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Effectiveness of three differential reinforcement techniques as a function of past reinforcement history and present schedule of reinforcement

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EFFECTIVENESS OF THREE DIFFERENTIAL REINFORCEMENT TECHNIQUES AS A FUNCTION OF PAST REINFORCEMENT HISTORY AND PRESENT SCHEDULE OF REINFORCEMENT

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THESIS ACCEPTANCE

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ABSTRACT

The effectiveness of three differential reinforcement techniques, extinction of the old response with reinforcement for the new response versus extinction of the old response with double reinforcement for the new response versus continuation of reinforcement for the old response with double reinforcement for the new response, in reducing lever-pressing behavior, was studied, as a function of past reinforcement history and present schedule of reinforcement. Thirty children, with a mean age of 5 years 10 months, were reinforced for tapping the assigned key on either a differential reinforcement of low rates (drl 10") or a differential reinforcement of high rates (VR 21 drh 4.5") schedule of reinforcement. This training provided divergent reinforcement histories and a behavior to be reduced. The children were then reinforced for responding on the other key on a variable ratio (VR 32) schedule.

Findings indicated that divergent reinforcement histories can influence later responding. Although the three differential reinforcement techniques tended to have differing effects in reducing the old response, the differences were not significant.

INTRODUCTION

A child enters school, an experiment, or a therapy session with his/her own reinforcement history. As no child's environment is quite like that of any other child's, his/her reinforcement history varies. Many children's reinforcement histories may be similar, but some children will have quite divergent reinforcement histories. Researchers are interested in how the person's reinforcement history interacts with the reinforcement procedures used to reduce undesirable behaviors.

To reduce undesirable behaviors, in treatment and in research with animals and humans, differential reinforcement techniques have been used. Leitenberg, Rawson, and Mulick (1975) found that pigeons who were given a high frequency of reinforcement for a competing behavior, made significantly less original responses in extinction than did the pigeons given a low frequency of reinforcement for a competing behavior, or those not reinforced for a competing behavior. Dietz and Repp (1973) found a differential reinforcement of low rates technique effective in reducing talking-out behavior of developmentally retarded children and of high school students. In 1974, Repp and Dietz reinforced other behaviors to successfully reduce aggression and self-injurious behavior of retarded children.

One factor involved with the effectiveness of differential reinforcement techniques is the magnitude of reinforcement. Many studies have investigated the effects of magnitude of reinforcement upon performance, with differing results. Calef, Hopkins, McHewitt, and

Maxwell (1973) found depressed runway performance in rats when large and small rewards were varied after consistent large reward training. Hulse, in 1973, also found a significant negative contrast effect when rats pressed for 1-pellet reward after a mixed 1- and 10-pellet reward in pretraining. However, he did not find a positive contrast effect with rats pretrained on 1-pellet reward when trained on a 10-pellet reward schedule. Mellgren, Seybert, Wrath, and Dyck (1973) found a positive contrast effect with rats pretrained on 1, 2, 4, 8-pellet rewards when shifted to an 8-pellet reward. Postshift running speed was inversely related to magnitude of preshift reward. McCain and Coony, in 1975, found positive contrast effects with rats when the second and third shifts were to large rewards. Myers and Anderson (1975) with rats, found that large reward led to faster acquisition and greater resistence to extinction than small rewards with groups given 30 or 90 large reward pretraining trials. Those given 300 trials, both small and large reward groups, responded equally in acquisition, but the small reward group was more resistent to extinction.

With pigeons, Catania (1963), found that on concurrent VI VI schedules equated for frequency of reinforcement, the number of responses on each manipulandum was a function of relative magnitude of reinforcement. Schneider, in 1973, found that pigeons responded more when reinforcers were delivered frequently in small amounts than when delivered in large amounts.

Bruning (1964) found a slight but nonsignificant decremental

effect on performance with large magnitude of reward in children. Hom, Corte, and Spradin, in 1966, found that concurrent performance on two bars with independent VI schedules by mildly retarded adolescent girls, was positively related to the amount of reinforcement. Todorov (1963) found that reinforcement frequency had more effect upon choice than did the magnitude of reinforcement. Masters and Mokros (1973) found that low magnitude of reinforcement led to more rapid acqusition in young children and increased their preference for the reinforced response.

Morse, in 1966, concluded that changing the reinforcement magnitude is effective when the response rate is low but has little effect when the rate is high. Dunham (1968), in his critique of contrasted reinforcement conditions, concluded that there was not "consistent evidence for a directional symmetry of contrasted effects" (p. 306), but there was substantial evidence "to support functional relationship between the relative frequency parameter and the magnitude of positive contrast" (p. 311).

Another factor interacting with differential reinforcement techniques in effectively reducing undesirable behaviors, is reinforcement history. For many years, animal researchers have been investigating the effects of experimental reinforcement histories (pretraining) on training procedures. Their results differ. Mandler and Goldberg (1973) found that pretraining had little effect on choices made by rats in training, but had varied effects on latency measures. Grant, Hale, and Fuselier (1974) also found that the training schedule, not pretraining,

was important in resistence to extinction in rats. In 1974, Pouthas found that rats pretrained on a differential reinforcement of low rates (drl) schedule had higher reinforcement rates when subsequently trained on a fixed interval (FI) schedule than did naive rats. However, FI pretrained rats and naive rats' reinforcement rates did not differ on drl training.

Results on studies investigating the interaction of experimental reinforcement histories with reinforcement techniques used in training, with humans, also differ. In 1972, Hamilton, found that children given a low social reinforcement history performed better on 100% reinforcement (praise) than did those given a high social reinforcement history. Both groups performed the same on 33% reinforcement. Weiner (1964, 1965, 1969) found that rates and patterns of responding taught in a pretraining session continued in training sessions under different reinforcement schedules. Using divergent reinforcement histories, DRL 20" versus fixed ratio (FR) 40 in 1964, and FR 40 versus FI 10" versus DRL 20" in 1965, he also showed that experimental reinforcement histories could be used to reduce intersubject variability. Weisberg, in 1970, also found that reinforcement history influenced young children's responding during training. Twelve subjects were trained on VR 10, FI 18", DRL 10", or DRL 2" schedules. Then they were tested on a DRL 18" schedule. During the first testing session, the DRL 10" trained subjects showed the lowest response rate, and the highest reinforcement rate, while the VR 10 trained subjects were consistently poorest on the

same measures of responding. By the sixth testing session, most subjects performed almost as well as the DRL 10" subjects, although the VR 10 subjects continued to show rapid sequential responding.

Leibowitz, in 1972, studied the effectiveness of three differential reinforcement techniques — extinction of the old response with reinforcement for the new incompatible response, extinction of the old response with greater reinforcement for the new incompatible response, and continuation of reinforcement of the old response with greater reinforcement for the new incompatible response in reducing lever-pressing behavior with retarded children. He concluded that extinction with greater quantitative reinforcement of an incompatible response was the most powerful technique, but if extinction could not be used, then greater reinforcement for an incompatible behavior without extinction could be used. In 1975, Leibowitz studied the effectiveness of those three differential reinforcement techniques in reducing lever-pressing behavior with children of average abilities, as a function of both past reinforcement history and present reinforcement schedules. He found no significant differences between the effectiveness of extinction of the old response with reinforcement for the new incompatible response technique and the continuance of reinforcement for the old response with quantitatively greater reinforcement for a new incompatible response technique. There were also no significant differences in the rate of responding as a function of the two reinforcement histories (VR 35 and VI 20"). The present reinforcement schedule was the only significant

determinant of the present response rate. Subjects reinforced on the VR 35 schedule responded more rapidly than did those on the VI 20" schedule.

However, there was an interesting non-significant trend concerning the effectiveness of the three differential reinforcement techniques between retarded and normal subjects (1970 vs. 1974). Extinction of the old response with greater reinforcement for the new response technique ranked first in effectiveness with retarded subjects and third with normal subjects. The extinction of the old response with reinforcement for the new response ranked first with normals and third with retarded subjects. The continuance of reinforcement for the old response with greater reinforcement for the new response ranked second with both groups of subjects. Also the response rates of the retarded subjects tended to be lower than the response rates of normal subjects. Perhaps these tendencies were due to the diverse natural histories of the two groups of subjects.

