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ROLE OF FEEDBACK STIMULI

RICK KEERT

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This dissertation, directed and approved by the candidate's committee, has been accepted by the Graduate Committee of The University of New Mexico in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

ROLE OF FEEDBACK STIMULI IN RESPONSE

Title

DISCRIMINATION AND DIFFERENTIATION

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ROLE OF FEEDBACK STIMULI IN RESPONSE
DISCRIMINATION AND DIFFERENTIATION

BY

EDWARD J. RICKERT

B.A., University of New Mexico, 1960

M.S., University of New Mexico, 1963

DISSERTATION

Submitted in Partial Fulfillment of the
Requirements for the Degree of
Doctor of Philosophy in Psychology
in the Graduate School of
The University of New Mexico
Albuquerque, New Mexico

June, 1968

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ROLE OF FEEDBACK STIMULI IN RESPONSE
DISCRIMINATION AND DIFFERENTIATION

By

Edward J. Rickert

ABSTRACT OF DISSERTATION

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ROLE OF FEEDBACK STIMULI IN RESPONSE
DISCRIMINATION AND DIFFERENTIATION

Edward J. Rickert, Ph.D.
Department of Psychology
The University of New Mexico, 1968

Two experiments were performed to assess two roles commonly assigned response-produced (feedback) stimuli in learning theories by comparing the behavioral outcomes of these inferred events against a known property of external stimuli. The particular property chosen was transfer of discrimination because of its consistency and generality.

The first experiment was designed to determine whether feedback produced by preceding behavior guides ensuing behavior by facilitating transfer in much the same way as environmentally-produced stimuli. By contrast, the second experiment investigated the role of feedback in response differentiation; it attempted to determine whether rats can utilize feedback from concurrent responding to mediate selection among alternative responses in such a way that the learning of a difficult differentiation may be facilitated by the learning of an easier differentiation. The difference between these two experiments resides in the temporal sequencing of response-produced stimuli.

Twelve rats were used in each experiment. In keeping with the transfer of discrimination paradigm, three groups of four rats were assigned to a gradual transfer condition (G), and abrupt transfer

condition (A), and a hard discrimination condition (H).

The results indicated that (a) making a difficult discrimination among feedback stimuli with respect to ensuing behavior was facilitated by initial training on an easy response discrimination, and (b) learning a difficult response differentiation was facilitated by previously learning an easier differentiation. The results apparently establish that response-produced feedback are sufficient for the selection of ensuing and coincident behavior and that these feedback stimuli share common properties with external stimuli. The relevancy of these findings for learning theories and two-state discrimination models are indicated.

...and a beta distribution function (1971).
The results indicate that the alpha distribution
...with respect to learning behavior and learning
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(b) learning a difficult response distribution was facilitated by
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...and that the response-graded feedback was sufficient for the
...selection of learning and subsequent behavior and that the feedback
...stimuli phase cannot be separated from the other stimuli. The results
of these findings for learning theories and two-stage distribution
...are not inconsistent.

TABLE OF CONTENTS

	Page
LIST OF FIGURES	vii
LIST OF TABLES.	viii
INTRODUCTION	1
EXPERIMENT I	4
Method	
Results	
EXPERIMENT II	13
Method	
Results	
DISCUSSION	19
REFERENCES	24
APPENDICES	26
Appendix I--Review of Literature	
Appendix II-A--Apparatus	
Appendix II-B--Preliminary training Procedure	
Appendix III-A--Response Discrimination	
Experiment--Percent	
Correct Responses	
Appendix III-B--Response Discrimination	
Experiment--Drive Shift Data	
Appendix III-C--Response Differentiation	
Experiment--Number of	
Correct Responses	
Appendix III-D--Response Differentiation	
Experiment--Number of "Counts"	
Before a Response	
Appendix IV--Vita

LIST OF FIGURES

Figure		Page
1.	Schematic representation of response discrimination . .	4
2.	Percent choice summed across R_a and R_b for the three groups as a function of trial blocks	8
3.	Percent choice on either R_a or R_b for the easy (Gradual + Abrupt) and hard groups	10
4.	Relative frequency of correct responses on R_a and R_b as a function of trial blocks for the three differentiation groups	16

LIST OF TABLES

Table	Page
1. Mean Choice Scores for Individuals in the Gradual, Abrupt, and Hard Groups Summed Over Last Eight Trial Blocks	9
2. Percent Choice of Individual <u>Ss</u> in Gradual, Abrupt, and Hard Groups Summed Over Six Trial Blocks Under Intermediate Condition	12
3. Response Discrimination Experiment--Percent Correct Responses of <u>Ss</u> in Gradual Group Summed Over Successive Trial Blocks	49
4. Response Discrimination Experiment--Percent Correct Responses of <u>Ss</u> in Abrupt Group Summed Over Successive Trial Blocks	50
5. Response Discrimination Experiment--Percent Correct Responses of <u>Ss</u> in Hard Group Summed Over Successive Trial Blocks	51
6. Response Discrimination Experiment--Effect of High and Low Drive on the Intermediate Task	53
7. Response Discrimination Experiment--Mean Performance of the Three Groups Under Conditions of High and Low Drive	53
8. Response Discrimination Experiment--Number of Correct Responses of <u>Ss</u> in Gradual Group Summed Over Successive Trial Blocks	54
9. Response Differentiation Experiment--Number of Correct Responses of <u>Ss</u> in Abrupt Group Summed Over Successive Trial Blocks	55
10. Response Differentiation Experiment--Number of Correct Responses of <u>Ss</u> in Hard Group Summed Over Successive Trial Blocks	56
11. Response Differentiation Experiment--Mean "Counts" (Bar Release) Before Emission of Correct or Incorrect Responses Summed Over Successive Trial Blocks--Gradual . .	57
12. Response Differentiation Experiment--Raw Data--"Counts" (Bar Release) Before Selection of Correct or Incorrect Responses--Gradual	58

LIST OF TABLES--Cont.

Table	Page
13. Response Differentiation Experiment--Mean "Counts" (Bar Release) Before Emission of Correct or Incorrect Responses Summed Over Successive Trial Blocks--Abrupt . .	59
14. Response Differentiation Experiment--Raw Data--"Counts" (Bar Release) Before Selection of Correct or Incorrect Responses--Abrupt	60
15. Response Differentiation Experiment--Mean "Counts" (Bar Release) Before Emission of Correct or Incorrect Responses Summed Over Successive Trial Blocks--Hard . . .	61
16. Response Differentiation Experiment--Raw Data--"Counts" (Bar Release) Before Selection of Correct or Incorrect Responses--Hard	62

1.	...
2.	...
3.	...
4.	...
5.	...
6.	...
7.	...
8.	...
9.	...
10.	...
11.	...
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INTRODUCTION

Although the importance of feedback stimuli has long been recognized (e.g., Hull, 1930; Guthrie, 1935; Miller and Dollard, 1941) and their use has recently acquired a paramount significance in learning theories (e.g., Mowrer, 1960; Miller, 1963; Logan, 1960; Seward, 1943; Sheffield, 1954; Spence, 1956; Hull, 1952), the roles assigned to them have remained obscure. One role of these inferred events is to guide ensuing behavior; feedback from previous responses become a part of the total stimulus complex to which the next response is made. The other, more enigmatic role, is to guide concurrent behavior; impending feedback from alternative responses may somehow mediate selection among them. The purpose of this research was to evaluate these two roles of feedback stimuli against known properties of external stimuli. If feedback stimuli, as commonly supposed, obey the laws of external stimuli, then comparable phenomena should be observed.

The particular property of external stimuli chosen was transfer of discrimination because of its reliability and generality. Transfer of discrimination refers to the fact first reported by Pavlov (1927) that learning a difficult discrimination may be facilitated by initial training on an easier discrimination along the same continuum. This finding has been repeated and extended across a variety of stimulus dimensions and a number of different species by Lawrence (1952), Baker and Osgood (1954), House and Zeaman (1963), Sutherland et al. (1963), and Logan (1966).

In view of the importance assigned to feedback stimuli in learning theories and the paucity of data concerned with them (but see Grice and

Davis, 1958, 1960; and Grice, 1965), two experiments were performed to determine whether the two roles of feedback indicated above show transfer effects comparable to external stimuli. The first experiment was concerned with response discrimination by permitting rats to use feedback stimuli of previous responses as cues for the selection of other responses. The second experiment was concerned with response differentiation by permitting rats to utilize the impending feedback from quantitatively different responses to mediate selection between those responses. The distinction between these experiments rests upon the temporal sequencing of potential response-produced stimulation; this distinction is developed more fully in the following section.

Response Discrimination and Differentiation

Consider a response chain consisting of R_x followed by R_a or R_b . For the response discrimination procedure, a predetermined duration of R_x causes the onset of external stimuli signalling termination of R_x and selection between R_a and R_b . Which of these latter responses is correct depends upon the duration of R_x preceding the signal. The presumed basis for selection between R_a and R_b is then the distinctive feedback resulting from different durations of R_x . Since these feedback cues are available before the choice is made, it may be considered a discrimination based on preceding behavior. In short, response discrimination is when the organism selects what to do next on the basis of what he has already done.

