

*ALTERNATIVE RESPONSE TRAINING, DIFFERENTIAL
REINFORCEMENT OF OTHER BEHAVIOR, AND
EXTINCTION IN SQUIRREL MONKEYS
(SAIMIRI SCIUREUS)¹*

J. A. MULICK,² H. LEITENBERG, AND R. A. RAWSON

UNIVERSITY OF VERMONT

In Experiment I, (a) extinction, (b) extinction plus reinforcement of a discrete alternative response, and (c) differential reinforcement of other behavior were each correlated with a different stimulus in a three-component multiple schedule. The alternative-response procedure more rapidly and completely suppressed behavior than did differential reinforcement of other behavior. Differential reinforcement of other behavior was slightly more effective than extinction alone. In Experiment II, reinforcement of specific alternative behavior during extinction and differential reinforcement of other behavior were used in two components, while one component continued to provide reinforcement for the original response. Once again, the alternative-response procedure was most effective in reducing responding as long as it remained in effect. However, the responding partially recovered when reinforcement for competing behavior was discontinued. In general, responding was less readily reduced by differential reinforcement of other behavior than by the specific alternative-response procedure.

Key words: alternative response, DRO, extinction, suppression, reinforcement, multiple schedule, lever press, squirrel monkey

Increasing interest has recently been evident in using positive reinforcement to supplement the suppressive effects of extinction. One approach follows from Boe's suggestion (1964) that extinction might be more effective if a different response were reinforced. In the alternative-response (ALT-R) procedure, positive reinforcement for a specific, new response is introduced at the start of extinction of the

original response. With this procedure, suppression of the original response was more rapid and complete than with the conventional extinction procedure alone (Enkema, Slavin, Spaeth, and Neuringer, 1972; Leitenberg, Rawson, and Bath, 1970; Leitenberg, Rawson, and Mulick, 1975; Rawson and Leitenberg, 1973). However, when reinforcement for the competing behavior was discontinued, the original response recovered with only a relatively small net saving in extinction resulting from prior ALT-R training.

The other major line of research combining positive reinforcement with extinction has concentrated on differential reinforcement of other behavior (DRO: Reynolds, 1961) or omission training (Grant, 1964). The basic DRO schedule provides reinforcement only when a specific response has been withheld for a given period of time. The DRO procedure makes reinforcement directly contingent on withholding the original response, although it may adventitiously reinforce other behavior (Zeiler, 1970). A number of between-groups comparisons of DRO and extinction (EXT) alone have indicated that suppression can proceed more efficiently during DRO (Buel, 1975; Nevin, 1968; Johnson, McGlynn, and Topping, 1973; Topping and Crowe,

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²Now at the Child Development Institute, Biological Sciences Research Center, Division for Disorders of Development and Learning, University of North Carolina, Chapel Hill, North Carolina 27514.

1974; Topping and Larmi, 1973; Topping, Pickering, and Jackson, 1971, 1972; Uhl and Homer, 1974); although a number of others have reported the opposite finding, that EXT alone was more efficient (Uhl, 1973; Uhl and Garcia, 1969; Uhl and Sherman, 1971). Zeiler (1971) employed a within-subject procedure in which pigeons were first given nondifferential response training under two different discriminative stimuli. Subsequently, one stimulus was associated with EXT and the other with DRO. The results indicated that suppression of responding was faster during the stimulus correlated with DRO, and that spontaneous recovery occurred only during the stimulus correlated with EXT. Topping and Ford (1974) replicated these findings using a three-component multiple schedule in which responding during one stimulus was maintained with variable-interval (VI) reinforcement, while EXT and DRO were compared during the other two stimuli.

Only a few experiments have directly compared DRO, ALT-R training, and simple extinction. Baisinger and Roberts (1972) demonstrated that shock-elicited fighting could be suppressed better by reinforcing a specific non-fighting response than by DRO, but the shocks used to elicit fighting were maintained. Harman (1973) indicated that DRO was more effective than reinforcement of alternative behavior during extinction, but failed to equate the scheduled frequencies of reinforcement used in the two procedures, which differed by a ratio of 4:1 in favor of DRO.