The purpose of this study was to investigate the effectiveness of three differential reinforcement techniques studied by Leibowitz (1972; 1975), using comparable procedures in reducing lever-pressing behavior with subjects having a past history of a differential reinforcement of low rates (drl) schedule, or a differential reinforcement of high rates (drh) schedule of reinforcement, and whose current behavior is reinforced on a variable (VR) reinforcement schedule.

It was hypothesized that these two diverse reinforcement histories

(pretraining) would have different effects upon the differential reinforcement techniques and rates of responding. Specifically it was hypothesized that:

(1) Extinction of the old response with greater reinforcement for the new incompatible response technique would be most effective with subjects with a drl history and be less effective with subjects having a drh history.

(2) Extinction of the old response with reinforcement for the new incompatible response would be most effective with subjects having a drh history and be less effective with subjects having a drl history.

(3) Continuance of reinforcement for the old response with greater reinforcement for the new incompatible response technique would be least effective with subjects having a drh history; alternation between the two keys would occur with the two similar concurrent schedules (VR 32 vs. VR 21 drh 4.5") and response opportunities. The technique would be somewhat effective with subjects having a drl history although some alternation would probably occur.

(4) Subjects having a drh history would continue to respond more rapidly than would the subjects having the drl history.

METHOD

Subjects

Thirty children, from summer camp programs sponsored by the Jewish Community Center of Omaha and from nearby neighborhoods, served as subjects. The 16 boys and 14 girls ranged in age from 3 years 8 months to 8 years 1 month, with a mean age of 5 years 10 months. The children's ages at the time of the study and their sex are listed in Appendix A. Twenty-three additional children participated, but their data were not utilized, due to mechanical problems (7 children), failure to finish the session (3 children), or failure to learn the required response as defined by never receiving reinforcers for responding on the drh or drl schedule (13 children).

Apparatus

The study was conducted in an air conditioned mobile trailer which contained a 3.35 m long by 2.34 m wide experimental room and a 2.67 m long by 2.34 m wide control room. The wall between the two rooms contained a door and a .91 m square one-way mirror. (See Appendix B for sketch.) Against one wall in the experimental room, was placed a 1.5 m long by .76 m wide table. At each front corner of the table, a standard black telegraph key was attached, so that the children could not operate both keys simultaneously. Between the two keys was placed a box containing a magazine through which the reinforcing stimuli, Hersheyette candies, were delivered, and a sonalert which delivered a brief 4.5 KHz

tone immediately preceeding the candy. The control room contained the solid state equipment which controlled the events in the study.

Procedure

Potential subjects were given informed consent forms to give to their parents or guardians by teachers, counselors, or the experimenter. (See Appendix C for copy of consent form.) Children returning signed consent forms were scheduled to participate at a time not interfering with special activities, by their teacher or the experimenter. All the children were assigned randomly to one of six groups before the experiment began (see Table 1).

The experimenter entered the activity areas of the younger children, was introduced to the child by the teacher, who asked if he/she wanted to play with the candy machine. If the child agreed, he/she was escourted to the nearby trailer. The older children were either escourted by their counselors to the trailer or came alone. A few children were brought to the trailer by their parents or friends. After entering the experimental room, the child was given the following instructions: "Hi. How would you like to play with the candy machine? All you must do to get the machine to work is tap the bars, and you may keep all the candy you earn. I will come for you when time is up. OK? If the child asked a question, the instructions were repeated. As the experimenter entered the control room, she repeated, "I will come for you when time is up. Please do not begin until I tell you." After turning on the apparatus, the experimenter opened the connecting door

Table 1

Research Design

Groups N = 30	Period I (3 minutes)	Period II (12 minutes)	Children instructed to respond on opposite key	Period III (12 minutes)	
				New Key	Old Key
A	BASELINE	Crf drl 10" one key		Crf VR 32	Extinction
B				Crf VR 32 2sr	Extinction
C				Crf VR 32 2sr	Continue drl 10"
D	No reinforcement	Crf VR 21 drh 4.5" one key		Crf VR 32	Extinction
E				Crf VR 32 2sr	Extinction
F				Crf VR 32 2sr	Continue VR 21 drh 4.5"

and told the child to begin. Occasionally minimal addition instructions were given in special circumstances (e.g., child trying to open outside door, tapping the keys too hard or too lightly).

During the first three minutes, baseline measures on both keys were determined. No reinforcement was available.

After baseline, acquisition on one key began. To rule out a key preference, the response initially reinforced was determined randomly so that one-half of the children would be reinforced for tapping the right key and one-half, for the left key.

Children in the Differential Reinforcement of Low Rates (drl) groups A, B, and C, were reinforced for responding on one key on a continuous reinforcement (Crf) schedule for five responses followed by a differential reinforcement of low rates 10 seconds (drl 10") schedule. This schedule parameter, also used by Weisberg (1970), was chosen so that children given a low rate reinforcement history would have reinforcement opportunities similar to that of the high rate reinforcement history groups. Children in the Differential Reinforcement of High Rates (drh) groups D, E, and F, were reinforced for responding on one key on a Crf schedule for five responses followed by a variable ratio 21 responses with differential reinforcement of high rates 4.5 seconds contingency (VR 21 drh 4.5") schedule. The lowest value that led to reinforcement was eight responses within 4.5 seconds. This schedule parameter was chosen to provide children with a high response rate history while keeping the reinforcement opportunity similar to that of

the low rate reinforcement history groups. Responding on the opposite key was not reinforced. This procedure continued for twelve minutes.

Then, the experimenter opened the door and said: "(Child's name), why don't you see if the other bar also works." The child's first response on the other key introduced the independent variables.

The following procedures were introduced to reduce the response rate on the previously reinforced key. Groups A and D were reinforced for responding on the previously nonreinforced key on a Crf schedule for five responses followed by a VR 32 schedule. The previously reinforced response was no longer reinforced (extinction). Groups B and E were reinforced for responding on the previously nonreinforced key on a Crf schedule for five responses followed by a VR 32 schedule, with the quantity of reinforcement doubled to two Hersheyettes. The previously reinforced response was no longer reinforced (extinction). Groups C and F were reinforced for responding on the previously nonreinforced key on a Crf schedule for five responses followed by a VR 32 schedule with quantity of reinforcement doubled to two Hersheyettes. The previously reinforced response continued to be reinforced as in the previous period, group C on a drl 10" schedule and group F on a VR 21 drh 4.5" schedule, with the same quantity of reinforcement as before, one Hersheyette. The VR 32 schedule, similar to the schedule used by Leibowitz (1972, 1975), was chosen in order to provide a medium response rate with reinforcement opportunity similar to that given by the drl and drh schedules in the previous period. Each group's procedure continued for twelve

minutes.

After the twenty-seven minute session ended, the experimenter re-entered the room, gave the child a bag for his/her candy if he/she had not eaten them, and escourted the child back to his/her activity area, counselor, friend, or parent.

RESULTS

The results were evaluated by comparing the number of responses emitted concurrently on either key by the children during each period of the experiment. The last three minutes of each period was chosen as the best indicator of the children's performances on the basis of prior work (Leibowitz 1972; 1975) and visual inspection of the data (see Figures 1 and 2), and was used in analyses involving the second and third periods. The total number of responses in the three-minute baseline was used in analyses involving the first period. The mean number of responses and standard deviations for all groups in the last three minutes of each period are listed in Table 2.

Period I

A two-factor (group x key) Analysis of Variance (AOV) with repeated measures on one factor (key) indicated that there were no signficant differences among groups A, B, C, D, E, and F on the number of responses emitted, no significant differences between the number of responses emitted on each key, and no significant interaction between the two factors, during baseline (Appendix D, Table 3).

A t-test comparing the total number of responses emitted during baseline by girls versus boys indicated that there were no significant sex differences, t (28) = .619, $p > .05$.

