R E P O R T R E S U M E S

ED 019 139 PS 000 874

EXTINCTION IN DISCRIMINATION LEARNING--PRESENTATION AND CONTINGENCY VARIABLES AND ASSOCIATED SIDE EFFECTS.

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REPORT NUMBER WORKING-PAPER-19 PUB DATE FEB 68
CONTRACT OEC-3-16-043
EDRS PRICE MF-$0.25 HC-$1.52 36P.

DESCRIPTORS- *BEHAVIORAL SCIENCE RESEARCH, *KINDERGARTEN CHILDREN, *DISCRIMINATION LEARNING, STIMULUS BEHAVIOR, CONDITIONED RESPONSE, *CONSTRUCTED RESPONSE, VISUAL STIMULI, TRAINING TECHNIQUES,

STUDIES HAVE SHOWN THAT IT IS POSSIBLE TO ESTABLISH DISCRIMINATORY RESPONSES TO PAIRS OF STIMULI WITHOUT ERROR RESPONSES TO THE UNREINFORCED (S-) STIMULUS. THE PURPOSE OF THIS STUDY WAS TO DETERMINE THE EFFECTS OF 2 METHODS OF INTRODUCING S- (FADING AND CONSTANT) AND 2 RESPONSE CONTINGENCIES (DELAY AND NO DELAY) ON THE OCCURRENCE OF S- RESPONSES. THE SUBJECTS WERE 27 KINDERGARTEN CHILDREN WHO WERE DIVIDED INTO 3 GROUPS WHICH RECEIVED 1 OF 3 TRAINING PROCEDURES--(1) FADING-NO DELAY, (2) CONSTANT-NO DELAY, AND (3) CONSTANT-DELAY. THE STIMULI WERE A HORIZONTAL AND A VERTICAL LINE PROJECTED ONTO A PLEXIGLASS SCREEN. THE RESPONSE CONSISTED OF PUSHING ON THE SCREEN, AND THE S+ STIMULUS WAS REINFORCED WITH CANDY. IN THE INITIAL SESSION THE S+ STIMULUS WAS PROJECTED 5 TIMES TO ESTABLISH THE RESPONSE, AND THEN THE S- STIMULUS WAS INTRODUCED IN A RANDOM FASHION. IN THE FADING PROCEDURE, ITS INTENSITY AND DURATION WERE GRADUALLY INCREASED UNTIL IT MATCHED THAT OF THE S+ STIMULUS. IN THE CONSTANT PROCEDURE IT WAS KEPT AT THE SAME INTENSITY AS S+. IF THERE WAS NO RESPONSE TO S-, IT TERMINATED IN 5 SECONDS. IN THE DELAY CONTINGENCY, 5 SECONDS HAD TO ELAPSE WITHOUT A RESPONSE BEFORE IT WOULD TERMINATE. IN THE NO-DELAY CONTINGENCY A RESPONSE IMMEDIATELY TERMINATED IT, AND IT WAS THEN REPROJECTED. THE SUBJECTS WERE TRAINED UNTIL THEY WENT THROUGH ONE SESSION OF 20 PRESENTATIONS OF EACH STIMULUS WITH NO S- RESPONSES. SUBJECTS TRAINED WITH THE FADING PROCEDURE MADE SIGNIFICANTLY FEWER RESPONSES IN THE COURSE OF TRAINING THAN SUBJECTS TRAINED WITH THE CONSTANT PROCEDURE. SUBJECTS TRAINED WITH THE CONSTANT-DELAY PROCEDURE MADE SIGNIFICANTLY FEWER RESPONSES THAN THE SUBJECTS TRAINED WITH THE CONSTANT-NO DELAY PROCEDURE. IN THE LATTER, IT WAS FELT THAT THE OFFSET OF THE S- STIMULUS WITH A RESPONSE WAS ACTING AS A REINFORCEMENT. (DR)

EXTINCTION IN DISCRIMINATION LEARNING: PRESENTATION AND CONTINGENCY VARIABLES AND ASSOCIATED SIDE EFFECTS

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February, 1968

The research reported herein was performed pursuant to Contract Nonr-624(18) with the Personnel and Training Branch, Psychological Sciences Division, Office of Naval Research. Additional support was provided under Contract OE-3-16-043 with the Office of Education, U. S. Department of Health, Education and Welfare.

Extinction in Discrimination Learning: Presentation and Contingency Variables and Associated Side Effects[1]

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Abstract

The purpose of the study was to assess the effects of two methods of stimulus presentation (fading and constant) and two response contingencies (delay and no-delay) on the course of discrimination learning; and to examine the effects of response histories on various aspects of discrimination performance. In the fading procedure S- was gradually faded along the dimensions of brightness and time, and in the constant procedure S- maintained a constant value throughout training. Subjects trained with the constant procedure made significantly more S- responses in the course of acquisition than subjects trained with the fading procedure. In the constant-delay procedure, S- responses were followed by a delay in the offset of S-. In the constant-no-delay procedure S- responses were followed by an intertrial interval. Subjects trained with the constant-no-delay procedure made significantly more responses to S- than subjects trained with the constant-delay procedure.

The amount of extinction which occurred during learning was highly correlated with intertrial responding and the stability of the learned discrimination. Discrimination reversal learning was also a function of original learning history. The results were discussed in terms of the differential processes which underlie discriminative performance when different training procedures are used.

Introduction

The classical view that extinction of S- responses is required for discrimination learning has been reexamined by Terrace (1963). His success in establishing discriminative behavior in pigeons with minimal or no S- responding raises questions about the variables which control the occurrence of S- responses. The emphasis in previous work on the necessity for error responses in discrimination learning has resulted in some neglect of the variables which control their occurrence.

Recent studies have shown that when a "fading" procedure is employed, fewer S- responses occur in the course of acquisition of the discrimination than when a constant method is used (Moore & Goldiamond, 1964; Ray, 1967; Sidman & Stoddard, 1967; and Terrace, 1963). In the fading procedure stimulus control is transferred from one set of stimuli to another; stimulus support is gradually withdrawn from a previously learned, or easily established discrimination, and control is transferred over successive trials to a new stimulus dimension. An analysis of the events following an S- response further indicates that when this response is followed by a delay in the offset of S-, there is less possibility for S- responses to be adventitiously reinforced by the onset of a new event (Sidman, 1960, p. 351). In the present study the effects of stimulus presentation methods (fading and constant) and response contingencies (delay and no-delay) on the course of S- responding in discrimination learning were investigated. The joint effect of manipulating these two variables was to provide subjects who had acquired the same discrimination performance but had different behavioral histories with regard to the amount of S- responding or extinction that had occurred in the course of acquiring the discrimination.

