

THE PERFORMANCE OF MONKEYS ON DISCRIMINATION PROBLEMS WITH REDUCED STIMULUS CUES¹

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The purpose of this study was to investigate the responses of rhesus monkeys to 2-trial discrimination problems in which the number of stimulus cues and the amount of reward is varied. This type of problem was suggested by Cowles and Nissen (1). Davis (2) later used reduced cue discrimination problems in a study of the effects of differential conditions of work and reward upon the problem solving performance of monkeys. He found that monkeys learn to solve reduced cue discrimination problems and that differential reward has considerable influence upon performance of monkeys on these problems.

METHODS

Subjects

Sixteen rhesus monkeys (nos. 1-16) who were undergoing an extensive program of training were used as subjects in this investigation. Their taming and training histories have been described elsewhere (3), (4).

Apparatus

All training of animals in this experiment was conducted in the South Dakota Modification of the Wisconsin General Test Apparatus, shown in Figure 1, and subsequently referred to as the SD-WGTA. This apparatus consists of a barred restraining cage and an adjacent table. The forward two-thirds of the table is covered overhead with a superstructure containing two movable screens, an opaque screen which can be lowered during problem setting and a one-way vision screen through which the observer can see the animals respond. A stimulus tray, held in a stimulus tray carrier, rides toward or away from the restraining cage on parallel steel tracks mounted on the table. The stimulus tray contains two food wells 12 in. apart center-to-center. The food wells were each covered with identical grey painted jar lids to prevent the animal from seeing the food reward. An added stimulus cue object consisting of a grey painted wooden cube 0.5 x 1.5 x 1.5 in. was used.

Procedure

A reduced cue discrimination trial is presented to a monkey in the following manner. The opaque screen of the SD-WGTA is lowered ending the previous trial and the stimulus tray is cleared. One or three

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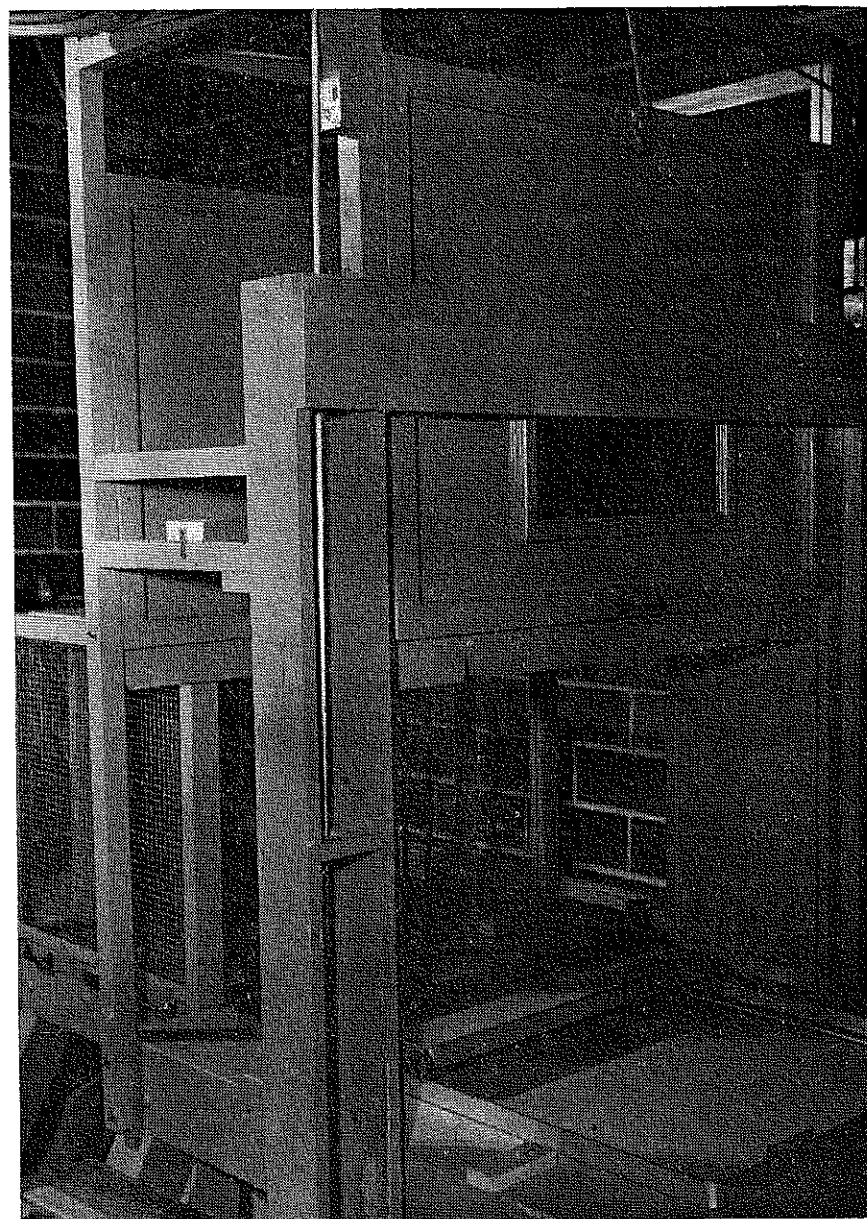