A one-way AOV comparing the ages of the children in each group indicated that there were no significant age differences among groups,

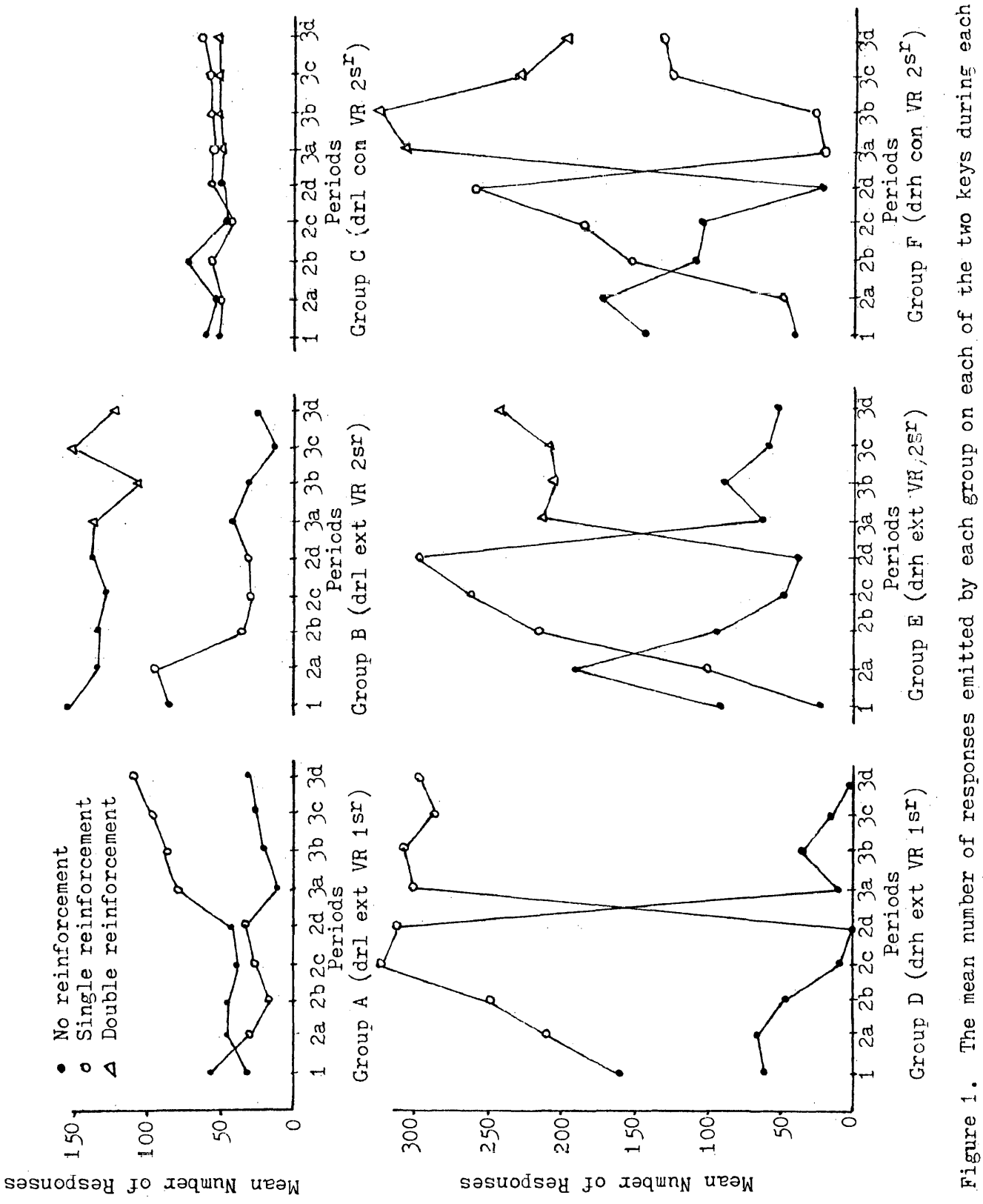


Figure 1. The mean number of responses emitted by each group on each of the two keys during each three minutes of the session.

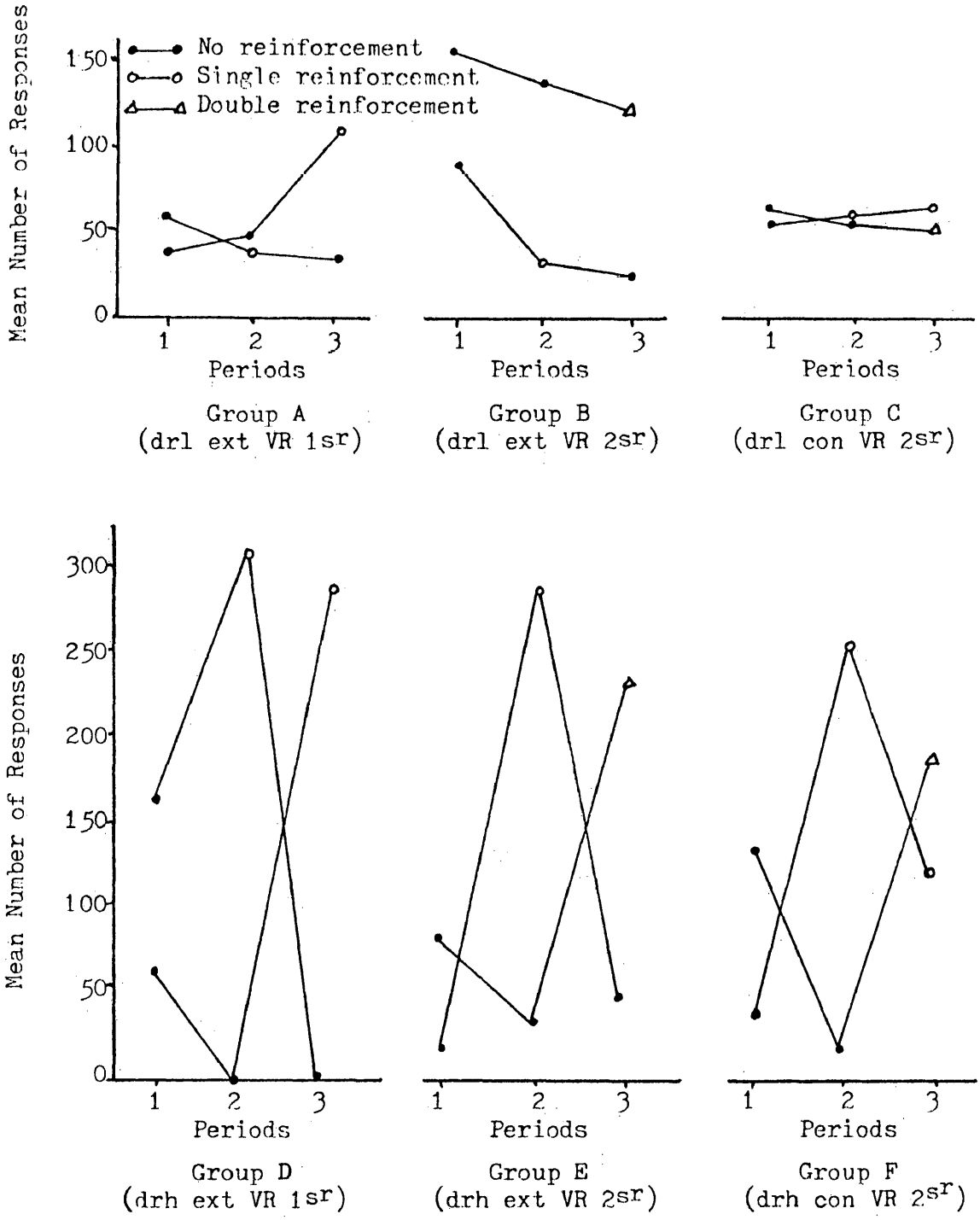


Figure 2. Mean number of responses emitted by each group on each of the two keys during the last three minutes of each experimental period.