With respect to the effect of this behavioral history on discrimination performance there is evidence to suggest that the effects observed in extinction with a single stimulus are also found when extinction occurs in discrimination learning. Terrace's (1966b) results indicated that spontaneous recovery of an extinguished response and concomitant side effects occur when the discrimination is learned with extinction. The mechanism underlying these effects seems to be inhibition. This was suggested by several kinds of evidence: the effect of the tranquilizing drugs which released this inhibition (Terrace, 1963), the demonstration of inhibitory gradients surrounding S- (Terrace, 1966a), and the peak shift in the postdiscrimination generalization gradients around S+ (Terrace, 1964). Terrace (1963) also found that S- responses were accompanied by intertrial responses. In contrast, in a discrimination acquired without extinction there was no evidence of the occurrence of these phenomena. These differences indicate that extinction in discrimination learning can have auxiliary side effects which are not present

when a discrimination is acquired without extinction. The present study investigated the effects of different amounts of extinction in discrimination learning on irrelevant intertrial behavior accompanying learning, the stability of the acquired discrimination, and the amount of inhibition associated with S-.

Method

Independent Variables

Stimulus presentation. A fading procedure was employed in which S- was introduced to the subject in two phases during the first experimental session. During Phase I, S- was of a constant duration, 0.5 seconds, and its brightness was gradually increased from very dark to full brightness, i.e., a level equal to S+. At the beginning of Phase II, S- was again made very dark and both the brightness and duration of S- were increased simultaneously. S- was dark initially and on successive presentations it became brighter and its duration was increased progressively from one to five seconds. The last four S- stimuli in the first session were of full brightness and full duration. There was no further fading of S- after the first session. The brightness and duration of S- on successive presentations during the fading sequence are presented in Table 1, in which Phase I and Phase II of the fading sequence are further subdivided into stages which will be referred to in the results section. This fading sequence is the sequence that was presented to those subjects who made no S- responses. If a subject made an S- response during the fading sequence, the same S- was presented again.

Insert Table 1 about here

A constant method of stimulus presentation was employed in which S- was as bright as S+ and of maximum duration (five seconds) on the first trial and on all subsequent presentations.

Reinforcement contingencies. The events which followed a correct response were the same in all of the training procedures. A response to

S+ and no response to S- constituted correct responses. When a response was made to S+, the subject received an M&M candy, the stimulus was terminated, and a new stimulus was presented after an intertrial interval. When no response was made to S- for five seconds, the stimulus was terminated, and a new stimulus was presented after the intertrial interval.

The events which followed an incorrect response differed in the different training procedures. No response to S+, or a response to S- constituted an incorrect response. The event which followed an incorrect response was either a delay or no delay in the offset of the stimulus. When the delay contingency was in effect, each response to S- reset a five-second timer. S- could not be terminated until five seconds without a response to S- had elapsed. S+ could not be terminated until a response to S+ had occurred. Thus, every trial ended with a correct response and a new stimulus was presented after the intertrial interval. In the no-delay contingency each response to the S- terminated the S-. The same S- was presented again after the intertrial interval. S+ was terminated after five seconds if the subject had not responded, and the same S+ was presented again after the intertrial interval. In this procedure the offset of S+ and S- was not contingent on the occurrence of a correct response.

The two methods of stimulus presentation and the two reinforcement contingencies were manipulated in three different training procedures: (1) a fading-no-delay procedure, (2) a constant-no-delay procedure, and (3) a constant-delay procedure.

Subjects

Twenty-seven kindergarten children were assigned to one of the three discrimination procedures. Four other subjects, for particular reasons to be discussed later, were trained first with one procedure, and then changed to another procedure.

Apparatus

The subject was seated in front of an aluminum panel 17 x 21 inches which had a circular aperture 5 1/2 inches in diameter. The stimuli, black lines on a white or gray background, were projected with a Kodak Carousel

slide projector, Model #550, on a plexiglass screen mounted behind the aperture. The black lines were 4 3/4 inches long and 1/8 inch wide. In the discrimination task the S+ stimulus was a vertical line and the S- was a horizontal line. The subject responded by pressing on the plexiglass screen and his response was recorded on an Esterline Angus event recorder, Model AW, which provided a trial-by-trial record of ongoing behavior. The reinforcement for S+ responses consisted of M&M's dispensed into a cup by an MMD-1 candy dispenser made by Davis Scientific Instruments. Between trials a shutter closed and the screen was dark. Any responses which occurred during this period were recorded. The shutter, M&M dispenser, and the back of the stimulus display unit were covered by a soundproofed masonite box. Relay equipment housed in an adjacent room was used to coordinate and control stimulus presentations and response contingencies.

Training Procedures

The following general procedures were employed for all three methods of discrimination training. When the subject first entered the room, the instructions to him were, "Press the window, and see if you can get an M&M." When the next stimulus appeared, he was told, "press the window," only if he had not already done so. No further instructions were given in any of the sessions after the first session. The first five stimuli presented to the subject in the first session were S+ stimuli and each response to the S+ was followed immediately by an M&M. After the first five S+ stimuli had been presented, S+ and S- were presented in a random sequence on successive trials, and the three different training procedures were put into effect. On the first day of training all subjects had a total of 55 stimuli (32 S+ and 23 S- stimuli). In all subsequent sessions there were 40 stimuli (20 S+ and 20 S- stimuli). All subjects were trained until they reached a criterion of one session (40 stimuli) with no responses to S-. After each subject had reached this criterion, he was given two post-criterion sessions.

Between each of the first five successive stimulus presentations there was an intertrial interval which was gradually lengthened. Responses to the dark screen during this interval were considered a measure of irrelevant responding in the course of discrimination learning. In order to eliminate (or shape out) these responses, the interval was a variable interval

with a range of one to four seconds and a mean of about two seconds. If a response occurred at any time during the interval it: 1) stopped the tape which was timing the variable interval, and 2) tripped off another timer which added ten seconds to the remaining time in the interval.

