
**SUCCESSIVE DISCRIMINATION-REVERSAL TRAINING AND
MULTIPLE DISCRIMINATION TRAINING IN ONE-TRIAL
LEARNING BY CHIMPANZEES**

RONALD J. SCHUSTERMAN

Stanford Research Institute, Menlo Park, California

Journal of Comparative and Physiological Psychology
1964, Vol. 58, No. 1, 153-156

SUCCESSIVE DISCRIMINATION-REVERSAL TRAINING AND MULTIPLE DISCRIMINATION TRAINING IN ONE-TRIAL LEARNING BY CHIMPANZEES¹

RONALD J. SCHUSTERMAN²

Stanford Research Institute, Menlo Park, California

6 chimpanzees received either successive discrimination-reversal training (SRT) with a single stimulus pair or multiple discrimination training (MDT). Upon achieving consistent 1-trial learning all Ss were shifted to a learning-set (LS) series of 200 4-trial discrimination problems. Once the tendency had been overcome to perseverate to the formerly rewarded stimulus under the reversal procedure, rates of learning under both techniques became similar. On the 1st block of 50 problems of the LS series, Trial-2 performances of Group SRT, Group MDT, and a control animal were 80%, 74%, and 52% correct, respectively. Results were found unfavorable to interpretation in terms of error factor theory and transfer suppression theory.

Recently, Schusterman (1962) showed that training experimentally naive adult chimpanzees on a series of discrimination-reversals, in which the rewarded member of a pair of stimulus objects was successively alternated after each problem was learned to a criterion, resulted in immediate and persistent transfer to a "learning-set" (LS) series of 180 six-trial object-quality discrimination problems. Inasmuch as successive discrimination-reversal training (SRT) and multiple discrimination training (MDT) both produce the ability to solve new discrimination problems in a single trial, a question arises as to the relative efficiency of these two training techniques in the acquisition of one-trial discrimination learning.

The experiment to be reported compared the performance of two groups of chimpanzees shifted to an LS series of 200 four-trial discrimination problems following differential training procedures. One group received SRT with a single pair of stimulus objects, the other group was given MDT. Under the latter technique, new stimuli are introduced for each problem. From the approach to problem-solving behavior of Kendler and Kendler (1962) the present study may be viewed as a comparison of *successive* reversal and nonreversal shifts with respect to

their transfer effects on subsequent successive nonreversal shifts.

METHOD

Subjects

Seven young adult chimpanzees of both sexes participated in this experiment. None of the Ss had lived at the laboratory for more than 2 yr. Insofar as could be determined they all were experimentally naive.

Apparatus and Procedure

Prior to formal testing all Ss were trained to displace a single gray planometric stimulus object covering one of the two foodwells. Position of the object was randomly determined and balanced within blocks of 20 trials. Pretraining was discontinued as soon as Ss were responding efficiently. Test conditions and apparatus were similar to those described by Hayes, Thompson, and Hayes (1953). During formal testing S's task was to displace one of two stimuli (differing from each other in several dimensions) in order to obtain a piece of grape or banana. A noncorrection technique was used throughout testing.

There were two experimental groups with three Ss each. The seventh S served as a control. The experiment was carried out in two phases. During Phase 1, Ss in the experimental groups received either SRT with a single pair of stimulus objects or MDT, in which each problem was a presentation of a new stimulus pair. As soon as S achieved criterion-learning on Phase 1, Phase 2 was begun and S was shifted to an LS series of 200 four-trial object-quality discriminations. Position was an irrelevant cue during both phases.

During Phase 1 each problem was presented until solved to a criterion of 12 consecutive correct responses. Since it was anticipated that the initial trial of each reversal problem would be nonre-

¹This research was carried out at the Yerkes Laboratories of Primate Biology while the author was on a postdoctoral fellowship from the National Science Foundation. Support for this research was also provided through Grant H-5691 from the National Institute of Health. The author wishes to thank W. A. Mason, F. Restle, and A. J. Riopelle for their critical readings of the manuscript.

²The author is now on leave from San Fernando Valley State College.

warded, a comparable Trial-1 procedure was used for Ss given MDT in which neither stimulus object was baited and the object not chosen on the first trial continued to be baited until the problem was solved. Naturally, Trial-1 errors were not scored for the SRT group.