Table 2

Mean Rate of Response and Standard Deviation for All Groups During the Last Three Minutes of Each Period

Group		Period I		Period II		Period III	
		Key reinforced in P II	Key not reinforced in P II	Reinforced Key	Nonreinforced Key	Reinforced Key	Previously reinforced Key
A	Mean	57.800	33.200	36.600	41.200	108.000	33.600
	SD	70.251	49.017	22.678	50.117	92.715	36.315
B	Mean	86.200	156.200	32.800	137.600	122.200	26.600
	SD	100.335	168.390	27.590	186.878	122.706	33.805
C	Mean	53.800	62.800	56.600	52.800	54.800	65.000
	SD	48.874	72.686	42.600	40.071	61.263	65.322
D	Mean	159.000	61.000	310.600	.000	288.400	3.400
	SD	124.654	136.400	136.518	.000	122.863	7.603
E	Mean	24.000	86.400	296.800	38.800	237.200	54.800
	SD	25.807	88.410	139.390	63.429	94.835	51.829
F	Mean	44.600	139.000	263.000	23.200	196.600	129.000
	SD	83.969	93.343	37.796	22.841	145.596	140.077

F (5, 24) = .298, $p > .05$.

These three baseline analyses indicated that the groups were comparable at the beginning of the study.

Period II

The following statistical tests were used to discover any significant changes in the children's rate of responding as a function of the drl and/or drh schedules of reinforcement.

A two-factor (history schedule x key) AOV with repeated measures on one factor (key) on the number of responses emitted during the last three minutes of the second period indicated that there were significant differences between drl groups A, B, and C versus drh groups D, E, and F on total responses emitted, significant differences between the number of responses emitted on the reinforced versus the nonreinforced keys, and a significant interaction between these two main effects (Appendix D, Table 4). These differences are illustrated in Figure 3.

Using data from the last three minutes of the second period and all three minutes of the first period, a two-factor (history schedule x period) AOV with repeated measures on one factor (period) compared the number of responses emitted on the reinforced key. This analysis indicated that there were significant differences between the drl groups A, B, and C versus the drh groups D, E, and F, significant differences between baseline and the last three minutes of Period II, and a significant interaction between these two main effects (Appendix D, Table 5 and Figure 3).

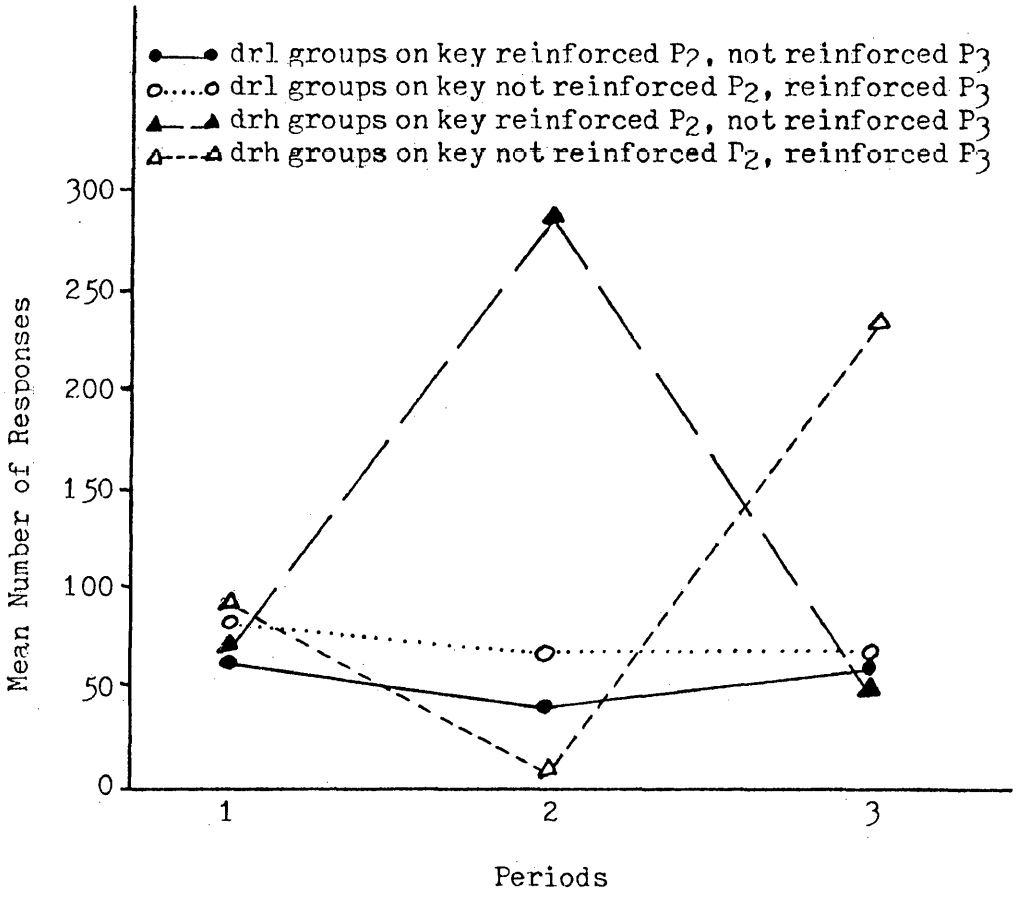


Figure 3. Mean number of responses on both keys during baseline, on the reinforced and nonreinforced keys during the last three minutes of Period II, and on the previously reinforced and the new reinforced keys during the last three minutes of Period III.

A similar two-factor (history schedule x period) AOV with repeated measures on one factor (period) was used to compare the number of responses emitted on the nonreinforced key. This analysis indicated that there were no significant differences between the drl and the drh groups, no significant differences between the first two periods, and no significant interaction (Appendix D, Table 6).

Two t-tests, comparing the number of responses emitted during the last three minutes of the second period on each key by girls versus boys, indicated that there were no significant differences in responding by girls versus boys on the reinforced key, $\underline{t}$ (28) = .285, $\underline{p} > .05$, and no significant differences in responding by girls versus boys on the nonreinforced key, $\underline{t}$ (28) = -.445, $\underline{p} > .05$.

To determine if the rate of responding on the reinforced key and on the nonreinforced key changed during Period II as a function of the reinforcement schedules, t-tests were used to compare the number of responses emitted on the keys during baseline versus the last three minutes of the second period. The children in the drl groups A, B, and C did not significantly alter their rate of responding on the reinforced key, $\underline{t}$ (14) = -1.168, $\underline{p} > .05$. The children in the drl groups also did not significantly reduce their rate of responding on the nonreinforced key, $\underline{t}$ (14) = -.208, $\underline{p} > .05$. However, the children in the drh groups D, E, and F did significantly increase their rate of responding on the reinforced key, $\underline{t}$ (14) = 5.299, $\underline{p} < .05$, and significantly reduced their rate of responding on the nonreinforced key, $\underline{t}$ (14) = -2.531, $\underline{p} < .05$.

The number of responses emitted by the children in the drl groups A, B, and C during the last three minutes of the second period were compared to the optimally efficient number of responses for a three minute period. On a drl 10" schedule, one can earn six reinforcers per minute, if he/she taps the key once every 10 seconds. So the optimally efficient number of responses for the three minutes is 18 responses. A t-test indicated that the children in the drl groups responded significantly more than the optimally efficient number of responses on the reinforced key, $\underline{t}\ (14) = 2.940$, $\underline{p} < .05$.

A t-test comparing the number of reinforcers earned during the last three minutes of the second period indicated that there were no significant differences between the number of reinforcers earned by the drl groups versus those earned by the drh groups, $\underline{t}\ (28) = 1.830$, $\underline{p} > .05$. This suggested that the results of the above analyses were due to the history reinforcement schedules, not the number of reinforcers earned.

The results of Period II indicated that the drl groups and the drh groups had the divergent histories required. Children in the drh groups D, E, and F learned to respond at a significantly higher rate (compared to baseline) on the reinforced key and at a significantly lower rate on the nonreinforced key. However, the children in the drl groups A, B, and C did not significantly change their rate of responding on the two keys. The drh groups responded at a significantly higher rate on the reinforced key than did the drl groups. The number of responses emitted on the nonreinforced key by all groups were not significantly different.