By contrast, response differentiation requires a selection of a duration on either R_a or R_b depending on which of the two is signalled as the correct response. That is to say, one duration is required if R_a is to be reinforced and another duration is required if R_b is to be

reinforced. Where in response discrimination external stimuli serve to terminate R_x and enable choice between R_a and R_b on the basis of what has already transpired, external stimuli in response differentiation indicate both which response, R_a or R_b , is next to occur and the duration of R_a or R_b necessary for that response to be reinforced. Accordingly, feedback from R_a or R_b is at best available concurrently, and more reasonably, after the choice is made. In short, response differentiation is when the organism selects what to do now on the basis of what he is going to do later.

Two distinctions between these situations should be emphasized. First, feedback from R_x as the relevant cue is available to guide selection of ensuing responses in discrimination whereas it occurs coincident with response selection in differentiation. Second, although the organism controls selection and initiation of response in both situations, response termination is controlled by an external stimulus in discrimination and by the organism in differentiation.

EXPERIMENT I

Transfer of Response Discrimination

In order to study the role of feedback stimuli in guiding ensuing behavior, an operant conditioning box containing three bars was used. The middle bar corresponds to R_x in the preceding discussion while the two side bars correspond to R_a and R_b . The procedure is schematically represented in Figure 1.

Fig. 1. Schematic representation of response discrimination.

Each trial begins with a response to the middle bar (R_M). After a predetermined time period, cue lights (C_L and C_R) appear above both the left (R_L) and right (R_R) bars. If the duration of R_M preceding the cue lights is short (r_s), the left bar is correct. If the duration of R_M is long (r_l), the right bar is correct. Presumably, the basis for the choice is the differential feedback produced by the response duration on the middle bar (s_s and s_l in Figure 1).

The hypothesis based on the notion that feedback stimuli obey the laws of external stimuli was that a difficult response discrimination would benefit from initial training on any easy response discrimination. Ease of discrimination in this context was presumed to depend upon the size of the difference between the short and long durations of R_M .

METHOD

Subjects. Ss were 12 female rats of Long-Evans stock from the breeding colony of the University of New Mexico. All Ss were approximately 100 days old at the time a deprivation cycle was imposed for 14 days. They were housed individually with water freely available and received a daily maintenance diet of 12 grams. Before exposure to the apparatus, each S was handled for 5 minutes prior to receiving its daily ration.

Apparatus. The experimental chamber was constructed by Lehigh Valley Electronics and measured 10" by 11" by 12". The intelligence panel housed three bars with indicator lights located above the left and right bars. The middle bar was mounted directly above a 1 1/2" by 1 1/2" by 2" food receptacle into which a single 20 mg. Noyes rat pellet was delivered as reinforcement. The middle bar had a distinctive shape, size and mounting from the side bars. All events were controlled by commercial programming equipment; responses were recorded on impulse counters. (See Appendix IIA for specification of apparatus details.)

Procedure. Prior to assignment to their experimental conditions, Ss were (a) trained to respond differentially to the cue lights associated with the side bars when presented singly, (b) required to press the middle bar to produce cue onset randomly over one or the other side bar, and (c) shaped to progressively longer durations on the middle bar beginning with .2 sec. and terminating with 1.4 sec. Prior to the experiment proper, each S had, thus, completed 100 trials on the 1.4 sec. value. This pre-training required 20 days of training. (Appendix IIB details the pretraining procedure.).

Design. The design called for the random assignment of 4 rats to each of three groups: a gradual transfer group (G); an abrupt transfer group (A); and a hard discrimination group (H). Ss in the G and A groups were begun on the easy problem: after a response of predetermined duration (either .2 or 1.2 sec.) on the middle bar, onset of the indicator lights occurred over both side bars. Since light onset occurred over both bars, the sole basis for deciding which side bar to press presumably resided in the differential feedback produced by the response duration on the middle bar. Each of the two durations was associated with a specific bar, e.g., .2 sec. press durations meant "go right" and 1.2 sec. press durations meant "go left." Durations of .6 and .8 sec. were imposed on the H group from the beginning, again with each duration correlated for any given S with one of the side bars. To counterbalance position preferences, two Ss in each group encountered the opposite correlation between duration and side bar.

After groups G and A had received 800 trials at 100 trials/day, 50 to each duration, and had apparently achieved asymptote on the easy task, the G group was shifted to an intermediate problem with durations of .4 and 1.0 sec. for an additional 400 trials. The A group continued on the easy task (.2 vs. 1.2 sec.) during this phase.

Both the G and A groups were then shifted to the difficult problem and all three groups received an additional 800 trials on the hard task. To evaluate more fully the differences among the groups, a subsequent test on the intermediate task was run for an additional 600 trials.¹

¹Drive shift effects - see Appendix III-B.

RESULTS

Percent choice for successive blocks of 100 trials is shown in Figure 2. The choice measure was determined by summing the number of correct responses over both R_a and R_b for each session (100 trial/day), 50 trials to each bar. Since a trial was terminated by a press to either R_a or R_b after cue onset, errors occurred when $\underline{S}$ pressed R_a when R_b was programmed or R_b when R_a was in effect (e.g., 50-correct R_a =incorrect R_b ; 50-correct R_b =incorrect R_a). The application of Krusal-Wallis analysis of variance by ranks revealed a significant difference between the groups over the first eight trial blocks ($H=9.85$, $p<.008$). This indicates that $\underline{S}$ s discriminating between duration of 1.2 and .2 sec. learn that discrimination more rapidly than $\underline{S}$ s required to discriminate between .6 and .8 sec.

The second set of data points (blocks 9-12) reflect the performance of the groups after the G group was shifted to the intermediate condition, i.e., durations of .4 and 1.0 sec. As may be seen, this condition produced only a slight decline in group G's performance relative to group A.

The crucial question of whether initial training on an easier discrimination improves performance on a difficult discrimination above that for the H group is reflected in the set of curves from blocks 13-20. The apparent superiority of the transferred groups was tested by a Krusal-Wallis analysis of variance on each $\underline{S}$'s mean over-all choice score summed over the last eight trial blocks (see Table 1).

Fig. 2. Percent choice summed across R_a and R_b for the three groups as a function of trial blocks. Gaps in functions indicate shifts by one or more transfer groups.

Table 1

Mean Choice Scores for Individuals in the Gradual,
Abrupt, and Hard Groups Summed
over Last Eight Trial Blocks

Gradual	Abrupt	Hard
68.2	75.8	55.6
61.8	56.2	58.2
59.1	67.5	45.1
67.5	57.8	54.4

The analysis revealed a significant effect among the three groups ($H=5.89$, $p<.05$). Post-hoc comparisons (Mann-Whitney U tests) were made to determine which of the groups differed from one another; the test indicated that the difference between G, A and H arose from the transfer groups practice on the easier discrimination ($U=2$, $p<.016$). These comparisons indicate that response-produced stimuli guide ensuing behavior in much the same way as external stimuli in the sense that they share the property of facilitating transfer of discrimination.

To determine whether any finer-grain effects existed among the groups with respect to discriminating the short and long durations, a comparison was made which reflected their respective choice behavior under the two durations. Since the transfer groups did not differ, their data were combined when the conditions they encountered were the same. Mean percent choice following either short or long duration for the transfer groups and H group is displayed in Figure 3. Trial blocks 9-12 were omitted because the G and A groups did not encounter identical conditions during this phase of training. The data during these blocks showed that performance paralleled those obtained during

BLOCKS OF 100 TRIALS

Fig. 3. Percent choice on either R_a or R_b for the easy (Gradual + Abrupt) and hard groups. Gap in abscissa denotes omission of blocks 9-12 since Gradual and Abrupt encountered different condition.

blocks 1-8 for the three groups, i.e., accuracy following the short duration exceeded that of the long.

During blocks 1-8, accuracy of performance for the easy group (G + A) and the H group was superior following the short duration. This finding was particularly prevalent for the H group. Since Ss within the groups were counterbalanced with respect to the correlation between duration on R_m and a side bar, then the probability that this difference following short and long durations was a result of position preference was only .167. A more likely possibility is that the difficult task imposed a limit as to how well S could do. S could only redistribute responses within the ceiling imposed by this constraint. Consequently, the response-systems for the H group are not independent; the better the performance on R_a , the poorer on R_b . During the last 800 trials, when all groups are exposed to the difficult discrimination, a reversal of accuracy following short and long durations occurred for the easy groups. Indeed, the overall superiority of the easy groups is based on the longer duration ($H = 6.07$, $p < .05$) but not the shorter one ($H = .12$, n.s.).

Table 2 shows the individual choice measures after they were shifted to the intermediate condition (durations .4 and 1.0 sec.). Ss were run an additional 600 trials under this condition in order to determine whether the H group had learned anything about the problem and whether the effect of being transferred to the difficult problem had a deleterious effect on the other two groups.

