On a conjecture of Bush and Mosteller

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Twenty-four rats were run in a successive T maze discrimination, with unequal frequency of stimulus presentation, and mixed random reinforcement. The contingencies of reinforcement were such that consistent position-habit responding would yield 65% random reinforcement, whereas errorless discriminative responding would yield 90% random reinforcement. Learning proceeded in two distinct phases that differed in response content: a position-habit phase, followed by a discriminative phase.

Bush & Mosteller (1951) presented a hypothetical curve of discrimination learning that exhibits pronounced nonmonotonicity in one of its branches. The curve describes acquisition in successive discrimination, wherein a response (A_1) is reinforced when it appears in conjunction with stimulus S, but is not reinforced in conjunction with S'. (When S' is present, another response A_2 may be reinforced instead.) The nonmonotonic branch of the curve represents $p(A_1|S')$, the probability of occurrence of A_1 to S'. The error probability $p(A_1|S')$ rises initially (reflecting generalization from S to S'), attains some maximum well below 1, then declines as discrimination progresses. Bush & Mosteller (1951) account for this phenomenon by assuming that "*the measure of the intersection I of the two sets S and S' decreases as discrimination progresses*" (p. 419).

This paper reports a study of successive discrimination in rats that resulted in nonmonotonicity of the kind envisioned by Bush and Mosteller. (Henceforth, S denotes "subject," to conform to standard usage. Stimulus conditions S and S' are relabeled S_1 and S_2, respectively). The interior of a T maze was unstriped (S_1) on some trials and striped (S_2) on others. Customarily, S_1 and S_2 are presented equally often. In this experiment, S_1 occurred with probability .65 and S_2 with probability .35. A_1 was reinforced at random on a large majority of trials in S_1 and A_2 on all but a few in S_2. The bias in the frequencies of presentation of S_1 and S_2 and the contingencies of reinforcement within each condition were such that if an S never deviated from A_1 it would undergo a 65% schedule of random reinforcement. An S that always made response A_1 in S_1 and A_2 in S_2 would encounter a 90% random reinforcement schedule. Two empirical questions ensue: (1) Does the bias of presentation probabilities induce an initial rise in the frequency of A_1 in both S_1 and S_2? (2) Do the Ss eventually discriminate?

Method

The Ss were 24 naive male hooded rats between 120 and 150 days old. Two weeks prior to experimental Day 1 they were put on a 20-h schedule of food deprivation, water ad lib, which was maintained throughout the experiment.

The apparatus was a single unit T maze, with 24 in. stem and arms and 12 in. goal boxes. The goal boxes had guillotine doors, and a second set of doors flanked the choice point. The walls and floor were flat black (unstriped), but could be lined with black-and-white striped Masonite. When installed, the stripes ran vertically on the walls and at right angles to the S's path along the floor.

On each of Days 1 and 2, five pretraining trials took place in S_1. Both food cups contained two 45 mg Noyes pellets, which constituted the incentive throughout training. If an S failed to turn at the choice point within 15 sec, it was detained in the stem for an additional 30 sec. Ss so detained ran extra pretraining trials until every S had made a total of 10 turns with a latency not exceeding 15 sec. Pretraining shaped the Ss to brief latencies, and identified turning preferences. In discrimination training, turns to the S's initially nonpreferred side were designated A_1 and turns to the other side were designated A_2. For Ss that showed no preference, right and left turns were designated A_1 and A_2 at random.

Training began on Day 3. Stimulus condition S_1 was presented on 65% of all trials and S_2 on 35%. Sequences were random with the restriction that there were exactly 13 S_1 and 7 S_2 trials in every block of 20. Training in S_1 was counter to initial position preferences. Contingencies were as follows: In each block of 20 trials, the goal box corresponding to A_1 was baited on 13 trials (12 in S_1 and 1 in S_2); the A_2 goal box was baited on 7 trials (6 in S_2 and 1 in S_1). Consequently, the incentive was in the "correct" goal box on 18 trials out of every 20 (12 in S_1 and 6 in S_2).

Beginning on Day 3, every S underwent 10 noncorrection trials daily for 24 consecutive days. The intertrial interval was 15 min. When the S entered a baited goal box it remained there for a maximum of 5 sec. (No S failed to consume the incentive during the allotted 5 sec.) The S was detained in an unbaited goal box for 30 sec before being returned to the home cage.

