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Transfer of Stimulus Control By Temporal Fading

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TRANSFER OF STIMULUS CONTROL BY TEMPORAL FADING

by

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ABSTRACT

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The present study was designed to analyze the transfer of stimulus control in temporal fading procedures. Several aspects of temporal fading procedures were manipulated including sources of inhibitory stimulus control, delays of reinforcement, and rates of increase in the temporal parameter of a fading procedure. In Experiment I, previous research producing transfer of stimulus control in a temporal fading procedure was directly replicated and controls were implemented for the operation of inhibition. The results showed that inhibitory stimulus control is not necessary in order to produce a transfer as participants with neutral stimulus backgrounds also transferred from one dimension to another without errors. However, positive stimulus backgrounds in the fading procedure prohibited the participants from achieving an errorless transfer of discrimination learning. In Experiment II, a fixed trial duration was employed with a constant and equal delay of reinforcement for both new and original stimulus dimensions. In this condition, participants did not transfer from one dimension to another with up to 30-second delays. Control participants were yoked to participants exposed to delayed and fading procedures to examine response latencies under delayed reinforcement for a simultaneous discrimination. There were no discernible response patterns under this condition except that participants continued to emit relatively short response latencies with a 40-second delay of reinforcement. In Experiment III, the effects of different steps of temporal fading on transfer were examined. The results showed that as the step of delay increased (10 sec. per trial), subjects transferred earlier in the fading series. Also, subjects with extremely low steps of delay (.1 sec. per trial) tended to remain with the original stimulus dimension. Experiments I through III demonstrated the necessity of either inhibitory or neutral stimulus backgrounds, differential delays of reinforcement correlated with each stimulus dimension, and relatively rapid increments in delay of the original stimulus dimension to obtain transfers of stimulus control in temporal fading procedures. When excitatory stimulus backgrounds were employed, or no differential delay of reinforcement was present, or the delay of the original stimulus dimension increased slowly, errorless transfers were not obtained.

Overall, the results indicate that temporal fading procedures are a reliable, although complexly controlled, means of obtaining transfer between two stimulus dimensions.

(94 pages)

CHAPTER I

Introduction

For years, the ability of an organism to discriminate between two stimuli has been the object of research by psychologists. The usual behavioral paradigm of discrimination entails one response class and two stimulus conditions. The response is reinforced in one of the stimulus conditions and extinguished in the other. The result of this process is that the organism comes to respond only in the presence of the reinforced stimulus and not in the presence of the unreinforced stimulus (Millenson, 1967; Keller & Schoenfeld, 1950).

Typically, this technique of teaching a discrimination requires many training sessions and produces a great number of errors, i.e., responses to the unreinforced stimulus. Traditional discrimination procedures are also associated with emotional behaviors occurring in the presence of the unreinforced stimulus. The unreinforced stimulus condition apparently possesses aversive properties which disturb the subject and influence his behavior.

In 1963, H.S. Terrace developed a training procedure which taught discrimination to pigeons without responses occurring in the presence of the unreinforced stimulus (S-). This performance was accomplished by having the S- differ in several ways from the reinforced stimulus (S+). Differences of schedule component duration, (i.e. S+ and S-), stimulus wavelength, and brightness were gradually reduced until the only difference was wavelength.

Terrace based his technique on earlier procedures. Skinner (1938, pp. 203-206) demonstrated that if discrimination training began immediately after a bar-press response was shaped, a brightness discrimination could be taught with virtually no responses to S-. Schlosberg and Solomon (1943) found rats able to discriminate between two slightly different gray stimulus cards if the stimuli were gradually changed from black and white to gray.

Transferring Stimulus Control

Terrace also demonstrated that stimulus control of responding could be transferred from one stimulus dimension to another by making small progressive physical changes in stimulus conditions. Terrace (1963b) successfully transferred stimulus control from a red-green discrimination to a discrimination between vertical and horizontal lines by superimposing the lines on the red-green backgrounds, and then progressively diminishing the intensity of the red and green stimuli. Pigeons acquired the line discrimination with few errors and no errors occurred during subsequent testing on the red-green discrimination.