Table 2

Percent Choice of Individual Ss in Gradual, Abrupt,
and Hard Groups Summed Over Six Trial Blocks
Under Intermediate Condition

Gradual	Abrupt	Hard
86.66	86.5	62.83
76.50	61.83	76.83
68.83	80.00	39.16
80.66	69.83	65.83

Inspection of Table 2 reveals that shifting from a difficult to an easier discrimination had differential effect on the three groups. Performance on the easier task (.4 and 1.0 sec.) depended on S's previous training. A comparison of the transfer groups (G + A) against the control indicated that the H groups' performance was not facilitated as much as the other two groups ($U = 2$, $p < .025$).

EXPERIMENT II

Transfer of Response Differentiation

METHOD

Subjects. The Ss were experimentally naive female rats of Long-Evans stock, ranging in age from 90 to 100 days, obtained from the same source and exposed to the same pre-experimental conditions as those from the previous experiment.

Apparatus. Except for the use of two additional Hunter Decade Timers the apparatus was the same as that used in the previous experiment.

Procedure. The Ss were (a) pretrained to respond differentially to the cue lights associated with the side bars when presented singly, (b) required to press the middle bar to produce cue onset randomly over one of the other side bars, and (c) shaped to progressively longer minimum durations on the side bars beginning with .2 sec. and terminating with 1.4 sec. Each S had by the 21st day of training completed 100 trials on the 1.4 sec. value.

Design. As in Experiment I, Ss were randomly assigned to a G, A, or H group, 4 rats to each group. Ss in the G and A groups were placed on the easy differentiation; a press to the middle bar produced the onset of an indicator light over only one of the side bars. Light onset served to inform the rat (a) which of the two side bars was correct, and (b) which duration associated with each side bar to emit before release of that bar (termination of the press within bands of .2 - .4 sec. and 1.2 - 1.4 sec. resulted in

reinforcement). Since no external stimulus was available to signal S to terminate the response, the presumed basis for his decision resided in the impending feedback available at best coincident with bar release. To obviate the differential effects of delay of reinforcement when durations were imposed on the side bars, only two events were designated as "responses": bar release must have either exceeded the prescribed band or it must have occurred within the band. If S released the bar before the timer activated the lower limit of the band, the cue light remained on and that trial remained in force. Each of the two bands was associated with a specific bar, e.g., .2 - .4 sec. correlated with the right bar and 1.2 - 1.4 sec. correlated with the left bar. Durations of .6 - .8 sec. and .8 - 1.0 sec. were imposed on the H group from the beginning. Two Ss in each group encountered the opposite correlation between band and side bars.

After the G and A groups had achieved stability of the easy task (1400 trials a 100 trials/day, 50 to each bar), the G group was transferred to an intermediate condition with bands of .4 - .6 and 1.0 - 1.2 sec. for an additional 400 trials. During this phase the A group remained on the easy task (.2 - .4 vs. 1.2 - 1.4 sec.) and H group remained on the difficult task (.6 - .8 vs. .8 - 1.0 sec.).

To determine whether experience on the easier tasks facilitate the learning of a difficult differentiation the G and A groups were then shifted to the difficult problem and all three groups received an additional 800 trials on the hard task.

RESULTS

The performance of the three differentiation groups over the entire course of training is shown in Figure 4. This graph shows the total percent frequency of correct response durations combined for the two responses. It is clear by inspection that all groups improved and hence achieved some degree of response differentiation.

It is also apparent in Figure 4 that the groups did not differ appreciably during the first 14 sessions ($H = .19$, n.s.). At first glance, this result is surprising since the more widely separated bands should comprise an easier differentiation. Closer inspection of the data, however, suggests that the hard task was indeed more difficult to differentiate but was an easier performance task. That is to say, the rats could learn only to differentiate one response duration between .6 and 1.0 sec., and receive intermittent reinforcement on both bars for this larger band-width response. This solution would result in about 50% reinforcement when the short band was required and somewhat more than 50% reinforcement when the long band was required, the latter because of the procedure of not terminating a trial when the response duration did not reach the lower limit of the band. During the first 5 sessions, the rats in the H group averaged 39.4% correct on the short band and 41.5% correct on the long band, and gradually improved to 51.9% correct on the short band and 62.3% correct on the long band by the last 4 days of training. Only one rat in group H did better than 50% correct on both bands, which would provide clear evidence of differentiating between them.

BLOCKS OF 100 TRIALS

Fig. 4. Relative frequency of correct responses on R_a and R_b as a function of trial blocks for the three differentiation groups.

A further indication that rats in the H group failed to differentiate between the durations may be seen by examining the number of presses made before selecting either a correct or incorrect response (see Appendix III-D). Rats in the H group averaged 76.6 presses on the short band and 94.1 on the long band during the first 5 sessions and little change ensued throughout training with 80.8 presses made to the short band as compared to 116.4 on the long band by the last 4 sessions. Presumably, the rats adopted a strategy of gradually increasing the duration of successive presses since the procedure required them to reach the lower limit of the band to terminate a trial.

By contrast, rats in the G group provide clear evidence of differentiating response durations. Although G group shows a similar pattern of responding during the initial condition with only 16.5 presses to the short band and 134.9 to the long band during the first 5 days of training, a shift to the difficult task produced an average of 114.1 presses to the short band and 72.4 presses to the long band even during the last 4 transfer sessions. The reversal in the number of presses on the two bands indicates that rats in the G group emitted response durations more appropriate to the earlier condition. This is to say, durations shorter than those required on the short band and longer than those required on the long band were obtained after the transfer to the difficult task. A similar effect was also observed for the A group after its shift.

That it was indeed easier to differentiate the widely separated bands, can be detected by further examination of the data of the gradual transfer group. During the initial five sessions, they achieved 24.4% correct on the short band and 48.2% correct on the long band, a difference presumably resulting from the shaping procedure which initially rewarded only very long responses. Prior to their first transfer, short-band performance had improved to 46.7% and their long band performance to 75.9%, an outcome that could not be achieved without clear differentiation of the two band durations. The decrement in performance at each change in the band requirements further indicates differentiation of both bands, and their terminal performance on the difficult task showed 70.2% correct on the short band and 77.6% correct on the long band.

This last result is reflected in Figure 4 over blocks 19-26 and addresses the critical issue of whether training on an easy task facilitates learning a more difficult differentiation. A Kruskal-Wallis rank-order analysis of variance was performed on the mean percent correct responses summed over the 8 trial blocks on the difficult task; the differences among the groups was significant ($H = 8.56$, $p < .016$). Post hoc comparisons revealed that the significant source of variance may be attributed entirely to the G group (G vs. H, $U=1$, $p < .029$; G vs. A, $U=0$, $p < .014$) while there was no difference between the abrupt and hard groups (A vs. H, $U=6$, $p > .20$). This last result, however, may reflect the use of the stringent test of including the early trials when the abrupt group suffered a severe transfer decrement, their terminal performance being somewhat above the hard group.

DISCUSSION

The results of the two experiments demonstrate that inferred response-produced stimuli obey one of the laws familiar with exteroceptive stimuli; namely, that training on any easy task may facilitate learning a more difficult task. Using response duration as the relevant feedback dimension, response discrimination was defined as selecting ensuing behavior on the basis of available feedback stimuli; training on widely separated durations facilitated learning to discriminate more similar durations. Using the same response dimension, response differentiation was defined as emitting the correct duration on the basis of exteroceptive stimuli; training on widely separated durations facilitated learning to differentiate between more similar durations. These results appear to demonstrate that response-produced stimuli are a sufficient basis for selection of both ensuing and coincident behavior, and they are thus consistent with the roles ascribed to these inferred events by a variety of contemporary learning theorists (e.g., Sheffield, 1954; Mowrer, 1960; and Miller, 1963).

Although the discrepancy between the abrupt transfer groups in the two experiments merits further investigation, the fact that exteroceptive stimuli in the discrimination experiment controlled bar release presumably enhanced the distinctiveness between the two durations and augmented the role of generalization mechanisms. This is to say, a change in the conditions in Experiment I made immediate contact on the organism; the lack of any external change in the

The results of the two experiments conducted in 1949 and 1950 are presented in Table I. The first experiment was designed to determine whether or not the subjects could distinguish between the two types of stimuli. The results showed that the subjects were able to distinguish between the two types of stimuli. The second experiment was designed to determine whether or not the subjects could distinguish between the two types of stimuli. The results showed that the subjects were able to distinguish between the two types of stimuli. The results of the two experiments are presented in Table I. The first experiment was designed to determine whether or not the subjects could distinguish between the two types of stimuli. The results showed that the subjects were able to distinguish between the two types of stimuli. The second experiment was designed to determine whether or not the subjects could distinguish between the two types of stimuli. The results showed that the subjects were able to distinguish between the two types of stimuli. The results of the two experiments are presented in Table I.

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differentiation experiment meant that S continued to emit response-produced stimuli appropriate to an earlier condition for a longer period. The necessity to change behavior and its associated feedback without the support of external stimuli probably accounts for the larger transfer decrements obtained with the differentiation groups. Be this as it may, because the differential training on trial blocks 15-18 required the gradual differentiation group to produce feedback more similar to those encountered on the difficult task than the abrupt group, the training enabled generalization mechanisms to exert a more powerful affect on the gradual group and is probably responsible for the difference between them.