Posttraining Procedures

After all subjects, nine in each of the three training procedures, had acquired the discrimination and had two postcriterion sessions, three subjects from each of the groups were assigned to one of three posttraining groups. One group was given a retention test after two weeks, consisting of a single session with 20 S+ and 20 S- stimuli, and procedures identical to those used during original training were employed. The other two groups were given discrimination reversal training, either immediately following or two weeks after the last postcriterion session. In reversal training the new S+ was a horizontal line (the old S-) and the new S- was a vertical line (the old S+). For all subjects, during reversal training the delay contingency was in effect. In the first day of reversal training, the new S+ was presented first. Latency of response to the new S+ was used as the index of inhibition. The S+ remained on the screen until the subject pressed the window. Since it had been observed that some subjects would begin to walk out of the room rather than press the window, a procedure was employed to try and prevent the subjects from leaving the room. If the subject began to leave the room a "free" M&M was dispensed. The free M&M fell into the cup in the presence of the new S+ without the subject having to press the window. The significant aspect of leaving the experimental situation is that it might be inferred that it represents one extreme of the continuum of inhibition; so much inhibition was associated to the new S+ that the subject walked out of the room to avoid a stimulus which had been associated with extinction. The other extreme of this continuum would be no inhibition to S+ in which case the subject would be expected to respond immediately to the new S+. The second stimulus presented in reversal training was another new S+. The stimulus remained on the screen until the subject pressed the window or started to leave the room, at which time he was given another free M&M. Five S+ stimuli were given in succession at the beginning of the first day of reversal training. The number of stimuli presented were the same as in original training.

Results

S- Responding in Discrimination Learning

A comparison of the groups trained with the three different procedures indicates that there were significant differences in the total number of S- responses that each group made in the course of discrimination learning. Table 2 shows the number of S- responses made by each subject, and the total number of S- responses for each of the three groups. An analysis of variance indicates that the differences between the groups were significant beyond the .01 level.

Insert Table 2 about here

Fading

Several different fading procedures had been tried in pilot work before a program was established in which a discrimination could be acquired with minimal S- responding. The development of the task and the fading procedure is described elsewhere (Cohen, 1967). Table 3 shows the data for the fading-no-delay group. The first column labeled Session 1 gives the number of S- responses that each subject made during each stage of the fading sequence. As shown in Table 1, the different stages refer to successive approximations to the terminal S-. The few S- responses that were made in stages 1, 2, 3, and 4 indicate that fading on the dimensions of brightness and time was effective in controlling the occurrence of S- responses. Since no S- responses occurred in Stage 5, it can be concluded that stimulus control had been transferred from brightness and time to the dimension of line orientation. The remainder of the columns in Table 3 show the number of S- responses that each subject made in each quarter-session after the fading sequence prior to reaching criterion. A quarter-session consisted of five S- stimuli presented in random sequence with S+ stimuli. The total number of S- responses that each subject made before reaching criterion is given in the right-hand column of Table 3. The data clearly indicate that the fading procedure employed was effective in establishing and maintaining the vertical-horizontal line discrimination with little or no S- responding.

Insert Table 3 about here

Constant-delay

When the course of extinction for each subject trained with the constant-delay procedure was plotted according to the number of S- responses that occurred in successive quarter-sessions a pattern of S- responding emerged which was the same for all of the subjects trained with this procedure. Figures 1, 2, and 3 show this typical pattern. The greatest number of S- responses occurred in the first quarter of the first session. On

Insert Figures 1, 2, and 3 about here

a given day a greater number of S- responses usually occurred in the first and second quarters of the session; few, and often no S- responses occurred in the third and fourth quarters of that session. On the following day, S- responses would occur again in the first and/or second quarter of the session. The number of S- responses in the first or second quarter was usually less than the number of S- responses which had occurred on the previous day in the same quarter session. The general pattern of the extinction curves indicates that there was extinction of S- responses within sessions and spontaneous recovery between sessions.

Constant-no-delay

When the course of extinction for each subject trained with the constant-no-delay procedure was plotted according to the number of S- responses that occurred in successive quarter-sessions, a pattern of S- responding emerged which was the same for all subjects. Figures 4, 5, 6, and 7 show this pattern. The maximum number of S- responses fell in some quarter after the first quarter session. For some subjects this peak quarter session fell

Insert Figures 4, 5, 6, and 7 about here

on the first day and for other subjects the peak quarter fell in some session after the first day. In quarter-sessions before the peak quarter session, S- responses increased in successive quarter-sessions. After the peak quarter, S- responses decreased in successive quarter-sessions. For two subjects, Tim and Kirk (shown in Figure 7), S- responses had not extinguished after 16 sessions, at which time training was terminated. The increase in S- responding before it began to decrease suggested that S- responses were being reinforced in some way. It seems likely that the stimulus change from a lighted screen to a dark screen immediately following an S- response was acting as a reinforcer. The data also indicate that if stimulus change was acting as a reinforcer, it lost its property as a reinforcer, since S- responding did decline.

Constant-no-delay Changed to Constant-delay

Four subjects who began training with the constant-no-delay procedure showed little evidence of learning after five days and on the sixth day they were switched to the constant-delay procedure. After the change in procedure, two of these subjects acquired the discrimination and the two others had not reached criterion after 16 sessions, at which time training was terminated. The total number of S- responses that each subject made during training is given in Table 2.

The course of S- responding in each training session for each subject is shown in Figures 8 and 9. The solid line between Sessions 5 and 6 indicates the change in procedure. Figures 8 and 9 show that S- responding was being maintained at a relatively stable rate or it was increasing in the first five sessions of training when the constant-no-delay procedure was in effect. When the delay procedure was instituted in Session 6, there was a

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Insert Figures 8 and 9 about here

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marked drop in the number of S- responses that occurred. This immediate drop can be attributed to the change in procedure, since the rate of S- responding had been fairly stable before the delay procedure was introduced. Although Figures 8 and 9 are not plotted by quarter sessions, the maximum number of S- responses occurred in the first quarter-session after the change to the delay

procedure. The data obtained with this change in procedure give further support to the explanation that S- responses were being reinforced by stimulus change in the constant-no-delay procedure. S- responses must have been reinforced during the first five sessions to have been maintained at such a high rate. As soon as the delay procedure was instituted, and an S- response was no longer followed by a stimulus change, S- responses began to extinguish.