A second manner of transferring stimulus control from one dimension to another is to make small and progressive *temporal* changes in stimulus conditions. Temporal changes were an aspect of Terrace's (1963a) work on errorless discrimination acquisition such that small and gradual increments in the S- component duration were made, but Terrace's work did not measure the moment of transfer. In fact, Terrace's procedure prevents measuring the moment of transfer since probing with new stimuli before the subject has transferred may produce an error which in turn would reduce the quality of the original discrimination. However, Touchette (1971) developed a temporal procedure to measure the transfer of stimulus control. In Touchette's procedure the new stimulus dimension was presented simultaneously with the onset of the trial and the subsequent addition of the established stimulus dimension was determined by a temporal parameter, which progressively increased with correct responses.

While Touchette's procedure was designed to ascertain the moment of transfer in a simultaneous discrimination task, it has been employed to produce transfer of stimulus control in a successive discrimination task, i.e., motor to verbal stimuli in retarded boys (Striefel, Bryan, & Akins, 1974) and is implicit in other applied procedures, i.e., graduated guidance (Foxx & Azrin, 1973). Applications of this technique are understandably few due to its recent development.

The purpose of the current research was to analyze the transfer of stimulus control in temporal fading procedures to further determine the variables which are in control. Several aspects of the temporal fading procedure were manipulated including possible sources of inhibitory stimulus control, delay of reinforcement, and step of increase in the temporal parameters of the fading procedure. These parameters of temporal fading were not examined previously and yielded further information on the nature of stimulus control and its transfer.

CHAPTER II

Review of Literature

The review of literature covers four areas within the experimental analysis of behavior; first, the major studies on errorless discrimination learning in both animals and human beings; second, the nature of a stimulus control shift; third, the topic of choice and relative delay of reinforcement in concurrent situations; and fourth, inhibitory stimulus control. It is neither possible nor desirable to review all the research completed in each of these areas, consequently the major and related studies are examined with an attempt to integrate their findings with the current research.

Errorless Discrimination Procedures

H.S. Terrace has been most associated with the procedure of errorless discrimination formation and the subsequent by-product of the errorless transfer of discriminations. Terrace (1963a) demonstrated that a discrimination could be taught without the subjects emitting responses to the stimulus correlated with nonreinforcement (S-). The critical aspect of this study was the time and manner of the introduction of S-. In Terrace's first experiment, S- was introduced early in the first conditioning session or for other subjects after a number of weeks of training in the presence of S+. These conditions were termed early and late respectively. Also under each of these conditions, S- was introduced in one of two ways. Either S- was initially equivalent to S+ in brightness and duration and different only with respect to wavelength, or S- had lower brightness and shorter duration values which were gradually increased till the brightness and duration of S+ was reached. These two conditions were called constant and progressive respectively. Combining these two sets of variables yielded four groups: early-progressive, early-constant, late-progressive, and late-constant introduction of S-.

The results showed that the pigeons of the early-progressive group learned the discrimination with virtually no errors and the pigeons exposed to the late-constant procedure emitted most errors; subjects in the early-constant and late-progressive procedures were located between the two extremes.

Terrace (1963b) further extended this work by achieving an errorless transfer of a discrimination across two dimensions. Initially subjects were taught a red-green discrimination without errors by a procedure similar to the early-progressive procedure in the first experiment. Subsequently, the pigeons were shifted to a vertical-horizontal discrimination by one of three procedures. The first was an abrupt shift from the red-green discrimination to the vertical-horizontal following the 15th red-green discrimination session. For two additional groups a vertical line and a horizontal line were superimposed on the red and green background respectively during sessions 11 through 15. For one superimposition group, the vertical and horizontal lines appeared without any color backgrounds from the start of the 16th session. However, for the superimposition and fading group, the S+ and S- background were slowly faded out during the course of the 16th session. The control group was trained only on the vertical-horizontal discrimination and all four groups were trained to a criteria of four successive sessions in which no responses to S- occurred. Once that criterion was met, the first 3 groups were each returned to the red-green discrimination for four sessions.

The pigeons that received superimpositions and fading training acquired the horizontal-vertical discrimination with no errors while the other three groups made many errors. Also upon return to the red-green discrimination, the birds of the superimposition and fading group, which acquired the vertical-horizontal discrimination without errors, performed errorlessly, while all others made errors.