Two additional aspects of Experiment I deserve comment. Inspection of Figure 3 shows that the side bar associated with the short duration was chosen more often during the initial task by the transfer groups but the bar associated with the long duration was selected more frequently when the groups were shifted to the difficult task. If effort is differentially associated with the two durations on R_x and is part of the feedback stimulus complex to which the rat responds, the effort component of this complex may have predisposed the rat to select the bar correlated with the short duration more frequently. If discriminative processes underlie response differentiation as the data suggest, then when the durations on R_x were changed a detection of this change would be more apparent on the short rather than the long duration. This argument assumes that feedback stimuli share psychophysical properties of external stimuli and that a Weber-Fechner relation obtains. If contrast

occurred with both durations following the shift but the magnitude of the contrast differed as between the two durations so that its effect was greater for the shorter of the two, then the net perceived effort would be greater for the bar associated with the short duration. The effect of the perceived difference in effort would be a reversal in preference for the side bars. Since choice of the side bar was controlled by the cue light in the second experiment, no change in the type of preference noted above should have been (or was) observed.

The other finding of interest appears in Table 2 which summarizes the performance of the 3 groups on the intermediate condition (durations of .4 and 1.0 sec.). The fact that the asymptotic level of H group was significantly below that of the transfer groups appears to have implications for two-state "subtractive" models of discrimination learning (see, Sutherland et al., 1963; Lawrence 1963). These models account for poor performance on the difficult task by positing an overlap of outputs from a selector mechanism. If an S exposed initially to a difficult discrimination is then transferred to an easier discrimination lying in the same dimension, an attention model anticipates two possible outcomes: either, (a) the S chooses the correct selector on the difficult problem so that the shift to an easier task results in rapid attainment of the same asymptotic level observed for a control S, or (b) the S selects an incorrect analyzing mechanism which is retained by partial reinforcement so that on the easy task performance is maintained at

its previous level. Since the H group showed improvement over its previous performance but failed to attain the same level obtained by the transfer groups, the data is not in accord with attention theory. Pending further investigation, these conclusions are tentative. This is to say, since no group was trained throughout on the intermediate task, the difference observed between G and A and the H groups may have been due to the training the transfer groups received on the initial task. This implies, of course, that the performance of H group and the hypothetical control would not differ.

Establishment of feedback as a sufficient condition in directing ensuing and coincident behavior supports a molecular analysis of the response (see, e.g., Mowrer, 1960; Logan and Wagner, 1965). A molecular analysis contends that the characteristic "feel" of response-produced stimuli feeds back into on-going behavior and directs it in much the same way as external stimuli. To this extent, the research reported here supports a conception of response which is closed-loop in the sense that an organism selects specific behaviors because it discriminates the stimuli arising from the act of emitting those behaviors. A further implication of this approach is that differentiation may be subsumed as a sub-set of discrimination; the sole distinction between these classes of events confined to the cue (internal or external) controlling behavior (Notterman and Mintz, 1965). An equally plausible approach is to assume an organism capable of monitoring its behavior over time so that at each instant it decides whether (say) to release or continue

holding the bar. Response termination may thus be viewed as a response cued by preceding response-produced stimuli. A dynamic, linear analysis not only applies to the data obtained but it avoids the circularity entailed when closed-loop properties are ascribed to the response, especially the problem of response initiation.

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APPENDICES

APPENDIX I

REVIEW OF LITERATURE

It is commonly supposed that response-produced stimulation obey the same principles as external stimuli but the paucity of data makes this supposition somewhat tenuous. Despite the lack of verification, these implicit stimulus events have acquired a paramount significance in learning theories because of the roles assigned to them (e.g., Hull, 1952; Seward, 1943; Sheffield, 1954; Spence, 1956; Mowrer, 1960; Logan, 1960; Miller, 1963). One use to which the concept has been put is to direct subsequent behavior; feedback from previous responses become a part of the environmental milieu and help set the occasion for the next response. Another, more obscure, role is to guide coincident behavior; impending feedback from alternative responses may somehow mediate selection among them. The purpose of this research was to evaluate these two roles of feedback against a known property of external stimuli. If feedback stimuli obey the laws of external stimuli, comparable phenomena should be observed.

Transfer of Discrimination

The particular property of external stimuli chosen was transfer of discrimination because of its generality and consistency. Transfer of discrimination refers to the fact that learning an easy discrimination prior to being shifted to a difficult test discrimination along the same continuum facilitates learning the test discrimination above that obtained when all training is confined to the latter. The

phenomena has been extended across a number of different stimulus dimensions and a variety of species by Baker and Osgood (1954), House and Zeaman (1963), Sutherland et al. (1963), and Logan (1966). Although reported as early as forty years ago (Pavlov, 1927), it captured little attention until the controlled investigation of Lawrence (1952). The finding is in conflict with the expectation of simple transfer theory which assumes that for a fixed amount of practice on a training discrimination the transfer effect to a test discrimination will be greatest when the training and test discriminations are identical (Osgood, 1953).

Theoretical Interpretations: The Two-State Models

The explanation of this transfer effect is usually cast in the form of a two-state perceptual learning theory. That aspect of the milieu the organism reacts to, the effective stimulus, is specified in terms of the output of a perceptual encoding mechanism or analyzing system (Lawrence, 1963; Sutherland et al., 1963; Mackintosh, 1965). The selector mechanism is presumed to switch in to a particular aspect of a potential stimulus. The extracted component of that stimulus produces a centrally located output which becomes attached to some instrumental activity of the organism. This theoretical position has been characterized as subtractive because it assumes that the encoding device operates as a selector which "subtracts" irrelevant stimuli from total stimulation (Tighe and Tighe, 1966).

Two processes are involved because the organism first learns (a) to switch in a selector mechanism which yields maximal differences in output for the two discriminanda, and (b) only then learns to attach

the correct response to the differential outputs. This latter condition can occur only after the correct encoding system has been selected.

When the organism receives its initial training on an easy discrimination, outputs of the selector mechanism do not overlap; there is a high probability of attending to the relevant dimension and of selecting S given that the organism is attending. For animals confined to the test discrimination throughout training, it is presumed that since the outputs of the perceptual mechanisms overlap, more errors will be made even though the organism may be attending to the relevant dimension.

The effect of errors weakens the correct selector and allows for the selection of a different mechanism. As a consequence, test discrimination subjects will always perform below unity provided, of course, that an overlap in output occurs.

Transfer of discrimination occurs because gradual shifts from the training to test discrimination permit strengthening of the perceptual mechanism which produces a consistency in attending.

Confining all training to the test discrimination, however, produces an inconsistency in attending, i.e., switching from one selector to another which accounts for a larger number of errors.

Although two-state theories have been criticized for their vagueness (see Mackintosh, 1966) and perceptual theory for its apparent mentalism and anthropomorphic characterization of data (Kendler and Kendler, 1967) their appeal apparently consists in the fact that orthodox uni-state S-R models have difficulty in accounting for transfer of discrimination, reversal learning, and the over-

learning reversal effect. For example, Lawrence (1955) in evaluating the applicability of concave downward and concave upward generalization gradients to transfer of a discrimination noted that several limitations must be imposed on a uni-state model if it is to account for this data. Lawrence (1955) argues that the transposition model of Spence (1937) is inappropriate in predicting differences between the abrupt training group (animals switch from the training to test discrimination on the thirty-first trial) and the control (animals confined to the test discrimination for eighty trials). In order for the Spence model to predict the abrupt group's superiority to the control in terms of their respective learning rates, the relative slopes of the gradients must increase when the absolute habit strength increases. A characteristic of parabolic (concave downward) functions is, however, that the relative slopes of the function are independent of absolute habit strength. Consequently, a necessary assumption underlying a theory of discrimination learning based on generalization gradients would appear to be that " . . . the slope of the generalization gradient at any point is an increasing function of the absolute habit strength built up on the training stimulus" (Lawrence, 1955, p. 42). Employing the algebra of inequalities and geometrical illustrations of hypothetical excitatory and inhibitory gradients, Lawrence shows that concave upward gradients--Hull's (1943) exponential functions of excitation and inhibition are representative of concave upward curves--are also inappropriate in that they fail to predict the difference between the abrupt and difficult groups on the thirty-first trial of the experiment. Such curves imply that for a fixed amount of

practice a higher level of accuracy is reached if all training is confined to the test discrimination.¹

The only attempt to explain transfer of a discrimination in terms of a unistate model was undertaken by Logan (1966). In addition to the standard procedure of varying both S^+ and S^- along the same continuum, Logan trained groups of rats where either S^+ remained unchanged and S^- was varied (positive condition) or where S^- remained constant and S^+ was changed (negative condition). A model utilizing hypothetical excitatory and inhibitory gradients was successful in predicting that subjects trained under the negative condition would show greater transfer than those trained under the positive or symmetrical conditions. The data is of particular interest in that it demonstrated the utility of a uni-state approach when subjects were gradually shifted to the test discrimination. Lawrence's (1955) criticism of the applicability of generalization gradients to transfer of a discrimination, it will be recalled, confined itself to a comparison of the control with the abrupt training group. Although

¹It should be pointed out that the uni-state models of Hull and Spence were developed to apply to discrimination experiments where non-correction, non-punishment procedures were used; Lawrence's (1952) experiment involved both correction and punishment procedures and Sutherland et al. (1963) while using a non-correction procedure with Octopus resorted to punishment of incorrect responses. Lawrence's (1955) criticism of the Hull and Spence model is based upon the data obtained from the abrupt and control groups. It is interesting to note in this context that Baker and Osgood (1954) using a non-punishment, non-correction procedure found that (a) the gradual group's performance was indeed superior to that of the control but (b) with abruptly shifted S s performance was significantly poorer than the control. This latter finding not only runs counter to Lawrence's data but would be, according to Lawrence's own analysis, consistent with a uni-state model of concave upward curves.