To provide a meaningful comparison of the efficiency of the two training techniques in producing one-trial learning, it was necessary that Ss in both experimental groups achieve rapid intraproblem learning before being shifted to the LS series of four-trial problems. Accordingly, *S* was required to average two or fewer errors during each of the last four five-problem blocks of the first 50 problems of Phase 1, or failing this criterion it received additional problems until it achieved an average of two or fewer errors on two successive five-problem blocks taken as independent units. A second criterion required that *S* make five or fewer errors on any given problem within each of the two successive five-problem blocks. Thus, during Phase 1, all experimental Ss received at least 50 problems.

Throughout Phase 1, Ss received 89–100 trials per session. A session was terminated when either an error or problem solution occurred during the last 12 trials. Generally, only one session was run each day. However, one *S* in the SRT group, who appeared to be an extremely slow learner, was sometimes given as many as three sessions in a single day.

During Phase 2 the rewarded member of the stimulus pair for each problem was determined by *S*'s Trial-1 response. Whereas on half of the problems (randomly determined) both stimulus objects were baited on Trial 1 and the stimulus chosen by *S* continued to be baited on subsequent trials, on the other half of the problems neither stimulus was baited and the stimulus not chosen on the first trial continued to be baited on all subsequent trials. Generally, 20 four-trial problems were presented each day. The control *S* was treated similarly to those Ss given MDT except that he received only *five* problems before being shifted

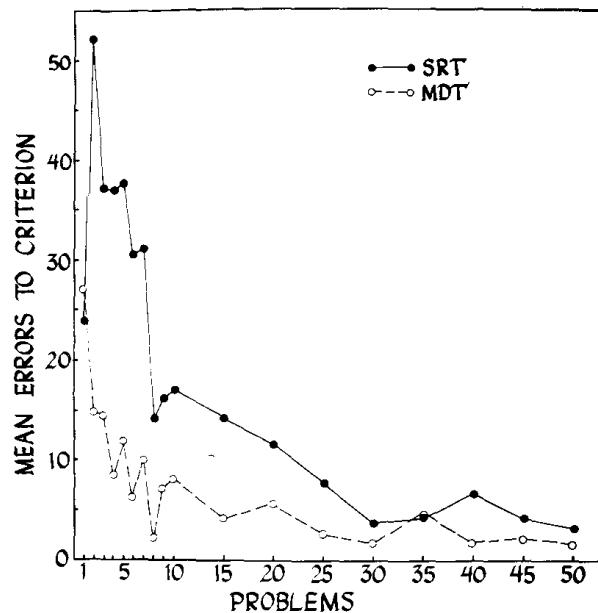


FIG. 1. Interproblem learning curves (in mean errors to criterion) on a successive discrimination-reversal task and on a multiple discrimination task.

2 mo. later to the LS series, whereas all Ss in the MDT group received at least 50 problems.

RESULTS

Phase 1

The assumption that Ss were achieving rapid intraproblem learning under both training methods before being shifted to Phase 2 is borne out by the mean number of errors during the final two five-problem blocks—1.1 for the SRT group and 1.3 for the MDT group.

Table 1 presents the number of trials and number of problems necessary for each *S* to reach criterion during Phase 1. Generally, both measures indicated more efficient over-all performance on the MDT task than on the SRT task, although the differences between groups were not statistically significant.

The principal data for Phase 1 are found in Figure 1, which depicts the course of the two interproblem learning curves for Problems 1–50. The data of Figure 1 were subjected to a repeated-measures analysis of performance on Problems 2–10 and on the next eight five-problem blocks. The first analysis yielded a significant over-all learning effect ($p < .05$) and a significant difference between groups ($p < .01$). However, the Groups \times Problems interaction was not significant ($F = 1.01$, $df = 8/32$, $p > .05$), indicating that after the initial reversal problem the rate of learning under either method was essentially the same. The analysis of Prob-

TABLE 1

TOTAL NUMBER OF TRIALS AND PROBLEMS TO REACH CRITERION DURING PHASE 1

Chimpanzee	Trials	Problems
SRT training		
288	1,511	50
209	2,442	85
262	3,652	100
MDT training		
245	995	50
215	1,358	65
264	2,106	85

Note.—Includes criterion trials.

lems 11-50 revealed a significant over-all learning effect ($p < .05$). However, neither the between-group difference ($F = 1.97, df = 1/4, p > .05$) nor the Groups \times Problems interaction ($F = 1.87, df = 7/28, p > .05$) was significant. The figure shows that beyond Problems 30-35 the MDT group is only slightly superior to the SRT group. However, a note of caution is necessary concerning conclusions drawn from the comparison of these learning curves, since one chimpanzee (288) was primarily responsible for the extremely rapid decline of errors under the reversal condition.