It would be of interest to determine the relative effects of each of these procedures within single organisms. It is possible to make the comparison without repeated reacquisition and extinction if the procedures are introduced simultaneously following nondifferential training on multiple schedules of reinforcement (e.g., Topping and Ford, 1974; Zeiler, 1971). To compare EXT alone with EXT plus reinforcement of a specific ALT-R, and with DRO, each procedure was correlated with a different discriminative stimulus on a three-component multiple schedule in Experiment I. The scheduled frequency of reinforcement during DRO was equated with that used in the ALT-R procedure, while the obtained rate of reinforcement differed as a function of the relative efficiency of the procedures. Experiment II compared the effectiveness of

the DRO and ALT-R procedures when reinforcement of the original response was maintained in one component in place of extinction. Possible recovery functions were examined in both experiments after the ALT-R and DRO procedures were discontinued.

EXPERIMENT I

METHOD

Subjects

The four adult male squirrel monkeys (*Saimiri sciureus*) weighed between 800 and 1100 g before the experiment began. All had been housed for at least 3 yr in the present monkey colony and had experience with both group and single cages. Cisco was experimentally naive. Pedro and Skip had experience with VI 2-min schedules of food reinforcement, and Emilio had previous experience with *conc* VI-VI and VI-EXT schedules, all in the same apparatus used in the present experiment. In all cases, this experience occurred about 2 yr before the present experiment began. The animals were maintained at 83 to 85% of their free-feeding body weights, based on a three-day average weight recorded immediately before food deprivation. All were individually housed with unlimited access to water in the home cage throughout the experiment. Feeding outside of the operant chamber consisted of Purina Monkey biscuits, and occurred daily approximately 1 hr after the experimental session, or at about the usual time of the session on days when the animals were not run. A normal 12-hr day/night cycle was maintained in the monkey colony.

Apparatus

A Lehigh Valley Large Animal Test Cage (Model 1317) was equipped with two retractable response levers (LVE Model 1405m) mounted 39.4 cm above the grid floor and centered 10.2 cm on either side of the vertical center of the stimulus panel. A downward force of approximately 35 g (0.35N) on each response lever was required to register as a response. The stimulus panel was equipped with an air vent, a 4-ohm speaker, and a circular 2.5-cm diameter stimulus light capable of transillumination with orange, green, white, or mixed light located 2.5 cm above each response lever. A 31.8-cm long black Plexiglas

barrier, projecting 7.6 cm from the stimulus panel, meeting the roof of the chamber and extending down to 29.2 cm above the grid floor, prevented simultaneous manipulation of both response levers when both were available. Reinforcement consisted of 190-mg Noyes banana pellets (Formula L) delivered by an LVE Pellet Feeder (Model 1548) to a recessed rectangular food cup (7 by 3.8 by 5.1 cm) centrally located 8.9 cm above the grid floor. A brief flash of light from a 6-W bulb inside the food cup occurred with each pellet delivery. The entire operant chamber was enclosed in a sound-attenuating LVE primate cubicle (Model 1317C) equipped with a one-way observation window, overhead houselight (two 32-V dc bulbs), baffled air intake, and 108-cfm exhaust blower.

White noise, clicks at the rate of four per second, and an 800-Hz tone were generated by a BRS-Foringer Audio Generator (AU-902). Stimulus intensity (with the exhaust fan in operation) was approximately 82 to 86 dB at the center of the operant chamber. Experimental conditions were arranged using standard electromechanical relay equipment, located in a separate room.

Procedure

Cisco was acclimated to handling and trained to respond on variable-interval (VI) schedules of food reinforcement about two months before the experiment. Following preliminary training, the monkey was not handled, and was maintained under free-feeding conditions until the experiment began. The other animals were already familiar with lever pressing for food reinforcement and received no additional training.

