Learning set without transfer suppression: A replication and extension¹

ALLAN M. SCHRIER, *Brown University, Providence, R.I. 02912*

Rhesus monkeys that had previously formed a discrimination-learning set were given six six-trial discrimination problems each day: five new problems followed by a reversal of one of the five. Marked negative transfer was obtained on Trial 1 of reversals over a period of many weeks, confirming results of an earlier study with stump-tailed monkeys. With continued training, performance improved on Trial 1 of reversals. The results support the contention that improvement in performance on Trial 1 of reversals that are interspersed during learning-set training represents learning to reverse when familiar stimuli reappear, rather than transfer suppression. Evidence from later trials of reversals suggested that stump-tailed monkeys persist in making old, inappropriate responses longer than do rhesus monkeys.

Stollnitz & Schrier (1968) recently reported evidence that raises serious doubts about Riopelle's (1953) transfer-suppression account of learning-set formation. According to this account, learning-set formation results from an increasing tendency of animals to treat the stimuli of each new discrimination problem as independent of those of previous problems; that is, the animals show an increasing tendency to suppress transfer. Riopelle (1953) tested his notion by giving rhesus monkeys (*Macaca mulatta*) learning-set training consisting of six object-discrimination problems per test session, with the first five always being new problems and the sixth always being a reversal of one of the preceding problems of the session. The results seemed to conform to the transfer-suppression hypothesis in that performance on first trials of reversals improved over the course of learning-set training. However, Stollnitz & Schrier (1968) suggested that Riopelle's Ss might simply have been learning to reverse their previous choice as soon as a familiar pair of stimuli reappeared. They tested this "stimulus-familiarity" hypothesis by training rhesus monkeys and stump-tailed monkeys (*M. arctoides*; formerly *M. speciosa*) to a high level of performance on the standard learning-set task before interspersing reversals in the manner that Riopelle did. Contrary to the

transfer-suppression hypothesis, Stollnitz and Schrier's monkeys showed substantial negative transfer (that is, a high percentage of errors) on the first trials of reversal problems, the trials which provide the clearest indication of transfer.

But the results did not conform to the stimulus-familiarity hypothesis either. According to this hypothesis, correct responses on the first trials of interspersed reversal problems should have increased with practice. Although Stollnitz and Schrier's rhesus monkeys were only given six sessions with the reversal procedure, their stump-tailed monkeys were given as many as 65 such sessions. The reversal performance of these latter Ss remained poor throughout. One explanation for this outcome offered by Stollnitz and Schrier takes note of the fact that stump-tailed monkeys seem to be unusually placid and curious animals (Schrier, 1965; Symmes & Anderson, 1967) and, hence, possibly relatively indifferent to nonreward. This, in turn, would mean that their reversal performance might be relatively poor, and, indeed, there is some evidence that this is the case (Schrier, 1966a). Perhaps, then, Stollnitz and Schrier would have obtained improvement in performance on interspersed reversals had they given prolonged training to their rhesus monkeys, rather than their stump-tailed monkeys. The present experiment was designed to test this possibility. The conditions were practically identical to those of Experiment II of the Stollnitz and Schrier study, except that the Ss in the present study were rhesus monkeys and some were given training with interspersed reversals for a longer period.

SUBJECTS AND APPARATUS

The Ss were nine wild-born young adult rhesus monkeys with a mean weight of 13.6 lb. They were tested in a WGTA with motor-operated screens (Schrier, 1961).

PROCEDURE

As before (Stollnitz & Schrier, 1968, Experiment II), all Ss were given six new six-trial object-discrimination problems per day until their performance on Trials 2-6 was above 90% correct for 5 consecutive days. After meeting this criterion, each S was given one session a day consisting of five new six-trial problems, followed by a six-trial reversal. During even-numbered sessions for each monkey, the first problem of the session was reversed, and during odd-numbered, the fourth problem of each

session was reversed. Five of the Ss were trained by one tester for a total of 11 weeks of reversal sessions, and the remaining four Ss were trained by a second tester for a total of 19 weeks of reversal sessions. The termination of testing of the five Ss after 11 weeks proved to be somewhat unfortunate, but was beyond E's control. There were five sessions per week. Each correct response was reinforced with a Noyes 45-mg sucrose pellet.