These points are illustrated in Figures 2 and 3.

Period III

A two-factor (history schedule x differential reinforcement technique) AOV comparing the number of responses emitted on the reinforced key indicated that there were significant differences between the drl groups A, B, and C versus the drh groups D, E, and F, during the last three minutes of the third period. This result supported the fourth hypothesis, that children having a drh history would continue to respond more rapidly than children having a drl history. However, there were no significant differences among the techniques, extinction of the previously reinforced response with reinforcement for the new reinforced response (groups A and D) versus extinction of the previously reinforced response with double reinforcement for the new reinforced response (groups B and E) versus continued reinforcement for the previously reinforced response with double reinforcement for the new reinforced response (groups C and F), and there was no significant interaction between the two factors (Appendix D, Table 7 and Figures 2, 3, and 4).

A two-factor (history schedule x differential reinforcement technique) AOV comparing the number of responses emitted on the previously reinforced key during the last three minutes of the third period indicated that there were no significant differences between the drl groups A, B, and C versus the drh groups D, E, and F. Also there were no significant differences among the techniques, extinction of the previously reinforced response with reinforcement for the new reinforced

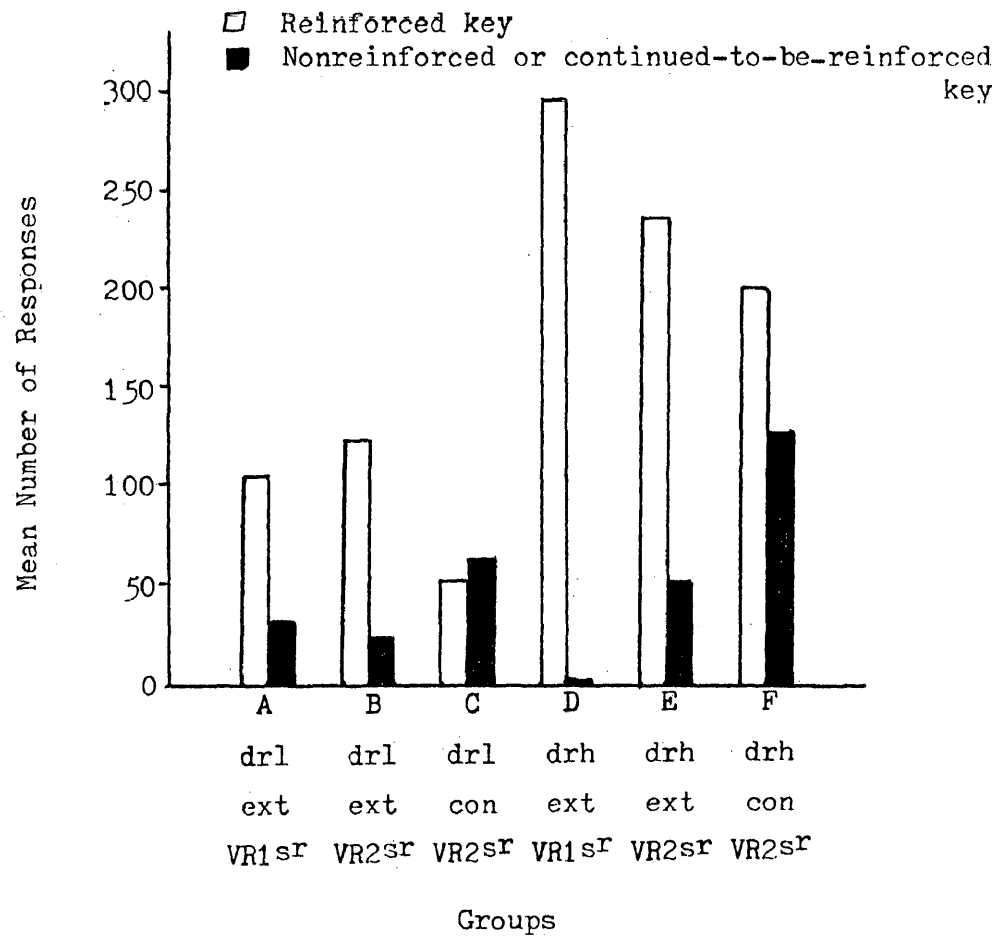


Figure 4. The relative effectiveness of three differential reinforcement techniques upon children with a drl history versus children with a drh history, during the last three minutes of Period III.

response (groups A and D) versus extinction of the previously reinforced response with double reinforcement for the new reinforced response (groups B and E) versus continued reinforcement for the previously reinforced response with double reinforcement for the new reinforced response (groups C and F). There was no significant interaction between the two factors (Appendix D, Table 8).

Two t-tests, comparing the number of responses emitted during the last three minutes of the third period on each key by girls versus boys, indicated that there were no significant differences in responding by girls versus boys on the reinforced key, $\underline{t}$ (28) = .354, $\underline{p} > .05$, and no significant differences in responding by girls versus boys on the previously reinforced key, $\underline{t}$ (28) = 1.361, $\underline{p} > .05$.

To determine if the rate of responding on the reinforced key and on the previously reinforced key changed during Period III as a function of the history reinforcement schedules and/or the differential reinforcement techniques employed, the following analyses were used to compare the number of responses emitted on the keys during the last three minutes of the second and third periods.

A three-factor (history schedule x technique x period) AOV with repeated measures on one factor (period) comparing the number of responses emitted on the new reinforced key indicated that the reinforcement history schedule differences between the drl groups A, B, and C versus the drh groups D, E, and F were not significant, that there were no significant differences among techniques, and that there was no

significant interaction between the history and technique factors. Thus, the first, second, and half of the third hypotheses, stating the effects that the reinforcement histories would have upon the effectiveness of the differential reinforcement techniques, were not supported. There were significant differences between Period II and Period III in the number of responses, and a significant interaction between the period and history factors. There were no significant interactions between the period and technique factors, and among the period, history, and technique factors (Appendix D, Table 9 and Figures 2 and 3).

Because the above analysis indicated a significant interaction between the period and history factors, F-tests for simple effects were employed. Significant differences were found between the drl groups B and C versus the drh groups D, E, and F (Appendix D, Table 10).

A three-factor (history schedule x technique x period) AOV with repeated measures on one factor (period), comparing the number of responses emitted on the previously reinforced key indicated that there was a significant history effect between the drl groups A, B, and C versus the drh groups D, E, and F. However, there were no significant differences among the techniques and no significant interaction between the history and technique factors. There were significant differences between the number of responses emitted during Period II versus Period III, and a significant interaction between the period and history factors. The interactions between the period and technique factors and among the period, history, and technique factors were not significant

(Appendix D, Table 11 and Figures 2 and 3).

Because a significant interaction between the period and history factors was found in the above analysis, F-tests for simple effects were employed. Significant differences were found between the following groups: group A (drl) versus group D (drh); group A (drl) versus group E (drh); group B (drl) versus group D (drh); group B (drl) versus group E (drh); group C (drl) versus group D (drh); group C (drl) versus group E (drh); group C (drl) versus group F (drh); and, group D (drh) versus group F (drh) (Appendix D, Table 12).

A one-way AOV comparing the number of reinforcement opportunities (number of times reinforced) on the reinforced key during the third period among technique groups indicated no significant differences, $\underline{F}$ (2, 27) = .712, $\underline{p} > .05$. A one-way AOV comparing the number of reinforcers earned on the reinforced key during the third period among the technique groups also indicated no significant differences, $\underline{F}$ (2, 27) = 1.419, $\underline{p} > .05$. A one-way AOV comparing the number of reinforcers or reinforcement opportunities on the previously reinforced key indicated significant differences, $\underline{F}$ (2, 27) = 35.156, $\underline{p} < .001$. This result was due to the fact that only two out of six groups continued to be reinforced on the "previously" reinforced key. Those two continuance technique groups C and F, were compared on the number of reinforcers and were found not to be significantly different, $\underline{t}$ (8) = .690, $\underline{p} > .05$. These results suggested that the results of the analyses involving third period data are due to the schedules and/or techniques, not the number

of reinforcers earned or the reinforcement opportunities.