In the prediscrimination or baseline condition, a three-component *mult* VI 30-sec VI 30-sec VI 30-sec schedule involved different compound auditory and visual discriminative stimuli associated with each component. One component of the multiple schedule (WN) was signalled by white noise and transillumination of the stimulus light located over Lever A (the left-hand lever) with white light, another (Tone) by the 800-Hz tone and a green stimulus light over Lever A, and the third (Click) by clicks occurring at the rate of four per second and orange stimulus lights over both response levers. There were five 3-min presentations of each discriminative stimulus

followed by a 12-sec timeout (TO). Sessions terminated after the fifteenth 3-min segment of the schedule. Only Lever A was present during baseline. In all phases of the experiment, during the TO between each stimulus presentation the houselights and stimulus lights were off, and Lever B was retracted (if present). Then, conditions appropriate for the next component were put into effect. A different random order of stimulus presentations was used for each successive experimental session, with the stipulation that no more than three consecutive presentations of the same stimulus could occur in a single session.

In Phase 2, during the WN component, EXT alone was in effect for Lever-A responding, the Click component was associated with EXT for Lever-A responding plus fixed-interval (FI) reinforcement for the alternative response on Lever B, and the Tone component was associated with a DRO schedule. Phase 2 therefore involved a *mult* EXT DRO *conc* EXT-FI schedule. In Phase 2, Pedro and Emilio received FI 30-sec and DRO 30-sec schedules, while Cisco received FI 20-sec and DRO 20-sec schedules. These schedules were introduced at their terminal values at the start of Phase 2. For Skip, the terminal FI 20-sec and DRO 20-sec schedules used in Phase 2 were introduced in gradually increasing interval steps during the first session in the first three stimulus presentations. Specifically, there was 1 min at FI or DRO 5-sec, and 2 min at FI or DRO 10-sec during the first presentations of Click and Tone; 1 min at FI or DRO 10-sec, and 2 min at FI or DRO 15-sec during the second presentations of Click and Tone; 1 min at FI or DRO 15-sec, and 2 min at FI or DRO 20-sec during the third presentations of Click and Tone.

In Phase 3, extinction was in effect during all three components. The schedule, therefore, was *mult* EXT EXT *conc* EXT-EXT. Emilio did not participate after the second day of Phase 3 because of a programming error. Extinction, in Phase 4, remained in effect during Click and Tone, but Lever-A responses were reinforced during WN on a VI 30-sec schedule. That is, a *mult* VI 30-sec EXT *conc* EXT-EXT was in effect.

RESULTS AND DISCUSSION

Figure 1 depicts the mean responses per minute on Lever A during each of the three

stimulus components of the multiple schedule. Response rates appeared to be stable by the end of the baseline phase, with no consistent differences apparent during any individual stimulus component for any of the animals.

The second panel of Figure 1 represents the major findings. During WN, conventional extinction was in effect. All four monkeys showed a gradual decline in response rate under simple EXT conditions. Response rates in general declined more quickly under ALT-R