Figure 1. South Dakota Modification of the Wisconsin General Test Apparatus

raisins are placed in either the right or left side food well according to a predetermined random order. The identical jar lids are placed simultaneously over both food wells. The wooden cube is then placed on the jar lid covering the food reward. The one-way vision screen is lowered, the stimulus tray carrier is advanced and the opaque screen is raised allowing the monkey to make a choice. On over 95 per cent of the trials the monkeys respond to the correct jar lid with the added stimulus cue. If a correct response is not made on trial-1, the trial is re-run.

After the monkey completes the first trial, the stimulus tray carrier is withdrawn from the reach of the monkey, the opaque screen is lowered and the second trial is commenced. The monkey is allowed only one choice on each trial. The second trial is similar to the first trial, but the wooden cube is not used as a cue and the monkey responds to the jar lid previously rewarded on the first trial of the problem.

Experimental Design

A total of 576 reduced cue discrimination problems were completed by each animal, 24 problems a day for 24 days. In each day of practice the amount of reward a monkey received for displacing the correct stimulus on a particular trial was varied on both trials of each problem. Four different reward conditions were used: (1) a reward of one raisin was available to the monkey on the first trial, and one on the second trial, (2) one raisin was available on the first and three raisins were available on the second trial, (3) three raisins on the first and one raisin on the second trial, and (4) three raisins were available on both the first and second trials. The amount of reward per trial was either varied within a 6-trial block or the reward condition remained constant for six trials. In the 24 trials presented to each monkey each day the reward condition was varied within two 6-trial blocks, and the order of occurrence of randomly and constantly arranged blocks was randomized.

The number of errors made by each monkey on the second trial of each problem was recorded and the results were arranged for analysis according to the five orthogonal variables of this experiment. These variables were: (1) the random or constant arrangement of reward conditions, (2) the number of pieces of food presented on the first trial, (3) the number of pieces of food presented on the second trial of all problems, (4) the six 4-day periods of practice, and (5) the 16 subjects.

RESULTS

Table I presents a summary of the analysis of variance of the results of this experiment. When the highest order interaction is used as the error term only the variables **practice** and **subjects** are significant. Two first order interactions, **practice x subjects** and **second trial reward x subjects** are significant at beyond the five per cent confidence level. One third order interaction, **massing of reward x first trial reward x second trial reward x practice**, is significant at the five per cent confidence level. The **F** value obtained by dividing the mean square of the variable

practice by the mean square of the **practice x subject** interaction is significant, ($p=.01$).

TABLE I
Statistical Analysis of Error Frequencies

Source	df	MS	F
1. Distrib. reward conditions	1	5.34	2.01
2. Ammt. reward, trial-1	1	7.53	2.84
3. Ammt. reward, trial-2	1	.01	.00
4. Practice	5	220.02	83.03***
5. Subjects	15	65.78	24.82
6. Drc x Art-1	1	8.74	3.30
7. Drc x Art-2	1	8.33	3.14
8. Drc x Pr.	5	2.01	.75
9. Drc x S's	15	1.46	.55
10. Art-1 x Art-2	1	2.51	.95
11. Art-1 x Pr.	5	.45	.17
12. Art-1 x S's	15	4.08	1.54
13. Art-2 x Pr.	5	2.28	.86
14. Art-2 x S's	15	5.67	2.14*
15. Pr. x S's	75	10.37	3.91***
16. Drc x Art-1 x Art-2	1	5.02	1.89
17. Drc x Art-1 x Pr.	5	1.46	.55
18. Drc x Art-1 x S's	15	2.28	.86
19. Drc x Art-2 x Pr.	5	2.01	.76
20. Drc x Art-2 x S's	15	2.05	.77
21. Drc x Pr. x S's	75	1.19	.45
22. Art-1 x Art-2 x Pr.	5	3.56	1.34
23. Art-1 x Art-2 x S's	15	2.42	.91
24. Art-1 x Pr. x S's	75	1.66	.63
25. Art-2 x Pr. x S's	75	1.21	.45
26. Drc x Art-1 x Art-2 x Pr.	5	6.51	2.46
27. Drc x Art-1 x Art-2 x S's	15	1.97	.74
28. Drc x Art-1 x Pr. x S's	75	3.13	1.18
29. Drc x Art-2 x Pr. x S's	75	3.40	1.28
30. Art-1 x Art-2 x Pr. x S's	75	2.02	.76
31. Drc x Art-1 x Art-2 x Pr. x S's	75	2.65	---