Auxiliary Effects of Extinction

In order to examine the byproducts of extinction, comparisons were made between two groups, the fading group which acquired the discrimination with few or no extinction trials and the constant-delay group which acquired the discrimination with extinction. The data of the subjects trained with the constant-no-delay procedure were treated separately, since "S-" responses in this procedure did not seem to constitute extinction trials.

Effect of S- Responding

Intertrial responding. No intertrial responses occurred for any subject until after S- responses had occurred. When all 18 subjects in the two groups were rank ordered in terms of the number of S- and intertrial responses that they made during acquisition, there was a correlation of .90 ($p < .001$). Subjects trained with the fading procedures made few intertrial responses and subjects trained with the constant-delay procedure made many intertrial responses. When the data were analyzed in terms of the number of intertrial responses that followed correct and incorrect responses it was found that 84% of the total number of intertrial responses for all subjects followed S- responses. The other 16% followed a correct response, which was either a response to S+ or no response to S-. These results indicate that when little or no extinction occurred during discrimination learning, the reinforced response was under precise stimulus control. It can also be concluded from this evidence that one of the byproducts of extinction was the occurrence of irrelevant intertrial behavior.

Postcriterion performance. For the 18 subjects a rank difference correlation of .79 ($p < .01$) was obtained between the total number of S- responses

that each subject made during acquisition and the two immediate postcriterion sessions. Retention measures were obtained for six subjects, three from each of the two groups. The rank difference correlation for these subjects between S- responses during acquisition and retention testing two weeks after the final postcriterion session was .82 ($p < .05$). It can be concluded from this evidence that when S- responses have been extinguished in discrimination learning, it is likely that there will be spontaneous recovery of the extinguished response. When S- responses have not occurred in original learning, and hence, have not been extinguished they are not likely to occur in postcriterion performance.

Discrimination reversal learning. The purpose of the reversal task was to assess the inhibitory properties of a stimulus that had been associated with extinction. It had been hypothesized that those subjects who had acquired the original discrimination with extinction would have inhibition associated to the old S- (new S+), and those subjects who had not undergone extinction would have less inhibition to the same stimulus. Response latency proved to be too variable a measure and no quantitative evaluation of the amount of inhibition associated to the new S+ could be made. However, two qualitative aspects of the subject's behavior in reversal learning were noteworthy. Table 4 shows those subjects who responded to the first S+ in reversal learning and those subjects who had to be given a free M&M before they responded to the new S+. In the immediate reversal group, subjects originally trained with fading procedures responded to the new S+. This suggested that these subjects had little inhibition associated to the stimulus. Those subjects originally trained with the constant-delay procedure

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Insert Table 4 about here

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did not respond to the first new S+ before being given a free M&M, suggesting that inhibition was present. In the delayed reversal group, two of the three subjects originally trained with the constant-delay procedure responded to the first new S+. This might be interpreted to mean that inhibition had dissipated over the two weeks and that there was spontaneous recovery of the

extinguished response. However, there is no apparent explanation for the fact that the subjects originally trained with the fading procedures did not respond to the new S+ in the delayed reversal task.

The right hand column of Table 4 indicates those subjects who completed reversal training and those who stopped coming to the laboratory before they reached criterion. The five subjects who would not continue training had all originally been trained with the constant-delay procedure. All subjects originally trained with the fading procedures completed reversal training. Subjects in the fading group were undergoing extinction for the first time and subjects in the constant-delay procedure were undergoing extinction for the second time. The data suggest that continued experience with extinction procedures may cause the experimental situation to become aversive.

Effects of "S-" Responding: A Reinterpretation

Since responses to the horizontal line, originally designated as S-, were apparently being reinforced in the constant-no-delay procedure, this stimulus can no longer be properly referred to as S-. S- is used to indicate a stimulus, in the presence of which there is no reinforcement (Keller & Schoenfeld, 1950, p. 118). Therefore the horizontal line used in the constant-no-delay procedure will be referred to as "S-."

Intertrial responding. A rank difference correlation of .72 ($p < .05$) was obtained between "S-" and intertrial responding for the nine subjects trained with the constant-no-delay procedure. Of the intertrial responses, 56% followed "S-" responses and 44% followed either an S+ response or no response to "S-." Since the same response was reinforced in the presence of two different stimuli, both S+ and "S-," and intertrial responses occurred with approximately equal frequency following S+ and "S-" responses, it is possible that intertrial responses were the result of stimulus generalization in the constant-no-delay procedure.

Postcriterion performance. For the seven subjects given the two postcriterion sessions (two subjects did not reach criterion), there was a rank difference correlation of .74 ($p < .05$) between the number of "S-" responses

during acquisition and the postcriterion sessions. This recurrence of "S-" responses following the criterion session may indicate that stimulus change had regained its power as a reinforcer after a period of time.

Discrimination reversal learning. Since "S-" responses in original learning had been reinforced, there was no basis for postulating that there was any inhibition associated to the new S+. Table 5 indicates that all subjects in the constant-no-delay group responded to the first new S+, apparently because it had been previously associated with reinforcement. Table 5 also indicates that all subjects continued training until they reached criterion. It is possible that subjects in this group were willing to complete the task because they had no prior history of extinction.

Insert Table 5 about here

Discussion

Stimulus Factors Influencing S- Responding

In this study it was demonstrated that techniques similar to those used by Terrace (1963) also controlled the occurrence of S- responses when children learned a discrimination (by the successive method) between a vertical and a horizontal line. A question raised by these findings is: why does the fading procedure control the occurrence of S- responses? Terrace (1963) postulated that the reason pigeons did not respond to the S- when fading procedures were employed was that they had been adventitiously reinforced for not responding to S- by the onset of S+. In the present study the intertrial interval was gradually lengthened during the early trials and the response of not responding to the dark screen was reinforced by the onset of S+. When the first S- in the fading sequence came on the screen it was dark and 0.5 seconds in duration; it looked similar to the dark screen during the intertrial interval. The subjects generalized to not responding to the initial S-, since they had already learned not to respond to the dark screen. In the first phase of fading, S- became progressively

brighter, and the stimulus remained constant at 0.5 seconds in duration. The behavior of not responding in Phase I, as S- became brighter, was probably maintained because of the brevity of S-, which made a response to it almost impossible. At the beginning of Phase II, S- was 0.5 seconds in duration and dark; as brightness and time increased, S- responding still did not occur. From the data it was not possible to determine whether brightness or time or both were controlling the occurrence of S- responses or whether different dimensions were controlling the occurrence of S- responses in different subjects. Brightness has been an effective fading dimension in several discrimination training procedures (Moore & Goldiamond, 1964; Sidman & Stoddard, 1967; Terrace, 1963, 1964). However, the critical properties of a stimulus dimension which makes it effective for controlling responding to a negative stimulus have not been determined.