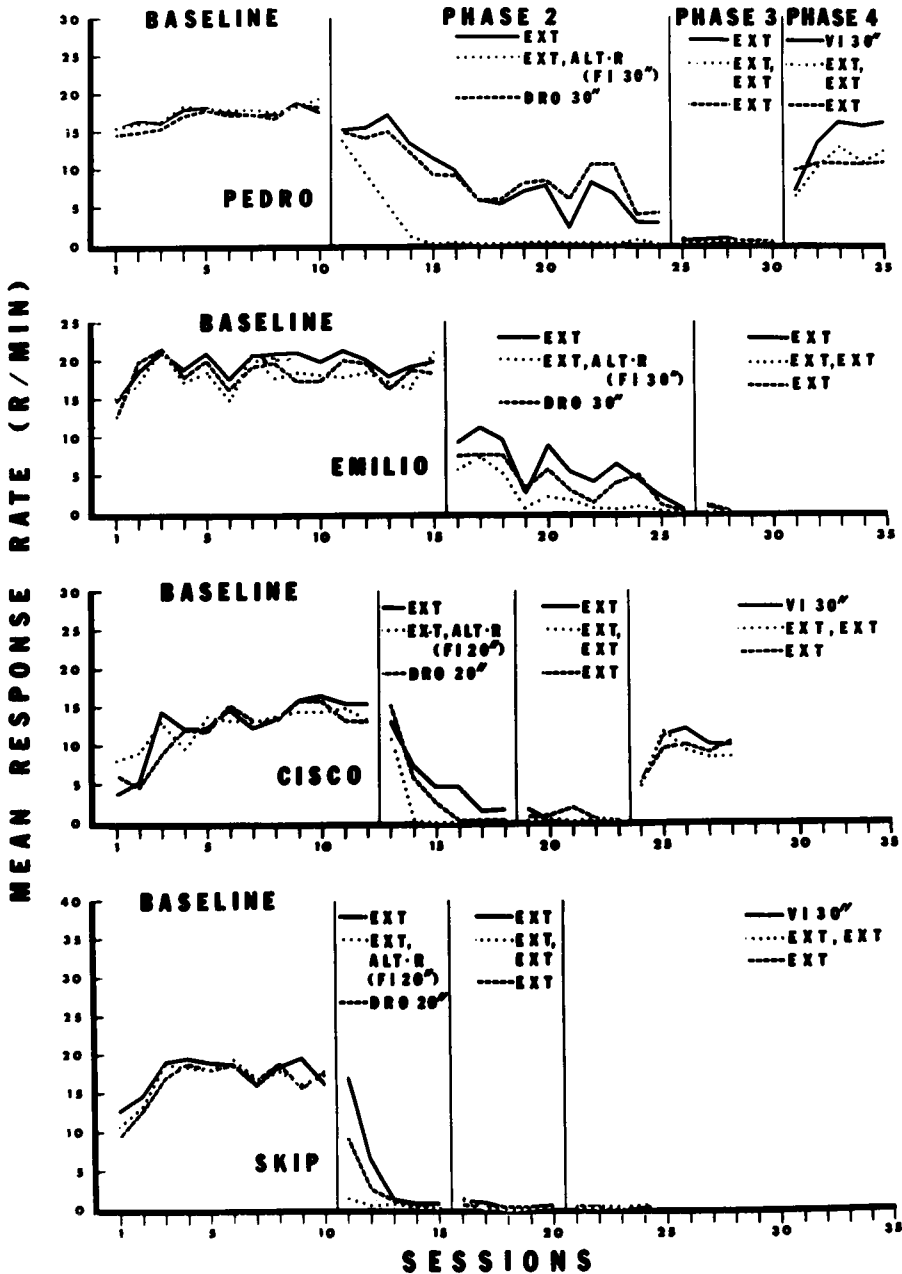


Fig. 1. Mean Lever-A response rate in Experiment I. Solid lines represent rate during WN, dashed lines during Tone, dotted lines during Click. Baseline conditions were *mult* VI 30-sec VI 30-sec VI 30-sec. Subsequent conditions are shown in the key for each phase. Skip received gradual introduction of the ALT-R and DRO procedures in the first session of Phase 2.

and DRO than under the conventional extinction procedure. Specifically, response rates on Lever A in Phase 2 during the ALT-R component declined to less than one response per minute for Cisco and Skip by the second session, and for Pedro and Emilio by the fourth session. In general, Lever-A responding remained negligible thereafter during the ALT-R component. Emilio showed a slight increase to two responses per minute during the ALT-R condition in the fifth session in Phase 2, but declined again to less than one response per minute in the seventh and all subsequent sessions. Acquisition of the alternative response on Lever B was correspondingly rapid. Lever-B response rates during the second session of Phase II for Cisco and Skip were approximately 18 responses per minute and 23 responses per minute, respectively. In addition, due to the gradual method used to introduce the FI 20-sec schedule on Lever B, Skip's Lever-B response rate (15 per minute) was substantial during the first session of Phase 2 and was associated with a very low mean response rate on Lever A (1.4 per minute) as well. Pedro's Lever-B response rate during the first four sessions of Phase 2 resembled an inverse linear function of the rate of decline on Lever A during the ALT-R component, increasing from about two responses per minute in the first session to 27 in the fourth. Emilio showed a similar increase on Lever B, from about four responses per minute in the first Phase 2 session to about 15 in the fourth. Since reinforcement during the ALT-R component occurred in the context of FI schedules of reinforcement for Lever-B responding, it should be clear that the actual rate of reinforcement was substantial as soon as the Lever-B response was acquired. In fact, nearly all scheduled reinforcement during the ALT-R component was actually obtained by the time responding on Lever A had declined to about two responses per minute or less.