RESULTS AND DISCUSSION

Table 1 summarizes the performance of the present rhesus monkeys, the previously run rhesus monkeys, and the previously run stump-tailed monkeys during the first 6 days of learning-set training with interspersed reversals. The performance of the present rhesus monkeys was similar to that of the previous rhesus for new problems and first trials (Trial 1) of reversals, though somewhat lower on Trials 2-6 of reversals. As noted in the earlier study, performance of the stump-tailed monkeys was considerably poorer than that of the rhesus monkeys on Trials 2-6 of reversals, but comparable in the other instances. The frequency of correct responses of the present rhesus monkeys (Table 1) was significantly below chance on Trial 1 of reversals ($t = -6.1$, $df = 8$, $p < .001$). Thus the present findings confirmed those of the earlier study (Stollnitz & Schrier, 1968): Contrary to what would be expected on the assumption of transfer suppression, substantial negative transfer was found on the first trials of reversals.

The results for the present rhesus monkeys during successive 5-day blocks (weeks) of learning-set training with interspersed reversals are summarized in Fig. 1. Five-day blocks are used here, rather than the 6-day blocks of the previous study, because the present rhesus, as well as the stump-tailed monkeys run previously, were tested 5 days a week. Over the course of the first 10 weeks, the performance of the present rhesus monkeys on Trial 1 of reversals remained at about the same low level as during the first week, despite an

Table 1
Performance of Present Rhesus Monkeys and Stollnitz and Schrier's Rhesus and Stump-tailed Monkeys During the First 6 Days of Learning-Set Training with Interspersed Reversals

	Previous Rhesus (N = 3)	Previous Stump-tails (N = 4)	Present Rhesus (N = 9)
Problems 1-5			
Trials 2-6	93%	90%	93%
Problem 6			
Trials 2-6	88%	54%	77%
Problem 6			
Trial 1	17%	25%	13%

Fig. 1. Performance of the present rhesus monkeys on Trials 2-6 of new problems (Problems 1-5), first trials of reversals (Reversals, Trial 1), and later trials of reversals (Reversals, Trials 2-6) during consecutive weeks of practice. Performance of Stollnitz & Schrier's (1968) stump-tailed monkeys on Trial 1 and on Trials 2-6 of reversals is also shown. Performance of these latter Ss on new problems was practically the same as that of the rhesus monkeys and was excluded so as not to clutter the graph unnecessarily. Vertical lines indicate a reduction in N—from 9 to 5 for the rhesus monkeys and from 4 to 3 for the stump-tailed monkeys.

increase in accuracy on Trials 2-6 of the same reversals. The data for the first 11 weeks, which was the period during which all nine rhesus monkeys were tested, were analyzed by means of treatment (weeks) by Ss analyses of variance. Though small, the increase in frequency of correct responses as a function of weeks of practice on new problems was significant ($F = 3.43$, $df = 10/80$, $p < .01$), as was the increase, apparent in Fig. 1, on Trials 2-6 of reversals ($F = 2.37$, $df = 10/80$, $p < .025$). There was no significant change in performance on Trial 1 of reversals during the first 11 weeks. Following Week 10, there was an increase in accuracy on Trial 1 of reversals. Unfortunately, that was just about the same time that testing of all but four of the rhesus monkeys had to be discontinued. Nevertheless, analysis of variance conducted on the complete data of the four remaining Ss for Trial 1 of reversals showed that the increase in frequency of correct responses during the 19 weeks of practice was significant ($F = 1.86$, $df = 18/54$, $p < .05$). Thus, with practice, performance on Trial 1 of reversals conformed to predictions based on the stimulus-familiarity hypothesis. Furthermore, the fact that one of the four Ss performed above the chance level (that is, made more than 50% correct responses) on Trial 1 of reversals during all but 1 of the last 11 weeks of practice and that a second S did so during all but 1 of the last 5 weeks of practice strongly suggests that the group curve would have eventually risen above the chance level as required by the hypothesis.

The performance of the previously run stump-tailed monkeys on Trial 1 and Trials 2-6 of reversals is also shown in Fig. 1. The performance of the two species on Trial 1 of reversals was quite similar except, perhaps, during the last few weeks of

training. A mixed within-Ss/between-Ss analysis of variance for the first 9 weeks of training revealed no significant difference between the nine rhesus monkeys and the four stump-tailed monkeys. (Testing of one of the stump-tailed monkeys had been discontinued after 9 weeks.) The results suggest, then, that the prolonged negative transfer obtained on Trial 1 of reversals in the experiment by Stollnitz & Schrier (1968) was not peculiar to the species of animal used.