Results and Discussion

The mean proportion of A_1 responses in each block of 10 trials was computed separately for the two stimulus conditions. Open circles in Fig. 1 represent the observed proportion of A_1 responses in S_1 and filled circles the proportion of A_1 in S_2, by blocks of 10 trials. The data yielded affirmative answers to both questions of fact raised in the study. The Ss initially adopted a position habit to the A_1 side, but they even-

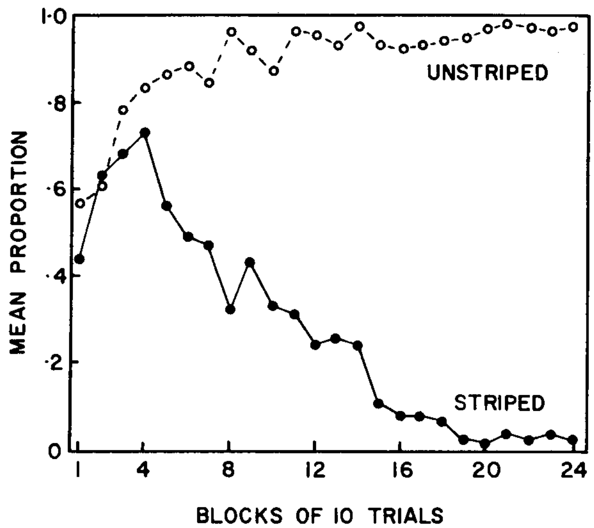

Fig. 1. Mean proportion of A_1 responses in unstriped (S_1) and striped (S_2) mazes.

tually abandoned it in favor of differential responding to S_1 and S_2. Discriminative learning took place notwithstanding the payoff ratio of approximately 2:1 afforded by the position habit.

The shape of the learning curve demonstrates that the learning proceeded in two distinct phases. The first phase is represented in the lower branch of the curve by the short, positively sloped portion, which depicts acquisition of the position habit. In the first four blocks of 10 trials, the proportion of A_1 responses (errors) in S_2 was statistically the same as the proportion of A_1 (correct) responses in S_1. The arcsin transformation was applied to the proportion of A_1 responses in S_1 and S_2 for Days 1 through 4. Transformed scores underwent an analysis of variance, which showed that the main effect of Stimulus was not significant ($F=1.36$, $df=1/23$, $p>.20$); nor was the Day by Stimulus interaction ($F=1.98$, $df=3/69$, $p>.10$). The increase in the proportion of A_1 responses from Day 1 through Day 4 was highly significant ($F=12.73$, $df=3/69$, $p<.001$). Thus, for Days 1 through 4, there was a (roughly) homogeneous uptrend in the proportion of A_1 responses under both S_1 and S_2. The acquisition of a position habit was evident in the data of individual Ss. A criterion of nine A_1 responses in 10 consecutive trials was met by 21 of the 24 Ss on or before Trial 50.

The second phase of learning became manifest on Day 5. It consisted primarily of the progressive elimination of errors under S_2, which continued until discriminative responding was virtually without error. In each of the last five blocks of 10 trials the combined proportion of correct responses (A_1 in S_1 and A_2 in S_2) did not deviate from .97 by more than .01 in either direction. Moreover, during the last five days, the proportion of A_2 responses in S_2 did not differ in the second significant digit from the proportion of A_1 responses in S_1. Whereas S_2 occurred only about half as often as S_1, and the ratio of reinforcement (6/7) in S_2 was less than the ratio (12/13) in S_1, the average level of performance attained in S_2 was identical to that in S_1.

This study differed radically from the paradigm that Bush and Mosteller considered. Nevertheless, the obtained learning curve (Fig. 1) is an unmistakable empirical realization of their theoretical curve (Bush & Mosteller, 1951, Fig. 4, p. 421). From the point of view of stimulus-sampling theory, some process of the sort they hypothesized is the most plausible way to account for the results. In the early stages of learning, elements of both S_1 and S_2 are conditioned to A_1. The net effect of the position habit must be to weaken the connection between A_1 and those elements that S_2 does not share with S_1, because of the relative rarity of reinforcement of A_1 in S_2. However, the gross frequency of reinforcement of A_1 is about twice the frequency of reinforcement of A_2. Hence, elements in the intersection (i.e., those common to S_1 and S_2) must retain their connection to A_1 responses. Consequently, the discrimination could not have taken place, as it ultimately did, unless the weight (i.e., "measure") attached to the stimulus elements in the intersection diminishes throughout training, as Bush and Mosteller hypothesized.

Reference

BUSH, R. R., & MOSTELLER, F. A model for stimulus generalization and discrimination. *Psychol. Rev.*, 1951, 58, 413-423