Logan acknowledges that his findings do not rule out the possibility of a perceptual mechanism, his model possesses an advantage over a perceptual theory in that differential predictions can be made regarding the optional training program leading to mastery of the test discrimination. One aspect of Logan's data troublesome to an absolute model was that an analysis of the type of errors made revealed that more errors of commission (responding to S^-) than errors of omission (not responding to S^+) were observed. This feature of the data might be a result of the "go--no go" discrimination procedure used, however. Conceivably, the subject must learn not only to press in the presence of S^+ but also suppress responding when S^- is presented. Of interest to the present investigation is whether the employment of a different paradigm and procedure will produce results more consistent with the implication of an absolute model.

Feedback Stimuli

Traditionally, it has been assumed that certain properties of the response, its sensory consequences, obey the same principles that govern other stimuli. Hull's (1930a) "pure stimulus act" and the logical extensions of this construct; namely, Miller and Dollard's (1941) "response-produced cues" and Osgood's (1953) "representational or mediational process" assumed that some fractional component of a preceding response enters into the total stimulus complex to guide subsequent behavior. This application of feedback focused on the proprioceptive events which presumably arise as an outcome of previous responding. Although learning theories ascribe many functions to these response-produced cues (e.g., they account for the apparent

"purposefulness" of behavior by serving as stimuli to which responses can be conditioned), there is little empirical evidence that these stimuli are used as cues for responding. The most systematic investigation of these implicit events was undertaken by Grice and Davis (1958, 1960) and Grice (in Mostofsky, 1965). They used a differential conditioning procedure in which three stimuli were presented. One of these was a conditioned stimulus which was always paired with an unconditioned stimulus, an air-puff. The other two stimuli were negative: they were never reinforced by the air-puff. Two instructed responses, manual or verbal, were required to be made to the three stimuli.

One of these responses was the same for the conditioned stimulus and one of the negative stimuli; the other response was made to the other negative stimulus. According to a response-produced cue hypothesis, more eye-blinks should be observed to the negative stimulus that shared the common response to the conditioned stimulus. Such evidence would be reflected in an asymmetrical generalization gradient. Although this result was obtained when the "mediating" response was overt, no asymmetric function was found when implicit responses were used. Their results failed to support a response-produced cue theory.

Despite the lack of empirical support for response-produced stimuli their role has been extended to encompass the guidance of on-going behavior. Mowrer (1960), for example, suggests that a response is steered by the emotional feedback conditioned to the cues that it produces so that "psychologically a response is the stimulation that it produces" (p. 489). Similarly, Sheffield (1954, 1960) channels the excitement generated by the frustration

entailed in goal-seeking behavior back into the on-going activity of the organism. And Miller (1963) postulates a "go" mechanism which acts to intensify coincident behavior and which is conditionable to the proprioceptive consequences of the on-going response. Although these viewpoints represent alternatives to drive-reduction, they, nonetheless, have implication for the problem of response selection and the roles cast for feedback stimuli. This is to say, if impending feedback is responsible for coincident behavior and shows a phenomena comparable to external stimuli, then their operation should help clarify the logical problem of how responses, presumably initiated prior to their feedback, are selected before their feedback occurs.

If response-produced cues follow the same behavioral laws as external stimuli and if impending feedback somehow directs on-going behavior, then response differentiation phenomena may be subsumed as a subset of stimulus discrimination. If feedback is a necessary and sufficient condition for the differentiation of behavior, then the sole distinction between discrimination and differentiation resides in whether the stimuli controlling these phenomena are external or internal.

Skinner (1938) performed the first systematic investigation of response differentiation. He concluded that it was necessary "to distinguish between the discrimination of stimuli and a process of differentiation between forms of response (p. 308)." The distinction between sensory (response) discrimination and differentiation rested on the argument that:

. . . the tendency to cast all behavior in the respondent mold with the implications of a strict and ubiquitous stimulus-response relationship, is perhaps, responsible for the neglect of this distinction in current work on discrimination. If for every response there was rigorously corresponding stimulus, a discrimination between two forms of either term would necessarily involve the corresponding form of the other, and there would be no need to consider more than one process. But in operant behavior the strength of a response may be independently varied and two closely related forms of a response may be independently varied and two closely related forms of a response may become distinguished by developing different strengths irrespective of discriminated stimuli (p. 308).

Skinner's analysis is that because operational and procedural differences exist in identifying discrimination and differentiation, there is also a process distinction between these phenomena.² After an extensive series of response differentiation experiments, Notterman and Mintz (1965) conclude that the distinctive feature "between discrimination and differentiation be not in any difference in 'process' but rather in the difference between the classes of discriminative stimuli cueing the organism's behavior" (p. 83). The type of cue (external or internal) is the crucial distinction between discrimination and differentiation for Notterman and Mintz. Discrimination occurs when the controlling stimuli are external; differentiation when differential reinforcement strengthens feedback stimuli produced by response emission. No provision is made in this schema for the two roles of feedback stimuli suggested earlier; clearly, the feedback that Notterman and Mintz assign to account for differentiation must be those that are on the point of occurring and not those that have occurred as a result of preceding behavior. Logically, the disagreement between Skinner and the position of Notterman and Mintz

²The phrase "process distinction" means that the mechanism responsible for these phenomena are not functionally equivalent; they obey different laws.

resides in whether impending feedback is a necessary condition for differentiation. A sufficient condition is demonstrated if the response discrimination and differentiation experiments show equivalent results. To establish that feedback is a necessary condition for differentiation requires only a demonstration of animals differentiating responses when the discrimination between those responses is no longer possible. Whether impending feedback are necessary for response differentiation is a question amenable to empirical test.

Response Definition

Typically, the study of choice behavior has been confined to the employment of external stimuli and qualitative, topographical responses such as might occur in maze learning or "matching to sample" (Blough, 1959). Only recently, with the advent of micromolar theory (Logan, 1956) and subsequent investigations of correlated reinforcement in both discrete (Logan, 1960) and free (Hendry, 1962; Hendry and Van Toller, 1964) situations have various quantitative properties of the response been shown to be a part of what gets learned. Response differentiation, on the other hand, exemplified by the "double-band" experiment (Skinner, 1938; Notterman and Mintz, 1965) entails a procedure in which the responses to be differentiated and their associated feedback belonged to a single continuum, i.e., responses investigated are quantitative in nature and the stimuli controlling them are internal. Response discrimination, as here defined, differs from differentiation in that the response available at the choice point are qualitative, although the stimuli controlling them are internal. This is to say, another feature of the research reported

above is to determine if discrete (response discrimination) or continuous (response differentiation) choices indicate identical behavioral processes, i.e., show comparable phenomena. A discrete choice problem refers to the selection of typographically, distinct (and hence, qualitatively different) responses following the presentation of either externally-controlled or self-produced stimuli. The selection of quantitatively different responses which occupy a single continuum characterizes the continuous choice situation. The discrete situation may be handled without considering time as an independent variable, but a situation involving selection of responses along a single quantifiable dimension appears to suggest that the organism is attempting to decide at each instant in time whether to respond (continue pressing) or not to respond (terminate the press). Casting these two paradigms in a framework which stresses a procedural difference between discrete and continuous choices may have implications for considering responses either statistically or dynamically.

A static approach is consistent with a molecular analysis of the response; this is to say, a level of analysis which treats qualitatively and quantitatively different aspects of responding as distinctively different behaviors. By emphasizing that qualitative properties of behavior are differentiated on the basis of their characteristic "feel," their proprioceptive consequences, a molecular analysis implies that the occurrence of impending feedback is a necessary condition for response differentiation and that differentiation is a special case of stimulus discrimination.

If, on the other hand, the response is viewed dynamically so that

an organism is continuously monitoring his behavior over time, then the static analysis which catalogs response phases (e.g., initiation, maintenance, termination) as different responses reduces to the dynamic problem of response selection. Logan (1966) trained rats to run under conditions of continuously negatively correlated reward. Specifically, the procedure entailed equating the number of pellets of food to the number of seconds the rat consumed in transversing an alley. In effect, the rat pitted the marginal utility of an additional pellet against the marginal disutility of an additional second delay. On the assumption that the rat selects responses so as to maximize his net incentive, Logan estimated the speed at which the rat would run from relative incentive functions of amount and delay obtained from a previous study (Logan, 1965). Differential quantitative predictions were made on the basis of whether the response made by the rat was viewed dynamically or statically. A static conception of the response assumes that the rat makes a single choice at the beginning of each trial as to the speed he will run--the duration of the response is as long as a trial. A dynamic approach, on the other hand, implies that the rat is continuously monitoring his behavior and selects at each instant a faster or slower speed. The data indicate that if the response is viewed dynamically selection among quantitatively different responses may be predicted from functions derived from choice behavior between qualitatively different responses.