Responding during the DRO component did not decline as rapidly or consistently to as low a level as did responding during the ALT-R component. Both Cisco and Skip declined to a rate of less than one response per minute in the fourth session of Phase 2 in which nearly all scheduled reinforcements during DRO were obtained. Emilio did not decline to as low a rate until the tenth session, in which only about 66% of all scheduled re-

inforcement was obtained. Pedro's rate never declined below about four responses per minute in a total of 15 sessions, and Pedro never received more than half the possible reinforcements in a single session—only one instance of reinforcement during DRO was recorded during the first six sessions of Phase 2. Overall, although opportunity for reinforcement was equivalent, obtained reinforcement rates were much lower during DRO than during ALT-R conditions, especially throughout the early sessions of Phase 2.

The decline in Lever-A response rate was least immediate during the EXT component. However, one monkey, Pedro, responded about as much on Lever A during the EXT component as during the DRO component throughout Phase 2. This was true in spite of the fact that from the seventh session of Phase 2 onward, Pedro did receive some of the scheduled reinforcement during DRO in each session. This suggests that, at least for Pedro, discrimination of the DRO condition from the EXT condition was more difficult than was discrimination of the ALT-R condition from the other two.

There was little or no evidence in Phase 3 of recovery of Lever-A extinction responding after the Phase 2 procedures were discontinued. This is somewhat at odds with the large rebound in original response rate previously reported following ALT-R training (Enkema *et al.*, 1972; Leitenberg *et al.*, 1970; Leitenberg *et al.*, 1975), and may result from the simultaneous comparison of the three procedures. In Phase 4, reinforcement for Lever-A responses was again provided during the WN component, but EXT was maintained in the other two components. Pedro's mean response rate on Lever A over the last three days of Phase 4 increased to about 16 responses per minute during WN, and to 12 and 11 during the previous ALT-R and DRO components, respectively. Cisco presented identical results with about 11 responses per minute during the reinforced component, and 9 and 10, respectively, during the previous ALT-R and DRO components. Skip's overall response rate was so low in Phase 4 that no reinforcements were earned during the WN component. These results for Phase 4 indicated that there were no consistent differential long-term effects on response elimination as a result of either supplementary reinforcement procedure. Both

temporary DRO and temporary ALT-R training failed to add discernible resistance to the effects of partially re-instating cues associated with baseline conditions, *i.e.*, VI 30-sec food reinforcement for Lever-A responding during the WN component.

EXPERIMENT II

Experiment II examined the relative suppressive effects of the two supplementary reinforcement procedures in the context of a three-component multiple schedule in which a response-elimination procedure did not occur during every stimulus component. The comparison is of interest because of the possibility that in Experiment I recovery from the suppressive effects of the reinforcement procedures may have been masked by earlier acquisition of a generalized avoidance response to Lever A. If Lever-A responding continued to be reinforced at least some of the time, one would not expect that Lever-A behavior in and of itself would come to signal the absence of reinforcement. Consequently, some recovery of responding during previous ALT-R and DRO components might be expected to occur in the transition to EXT.

METHOD

Subjects

Four adult male squirrel monkeys weighed between 800 and 1000 g before the experiment began. Tony was experimentally naive and received the same preliminary training and handling described for Cisco in Experiment I. Poncho had previous experience on a VI 2-min schedule of food reinforcement, and Charlie had been exposed to *conc* VI-VI and VI-EXT schedules 2 yr previously. All housing and handling conditions were the same as those described for animals used in Experiment I.

Apparatus

The apparatus was the same as that used in Experiment I.