The results of Period III indicated that the children with drh histories (groups D, E, and F) responded at a significantly higher rate on the reinforced key during Period III than did the children with drl histories (groups A, B, and C). The children did not differ on the rate of responding on the previously reinforced key during the last three minutes of Period III. Differences among the three differential reinforcement techniques were not significant on either the reinforced or the previously reinforced keys, during the last three minutes of the third period.

A comparison of the change in rate of responding between the second and third periods indicated significant differences on both the reinforced and the previously reinforced keys. Reinforcement history did not exert a significant effect upon change in the rate of responding on the reinforced key during Period III but did exert a significant effect upon the change in rate of responding on the previously reinforced key.

The children in the drh groups learned to respond at a significantly higher rate on the reinforced key, $\underline{t}\,(14) = 6.835$, $\underline{p} < .001$, and at a significantly lower rate on the previously reinforced key, $\underline{t}\,(14) = -5.900$, $\underline{p} < .001$. However, children in the drl groups did not significantly change their rate of responding on the reinforced key, $\underline{t}\,(14) = .643$, $\underline{p} > .05$, or on the previously reinforced key, $\underline{t}\,(14) = -.028$, $\underline{p} > .05$. Figure 5 illustrates the continuing effect of the reinforcement histories on the overall rate of responding on both keys during Period III.

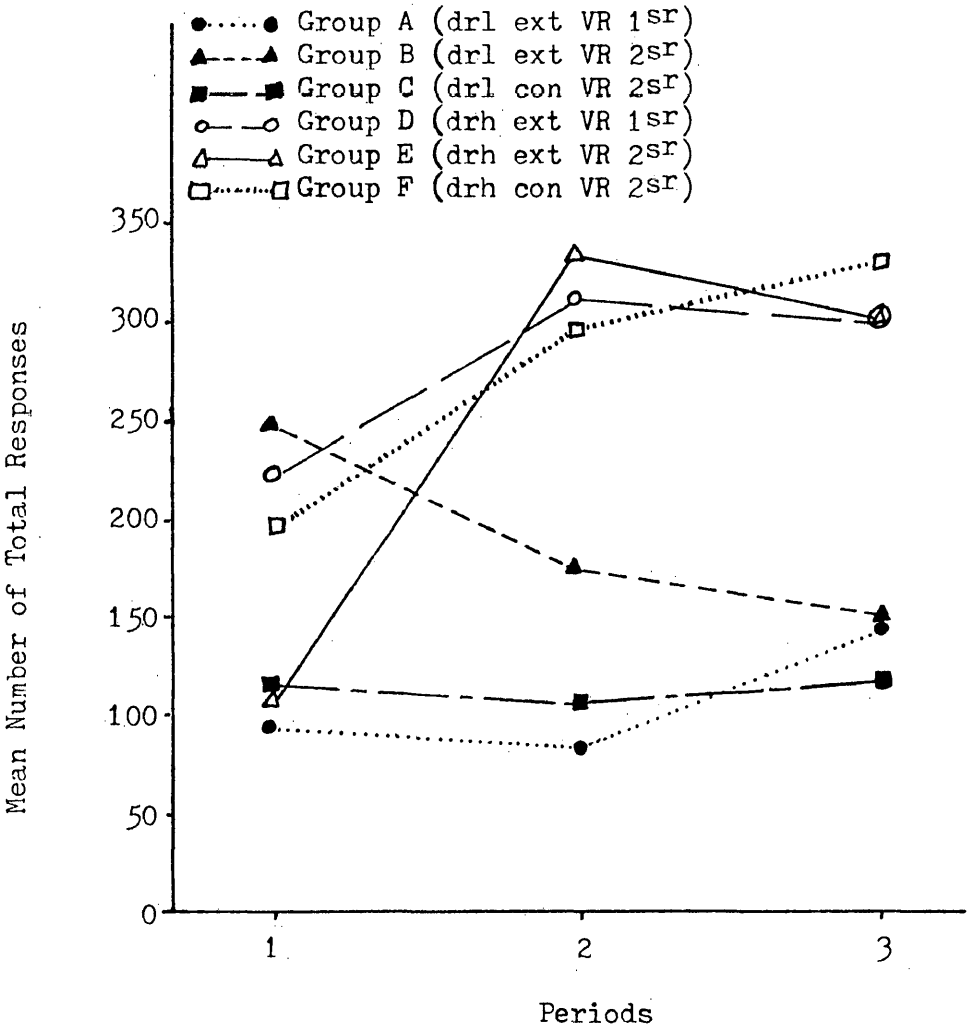


Figure 5. Mean number of total responses on both keys emitted by each group during the last three minutes of each period.

DISCUSSION

The general hypothesis that the two diverse reinforcement histories would have different effects upon the rates of responding, was partially supported. The children in the drh groups D, E, and F significantly increased their rate of responding on the reinforced key and significantly reduced their responding on the previously reinforced key; however, the children in the drl groups A, B, and C did not. The reinforcement histories did not have a significant effect upon the effectiveness of the differential reinforcement techniques. Hypothesis 1, that extinction of the old response with greater reinforcement for the new incompatible response technique would be most effective with children having a drl history and be less effective with children having a drh history, was not supported. Hypothesis 2, that extinction of the old response with reinforcement for the new incompatible response would be most effective with children having a drh history and be less effective with children having a drl history, was not supported. Half of hypothesis 3, that continuance of reinforcement for the old response with greater reinforcement for the new incompatible response technique would be least effective with children having a drh history and be somewhat effective with children having a drl history, was not supported. However, as suggested by the second half of the third hypothesis, alternation between the two reinforced keys (by both continuance groups C and F) did occur. Hypothesis 4, that children having a drh history would continue to respond more rapidly than would the children having a

drl history, was supported.

By the end of Period II, the children in the drl groups A, B, and C and the children in the drh groups D, E, and F had divergent reinforcement histories. Children in the drh groups learned to respond at a significantly higher rate on the reinforced key and at a significantly lower rate on the nonreinforced key, as compared to baseline data. However, the children in the drl groups did not significantly change their rate of responding on the two keys. Even though they received positive consequences for responding on the drl schedule, they maintained their baseline rate of responding, exhibiting low rates of responding including alternating patterns of responding maintained adventitiously. As seen in Figures 1, 2, and 4, children in group C continued to respond equally on both keys with many children alternating throughout the session. These findings suggest that the children in the drh groups learned their task (i.e., learned to respond at a high rate to receive reinforcers), while the children in the drl groups did not learn to respond slowly in order to receive reinforcers. While one would expect a low rate of responding by children on the drl schedule, the children responded at a significantly higher rate than needed to obtain reinforcers, and in fact did not alter their rate of responding from baseline. Most of the children entered the experimental session with a natural history of low rate responding (see baseline data, Table 2). Perhaps the drl task was not learned because the natural history and other factors allowed the children to obtain reinforcers without

learning the specific contingencies, encouraging such adventitious and alternating behavior. Not requiring the children to reach a criterion level of responding before beginning the last phase of the session, as did Weisberg (1970), is one factor that would contribute to such a finding. The shortness of the reinforcement history training period could also be a factor involved. Weiner's subjects in 1965 received reinforcement history training in 10 one-hour sessions. Increased reinforcement history training time would also be expected to have reduced intersubject variability, as suggested by Weiner (1965), allowing the differential reinforcement techniques to be equally effective across all members of a group. The large variances obtained (see Table 2) indicate that these techniques were not equally effective within each group.

Another possible factor is that the consequences used were reinforcing only for the children in the drh groups D, E, and F and not for the children in the drl groups A, B, and C. This may be supported by the children who failed to complete the session; they were younger, low rate responders who accepted a few Hersheyettes and then discontinued responding. With the children on the drh schedule, the reinforcers increased the rate of responding and determined which key the children continued to tap. However, with the children on the drl schedule, the reinforcers only somewhat determined which key they tapped.