Additional mixed analyses of variance indicated that the performance of the stump-tailed monkeys did not differ significantly from that of the present rhesus monkeys on new problems presented during the first 9 weeks, but that their performance on Trials 2-6 of reversal problems was significantly poorer ($F = 11.49$, $df = 1/11$, $p < .01$).

Although it is clear that the persistence of poor performance on first trials of reversals found by Stollnitz & Schrier (1968) cannot be attributed solely to the fact that they used stump-tailed monkeys, the relatively poor performance of these monkeys on later trials of reversals suggests that there still may be something special about their behavior. Further evidence of this was obtained in another study (Schrier, 1966a) in which it was found that the initial performance of these animals on a series of reversals was considerably poorer than that of the closely related Philippine cynomolgus monkeys (*Macaca fascicularis*; formerly *M. irus*). Stollnitz & Schrier (1968) have suggested that stump-tailed monkeys might be relatively indifferent to nonreward, but the fact that the performance of these animals is about the same as that of other monkeys on the acquisition of the learning-set task (Schrier, 1966b; also the results of the

present study for new problems) and other tasks (Symmes & Anderson, 1967) indicates that this may not be the case. Rather, the results seem to suggest that stump-tailed monkeys tend to persist in making learned responses that are no longer appropriate.² As might be expected, these animals do not continue making such responses indefinitely (Schrier, 1966a). Therefore, with regard to the results on transfer suppression, the prediction would be that with continued training under conditions of those of the present experiment, the same changes in reversal performance would take place with stump-tailed monkeys as do with rhesus monkeys, but would do so more slowly.

REFERENCES

- RIOPELLE, A. J. Transfer suppression and learning sets. *Journal of Comparative & Physiological Psychology*, 1953, 46, 108-114.
- SCHRIER, A. M. A modified version of the Wisconsin General Test Apparatus. *Journal of Psychology*, 1961, 52, 193-200.
- SCHRIER, A. M. Pretraining performance of three species of macaque monkeys. *Psychonomic Science*, 1965, 3, 517-518.
- SCHRIER, A. M. Transfer by macaque monkeys between learning-set and repeated reversal tasks. *Perceptual & Motor Skills*, 1966a, 23, 787-792.
- SCHRIER, A. M. Learning-set formation by three species of macaque monkeys. *Journal of Comparative & Physiological Psychology*, 1966b, 61, 490-492.
- STOLLNITZ, F., & SCHRIER, A. M. Learning set without transfer suppression. *Journal of Comparative & Physiological Psychology*, 1968, 66, 780-783.
- SYMME, D., & ANDERSON, K. V. Comparative observations on *Macaca speciosa* and *Macaca mulatta* as laboratory subjects. *Psychonomic Science*, 1967, 7, 89-90.

NOTES

1. This research was supported by research grants from the National Institute of Mental Health (MH-15389) and the National Science Foundation (GB-7590).

2. On this basis, it would be predicted that stump-tailed monkeys would show a slower rate of extinction than other animals. John W. Davenport (personal communication, 1969) at the Regional Primate Research Center, University of Wisconsin, has some evidence that this is the case following acquisition of a chain of eight pushbutton responses and during the later stages of alternation

of acquisition and extinction of a discrete-trial bar-press response reinforced on a FR-5 schedule. Furthermore, these animals seem to be relatively slow to acquire a free-operant discrimination. Davenport has also found that stump-tails perform poorly during repeated reversals of a spatial discrimination, thus supporting the findings for

repeated reversals of an object discrimination. On the other hand, they do not appear to be especially slow in extinguishing a discrete-trial bar-press response reinforced on a CRF schedule, although perhaps they would be if acquisition and extinction were repeatedly alternated as was done when the FR-5 schedule was used.

containers which were kept in the experimental room where the temperature was between 82 and 90 deg F and the humidity between 30% and 50%. They remained in these cartons throughout the experiment.

Between 3:00 and 4:30 p.m. (of the same day), after the chicks had had a chance to become accustomed to their new environment, they were trained in one trial not to peck at a small metal lure. The lure consisted of a 3-mm metal bead held on a long, stiff wire. This lure was dipped in methyl anthranilate (MeA), a chemical which chicks find distasteful, and then held 1 cm from each chick's beak for 5 sec (measured from the time it oriented toward it). Ninety per cent of the chicks pecked at the metal lure, most within 2 sec. Those that didn't peck were not included in the results. Chicks that did peck would typically shake their heads 2-3 sec later, presumably indicating the time when they tasted the MeA.