Response Contingencies Influencing S- Responding

The results of this study suggest that an event following an S- response, with the exception of the continued presence of S-, may adventitiously reinforce the response. When the delay contingency was in effect, S- responses decreased progressively in successive sessions indicating that they were not being reinforced when they were followed by a delay in the offset of S-. It is probable that variations in the delay of the offset of S- (following a response to it) would influence the course of extinction. Long periods of delay might, as Blough (1966) has suggested, prolong a period of nonreinforcement to the extent that it may be punishing.

When a response to "S-" was not followed by a delay, "S-" responding increased in frequency. The increase in frequency of "S-" responses in the beginning of training can be interpreted to mean that the response-contingent light termination (the onset of the intertrial interval following an S- response) acted as a reinforcer for all subjects. Antonitis and Barnes (1961) found that lever pressing increased in a group operant procedure with kindergarten children when it was followed by light termination. Similar results have been obtained with rats (Leaton, Symmes and Barry, 1963; and

Roberts, Marx, and Collier, 1958). These results support the sensory reinforcement hypothesis which postulates that response-contingent stimulation in many modalities is reinforcing (Kish, 1966).

The wide range in the total number of "S-" responses that occurred for subjects trained with the constant-no-delay procedure (see Table 2) suggests that the power of light termination as a reinforcer varied considerably from subject to subject. The fact that two subjects were still responding to "S-" after 16 sessions indicates that in these two cases stimulus change was an effective reinforcer. However, with continued training, "S-" responses decreased for all subjects in the constant-no-delay group indicating that light termination was no longer acting as a reinforcer. Studies which have used light onset (Kish and Baron, 1962; and Roberts, Marx and Collier, 1958) and other sensory reinforcers have also found that prolonged exposure to a sensory reinforcer leads to a weakening of its reinforcing effects; with lack of exposure, the stimulus change recovers its reinforcing property (Kish, 1966).

S- Responding and "S-" Responding

Similar terminal behavior--differential responding to vertical and horizontal lines--was observed for the subjects trained with the constant-delay and constant-no-delay procedures. A similar degree of stimulus control, as indicated by intertrial responses, the absence of S- or "S-" responses in criterion performance, and the recurrence of S- or "S-" responses in postcriterion performance, was observed for the subjects trained with both procedures. However, on the basis of the results of this study, it can be postulated that this similar behavior was the result of different underlying processes: extinction in the constant-delay situation, and satiation in the constant-no-delay situation. In the constant-delay procedure, the absence of S- responses may have been due to inhibition which was built up to a stimulus that was associated with non-reinforcement as the result of extinction. The recurrence of S- responses (spontaneous recovery) was due to the dissipation of inhibition associated with that stimulus. For those subjects trained with the constant-no-delay procedure, the absence of

"S-" responses was due to satiation on the reinforcing stimulus. The recurrence of "S-" responses was due to a recovery from the satiating effects of a sensory reinforcer. One method of testing this conjecture is to examine the generalization gradients surrounding S-. If the S- and "S-" stimuli have different properties in these two cases, the shape of the gradients should differ. The generalization gradients for those subjects who are reinforced for "S-" responses should be a typical generalization gradient, in which the peak number of responses occur at "S-" and responding decreases as the stimulus varies along the relevant dimension. The generalization gradient for those subjects who are not reinforced for S- responses should be an inverted U. That is, few responses should occur at S-, and as the stimulus departs from S-, responses should increase, since S- is controlling the tendency not to respond. Carrying out this experiment would require that S+ and S- ("S-") be on different continua so that responding to S- ("S-") is not confounded with the excitatory tendency surrounding S+ (Jenkins, 1965; Terrace, 1966a). Such a study would facilitate an analysis of the processes underlying discrimination learning when different training procedures are used to establish the discrimination.

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Footnotes

[1]This article is based upon a dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy from the University of Pittsburgh. Project support was provided by the Personnel and Training Branch of the Office of Naval Research under contract Nonr-624(18), with additional support from the Office of Education, U. S. Department of Health, Education and Welfare. Grateful acknowledgment is given to Mr. Nicholas Kostuik of Frick School, Sister M. Laurencia of Mt. Mercy School, and Dr. Harry Sartain of Falk School for their cooperation in carrying out this study. The authors would also like to thank Mrs. Merryl Samuels for her assistance in many phases of this research.

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TABLE 1

Brightness and Duration Values of S- during the Fading Sequence

Phase I	Duration (seconds)	Brightness (foot candles[a])
Stage 1		
S-	0.5	8.33[b]
S-	0.5	9.00
S-	0.5	10.33
S-	0.5	11.00
S-	0.5	13.00
Stage 2		
S-	0.5	13.66
S-	0.5	14.66
S-	0.5	15.33
S-	0.5	16.50
S-	0.5	17.25
Phase II		
Stage 3		
S-	1.0	8.33
S-	1.5	9.00
S-	2.0	10.33
S-	2.5	11.00
S-	3.0	13.00
Stage 4		
S-	3.5	13.66
S-	4.0	14.66
S-	4.5	15.33
S-	5.0	16.50
Stage 5		
S-	5.0	17.25[c]
S-	5.0	17.25
S-	5.0	17.25
S-	5.0	17.25

[a]The values given are an approximate measure of incident light.

[b]Very dark.

[c]Full brightness.