During Period III, the children in the drh groups D, E, and F continued to respond at a significantly higher rate on the new reinforced key, than did the children in the drl groups A, B, and C,

supporting hypothesis 4. This finding is in agreement with Weiner (1964, 1965) who also used divergent reinforcement histories (DRL 20" vs. FR 40 in 1964, and FR 40 vs. FI 10" vs. DRL 20" in 1965). Weisberg (1970) also found continued rates of responding after using divergent histories (VR 10 vs. FI 18" vs. DRL 10" vs. DRL 2") until the sixth training session on a DRL 18" schedule, although the children having the VR 10 history continued to show rapid sequential responding. However, Leibowitz (1975) did not find that reinforcement history significantly influenced the rate of responding during the third period. The length of time in each part of the session was equal to that in the present study. However, the schedules (VR 35 and VI 20") used to develop reinforcement history were not as divergent as in the present study. When Leibowitz compared the rates of responding by normal children in his 1974 study (Note 2) with that of the retarded children in a similar study in 1970 (Note 1), he found that the rates of the retarded children tended to be slower than the response rates of the normal children. The results of the present study support the possibility that those tendencies were due to the diverse natural histories of the two groups in Leibowitz's 1972 and 1975 studies because the rates of responding by the children in the drl groups were comparable to those in his 1972 study, and the rates of responding by the children in the drh groups were comparable to those emitted by the children in his 1975 study.

The three differential reinforcement techniques tended to have different effects (although this was not statistically significant; see

Appendix D, Table 8), on the rate of responding on the previously reinforced key. Extinction of the old response with single reinforcement for the new response technique was more effective with children having a drh history (group D) and less effective with children having a drl history (group A), (hypothesis 2). The extinction of the old response with double reinforcement for the new response technique was effective with children having a drh history (group E), (second half of hypothesis 1), but not as effective as extinction of the old response with single reinforcement for the new response technique. However, the continuance of single reinforcement for the old response paired with double reinforcement for the new response technique tended to be ineffective in reducing the old response for children having a drl history (group C) and was the least effective technique for children having a drh history (group F).

As hypothesis 3 predicted, children (groups C and F) alternated between the two concurrently reinforced keys. The findings suggest that double reinforcement may not have been effective since the alternation was closer to a 1-1 alternation rather than a 2-1 alternation. The quantity of reinforcement was not a potent variable for these children, possibly due to the children not discriminating the differences in quantity, even though auditory cues which preceded delivery would be expected to overcome this problem, or possibly because the children were satisfied to be earning the Hersheyettes and to them the quantity was not important.

Not finding significant differences among the three differential reinforcement techniques in effectively reducing the old response, is in agreement with Leibowitz (1975). Comparison of the two diverse groups in his two studies also indicated similar trends concerning the effectiveness of the three differential reinforcement techniques. Perhaps the small group size and short duration of the present study was a factor in not finding significant differences among the three techniques. To avoid this possible factor, future research should use larger groups and longer time periods if possible.

The present study investigated the effectiveness of three differential reinforcement techniques in reducing lever-pressing behavior. Children were given either a drl or drh history of reinforcement and were then reinforced on a VR 32 schedule for responding on the other key. Findings indicated that divergent reinforcement histories can influence later responding. Although the three differential reinforcement techniques tended to have differing effects in reducing the old response, the differences were not significant.

More research, utilizing children's natural reinforcement histories in comparing differential reinforcement techniques, would provide more useful information for the therapist, experimenter, and other professionals. Results from this study indicate that in reducing undesirable behavior, the reinforcement techniques utilized may have to be chosen as a function of the rate of the undesired behavior. History seems to be crucial when differential reinforcement techniques are used. These

techniques seem to be effective with high rate responders but apparently are less effective with low rate responders. Therfore, differential reinforcement techniques may not be the most useful for this population and alternative techniques such as ommission training may have to be employed. Recognizing the effects of children's natural reinforcement history, could be very important in successful and rapid reduction of undesirable behaviors.

APPENDIX A

Age and Sex of Children Participating in this Study

Appendix A

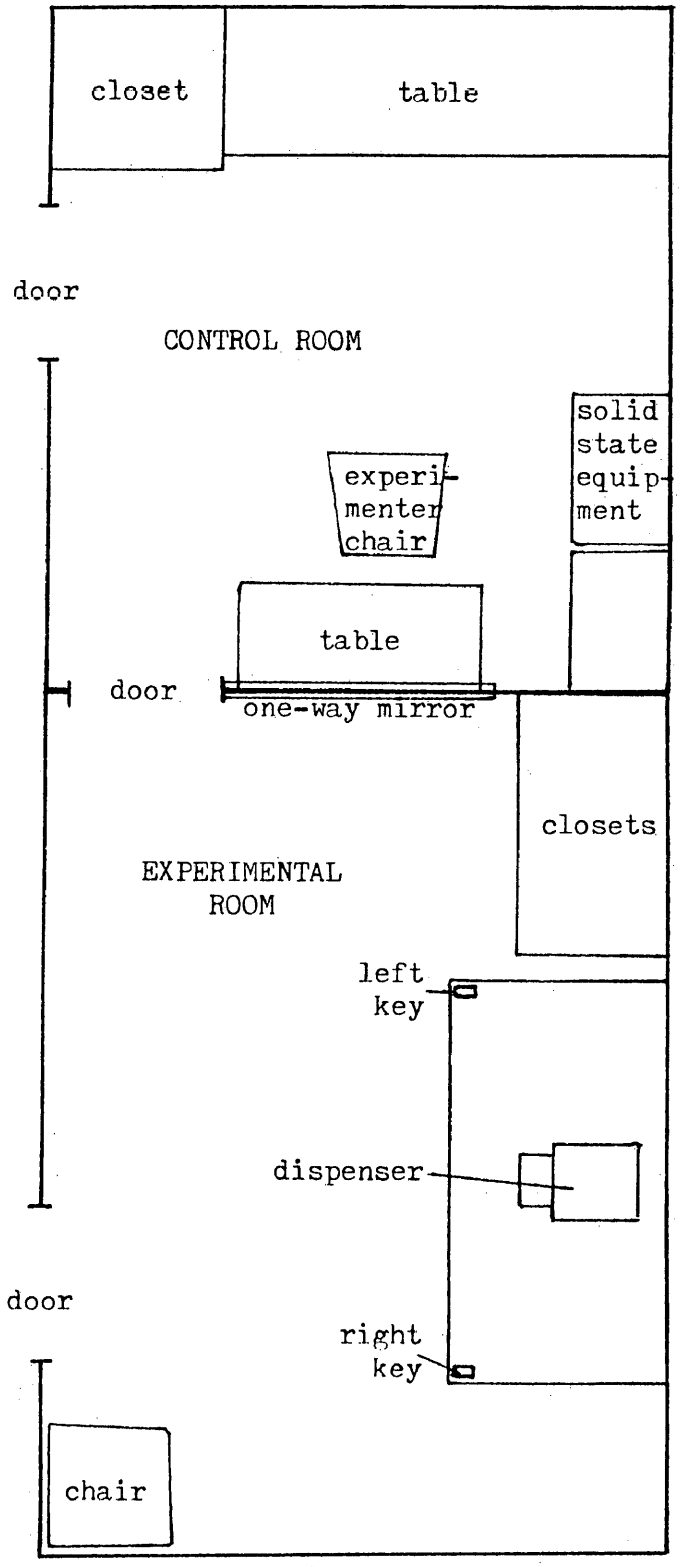
Age and Sex of Children Participating in this Study

Subject	Sex	Age	Subject	Sex	Age
1	m	6-5	16	m	4-10
2	m	4-11	17	f	5-0
3	m	5-4	18	m	7-10
4	f	5-2	19	f	6-6
5	f	6-7	20	f	5-5
6	m	7-0	21	f	5-5
7	f	3-8	22	m	4-2
8	m	6-2	23	f	7-10
9	m	7-8	24	m	5-5
10	f	5-10	25	m	4-1
11	m	6-11	26	f	7-1
12	f	5-4	27	m	6-6
13	f	4-9	28	m	4-5
14	m	8-1	29	f	5-11
15	f	4-5	30	m	6-0

APPENDIX B

Sketch of Experimental Setting

Sketch of Experimental Setting



APPENDIX C

Consent Form

THE UNIVERSITY OF NEBRASKA
MEDICAL CENTER
42ND STREET AND DEWEY AVENUE
OMAHA, NEBRASKA 68105

C. LOUIS MEYER
CHILDREN'S REHABILITATION INSTITUTE
444 South 44th Street
Omaha, Nebraska 68131

Dear Parent:

We would like your child to participate in a study of behavior. We hope to find out if children's previous learning experiences influence the effectiveness of three different positive methods in changing behavior. Your child was selected as a possible participant in this study because of his/her age and enrollment at the Jewish Community Center's Camp Funshine.