Variations of Terrace's techniques have been widely used in both applied and basic research. Applications have been made to oral reading in nursery school children (Corey & Shamow, 1972) and retarded children (Dorry & Zeaman, 1973). Other applied uses of Terrace's techniques include the decrease of smoking behavior (Azrin & Powell, 1968) and the treatment of elective mutism (Wolbert, Nyman, Snow, & Owen, 1973).

Terrace's techniques have been used to teach form discriminations to retarded children (Sidman & Stoddard, 1967) to establish angular discriminations in normal children (Moore & Goldiamond, 1964), and to establish color discriminations in normal pre-school children (Powers, Cheney, & Agostino, 1970).

Moore and Goldiamond (1964) systematically replicated Terrace's (1963) procedures and established the generality of Terrace's results with pre-school children. The study applied fading procedures to a visual discrimination in a matching-to-sample procedure.

The pre-school children received two series: a full presentation and a fading series. During full presentations, the sample, an isosceles triangle with a particular spatial orientation was displayed briefly at full intensity. Next, the sample was turned off and three comparison windows were illuminated at full intensity. Each window contained an isosceles triangle, however, only one matched the spatial orientation of the sample exactly. The matching responses produced either a trinket or food while errors resulted in the same trial occurring again. If the child made two consecutive errors, the procedure regressed to a previous step. During the fading series, the two S- comparisons were presented at lower intensities than the S+ comparison. Children were exposed to either full intensity presentations or presentations of faded intensity in various sequences. The results indicated that when fading procedures were used, the discrimination was readily established, with few errors. Systematically initiating and dropping the fading procedures produced errors during the full presentation and almost no errors during the fading presentation.

Sidman and Stoddard (1967) compared the efficacy of a teaching program based on Terrace's techniques together with reinforcement to the same reinforcement techniques without errorless discrimination training. The objective of both programs was to teach retarded children to discriminate between circles and ellipses. The outer keys of a 9-key matrix were illuminated with a variety of ellipses and a circle. The correct choice was always the key on which the circle was projected.

The errorless program for teaching the circle-ellipse discrimination had two stages. The first, background fading, consisted of the 9-key display with a circle on one bright key while the remaining were dark keys. A series of slides increased the brightness of the incorrect keys until discriminative control was "a key with a form vs. a key with no form". Next, ellipses were gradually made brighter on the incorrect keys until the ellipses and circle were equally bright.

The children of the control group were first exposed to a program which required discrimination between circles and ellipses without any stimulus fading. Children who failed to learn this discrimination were exposed to a form vs. no form program. If run successfully, the circle versus ellipse program was again presented. If not, the children were given the ellipse-fading segment of the program or on failure, were given the background-fading program.

The results demonstrated that the errorless training techniques could teach the children the final objective much more effectively than procedures which generate errors and depend only on reinforcement and extinction processes.

Powers, Cheney, and Agostino (1970) extended Terrace's techniques to establish color discrimination in normal pre-school children. Both traditional techniques and Terrace's techniques were employed to teach the final discrimination which errorless subjects acquired with very few errors relative to the children in the traditional group. The study extended Terrace's techniques to new sensory modalities, vision and audition, instead of the usual vision only modality and demonstrated the advantage of sound as an S- stimulus.

The Nature of a Stimulus Control Transfer

Since the stimulus change in fading procedures is a continuous and gradual procedure, whether or not the transfer in control of behavior occurs in a similar fashion has been questioned. Schusterman (1967) explored the possibility of the shift being sudden or gradual and whether it occurred early or late in fading. California sea lions were presented with a fading program used to effect nine errorless reversals of a form discrimination. A series of probe trials inserted at several points in the program revealed that subjects differed in the point at which they transferred from a size cue to the reversed forms. Schusterman concluded that attention was primarily focused on the original dimension and then gradually shifted to the new stimulus dimension since he summarized data of individual subjects across many trials, producing a smooth curve.

On the other hand, Schusterman's analysis agrees with the predictions of continuity theories of discrimination learning (Mackintosh, 1965), and it seems likely that the subject's attending behavior would closely parallel the environment's changes. Consequently, the different analyses exist. First, it appears that subjects may attend to both stimulus dimensions and gradually transfer the basis of their response to the new dimension or second, perhaps, the subject attends in a dichotomous fashion, i.e., to one dimension or the other, but not both. In the latter, the change in responding from the old to the new dimension is rapid and may occur within a single trial.

