely, stimulus preferences and response biases also play a significant role in visual discrimination learning in T-mazes and related apparatuses. It is well known, for example, that even with immediate reward, animals frequently fall into response (position) biases from which they must recover before they can master the discriminative task. Such response biases are difficult to eradicate because of the partial reinforcement they receive; with delayed reinforcement, once established, they may be immutable (cf. D'Amato, Safarjan, & Salmon, in press; D'Amato & Cox, Note 1).

In the present T-maze experiment, monkeys had their position bias and arm (black or striped) preference assessed by preference tests that disassociated the two variables. Subsequently, the animals were trained on a simple visual discrimination with a 30-min delay of reinforcement. For one animal, the preferred arm was assigned as S+; for two others, S+ was identified as the nonpreferred arm. The expectation was that the first animal would show extremely rapid "learning" of the visual discrimination task, whereas the latter two would show little evidence of learning, possibly falling into strong position biases. An attempt was made to extinguish arm and response preferences in a fourth animal prior to visual discrimination training, in the hope of demonstrating efficient visual discrimination learning with a 30-min delay of reinforcement.

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METHOD

Apparatus and Subjects

The same T-maze used in previous experiments (D'Amato & Buckiewicz, 1980; D'Amato et al., 1981) was employed in this study. The walls of the arms could be made either black or striped by means of plastic inserts that attached to the walls. The end walls of the arms were made black or striped by appropriate positioning of the rear wall door, which was black on one side and striped on the other.

The four subjects ranged in age from 7.5 to about 18 years. Jocko, Pat, and Dagwood (the only female) had participated in a T-maze preference study (D'Amato & Buckiewicz, 1980); Phurp had no prior T-maze experience. The animals were maintained at approximately 85%-95% of their free-feeding body weights.

Procedure

Preference tests. Pat, Phurp, and Jocko were given four 3-min preference tests on separate days. The right arm of the T-maze was black and the left was striped during Tests 1 and 3; the opposite arrangement prevailed on Tests 2 and 4. During the preference tests, the guillotine doors leading to the arms of the T-maze were open, and the amounts of time spent in the left and right arms were recorded. The animal's initial choice (left or right) was taken to reflect its response (position) preference. The animal's preference for the black or the striped arm was defined as the percentage of time spent in the respective arms (time spent in the stem of the maze was excluded).

Visual discrimination training. One hundred free-choice trials were given on the visual discrimination task, one per day. During Days 1-50, the animal was given a second, forced, trial to the correct arm if it had been incorrect on the free-choice trial (S+ and S– remaining as they were on the free-choice trial). During each block of 10 free-choice trials, the right arm was black on 5 trials and striped on the other 5, arranged in a quasirandom sequence. Between each trial, the apparatus was wiped clean with a damp cloth.

A training trial proceeded as follows. The startbox door was raised 15 sec after the animal was introduced into the startbox. After making a choice (defined as entry into an arm sufficient to trip a contact circuit), the guillotine door leading to that arm was closed and the animal remained in the chosen arm for 20 sec, after which it was removed from the T-maze and transported to its living cage in the colony room, where it spent the 30-min delay interval. After correct responses, the animal was returned to the startbox, in which it found 25 raisins in a food cup; after incorrect responses, it spent 1 min in the empty startbox. At least 30 min separated forced from free trials.

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Preextinction sessions. Dagwood was given 20 10-min preextinction sessions in the T-maze in an attempt to extinguish any arm or response preference that she might have. The right arm was black on 10 of these sessions and striped on the other 10. The animal's preference for the black and striped arms was measured during the first 3 min of each session, and its initial turning response was recorded.

Because the left arm was Dagwood's initial choice on 19 of the 20 sessions, she was given an additional 10 days' extinction experience in which the door to the left arm was closed, forcing the subject to the right. Visual discrimination training followed, which was the same as that given to the other three animals, except that the forced-trial procedure was applied throughout training.

RESULTS

Preference Tests

On the four preference tests, Pat, Phurp, and Jocko averaged, respectively, 90.2%, 98.7%, and 66.0% time in the black arm. The left arm was initially chosen by all three animals on three of the four preference tests. Thus, the animals displayed a moderate to strong preference for the black arm; their response (position) preference, if any, was a left-turn bias. The black arm was assigned as S+ for Phurp and as S– for Pat and Jocko.

Preextinction Sessions

As already indicated, Dagwood had a very strong left-turn bias, directing her initial choice to the left arm on 19 of the 20 extinction sessions. Coupled with this response bias was a mild (55.4%) preference for the black arm. Preference for the black arm interacted with its position, so that when the black arm was on the left side of the T-maze, Dagwood's preference for that arm was 68.3%. The striped arm was assigned as S+ for this animal.

Visual Discrimination Learning

Figure 1 presents the percentage of correct responses on free-choice trials for Pat, Phurp, and Jocko; the percentage of choices of the left arm also appears in the figure. As might have been predicted from the preference data, Pat was unable to learn to choose the striped arm. Although at the outset of training, Pat responded to the left consistently, this predilection dissipated somewhat in the fourth block of free-choice trials, only to strengthen subsequently, so that over the last 50 free-choice trials, he chose the left arm 49 times. On those few occasions that he did venture into the right arm, it was black in all but one instance.

Phurp maintained his strong initial preference for the black arm throughout visual discrimination training, choosing the black arm exclusively during the last two blocks of trials. This preference for the black arm, coupled with a less strong left-turn bias, is responsible for the fact that Phurp's percent correct and percent left response functions were mirror images of each other: All of Phurp's errors occurred with the striped arm on the left.