A dynamic conception of the response is consistent with and complementary to micromolar theory (Logan, 1956). Micromolar theory defines the response as a molar act (e.g., pressing a bar, running an

alley, jumping a hurdle) and treats variation in quantitative properties of the response in a manner similar to qualitatively different behaviors. Since both stimulus and response concepts within this framework possess quantitative as well as qualitative properties, micromolar theory emphasizes the similarity between them. But it does not imply that feedback is a necessary component of differentiation phenomena; it suggests rather that feedback stimuli appear to be sufficient for the selection of either quantitatively or topographically different responses. A molecular analysis assumes that feedback is both a necessary and sufficient condition for response selection; this implies that feedback must be discriminable to play a role in differentiation.

Possible Extensions

Since a major aspect of the research reported above was to demonstrate that response-produced stimuli share properties similar to those known to be effective for external stimuli, it should be noted that the procedures outlined earlier are in fact response analogs of the successive discrimination paradigm (see, e.g., Bitterman and Wodinsky; Eninger, 1953). By emphasizing the commonality of procedure in investigations of response- and externally produce stimuli confidence in the assertion that the two sources of stimulation are monitored by the same mechanisms is strengthened and possible extensions for the elucidation of the properties of feedback stimuli are suggested. For instance, the paradigm developed to investigate the role of feedback stimuli in guiding ensuing behavior may be extended to investigate the psychophysical properties of response-produced

stimuli. Recall that with this procedure the rat learned a response chain consisting of two components. In the first component of the chain, the rat was required to complete one of two alternative durations which were presented in a random sequence on the middle bar; when this requirement was fulfilled, the onset of external stimuli signaled termination of that press. In the second component, a single bar press on the right bar produced reinforcement if the short duration had been encountered on the middle bar and a press on the left bar produced reinforcement if the long duration had been completed on the middle bar. The psychophysical method of minimal changes (Postman and Egan, 1949) could determine the differential thresholds for response duration. Briefly, the procedure would entail using one of the two pre-determined durations on the middle bar as the standard stimulus. The magnitude of the other duration, the comparison stimulus, would be changed by a small amount from trial to trial in both ascending and descending series. Although few studies have investigated discrimination behavior where there are no external, experimenter-provided discriminative stimuli, two recent experiments (Mintz and Notterman, 1965; Leckart and Bishop, 1967) have indicated the possibility of developing psychophysical scales for various response dimensions. Mintz and Notterman trained human Ss to differentiate force of response by using a quantitative visual feedback procedure which informed S as to the force exerted after termination of the response. When the ratio of standard deviations to the required values for response peak force ($\Delta F/F$) were plotted against the peak force criterion (F), their results bore a striking

resemblance to psychophysical data in that the measures were comparable to the familiar Weber ratio. In a similar manner, Leckart and Bishop obtained Weber constants for concurrent FR FR schedules when one member of the schedule was held constant (FR 10) while the other member was varied from FR 6 to FR 9.

If discriminative processes do indeed underlie the phenomenon of response differentiation, then the conventional analytic techniques of psychophysics should facilitate their description. Furthermore, psychophysical scales of response dimensions might also elucidate the nature of the response by determining whether an organism can differentiate behaviors even though he can no longer discriminate the feedback generated by those behaviors..

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APPENDIX II-A

APPARATUS

The experimental chamber, constructed by Lehigh Valley Electronics, measured 10"h x 11"w x 12"d. The chamber was housed in a LVE environmental cubicle whose inner dimensions measured 14½" x 20" x 13½". The intelligence panel housed three bars with indicator lights located above the left and right bars. The side bars were standard retractable paddle levers measuring 1¼" x 1½" x ¾". The middle bar, rectangular in shape, measured 1¼" x ½" x ½" and was mounted in the former water spout housing located directly above a 1½" x 1½" x 2" food receptacle into which a single 20 mg. Noyes rat pellet was delivered as reinforcement. The middle bar rested on an imaginary plane parallel to and about ½" away from the panel facing.

Experiment I. A press to the middle bar closed a microswitch which activated one of two Hunter Decade Interval Timers. The timers were calibrated by a Textronic Oscilloscope prior to the experiment to insure reasonably accurate durations of response. Which of the two timers rendered operative on any given trial depended upon a 33 pole stepping switch, activated by microswitches attached to the side bars. The stepping switch stepped at the end of the impulse and hence at the release of a side bar. The microswitches controlling the side bars were effective only after the predetermined duration on one of the timers had finished (timed out); this resulted in the onset of cue lights over both side bars. A press to either side bar

when the trial was in effect (cue lights on) unlocked a holding circuit on the timer, terminating the trial. If the correct side bar was selected, a Foringer feeder delivered the reinforcement in a receptacle located below the middle bar. Another consequence of releasing a side bar was to direct an impulse to a predetermining counter which counted down when the trial was terminated. At the completion of a session (100 trials) an impulse from the predetermining counter rendered the three bars inoperative and activate a house light in the cubicle. Onset of the light signalled the end of the session.

Experiment II. A response on the middle bar started the trial by closing a circuit which produced the onset of a cue light over one of the side bars. A 33 pole stepping switch determined which of the two cue lights were to be activated. A bank of four Hunter Decade Interval Timers were used, two for each bar. A press to the bar associated with the cue caused the activation of one of the timers. This timer defined the lower limit of the band while the other prescribed the band's upper limit. The two timers operated in sequence, i.e., the second timer could only be activated after the first timer had timed out. If bar release occurred prior to the first timer finishing, the trial remained in effect. The trial ended only if release occurred (a) after the first timer had finished but before the second was made (correct response), or (b) after the second timer had finished (incorrect response). Bar release under these two conditions advanced the stepper and predetermining counter. All other aspects of Experiment II were identical to Experiment I.

APPENDIX II-B

PRELIMINARY TRAINING PROCEDURE

Stage I. Ss were shaped to approach the food receptacle located below the middle bar when a click generated by the operation of a Foringer feeder occurred. The presentation of each pellet, and hence the click, was controlled by E; the magazine training continued until each S had received a total of 50 reinforcements. After magazine training Ss were required to press either the right or left bar when the indicator light situated above its respective bar was "on." For the first session each S received a total of 30 light onsets, 15 to each bar. The number of light onsets over each bar was increased so that by the fourth day Ss received 100 trials. At the completion of each session the house light mounted in the experimental cubicle came "on," acting as a signal to terminate responding. The sequence of presentations for light onset was random so that preference effects could be controlled. Stage I remained in effect until all Ss achieved a criterion of 80% correct to both bars. An ITI was imposed during this phase to enhance the distinctiveness of the cue and to obviate any possible fortuitous conditioning effects.

Stage II. Unlike the first training phase where a press on the middle bar had no effect and where the apparatus controlled trial onset, during the second phase S was required to press the middle bar to produce the onset of a light over one of the side bars. Ss were placed on this condition at the 9th session and it remained in effect

through the 13th session, i.e., until Ss' mastery of the prescription achieved the same level of accuracy required for Stage I. Since the onset of the light over its appropriate bar was dependent upon pressing the middle bar, session length was under S's control.

Stage III. Beginning with the 14th session, Ss were required to hold the middle bar for .2 sec. in order for the cue to occur. An additional .2 sec. duration was added each day until S had to depress the middle bar for 1.4 sec. before the cue onset. This condition was met by the 20th session. For the response differentiation Ss, the procedure was identical except that durations were programmed on the side bars rather than the middle bar. Duration requirements and criterion imposed on these Ss were identical to those in the response discrimination study.

APPENDIX III-A

Response Discrimination Experiment
Table 3

Percent Correct Responses of Ss in Gradual Group Summed
Over Successive Trial Blocks

Subscripts attached to R's denote short (R_s) and long (R_l) durations.
 R_t denotes percent correct response for both durations. Trial Blocks
21-26 show performance on the intermediate task.