Procedure

The procedure for Phase 1 was the same as that employed in Experiment I. In Phase 2, Charlie had a *mult* VI 30-sec DRO 30-sec *conc* EXT-FI 30-sec schedule, and Poncho had a

mult VI 30-sec DRO 20-sec *conc* EXT-FI 20-sec schedule. Tony had a *mult* VI 30-sec DRO 20-sec *conc* EXT-FI 20-sec schedule, in which the FI and DRO schedules were introduced gradually as with Skip in Experiment I.

In Phase 3, Charlie, Poncho, and Tony all received *mult* VI 30-sec EXT *conc* EXT-EXT schedules. The VI 30-sec schedule remained in effect during WN, but all additional reinforcement procedures during Click and Tone were discontinued.

RESULTS AND DISCUSSION

Figure 2 shows the mean response rates on Lever A for each subject. All animals acquired the original response on Lever A in each of the three VI 30-sec components of the baseline condition. Tony exhibited consistently higher response rates in baseline during the Click stimulus, which was later associated with the ALT-R procedure in Phase 2.

In Phase 2, there was a striking difference in the effectiveness of the two response-elimination procedures. The availability of a reinforced alternative response during extinction produced the most rapid and complete suppression of Lever-A responding in all three monkeys, whereas the DRO procedure produced little or no immediate effect. Lever-A responding during the ALT-R component declined to less than one response per minute in the sixth session with Charlie, in the seventh session with Poncho, and in the third session with Tony. Poncho showed the sharpest decline during the ALT-R component between the first and second sessions of Phase 2, but fluctuated between about two and five responses per minute until the seventh session. The rate of response on Lever B stopped increasing sharply with Charlie in the fourth session (38 responses per minute), with Poncho in the second session (30), and with Tony in the third session (35), by which time the rate of reinforcement for each was close to maximum on the schedules used.

The effects of DRO were less consistent. Charlie declined to a rate of about five responses per minute in the twelfth session, and never declined to below two responses per minute. Charlie received little reinforcement during DRO until Sessions 11 to 15 in which there were 3, 5, 13, 16, and 14 reinforcements, respectively. Poncho never declined below 14 responses per minute (Session 9), and total re-