TABLE 2

Number of S- Responses during the Course of Acquisition for the Different Training Procedures

Training Procedure	Number of S- Responses
Fading	
Alexandra	0
Mary Beth	0
Artemise	0
Michael D.	2
Greg	2
Connie	2
Frank	3
Jackie	8
Mark	8
	25 - Total
Constant-delay	
Philip	22
Jessica	22
Laurie	24
Helen	25
Angela de P.	27
Tony	37
Angela G..	60
Eric	65
Ernie	79
	361 - Total
Constant-no-delay	
Mary Jane	51
Michael S.	53
Kim	58
Susan	64
Charles	89
Ann	104
Jonathan	274
Kirk[a]	512[a]
Tim[a]	1147[a]
	2352 - Total
Constant-no-delay-- Constant-delay	
Janet	427
Paul	514
Michael O.[a]	547[a]
David[a]	642[a]

TABLE 3

The Occurrence of S- Responses for Subjects Trained with the Fading Procedure

	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	TOTAL
	PHASES I II						
	STAGES 1 2 3 4 5	QUARTERS 1 2 3 4	QUARTERS 1 2 3 4	QUARTERS 1 2 3 4	QUARTERS 1 2 3 4	QUARTERS 1 2 3 4	
Mark	0 0 0 2 0	1 0 0 0	0 1 0 0	0 0 1 0	3 0 0 0	0 0 0 0	8
Jackie	0 0 1 0 0	2 0 0 0	2 1 0 0	1 0 0 0	0 1 0 0	0 0 0 0	8
Frank	1 1 0 1 0	0 0 0 0					3
Greg	0 0 0 0 0	2 0 0 0	0 0 0 0				2
Michael D.	0 1 1 0 0	0 0 0 0					2
Connie	0 0 0 1 0	1 0 0 0	0 0 0 0				2
Artemise	0 0 0 0 0	0 0 0 0					0
Alexandra	0 0 0 0 0	0 0 0 0					0
Mary Beth	0 0 0 0 0	0 0 0 0					0

TABLE 4

Responses during Original and Reversal Learning
for Subjects in the Fading and Constant-delay Groups

	Original Training	Subject	S- Responses in Original Learning	Trial 1 Response to S+ in Reversal Learning	Completion of Training in Reversal Learning
	F	Alexandra	0	R[a]	C[c]
	F	Michael D.	2	R	C
Immediate	F	Frank	3	R	C
Reversal	CD	Philip	22	F[b]	$\overline{C}$[d]
	CD	Angela de P.	27	F	$\overline{C}$
	CD	Ernie	79	F	$\overline{C}$
	F	Mary Beth	0	F	C
	F	Greg	2	F	C
Delayed	F	Mark	8	F	C
Reversal	CD	Jessica	22	R	C
	CD	Tony	37	F	$\overline{C}$
	CD	Eric	65	R	$\overline{C}$

[a] R = response to the first new S+.

[b] F = free M&M dispensed.

[c] C = completed reversal training.

[d] $\overline{C}$ = did not complete reversal training.

TABLE 5

Responses during Original and Reversal Learning

	Original Training	Subject	S- Responses in Original Learning	Trial 1 Response to S+ in Reversal Learning	Completion of Training in Reversal = Learning
Immediate Reversal	CND	Kim	58	R[a]	C[b]
	CND	Charles	89	R	C
	CND	Ann	104	R	C
Delayed Reversal	CND	Mary Jane	51	R	C
	CND	Susan	64	R	C
	CND	Jonathan	274	R	C

[a] R = response to the first new S+.

[b] C = completed reversal training.

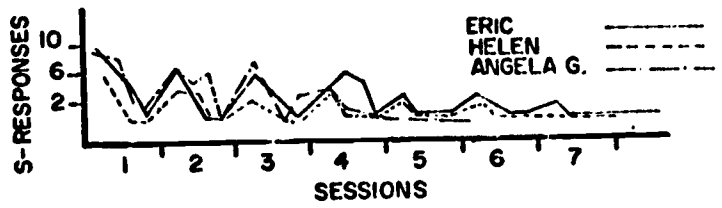

Figure 1
Constant-delay: S- responses in acquisition.

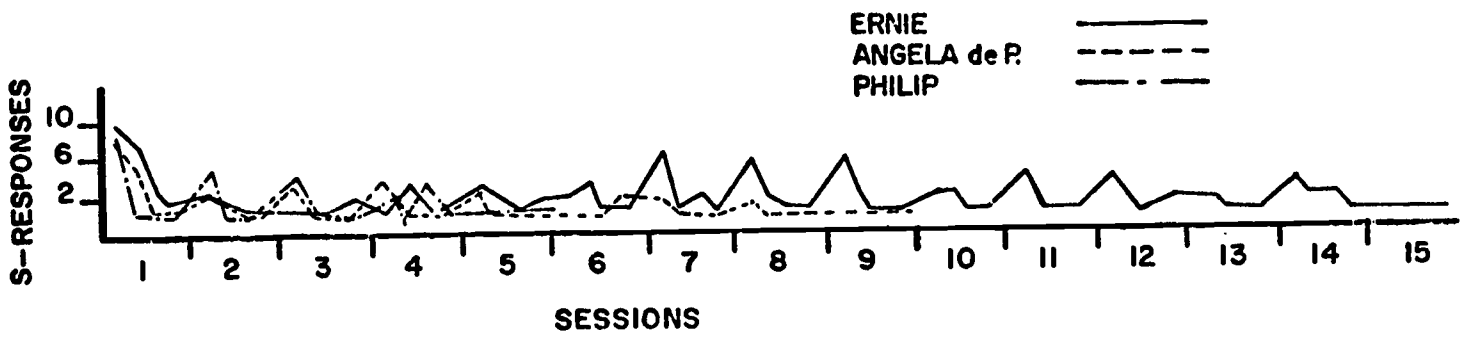

Figure 2
Constant-delay: S- responses in acquisition.

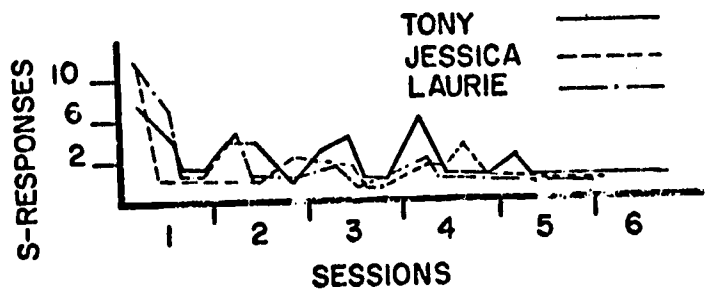

Figure 3
Constant-delay: S- responses in acquisition.

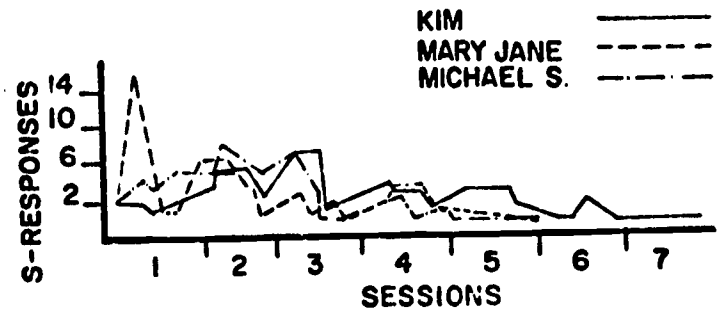

Figure 4
Constant-no-delay: S- responses in acquisition.