Gradual

5

9

Trial Blocks	R_s	R_l	R_t	Trial Blocks	R_s	R_l	R_t
1-4	58.00	66.00	62.00	1-4	65.50	70.00	67.75
5-8	80.00	84.50	82.25	5-8	80.50	73.00	76.75
9-12	82.00	85.00	83.50	9-12	69.00	84.50	76.75
13-16	63.00	75.50	69.25	13-16	52.00	70.50	61.25
<u>17-20</u>	<u>54.50</u>	<u>80.00</u>	<u>67.25</u>	<u>17-20</u>	<u>55.00</u>	<u>69.50</u>	<u>62.25</u>
21-26	83.34	90.00	86.66	21-26	78.00	75.00	76.50

11

14

Trial Blocks	R_s	R_l	R_t	Trial Blocks	R_s	R_l	R_t
1-4	78.00	52.00	65.00	1-4	72.00	62.50	67.25
5-8	91.50	47.50	69.50	5-8	72.00	91.00	81.50
9-12	72.50	78.50	75.50	9-12	76.00	78.50	77.25
13-16	52.00	63.50	57.75	13-16	68.50	64.50	66.50
<u>17-20</u>	<u>60.50</u>	<u>60.50</u>	<u>60.50</u>	<u>17-20</u>	<u>65.00</u>	<u>72.00</u>	<u>68.50</u>
21-26	74.00	63.67	68.83	21-26	83.33	78.00	80.66

Table 4

Percent Correct Responses of Ss in Abrupt Group

Summed Over Successive Trial Blocks

Abrupt

1				2			
Trial Blocks	R _s	R ₁	R _s	Trial Blocks	R _s	R ₁	R _t
1-4	64.50	49.50	57.00	1-4	54.50	57.50	56.00
5-8	83.50	57.50	70.50	5-8	67.00	74.00	70.50
9-12	93.00	96.00	94.50	9-12	69.00	74.00	71.50
13-16	74.00	79.00	76.50	13-16	46.00	65.00	55.50
<u>17-20</u>	<u>68.50</u>	<u>81.50</u>	<u>75.00</u>	<u>17-20</u>	<u>53.00</u>	<u>61.00</u>	<u>57.00</u>
21-26	89.33	83.67	86.50	21-26	53.00	70.67	61.83

6				10			
Trial Blocks	R _s	R ₁	R _s	Trial Blocks	R _s	R ₁	R _t
1-4	60.00	40.50	50.25	1-4	64.00	61.00	62.50
5-8	75.00	68.00	71.50	5-8	80.50	60.00	70.25
9-12	90.00	68.00	79.00	9-12	76.00	81.50	78.75
13-16	74.50	62.00	68.25	13-16	43.50	71.50	57.50
<u>17-20</u>	<u>76.00</u>	<u>57.50</u>	<u>66.75</u>	<u>17-20</u>	<u>45.50</u>	<u>70.50</u>	<u>58.00</u>
21-26	88.67	71.33	80.00	21-26	61.33	78.33	69.83

Table 5

Percent Correct Responses of Ss in Hard Group Summed

Over Successive Trial Blocks

Hard

3				8			
Trial Blocks	R _s	R ₁	R _t	Trial Blocks	R _s	R ₁	R _t
1-4	69.50	29.50	49.50	1-4	58.00	30.50	44.25
5-8	69.50	40.00	54.75	5-8	47.00	58.50	52.75
9-12	67.00	47.50	57.25	9-12	40.00	60.00	50.00
13-16	64.00	46.50	55.25	13-16	58.00	52.00	55.00
<u>17-20</u>	<u>73.00</u>	<u>39.00</u>	<u>56.00</u>	<u>17-20</u>	<u>60.50</u>	<u>62.50</u>	<u>61.50</u>
21-26	69.66	56.00	62.83	21-26	75.00	78.67	76.83

12				13			
Trial Blocks	R _s	R ₁	R _t	Trial Blocks	R _s	R ₁	R _t
1-4	72.00	28.00	50.00	1-4	40.50	51.00	45.75
5-8	75.00	15.50	45.25	5-8	49.50	47.00	48.25
9-12	78.00	24.50	51.25	9-12	55.00	50.50	52.75
13-16	65.00	27.50	46.25	13-16	45.00	59.50	52.25
<u>17-20</u>	<u>55.50</u>	<u>32.50</u>	<u>44.00</u>	<u>17-20</u>	<u>50.50</u>	<u>62.50</u>	<u>56.50</u>
21-26	52.33	26.00	39.16	21-26	69.66	62.00	65.83

APPENDIX III-B

Response Discrimination Experiment

Drive Shift Data

The effect of drive level was evaluated on the intermediate task by feeding rats on alternate days either 6 or 18 gms. for six additional days. The maintenance schedule was varied in this way to avoid presumed inanition and satiation effects. The data presented in Table 6 represents the mean choice performance of each group. The values were determined by summing over the number of correct responses to both R_A and R_B . Since the drive level was shifted from day to day, odd trial blocks (i.e., 1, 3, and 5) represent the high drive condition, while even trial blocks (i.e., 2, 4, and 6) denote low drive.

A Friedman two-way analysis of variance revealed that changes in drive failed to have a significant effect on the groups' performance ($\chi^2_r = 2.72$, $df = 5$). Further evidence that drive shifts had negligible effects may be seen in Table 7 which summarizes the mean high and low drive conditions for the three groups.

Table 6

Effect of High and Low Drive on the Intermediate Task

Trial Blocks	1	2	3	4	5	6
Gradual	83.00	83.50	84.50	82.75	87.20	84.50
Abrupt	79.25	79.00	77.00	73.75	79.50	75.80
Hard	60.00	65.80	61.00	62.80	63.00	62.50
Mean of the Groups	74.08	76.10	74.16	73.10	76.56	74.26

Table 7

Mean Performance of the Three Groups Under Conditions
of High and Low Drive

Values Obtained by Summing Over Odd and Even Trial Blocks.

	Mean High Drive	Mean Low Drive
Gradual	84.90	83.58
Abrupt	78.58	76.18
Hard	61.33	63.70
Mean of the Groups	74.93	74.48

APPENDIX III-C

Response Differentiation Experiment

Table 8

Number of Correct Responses of Ss in Gradual Group

Summed Over Successive Trial Blocks

Subscripts attached to R's denote short (R_s) and long (R_l) bands.

R_t denotes total number correct responses summed over both bands

($R_t = R_s + R_l$).

Gradual

4				6			
Trial Blocks	R_s	R_l	R_t	Trial Blocks	R_s	R_l	R_t
1-5	2.2	20.6	22.8	1-5	15.6	28.6	44.2
6-10	16.4	38.8	55.2	6-10	22.4	36.6	59.0
11-14	22.0	42.3	65.3	11-14	22.0	28.0	60.8
15-18	22.5	44.8	67.3	15-18	25.0	36.5	61.5
19-22	28.0	46.8	74.8	19-22	22.8	41.0	63.8
23-26	37.2	45.5	82.7	23-26	24.0	38.5	62.5

8				9			
Trial Blocks	R_s	R_l	R_t	Trial Blocks	R_s	R_l	R_t
1-5	28.6	21.6	50.2	1-5	2.4	25.6	28.0
6-10	43.8	29.0	72.8	6-10	2.9	34.4	37.3
11-14	43.3	29.0	72.3	11-14	6.0	39.8	45.8
15-18	41.2	24.0	65.2	15-18	14.2	43.2	57.4
19-22	45.2	34.2	79.4	19-22	29.2	43.2	72.4
23-26	44.2	34.0	78.2	23-26	35.0	37.2	72.2

Table 9

Number of Correct Responses of Ss in Abrupt Group

Summed Over Successive Trial Blocks

1				2			
Abrupt				Abrupt			
Trial Blocks	R _S	R _L	R _T	Trial Blocks	R _S	R _L	R _T
1-5	3.8	27.0	30.8	1-5	24.0	18.1	42.1
6-10	8.1	23.0	31.1	6-10	28.2	25.8	54.0
11-14	22.5	20.0	42.5	11-14	31.5	28.5	60.0
15-18	23.9	22.5	46.4	15-18	29.5	26.8	56.3
19-22	15.0	29.0	44.0	19-22	18.0	24.2	42.2
23-26	15.7	27.0	42.7	23-26	28.5	25.8	54.3

5				7			
Trial Blocks	R _S	R _L	R _T	Trial Blocks	R _S	R _L	R _T
1-5	14.8	22.8	37.6	1-5	24.6	17.2	41.8
6-10	14.0	26.8	40.8	6-10	36.4	32.8	69.2
11-14	23.8	16.5	40.3	11-14	35.5	28.0	63.5
15-18	32.5	20.2	52.7	15-18	37.0	35.8	72.8
19-22	12.5	30.0	42.5	19-22	25.5	31.5	57.0
23-26	25.5	34.8	60.3	23-26	28.0	40.0	68.0

Table 10

Number of Correct Responses of Ss in Hard Group

Summed Over Successive Trial Blocks

3				11			
Hard				Hard			
Trial Blocks	R _s	R ₁	R _t	Trial Blocks	R _s	R ₁	R _t
1-5	17.8	26.6	44.4	1-5	27.5	28.8	56.3
6-10	29.6	39.5	69.1	6-10	32.8	16.8	49.6
11-14	31.2	42.2	73.4	11-14	27.2	17.0	44.2
15-18	46.0	33.7	79.7	15-18	18.0	21.5	39.5
19-22	42.0	31.5	73.5	19-22	21.5	17.5	39.0
23-26	34.2	35.2	69.4	23-26	24.8	20.8	45.6