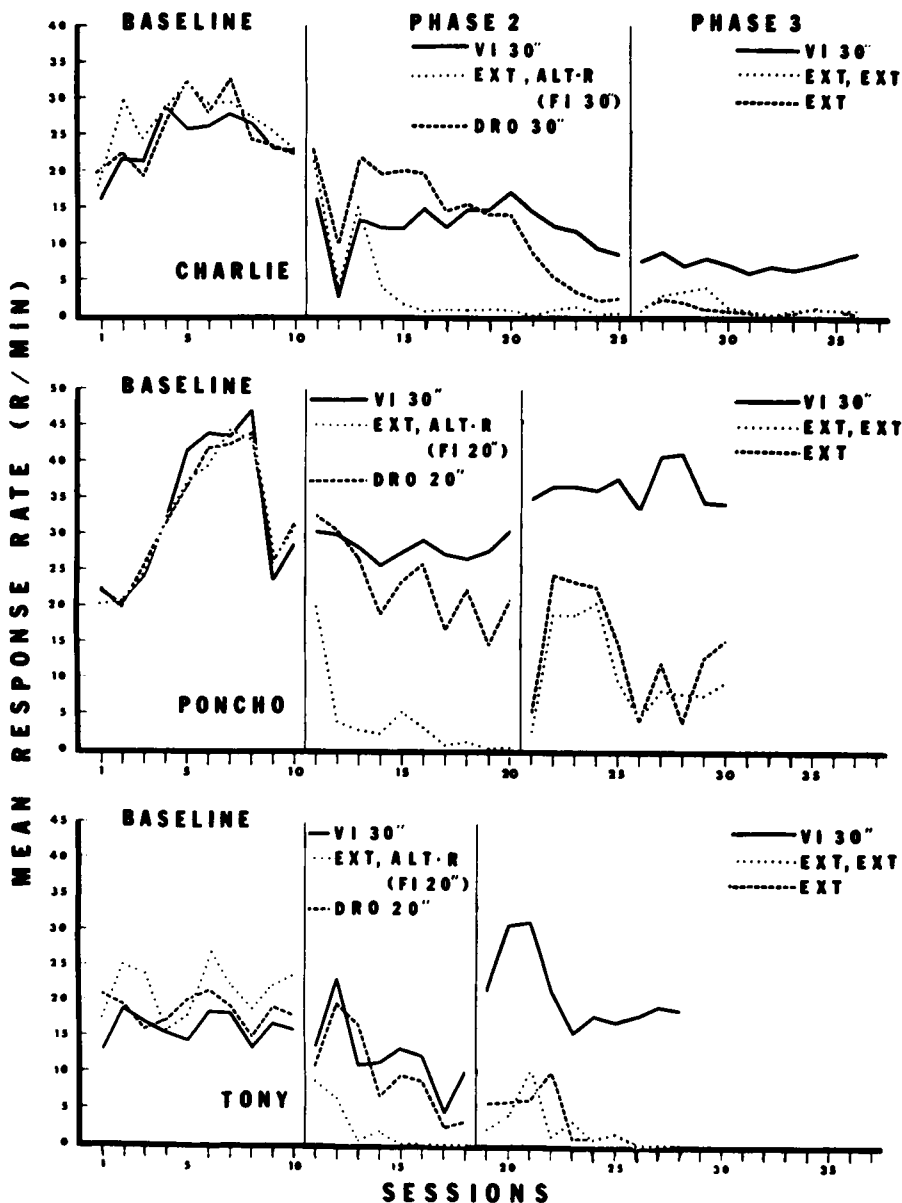


Fig. 2. Mean Lever-A response rate per minute in Experiment II. Solid lines represent response rate during WN, dashed lines during Tone, dotted lines during Click. Baseline conditions were *mult* VI 30-sec VI 30-sec VI 30-sec. Subsequent conditions are shown in the key for each phase. Tony received gradual introduction of the ALT-R and DRO procedures in the first session of Phase 2.

inforcement during DRO was never greater than two per session, starting with the fourth session of Phase 2. The most immediate decline during DRO occurred with Tony: a rate of about seven responses per minute as early as the fourth session, and eventually declined to three responses per minute. Tony got some reinforcement during DRO in each session of Phase 2, including a substantial number (26)

during the first session due to introducing the DRO procedure gradually.

Response rates during the component in which VI 30-sec reinforcement for Lever-A responding was maintained declined with both Charlie and Tony. This occurred with Charlie at about the same time as rate of reinforcement under the DRO condition began to increase. Tony's rate during the VI component

tended to parallel rate during DRO. Similar declines during the VI component of *mult* VI DRO schedules, termed induction (Catania, 1968, p. 336), have been reported previously (Nevin, 1968; Reynolds, 1961; Uhl and Homer, 1974).

In Phase 3, responding during the DRO component continued to decline in extinction. On the other hand, there was a pronounced recovery during the ALT-R component similar to that reported previously when reinforcement of alternative behavior during extinction was discontinued (Enkema *et al.*, 1972; Leitenberg *et al.*, 1970; Leitenberg *et al.*, 1975). Such recovery in Phase 3 suggests that even though Lever-A responding during the ALT-R component had been well suppressed in Phase 2, it had not been eliminated. Lever-B responding declined steadily in Phase 3, in each case reaching a rate of less than 10% of the rate at the end of Phase 2 by the third session of Phase 3.

GENERAL DISCUSSION

A major finding was that the alternative response (ALT-R) procedure consistently produced more rapid and complete suppression than did either EXT alone or DRO. The superiority of providing reinforcement for a specific competing response was not affected within the scheduled reinforcement intervals used (30 sec and 20 sec) or by introducing the procedures gradually. These results are in agreement with earlier group comparisons of ALT-R training and simple EXT (Enkema *et al.*, 1972; Leitenberg *et al.*, 1970; Leitenberg *et al.*, 1975; Rawson and Leitenberg, 1973). Three of the four monkeys in Experiment I declined more rapidly during DRO than during EXT. This is comparable with previous reports that responding declines faster during the DRO component of *mult* DRO EXT (Zeiler, 1971) and *mult* VI DRO EXT schedules (Topping and Ford, 1974).