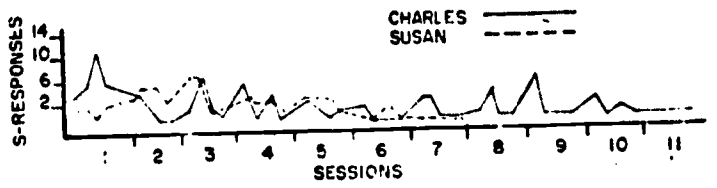

Figure 5
Constant-no-delay: S- responses in acquisition.

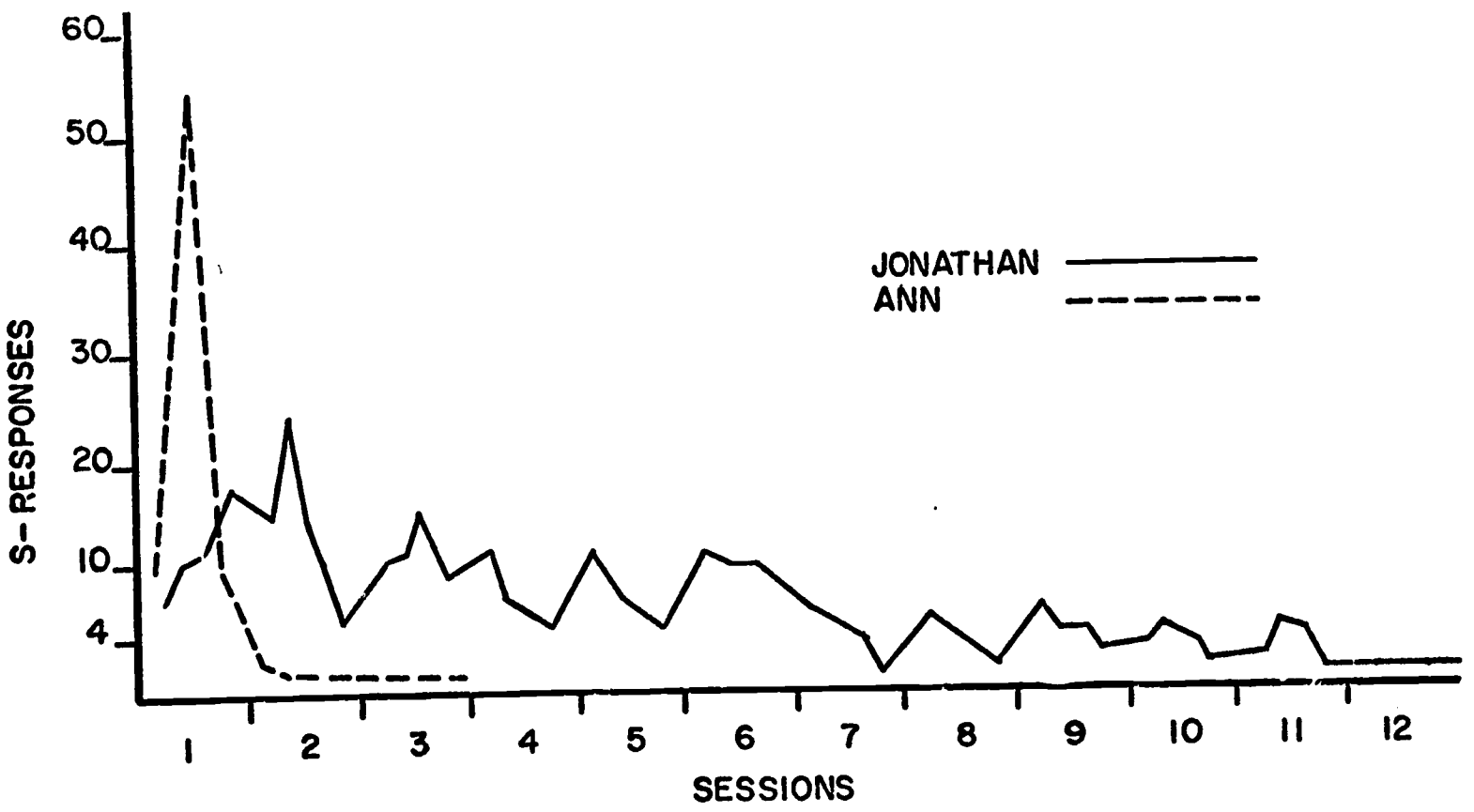

Figure 6
Constant-no-delay: S- responses in acquisition.