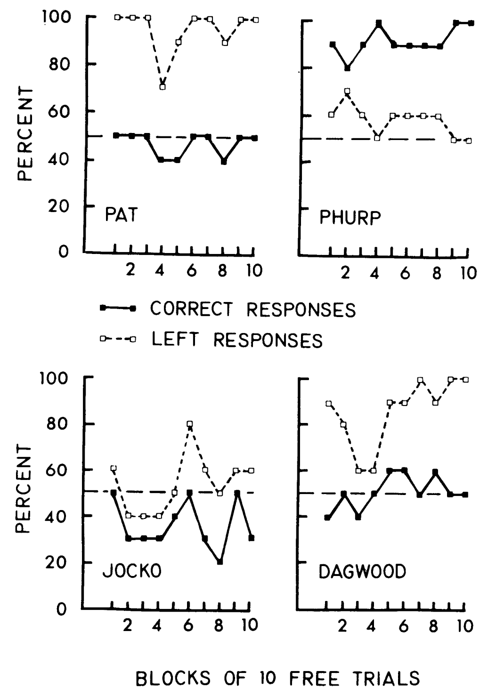

Figure 1. Percentage of correct responses and percentage of left-turn responses during the 100 free-choice visual discrimination trials. For Phurp, S+ was the preferred arm, as determined by preference tests that preceded visual discrimination training; for the other three animals, S+ was the nonpreferred arm.

Despite Jocko's relatively moderate initial preference for S– (66%), he gave no evidence of learning the visual discrimination by the end of the 100 free-choice trials. As is clear from the percent correct response function, the initial preference for S– was largely maintained throughout training. The fact that the graphs of percent correct responses are roughly parallel reflects the somewhat greater tendency for Jocko to be correct when the striped arm was on the left than when it was on the right (40% vs. 32%).

It will be recalled that Dagwood received 20 10-min extinction sessions prior to the beginning of visual discrimination training and an additional 10 trials in which she was forced to the right arm of the T-maze. Despite these measures, aimed at reducing or eliminating spatial and response preferences, Dagwood showed no sign of learning the visual discrimination by the end of training. She averaged 47.5% correct responses over the first block of 20 free-choice trials and 50% over the last two blocks. Rather than learn the programmed discrimination, she seems to have "learned" a left-turn response, averaging 72.5% left responses over the first 40 free-choice trials and 97.5% over the last 40 trials.

DISCUSSION

Clearly, other than Phurp, none of the animals showed the slightest indication of acquiring the visual discrimination within the allotted number of trials, which ranged from 127-149, including forced-choice trials. Would the animals learn this simple visual discrimination task with additional training? Possibly so, but there is reason to believe that the additional training would have to be very extensive. Jocko seemed to be the most promising prospect for profiting from additional training, and he was given 120 additional daily training sessions, which began immediately after the 100 sessions described above. During the first 50 of these, one free-choice trial was given, and, if Jocko was incorrect, it was followed by a forced-choice trial to S+. During the last 70 sessions, a second free-choice trial was given if the subject was incorrect on the initial free-choice trial. In all, Jocko had the benefit of 187 additional training trials, of which 141 were free-choice trials, making a grand total of 319 trials (241 free) administered over a 9-month period. Despite this prolonged training on the simple visual discrimination, over the last 30 free-choice trials, Jocko managed only 50% correct responses.

Phurp's high level of responding to S+, the black arm, does not in our view represent bona fide learning of the delayed-reinforcement contingency, anymore than Dagwood's performance indicates that she "learned" to go to the left side of the T-maze. Both instances appear to reflect a nonassociative amplification of a strong initial preference, perhaps due in part to receipt of reward in the experimental situation.

The possibility that receipt of reward in a delayed-reward situation will augment preexisting response or stimulus preferences presents a serious methodological problem with regard to demonstrating genuine long-delay discrimination learning. Suppose, for example, that animals enter a cue-correlated spatial discrimination situation with a relatively strong preference for the black over the white arm, and suppose that 50% of the animals are run with black and 50% with white as S+. This control procedure may not suffice if the animals for which black serves as S+ give indications of learning the delayed-reinforcement task but those trained with white as S+ do not. The increase in "correct" responses exhibited by the former group may simply reflect an amplification of the initial stimulus preference due to the receipt of reward in the experimental situation. Because the animals for which the white arm serves as S+ are likely to be less frequently rewarded, augmentation of their initial preference (for S−) may be less marked. Consequently, averaging the performance of the two groups does not necessarily provide an accurate estimate of the degree of bona fide long-delay learning that has been achieved.

Of course, little question can be raised about the genuineness of long-delay learning achieved when S+ is a nonpreferred alternative, but, as the present and earlier (D'Amato et al., 1981) results show, this is a risky procedure, one that greatly reduces the chances that long-delay learning will be observed. It is of interest in this connection that Grice (1948), who reported that rats were incapable of learning a black-white visual discrimination in a discrimination box with delays as short as 10 sec, trained his rats with the nonpreferred alternative (white) as S+, eliminating three animals that appeared to have initial preferences for the white discriminandum.

Perhaps a better control procedure is to select for long-delay discrimination training those animals that by pretest do not show a strong preference for any of the possible experimental alternatives. Judging from earlier results (D'Amato et al., 1981), this procedure is probably an adequate control for long-delay spatial discrimination learning, but in the case of visual discrimination learning it might not be sufficient, because of the possibility that position (or stimulus) preferences may develop during discrimination training itself. Once established (presumably on the basis of unprogrammed sources of reinforcement; e.g., removal from the experimental apparatus), such preferences are likely to be insensitive to the delayed reinforcement contingencies and may even be augmented by the partial reward schedule associated with incorrect alternatives.

REFERENCE NOTE

1. D'Amato, M. R., & Cox, J. K. *Long-delay discrimination acquisition and performance in monkeys.* Paper presented at the annual meeting of the Psychonomic Society, St. Louis, Mo., November 13, 1976.

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