Phase 2

Figure 2 shows transfer of training to the four-trial LS series of Phase 2. It is quite evident that both training methods produced a high level of correct responses on Trial 2. All Ss in the experimental groups were performing at a level significantly above chance on the first block of 50 problems ($p < .01$, binomial). In contrast to the performance of the trained Ss, the control S was operating at a chance level on the first block of problems and did not reach the performance level achieved by the trained Ss on the initial block of 50 problems until it had received over 200 problems.

The learning effect over problems for both experimental groups was small but statistically reliable for measures of both Trial 2 ($p < .05$) and Trials 3 and 4 ($p < .05$). The differences between groups for measures of both Trial 2 ($F = 3.04, df = 1/4, p > .05$) and Trials 3 and 4 ($F = 2.75, df = 1/4, p > .05$) were not significant nor were the Groups \times Problems interactions significant ($F < 1.00$ in both cases).

DISCUSSION

Despite different methodologies the interproblem discrimination-reversal learning curve obtained from adult chimpanzees in the present experiment is quite similar to those obtained with two 6-year-old chimpanzees (Nissen, Riesen, & Nowlis, 1938) and with chickens (Bacon, Warren, & Schein, 1962), where position was an irrelevant cue, and also to curves obtained on positional-reversal tasks with a raccoon (Warren & Warren, 1962), rats (Dufort, Guttman, & Kimble, 1954) and low-grade human retardates (House & Zeaman, 1959). The learning curves from these studies all have the common characteristics of an increase in errors on the first reversal problem followed by rapid improvement until a final consistently high level of one-trial reversal is attained.

The negative transfer found on the early prob-

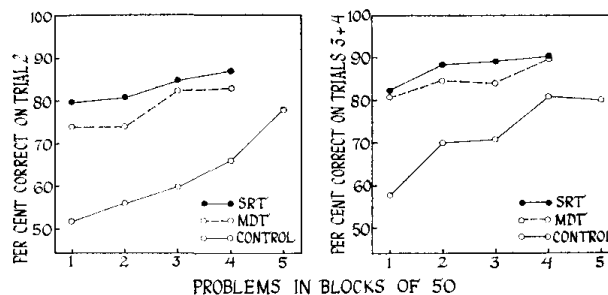


FIG. 2. Percentage of correct responses on Trial 2 (left panel) and Trials 3 and 4 (right panel) on a learning-set series of four-trial discrimination problems following differential training methods.

lems under SRT may be contrasted to the positive transfer found on comparable problems under MDT. These results support the generalization by Kendler and Kendler (1962) that the reversal-shift task is more difficult than the non-reversal-shift task for nonverbal Ss.

The present results are somewhat at variance with results of a previous experiment conducted by the author (Schusterman, 1962). Even though the total number of trials during SRT was considerably less in the previous study, performance was better on both the reversal task and on the LS series, and there was no evidence of improvement during the LS series. Differences in the results of the two experiments may be accounted for by a procedural difference during both the training phase and the LS series. A noncorrection procedure was used throughout testing in the present experiment, whereas the previous study employed a delayed correction procedure. Although there is no direct evidence that a correction procedure facilitates LS formation by the experimentally naive chimpanzee, it is reasonable to suppose that such a procedure provides more information to the animal and should diminish considerably the strong tendency on the part of the chimpanzee to explore the stimulus situation (Schusterman, 1963), and thus make the kind of response-shift errors found in rhesus monkeys (Harlow, 1950).

As Pubols has noted (1962), although MDT and SRT have certain similarities, they cannot be classed as methodological or theoretical equivalents. This is demonstrated by the initial difference in the two learning curves (see Figure 1). On the other hand, once the tendency has been overcome to perseverate to the formerly rewarded stimulus under the reversal procedure, the rate of learning under both conditions becomes similar and both methods lead to efficient one-trial learning. The two methods are equivalent in the sense that they lead to consistent use of the information from Trial 1 in solving a

series of four-trial discrimination problems on Trial 2.