Touchette (1971) offered evidence that the actual transfer in control, at least in retarded subjects, was a discrete and rapid change and that the subject did not attend to both dimensions for possibly more than one trial. Touchette measured the moment of transfer by fading out an established stimulus dimension on a temporal basis. By using a temporal fading procedure, Touchette was able to separate the two stimulus dimensions and ascertain to which dimension the subject attended. Severely retarded adolescent boys were taught to discriminate between a red and a simultaneously present white key. The red vs. white discrimination served as a stimulus control baseline. The fading procedure consisted of the superimposition of letter E with legs pointing down (S+) and up (S-) on the red and white stimuli. The positive stimulus was on the red and the negative on the white. The correct response on the first trial affected the next trial by delaying the onset of the red stimulus an additional 0.5 seconds. Consequently on the second trial, both figures were projected on white backgrounds and after 0.5 seconds delay, red was added to the correct key. Following a correct response on that trial, red was added after 1 second, etc. An incorrect response terminated the trial and reduced the stimulus delay on the following trial by 0.5 seconds. However, the number of errors that occurred was insignificant. Touchette followed this basic transfer procedure with a series of discrimination reversals, each accomplished by reintroducing the red stimulus and delaying its onset as before. However, the line stimulus previously associated with S- was now associated with S+ and vice versa.

The results showed that as the temporal delay of the onset of the red stimulus was increased, each subject lengthened his response latencies to await the onset of S+. However, for each subject there came a point when the subject did not wait for the onset of the original S+, but instead responded to the new stimulus dimension. Subsequent response latencies were then generally shorter than previously and the subject discriminated solely on the basis of the new stimulus dimension. A series of discrimination reversals replicated this performance in each of three boys.

Touchette's data indicated that the point of transfer from one stimulus dimension could vary greatly between subjects and even within subjects from reversal to reversal. However, no matter when the point of transfer, the data demonstrated that the transfer was abrupt.

In an applied study, Striefel, Bryan, and Aikins (1974) transferred stimulus control from motor to verbal stimuli with a temporal fading procedure. When mentally retarded adolescents were under imitative control of behavior, a verbal instruction was presented before the behavior was modeled. Each correct response produced a longer delay between the verbal instruction and the modeling of the behavior. Temporal fading in the present study differed from Touchette (1971) in that the discrimination task was successive rather than simultaneous, but the procedure was effective and all subjects responded correctly to verbal instructions after training. Additionally, Striefel et al. (1974) extended Touchette's procedure to two sensory modalities (visual-auditory) and provided additional evidence that stimulus control transfer was a discrete process since a transfer of stimulus control generally occurred on the first trial where a temporal delay occurred between the verbal instruction and the modeling of the behavior.

Several researchers have proposed that stimulus control transfers occur in two stages. Most recently, Fields, Bruno, and Keller (1976) demonstrated that new stimuli acquire dimensional control in two sequential stages. First, the combined stimulus is faded out and the new element controls responding and second, the new stimulus alone controls responding. This analysis concurred with suggestions by Ray and Sidman (1970) regarding controlling stimulus-response relationships.

Fields, Bruno, and Keller (1976) demonstrated this type of transfer using pigeons. First, the subjects were exposed to a stimulus fading procedure where responding was transferred from red and black stimuli to lines of different orientation. Subsequent to superimposing one line on the red stimulus and the other line on the black stimulus, line intensity was increased and that of the red stimulus background was decreased. The control exerted by each element of the compound stimulus was assessed with probes consisting of red and line stimuli presented separately during the course of fading. The results showed that as the lines were faded in they did not acquire control of responding. But as the red was faded out, the lower intensity red stimulus in combination with the line stimulus controlled responding and subsequently the angular orientation of the lines controlled responding. Finally, probes of line stimuli determined the point at which lines alone maintained stimulus control. Fields, Bruno, and Keller concluded that new stimuli in a fading procedure acquire dimensional control in sequential stages and that the acquisition of stimulus control during fading procedures can be explained in terms of attenuation of stimulus blocking. In this sense, blocking means that previous discrimination training with one set of stimulus elements found in the compound stimuli reduces the control acquired by other elements.