*Significant at the .05 confidence level

***Significant at the .001 confidence level

Drc-Distribution of reward conditions

Art-1-Amount of reward on trial-1

Art-2-Amount of reward on trial-2

Pr.-Practice

S's-Subjects

From the results of the analysis of variance the conclusion must be made that neither the amount of food on the first trial nor the amount on the second trial has a noticeable effect upon the performance of the monkeys in this experiment. The primary effect, **practice**, was significant in spite of large individual differences in rate of learning as can be seen in Table II.

TABLE II

Performance of Monkeys on Reduced Cue Discrimination Problems As a Function of Practice
(Per Cent Errors)

Animal	Days of Practice					
	1-4	5-8	9-12	13-16	17-20	21-24
1	42.7	42.7	51.0	48.9	46.9	50.0
2	55.2	47.9	45.8	27.1	47.9	41.7
3	45.8	28.1	22.9	15.6	15.6	15.6
4	55.2	40.6	46.9	35.4	29.2	9.4
5	38.5	31.2	31.2	39.6	30.2	32.3
6	62.5	54.2	47.9	45.8	50.0	36.4
7	52.1	45.8	43.7	44.8	27.1	25.0
8	50.0	42.7	37.5	27.1	23.9	15.6
9	55.2	53.1	43.7	38.5	33.3	22.9
10	56.2	48.9	43.7	25.0	17.7	18.7
11	48.9	50.0	51.0	51.0	48.9	44.8
12	57.3	47.9	26.0	11.4	6.2	5.2
13	55.2	26.0	6.2	0.0	1.0	1.0
14	64.6	67.7	44.8	40.6	19.8	13.5
15	47.9	53.1	39.6	36.4	23.9	10.4
16	52.1	57.3	55.2	53.1	33.3	32.3
Total	52.4	46.0	39.8	33.7	28.4	23.4

DISCUSSION

The stimulus and reward conditions of the present experiment were patterned after the stimulus and reward conditions used by Davis (2) in an experiment on the effect of work variables upon the performance of monkeys. However, there were four apparent differences between the two experiments:

1. Conditions of work were systematically varied in Davis' original experiment, but in the present experiment the work variable was not controlled.

2. The reward conditions in the first experiment were held constant within blocks of six problems and varied between blocks. In the present experiment the reward condition varied from problem-to-problem within half of the 6-problem blocks.

3. The experiments differed from each other in the amount of spacing of practice given to the monkeys. In the first experiment 48 problems were given per day for 16 days to each animal, and in the second experiment 24 problems were given per day for 24 days to each animal.

4. Probably one of the most important differences between the experiments was the use of different groups of animals in each experiment, and this difference was accompanied by a difference in training histories of the animals in the two groups.

Because of these differences in procedure it is not surprising that the results of the two experiments differ strikingly. The amount of reward on both the first and second trials of the problems in the first experiment significantly modified the performance of the monkeys serving as subjects in that experiment, but the amount of reward on either first or second trial did not produce a significant variation in the performance of animals in the second experiment. Also the final level of performance of the animals in the second experiment is 23 per cent errors, but in the original experiment the animals made 33 per cent errors during the final period of practice. This difference in performance is not large but the animals in the present experiment had received fewer problems by the end of practice than the animals in the first experiment.

The differences in the results of these two experiments obviously cannot be ascribed to any one of the differences in the experimental procedures of the two experiments. However the different results do show the variable expression and change in relative importance of the variable of amount of reward in determining the level of performance of monkeys on this type of learning problem. Meyer (5) previously noted the inefficacy of the differential reward variable in discrimination learning in monkeys, and the present results corroborate his findings.

SUMMARY AND CONCLUSIONS

Sixteen rhesus monkeys were each given 24 reduced cue discrimination problems a day for 24 successive days under eight different conditions of reinforcement.

1. The performance of the animals was not significantly affected by different amounts of rewards given on either the **cue-trial** or the **reduced-cue-trial** of reduced cue discrimination problems.

2. Considerable improvement in the performance of all animals occurred with practice.

3. The results of this experiment were unlike the results of another experiment employing the learning of reduced cue discrimination problems by monkeys under differential reward conditions.

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