The finding that chimpanzees receiving SRT with only a single stimulus pair do at least as well on a four-trial LS series as chimpanzees trained on a series of problems with multiple stimulus pairs (like those used in conventional LS experiments) calls into question LS theories, which emphasize supporting habits, or responses to the physical properties of the stimulus objects and their mode of presentation. This interpretation stems from a discussion of the stimulus perseveration error (Harlow, 1950, 1959). Riopelle (1960) notes that the most significant interfering tendency for efficient LS formation is that due to learned or innate preferences and aversions for certain stimuli. Riopelle (1953) has demonstrated the progressive reduction of the former class of stimulus-perseveration errors and describes the phenomenon as "transfer suppression." Successive reversal training with a single stimulus pair may be expected to produce only modest transfer suppression, since this type of training does not expose the animal to multiple new stimuli as does MDT. Therefore, the present results are viewed as unfavorable to interpretation in terms of error factor theory (Harlow, 1959) and transfer suppression theory (Riopelle, 1953). Theories more predictive of the present results are those of Restle (1958) and Levine (1959), which suggest that LS formation, culminating in one-trial learning, depends primarily on the conditioning of responses to food signs or reward cues. This conditioning process has been described as the acquisition of a "win-stay, lose-shift" strategy (with respect to the stimulus object) by means of 100% reinforcement and seems to be a sufficient basis for one-trial discrimination learning (Levine, 1959; Schusterman, 1962).

REFERENCES

- BACON, H. R., WARREN, J. M., & SCHEIN, M. W. Non-spatial reversal learning in chickens. *Anim. Behav.*, 1962, **10**, 239-243.
- DUFORT, R. H., GUTTMAN, N., & KIMBLE, G. A. One-trial discrimination reversal in the white rat. *J. comp. physiol. Psychol.*, 1954, **47**, 248-249.
- HARLOW, H. F. Analysis of discrimination learning by monkeys. *J. exp. Psychol.*, 1950, **40**, 26-39.
- HARLOW, H. F. Learning set and error factor theory. In S. Koch (Ed.), *Psychology: A Study of a science*. Vol. 2. New York: McGraw-Hill, 1959. Pp. 492-537.
- HAYES, K. J., THOMPSON, R., & HAYES, C. Discrimination learning set in chimpanzees. *J. comp. physiol. Psychol.*, 1953, **46**, 99-104.
- HOUSE, B. J., & ZEAMAN, D. Position discrimination and reversals in low-grade retardates. *J. comp. physiol. Psychol.*, 1959, **52**, 564-565.
- KENDLER, H. H., & KENDLER, T. S. Vertical and horizontal processes in problem solving. *Psychol. Rev.*, 1962, **69**, 1-16.
- LEVINE, M. A model of hypothesis behavior in discrimination learning set. *Psychol. Rev.*, 1959, **66**, 353-366.
- NISSEN, H. W., RIESEN, A. H., & NOWLIS, V. Delayed response and discrimination learning by chimpanzees. *J. comp. Psychol.*, 1938, **26**, 361-386.
- PUBOLS, B. H. Serial reversal learning as a function of the number of trials per reversal. *J. comp. physiol. Psychol.*, 1962, **55**, 66-68.
- RESTLE, F. Toward a quantitative description of learning set data. *Psychol. Rev.*, 1958, **65**, 77-91.
- RIOPELLE, A. J. Transfer suppression and learning sets. *J. comp. physiol. Psychol.*, 1953, **46**, 108-114.
- RIOPELLE, A. J. Complex processes. In R. H. Waters, D. A. Rethlingshafer, & W. E. Caldwell (Eds.), *Principles of comparative psychology*. New York: McGraw-Hill, 1960, Pp. 208-249.
- SCHUSTERMAN, R. J. Transfer effects of successive discrimination-reversal training in chimpanzees. *Science*, 1962, **137**, 422-423.
- SCHUSTERMAN, R. J. The use of strategies in two-choice behavior of children and chimpanzees. *J. comp. physiol. Psychol.*, 1963, **56**, 96-100.
- WARREN, J. M., & WARREN, H. B. Reversal learning by horse and racoon. *J. genet. Psychol.*, 1962, **100**, 215-220.

(Received October 8, 1963)