If you permit your child to participate, we will first get his/her teacher's permission and then will accompany him/her to the experimental room, provided he/she says yes when asked if he/she would like to play with a candy machine and keep the candy earned. The candy machine consists of two telegraph keys, which when pressed will deliver M&Ms. This task will last about thirty minutes, after which your child will be taken back to his/her activity area.

There are no physical or psychological risks involved with participating in this study. Information obtained from this study may not directly benefit your child, but could provide clinicians, teachers, and other professionals with valuable information concerning children's behavior. Your child's name and any other identifying information will not be disclosed.

Your decision whether or not to allow your child to participate will not prejudice your future relations with The University of Nebraska or the Jewish Community Center. If you permit your child to participate, you are free to withdraw your consent at any time.

If you have any questions, please contact Dr. Michael Leibowitz of the M.C.R.I. Psychology Department (telephone: 541-7608). Please keep one copy of this form and return the signed witnessed copy to the J.C.C.

YOUR SIGNATURE INDICATES THAT YOU PERMIT YOUR CHILD TO PARTICIPATE HAVING READ THE INFORMATION PROVIDED ABOVE.

_____ _____

Date Signature of Parent(s)

_____

Witness

J. Michael Leibowitz

J. Michael Leibowitz, Ph.D.
Director, Psychological Services

Child's Name:_____

Child's Birthdate; _____

APPENDIX D

Analyses of Variance and F-tests for Simple Effects

Tables 3 - 12

Table 3

Two-factor Analysis of Variance

Number of Responses Emitted on the Left vs. Right Key During Period I

Source	df	MS	F	p
Total	59			
Between subjects	29			
Groups	5	10024.388	1.615	>.05
$Error_b$	24	6205.142		
Within subjects	30			
Keys (l vs r)	1	17888.270	1.359	>.05
Keys x groups	5	6911.906	.525	>.05
$Error_w$	24	13162.675		

Table 4

Two-factor Analysis of Variance

Number of Responses Emitted on the Reinforced Key vs. the Nonreinforced Key by Drl vs. Drh Children During the Last Three Minutes of Period II

Source	df	MS	F	p
Total	59			
Between subjects	29			
History (drl vs drh)	1	137664.600	31.457	$< .001$
$Error_b$	28	4376.336		
Within subjects	30			
Keys (rein vs nonr)	1	205803.260	32.725	$< .001$
Keys x history	1	348081.540	55.349	$< .001$
$Error_w$	28	6288.864		

Table 5

Two-factor Analysis of Variance

Number of Responses Emitted on the Reinforced Key by Drl vs. Drh Children During Period I vs. the Last Three Minutes of Period II

Source	df	MS	F	p
Total	59			
Between subjects	29			
History (drl vs drh)	1	249744.000	38.672	$< .001$
$Error_b$	28	6457.946		
Within subjects	30			
Period (I vs II)	1	135850.420	17.630	$< .001$
Period x history	1	212772.080	27.613	$< .001$
$Error_w$	28	7705.500		

Table 6

Two-factor Analysis of Variance

Number of Responses Emitted on the Nonreinforced Key by Drl vs. Drh Children During Period I vs. the Last Three Minutes of Period II

Source	df	MS	F	p
Total	59			
Between subjects	29			
History (drl vs drh)	1	7638.810	.834	>.05
$Error_b$	28	9162.441		
Within subjects	30			
Period (I vs II)	1	25010.410	3.402	>.05
Period x history	1	17306.010	2.354	>.05
$Error_w$	28	7351.574		

Table 7

Two-factor Analysis of Variance

Number of Responses Emitted on the Reinforced Key During the Last Three Minutes of Period III as a Function of Reinforcement History and Differential Reinforcement Technique

Source	df	MS	F	p
Total	29			
History	1	159286.500	13.147	$< .001$
Technique	2	14190.835	1.171	$> .05$
History x technique	2	2702.265	.223	$> .05$
Error	24	12115.533		

Table 8

Two-factor Analysis of Variance

Number of Responses Emitted on the Nonreinforced Key During the Last Three Minutes of Period III as a Function of Reinforcement History and Differential Reinforcement Technique

Source	df	MS	F	p
Total	29			
History	1	3203.333	.661	$> .05$
Technique	2	16374.635	3.377	$> .05$*
History x technique	2	5652.434	1.166	$> .05$
Error	24	4849.017		

*F (2,24) = 3.40, $p < .05$.

Table 9

Three-factor Analysis of Variance

Number of Responses Emitted on the Reinforced Key During the Last Three Minutes of Periods II vs. III as a Function of Reinforcement History and Differential Reinforcement Technique

Source	df	MS	F	p
Total	59			
Between subjects	29			
History	1	29837.400	3.281	$> .05$
Technique	2	13587.050	1.494	$> .05$
History x technique	2	5223.750	.575	$> .05$
$Error_b$	24	9092.642		
Within subjects	30			
Period	1	212177.060	31.494	$< .001$
Period x history	2	153419.240	22.772	$< .001$
Period x technique	2	12924.720	1.918	$> .05$
Period x history x technique	2	912.250	.135	$> .05$
$Error_w$	24	6737.073		

Table 10

F-tests for Simple Effects

Differences Between Groups (Period x History Interaction) on Number of Responses Emitted on the Reinforced Key During the Last Three Minutes of Periods II vs. III as a Function of Reinforcement

Groups Compared	F	p
A x B	1.254	$>.05$
A x C	.779	$>.05$
A x D	2.736	$>.05$
A x E	3.213	$>.05$
A x F	2.108	$>.05$
B x C	.056	$>.05$
B x D	17.124	$<.05$
B x E	8.481	$<.05$
B x F	6.614	$<.05$
C x D	15.219	$<.05$
C x E	7.157	$<.05$
C x F	5.451	$<.05$
D x E	1.503	$>.05$
D x F	2.498	$>.05$
E x F	.116	$>.05$

Table 11

Three-factor Analysis of Variance

Number of Responses Emitted on the Nonreinforced Key During the Last Three Minutes of Periods II vs. III as a Function of Reinforcement History and Differential Reinforcement Technique

Source	df	MS	F	p
Total	59			
Between subjects	29			
History	1	270950.300	40.843	$< .001$
Technique	2	5831.070	.879	$> .05$
History x technique	2	734.500	.111	$> .05$
$Error_b$	24	6633.932		
Within subjects	30			
Period	1	194940.000	36.693	$< .001$
Period x history	1	193945.700	35.506	$< .001$
Period x technique	2	11031.700	2.076	$> .05$
Period x history x technique	2	8287.830	1.560	$> .05$
$Error_w$	24	5312.718		

Table 12

F-tests for Simple Effects

Differences Between Groups (Period x History Interaction) on Number of Responses Emitted on the Nonreinforced Key During the Last Three Minutes of Periods II vs. III as a Function of Reinforcement

Groups Compared	F	p
A x B	.002	> .05
A x C	.031	> .05
A x D	21.773	< .05
A x E	13.440	< .05
A x F	4.038	> .05
B x C	.050	> .05
B x D	21.317	< .05
B x E	13.082	< .05
B x F	3.843	> .05
C x D	25.417	< .05
C x E	14.752	< .05
C x F	4.771	< .05
D x E	1.000	> .05
D x F	7.058	< .05
E x F	2.744	> .05

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