12				13			
Trial Blocks	R _s	R ₁	R _t	Trial Blocks	R _s	R ₁	R _t
1-5	18.0	11.2	29.2	1-5	15.5	16.4	32.0
6-10	16.6	13.6	30.2	6-10	21.8	25.8	47.6
11-14	20.2	16.7	36.9	11-14	29.5	41.0	70.5
15-18	17.4	29.0	46.4	15-18	26.0	35.7	61.7
19-22	29.0	30.0	59.0	19-22	25.0	36.0	61.0
23-26	25.2	30.0	55.2	23-26	19.7	28.5	48.2

APPENDIX III-D

Response Differentiation Experiment

Table 11

Mean "Counts" (Bar Release) Before Emission of Correct or Incorrect
Responses Summed Over Successive Trial Blocks

Gradual

4			6		
Trial Blocks	R _S	R _I	Trial Blocks	R _S	R _I
1-5	1.2	158.8	1-5	28.6	153.4
6-10	4.8	201.4	6-10	98.4	78.8
11-14	22.5	207.7	11-14	170.7	110.2
15-18	50.2	106.2	15-18	80.0	78.7
19-22	103.2	94.2	19-22	160.2	34.0
23-26	83.2	111.7	23-26	194.7	43.5

8			9		
Trial Blocks	R _S	R _I	Trial Blocks	R _S	R _I
1-5	35.4	96.0	1-5	1.0	131.6
6-10	19.0	101.6	6-10	2.4	212.4
11-14	25.5	78.7	11-14	10.0	105.5
15-18	67.7	31.0	15-18	15.2	37.7
19-22	70.0	12.5	19-22	99.7	26.7
23-26	75.5	31.7	23-26	103.0	104.0

Table 12

Raw Data

"Counts" (Bar Release) Before Selection of Correct

or Incorrect Responses

Trial Blocks	4		6		8		9	
	R _S	R _I	R _S	R _I	R _S	R _I	R _S	R _I
1	0	69	12	81	7	45	2	104
2	0	100	15	109	40	89	1	150
3	2	124	22	84	48	115	0	158
4	1	157	48	262	41	143	1	147
5	3	344	46	231	41	88	1	99
6	1	217	68	53	38	146	7	315
7	6	208	39	65	25	81	3	289
8	1	240	148	112	11	106	2	7
9	10	189	122	84	7	63	0	291
10	6	153	115	80	15	112	0	160
11	18	259	171	104	21	114	1	190
12	19	120	162	102	9	37	3	64
13	25	268	133	74	33	79	10	85
14	27	184	217	161	42	85	26	83
15	59	169	60	77	70	15	5	22
16	35	58	119	55	65	29	18	63
17	34	70	63	50	62	35	8	40
18	73	128	78	133	74	45	30	26
19	82	50	96	25	100	7	25	5
20	160	77	169	24	70	15	137	25
21	61	62	218	49	66	4	149	34
22	110	188	158	38	44	23	88	43
23	90	134	190	24	130	56	66	161
24	121	138	263	62	70	1	42	111
25	108	117	175	76	47	33	60	49
26	14	58	151	12	55	37	244	95

Table 13

Mean "Counts" (Bar Release) Before Emission of Correct or Incorrect

Responses Summed Over Successive Trial Blocks

Abrupt

1			2		
Trial Blocks	R _S	R _I	Trial Blocks	R _S	R _I
1-5	1.6	108.0	1-5	36.2	100.0
6-10	4.6	122.0	6-10	66.8	136.0
11-14	9.5	142.7	11-14	64.0	137.5
15-18	10.5	155.0	15-18	54.7	127.5
19-22	60.2	75.2	19-22	184.2	46.0
23-26	98.2	76.5	23-26	159.7	77.2

5			7		
Trial Blocks	R _S	R _I	Trial Blocks	R _S	R _I
1-5	18.2	279.2	1-5	64.2	62.8
6-10	23.8	278.4	6-10	111.6	116.0
11-14	28.5	217.2	11-14	98.5	79.0
15-18	56.6	118.7	15-18	78.7	63.5
19-22	131.5	91.5	19-22	281.5	30.2
23-26	178.5	49.0	23-26	161.7	41.2

Table 14

Raw Data

"Counts" (Bar Release) Before Selection of Correct
or Incorrect Responses

Trial Blocks	Abrupt							
	1		2		5		7	
	R _s	R ₁	R _s	R ₁	R _s	R ₁	R _s	R ₁
1	2	72	25	101	3	321	46	76
2	0	103	29	61	14	273	37	77
3	1	114	34	107	20	334	100	66
4	0	109	37	143	26	368	82	42
5	5	142	56	88	28	101	56	53
6	2	185	101	143	23	293	116	116
7	3	118	67	75	25	181	117	121
8	12	141	48	167	28	301	105	111
9	3	77	39	161	18	277	144	133
10	3	90	79	134	25	340	76	99
11	9	170	73	120	24	287	107	107
12	10	73	85	49	35	225	99	39
13	7	141	43	189	17	137	65	94
14	12	187	55	192	38	220	123	76
15	8	139	93	87	47	110	98	77
16	15	115	49	132	55	94	88	73
17	5	162	48	123	63	100	62	37
18	15	204	29	168	61	171	67	67
19	45	88	184	11	78	167	185	19
20	67	97	162	49	185	95	315	19
21	28	71	223	83	158	56	400	55
22	101	45	168	41	105	48	126	28
23	121	77	270	93	241	60	164	30
24	74	120	171	60	159	28	192	20
25	42	120	90	95	151	64	140	32
26	56	89	99	61	164	44	151	83

Table 15

Mean "Counts" (Bar Release) Before Emission of Correct or Incorrect
Responses Summed Over Successive Trial Blocks

Hard

3			11		
Trial Blocks	R _S	R _I	Trial Blocks	R _S	R _I
1-5	70.8	96.4	1-5	90.6	62.8
6-10	98.6	125.4	6-10	46.0	86.6
11-14	119.2	150.0	11-14	70.7	78.5
15-18	88.7	202.2	15-18	63.7	50.7
19-22	58.5	189.0	19-22	55.5	50.7
23-26	32.5	78.0	23-26	51.7	80.2

12			13		
Trial Blocks	R _S	R _I	Trial Blocks	R _S	R _I
1-5	78.2	120.6	1-5	66.8	96.6
6-10	99.6	132.6	6-10	74.2	150.4
11-14	110.2	170.7	11-14	56.0	106.2
15-18	157.7	140.7	15-18	55.6	176.7
19-22	171.0	195.2	19-22	45.0	101.7
23-26	172.5	178.2	23-26	66.7	129.2

Table 16

Raw Data

"Counts" (Bar Release) Before Selection of Correct
or Incorrect Responses

Trial Blocks	3		11		12		13	
	R _s	R ₁	R _s	R ₁	R _s	R ₁	R _s	R ₁
1	41	45	219	10	180	31	17	35
2	33	56	23	46	72	81	15	99
3	95	66	37	92	72	90	40	79
4	90	166	111	65	77	146	176	163
5	95	149	63	101	85	255	86	107
6	115	130	65	99	119	187	87	175
7	96	105	52	64	103	91	91	261
8	167	181	52	101	112	148	54	106
9	64	137	31	102	84	122	82	93
10	51	69	30	67	80	115	57	117
11	113	64	83	105	104	171	47	46
12	85	102	31	41	102	162	40	94
13	134	163	76	67	74	133	53	91
14	144	271	93	101	161	217	84	194
15	99	198	52	22	147	143	50	115
16	101	223	63	64	212	117	72	310
17	45	166	57	30	126	176	60	181
18	110	222	83	87	146	127	41	101
19	39	209	40	15	186	197	54	113
20	103	208	78	73	169	186	55	124
21	45	152	40	37	155	168	55	104
22	47	187	64	78	174	230	16	66
23	31	81	41	18	191	214	8	83
24	20	40	34	18	177	221	68	147
25	53	105	63	151	169	167	126	154
26	26	76	69	134	153	111	65	133

APPENDIX IV

Edward J. Rickert

Vita

Personal Data

Born July 24, 1936, Houston, Texas.

Education

University of New Mexico, Albuquerque, N. M., B.A., 1960.

University of New Mexico, Albuquerque, N. M., M.S., 1963.

Honors

Phi Kappa Phi

Sigma Xi

University Fellow

Publications and Papers

Application of Bower's Association Model to Paired-Associate Transfer. Unpublished Master's Thesis. University of New Mexico, 1963.

Use of the premack principle in controlling the behavior of nursery school children. *J. exp. Anal. Behav.*, 1963, 6, 544. (with L. E. Homme, D. C. DeBaca, J. V. Devine, and R. Steinhorst).

Appointments

Assistant Professor in Psychology, Sacramento State College, 1967-present.

Research Assistant, University of New Mexico, 1965-1967.

Part-time laboratory Instructor in College of Education, University of New Mexico, 1965.

Part-time Instructor in Psychology, University of New Mexico, 1964.

Research Assistant, Economics, University of New Mexico, 1964-1965.

Program Writer-Supervisor, Teaching Machines, Inc., 1962-1964.

Program Writer, General Programmed Teaching Corporation, 1961-1962.

Graduate Assistant, University of New Mexico, 1960-1961.

Research Assistant, University of New Mexico, Summer 1960.

MILLERS FALLS

ERASE

COTTON CONTENT