The next morning (Day 2) between 11 a.m. and 1 p.m., the chicks were given a similar training on a slightly different lure. This lure had a red plastic bead in place of the metal bead described above. In this training, however, the chicks were given a 12-mA, 0.25-sec, 60-cycle subconvulsive current as soon as they shook their heads. Chicks that did not peck at the red lure (about 30%) were not included in the results. The red lure was used as a means of readministering the unconditioned stimulus of the first training (i.e., the taste of MeA). The metal lure was not used since the chicks had just been trained not to peck at it.

The chicks' retention of their first training was tested between 3 and 4 p.m. of Day 2 (24 h after training) by presenting the metal lure (wet with MeA) for 5 sec and noting whether they pecked at or avoided it.

Besides the experimental group whose treatment has been described above, four control groups were run simultaneously. The groups were mixed randomly together and tested blind. They received identical treatment as the experimental group except where otherwise noted. The chicks in the basic control group (C1) were trained with both lures wet with MeA as before, but weren't given SCC after the red lure training. Those in a second control group (C2) were "trained" on dry lures but received SCC after the second training. The chicks in the third group (C3) were "trained" on dry lures and not given SCC. Those in the fourth control group (C4) were trained with wet lures but not given SCC until 2 min after the second training. The 2-min delay is much greater than the chick's apparent attention span and memory consolidation time (Lee-Teng & Sherman, 1966).

Effect of unconditioned stimulus linked subconvulsive current in chicks¹

THOMAS A. WEAVER and J. GEOFFREY MAGNUS, California Institute of Technology, Pasadena, Calif. 91109

An experiment was done to see if amnesia of one-trial passive-avoidance training could be induced in chicks by readministering the unconditioned stimulus 20 h after training and then giving immediate subconvulsive current. A similar experiment by Schneider and Sherman using rats had given positive results—results that could not be explained by the "consolidation-interruption" hypothesis used as the basis for much memory work. A significant amount of such amnesia was not found in chicks despite the use of a large number of animals. An upper limit of 20% was established for the magnitude of the effect. These results reconfirm the "consolidation-interruption" hypothesis in the case of chicks.

Many investigators have used electroconvulsive shock (ECS) to produce retrograde amnesia in a variety of animals (Quartermain et al, 1965; McGaugh, 1966; Lee-Teng & Sherman, 1966). The animals seem unable to remember events that immediately preceded ECS. The percentage of Ss forgetting has been found to decrease with increasing time between the event and ECS. The half-time for this decay has been variously reported from 8 sec (Lee-Teng & Sherman, 1966) to several minutes (McGaugh, 1966).

The first hypothesis ("consolidation-interruption" hypothesis) drawn from such results was that ECS interrupts the consolidation of long-term memories, with normal consolidation taking place in the order of seconds to minutes. Thus the amount of memory retained by the animal is just the amount that was consolidated before ECS. Recently, however, it has been suggested (Schneider & Sherman, 1968; Misanin et al, 1968; Robustelli et al, 1968) that the amnesia

produced by ECS could be the result of an inhibition of the S's ability to retrieve or act on a consolidated memory. An experiment done by Schneider & Sherman (1968) seems to support this new interpretation. They trained rats in one trial to passively avoid a footshock (US), and 6 h later they repeated the footshock and then gave immediate ECS. This resulted in a significant level of amnesia. When the footshock was not given with the ECS, or when the interval between footshock and ECS was increased to 30 sec, no amnesia resulted. Their interpretation of this effect is that this treatment puts the animal in an "aroused" state in which immediate ECS can suppress the subsequent performance of the avoidance response. This effect will be referred to as "rearousal amnesia." Its occurrence casts doubt on the "consolidation-interruption" hypothesis which predicts that ECS given under any conditions after the conclusion of the consolidation period (about 30 sec) should produce no amnesia.

The present experiment was done to check the existence of "rearousal amnesia" in chicks. Subconvulsive current (SCC) was used in place of ECS in this experiment since it has been used most often in memory consolidation work with chicks. Lee-Teng (1969) has shown that SCC just below the convulsive threshold produces retrograde amnesia with the same effectiveness and time dependence as ECS.

METHOD

The basic experimental setup is that developed by Lee-Teng (Lee-Teng & Sherman, 1966). Newly hatched white leghorn cockerels (Strain k155) were used in the experiment. Between 10 and 11 a.m. on the morning of their first day, the chicks were briefly anesthetized with halothane, and small electrodes (No. 16 fishhooks) were implanted under the skin just above each ear. The chicks were then placed individually in topless, white cylindrical