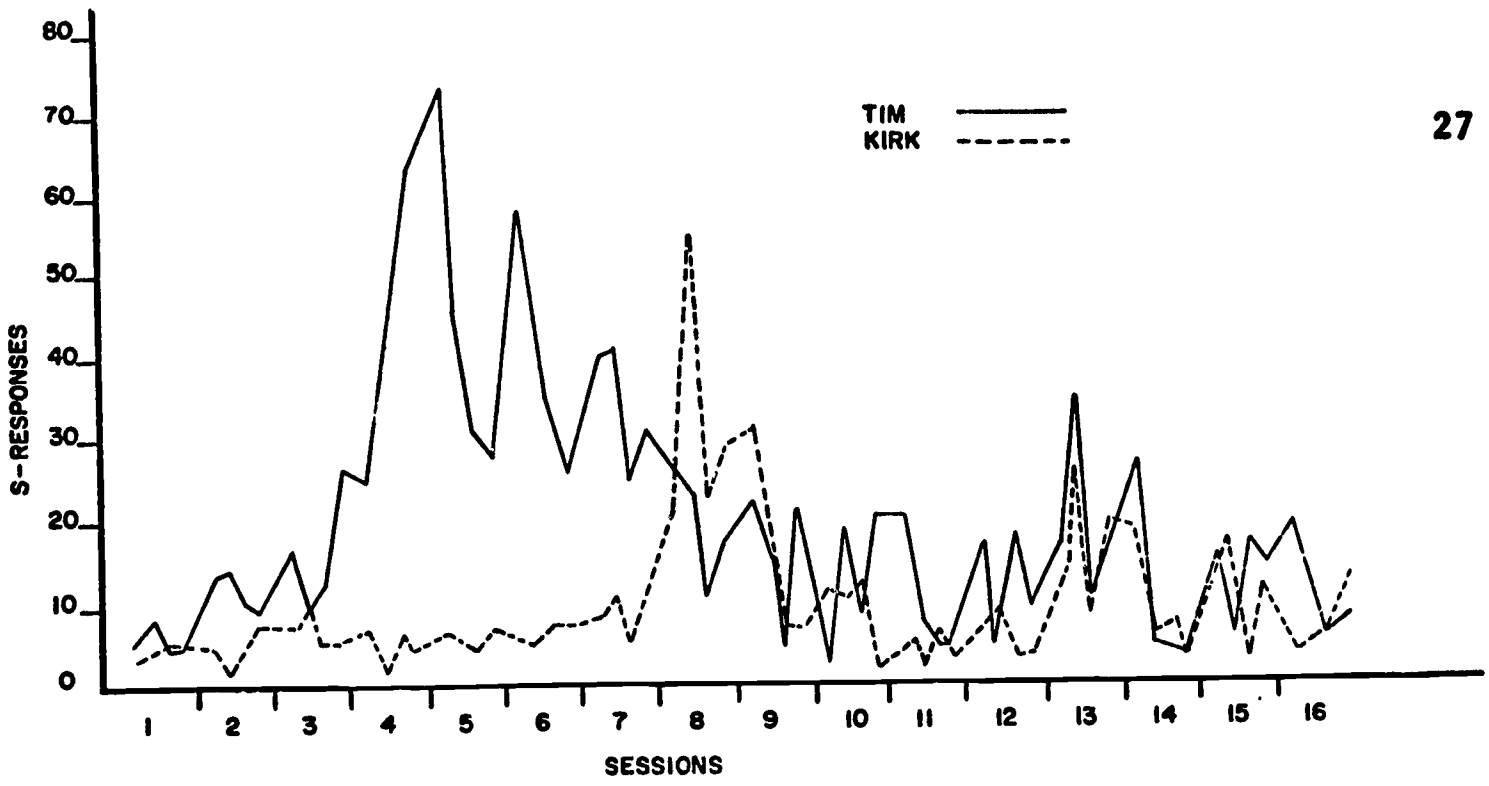

Figure 7
Constant-no-delay: S- responses in acquisition.

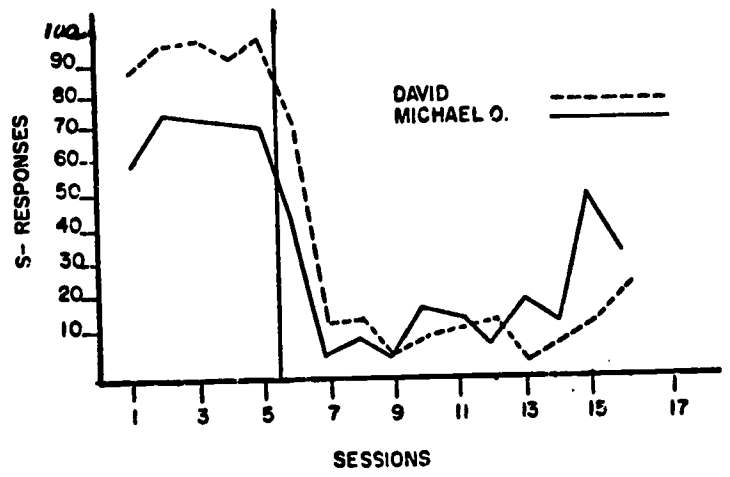

Figure 8
Constant-no-delay changed to constant-delay: S- responses in acquisition.

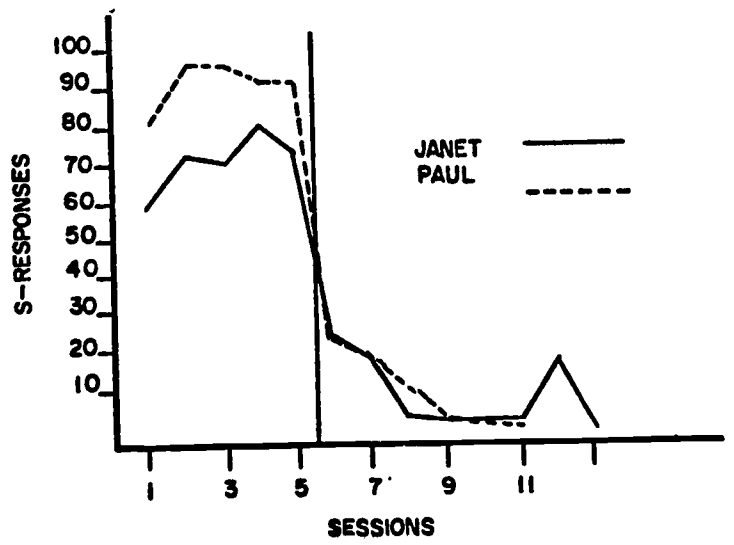

Figure 9
Constant-no-delay changed to constant-delay: S- responses in acquisition

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4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*
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5. AUTHOR(S) *(Last name, first name, initial)*
Cohen, Miriam, Glaser, Robert, and Holland, James G.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
February, 1968	27	17

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Nonr-624(18)	Working Paper 18
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The purpose of the study was to assess the effects of two methods of stimulus presentation (fading and constant) and two response contingencies (delay and no-delay) on the course of discrimination learning; and to examine the effects of response histories on various aspects of discrimination performance. In the fading procedure S- was gradually faded along the dimensions of brightness and time, and in the constant procedure S- maintained a constant value throughout training. Subjects trained with the constant procedure made significantly more S- responses in the course of acquisition than subjects trained with the fading procedure. In the constant-delay procedure, S- responses were followed by a delay in the offset of S-. In the constant-no-delay procedure S- responses were followed by an intertrial interval. Subjects trained with the constant-no-delay procedure made significantly more responses to S- than subjects trained with the constant-delay procedure.

The amount of extinction which occurred during learning was highly correlated with intertrial responding and the stability of the learned discrimination. Discrimination reversal learning was also a function of original learning history. The results were discussed in terms of the differential processes which underlie discriminative performance when different training procedures are used.

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