Both experiments showed that the ALT-R procedure produced more efficient response suppression than did the DRO procedure. Earlier findings indicate that when the scheduled frequency of reinforcement during DRO is higher than that used for the ALT-R, the rate of decline during DRO is more rapid (Harman, 1973). In the present experiments, opportunities for reinforcement were equal.

However, the actual rate of obtained reinforcement was higher and was consistently experienced sooner during the ALT-R condition for making a specific competing response than during DRO for withholding the original response. In this sense, then, the ALT-R procedure was more efficient in terms of rapid exposure to the schedule dependencies that maintained competing behavior. Perhaps the use of a different kind of DRO procedure involving more frequent initial rates of reinforcement would have produced more rapid decrements in responding. Nevertheless, our results are compatible with those of Baisinger and Roberts (1972), who showed that reinforcement of a specific ALT-R reduced shock-elicited aggression more efficiently than DRO.

The technique of comparing each of these procedures in the context of multiple schedules resulted in some simultaneous interactions between components. Two subjects showed induction from DRO to VI in Experiment II. In Experiment I, the rate of decline during the EXT component appeared to be highly correlated with the rate of decline during DRO. Sequential interactions may also have influenced the behavior of the animals in both experiments. For example, the frequently observed recovery of original behavior after ALT-R training was discontinued (*e.g.*, Leitenberg *et al.*, 1970) was not observed in Experiment I. This may have resulted from the combined effects of employing three response-elimination procedures in Phase 2. Recovery following ALT-R training was observed in Experiment II, but it is not clear if this occurred (1) because such sequential interactions that might "mask" recovery were eliminated, (2) because maintaining reinforcement for Lever-A responding during the VI component produced induction in Phase 3, (3) because ALT-R training itself does not permanently eliminate the original response, or (4) because a combination of such interactions occurred.

These considerations make it very difficult to draw any conclusions regarding recovery of the original response. Previous experiments have shown that when ALT-R training takes place during S^A periods, subsequent recovery is generally greater than when ALT-R training is provided during simple extinction. Leitenberg *et al.* (1975) speculated that because the original response continues to be

reinforced during S^D periods throughout experiments conducted in the context of discrimination learning, the original response remains at a higher strength due to a generalization process. However, it is not clear if such an interpretation is relevant to the present data. There was no evidence of recovery immediately after DRO was discontinued. Whether this is due to an artifact of the multiple-schedule design or to a genuine long-term effect of DRO training cannot be determined from the present data. Uhl and Garcia (1969) reported that recovery occurred during extinction tests following a period of DRO training, but no other data comparing recovery following DRO and ALT-R training are available.

The last point that can be raised concerns procedures used to assess durability of response elimination. Reports of a high degree of durability of response elimination following DRO training abound in the literature (Buel, 1975; Harman, 1973; Topping and Ford, 1974; Topping and Larmi, 1973; Topping *et al.*, 1972; Uhl, 1973, 1974; Uhl and Garcia, 1969; Uhl and Homer, 1974; Uhl and Sherman, 1971). However, these all pertain to tests conducted with response-independent reinforcement. Although the response-eliciting effects of the reinforcing event (Reid, 1958) may in some cases slow the rate of decline during DRO training (Uhl and Garcia, 1969), as DRO training proceeds the reinforcing event becomes associated with periods of not-responding and may gradually lose stimulus control over the original response. Nothing occurs during simple extinction to affect the controlling relation between the reinforcing event and responding. Thus, response-independent reinforcement *should* elicit more responding following EXT than DRO. In Experiment I, Lever-A responding recovered equally in Phase 4 during the stimuli previously correlated with the ALT-R and DRO conditions when VI 30-sec reinforcement was reintroduced in the presence of the other stimulus. Re-instatement of cues associated with baseline conditions during only one component did not reveal differential long-term effects of either response-elimination procedure. Although this finding must be viewed with caution, because the multiple-schedule procedure itself may have contributed to the outcome, it does suggest that durability of re-

sponse elimination should be assessed under a wider range of conditions.

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