Transfers of stimulus control also have been achieved without direct pairing of the stimulus dimensions. Subjects are taught to match one set of stimuli (A) to another set (B) and to match (B) to a third set (C) in a match-to-sample paradigm. Subsequently, the subjects are able to correctly match set (A) to set (C) without being taught that task. The emergence of this untaught match-to-sample performance has been labeled mediated transfer (Peters, 1935, pp. 20-21) and has been employed to teach oral reading in retarded children (Sidman, Cresson, & Willson-Morris, 1974; Sidman & Cresson, 1973) and reading comprehension (Sidman, Cresson, & Willson-Morris, 1974). As this technique varies greatly from the other techniques discussed, it is not examined further.

Relative Delay of Reinforcement

It is well established that stimulus fading produces a transfer of stimulus control but, as yet, there is no explanation why a transfer of stimulus control occurs or what controls the moment of transfer. Apparently, a stimulus control transfer in the physical fading procedure is not dictated by psychophysiological constraints, e.g., the original dimension being imperceptible. If that were the case, the organism would produce an acquisition pattern, i.e., would commit errors to the new stimulus dimension and there would be no errorless transfer in the physical fading procedure. In the temporal fading procedures as well, there is no physical constraint on transfer. In fact, the subject could remain with the original dimension indefinitely and continue to be reinforced. Consequently, the question remains as to why stimulus control does transfer.

The current research analyzes transfers of stimulus control, in part, in terms of the contingencies of reinforcement which exist in a temporal fading procedure. When a temporal fading procedure offers two alternate routes to reinforcement, the subject may base his response upon the relative delay of reinforcement engendered by each alternative. In concurrent response situations, Chung and Herrnstein (1967) have analyzed choice as a function of immediacy of reinforcement for two concurrent operants.

Chung and Herrnstein (1967) initially exposed pigeons to concurrent VI 1-minute schedules of reinforcement. After stable performance was obtained, delays of reinforcement were initiated for 8 seconds on one key (standard key) and for various durations ranging from 1 to 30 seconds on the remaining key (experimental key). When a response to be reinforced occurred, the experimental chamber darkened until the reinforcer was delivered. Exposure to various delays of reinforcement in an irregular order revealed that the relative frequency of responding on the key with variable delays was a function of the relative duration of the delay intervals on the standard and experimental keys. In other words, the relative frequency of responding on the experimental key matched the ratio of the duration of the delay for that key over the sum of the duration of the delays for both keys. The data showed that the pigeon preferred, i.e., responded more to, that key on which the relative immediacy of reinforcement (the reciprocal of delay) was greater.

Similarly, Rachlin and Green (1972) analyzed the relationship between choice and delay of reinforcement in a trials procedure. When pigeons were exposed to a choice between a small immediate reward and a large delayed reward, they invariably chose the small immediate reward. However, if a delay was imposed between the availability of both alternatives, the pigeon's choice depended upon the length of that delay.

Rachlin and Green's study is relevant to the current investigation in terms of the preference produced by a choice between a small immediate reward and a large delayed reward. In the temporal fading procedure, there is a greater certainty of reinforcement, due to past history, associated with the original stimulus dimension then there is with the new stimulus dimension. As the delay in the onset of the original stimulus dimension increases, the value of responding to the more uncertain alternative, the new stimulus dimension, may begin to exert control over choice. At some point in time the subject then responds to the new dimension rather than delay reinforcement until the onset of the original dimension. After this discriminated response has occurred and been reinforced, the subject almost invariably responds to the new stimulus dimension providing an immediate payoff (cf. Touchette, 1971).

A delay of reinforcement, i.e., from the trial onset to the response, occurs in the temporal fading procedure used by Touchette (1971) because there is an increasing delay between the availability of a reinforcer and the actual production of that reinforcer. The length of that delay is dependent upon the stimulus dimension to which the subject attends. If the subject waits for the original stimuli to appear, then the subject delays reinforcement longer from the onset of each successive trial. However, if he transfers his responding to the new stimuli, reinforcement is immediate for a response to the S+. Consequently, the procedure offers two alternatives to reinforcement, one immediate for responses to the new S+, and one increasingly delayed for responses to the original S+.

Several researchers have demonstrated relationships between choice and delay of reinforcement with children (Ebbesen & Mischel, 1970; Burns & Powers, 1975). Burns and Powers (1975) replicated Rachlin and Green's model in normal children. Two young boys were exposed to a choice situation where one alternative (left) led to a choice between a small immediate reward or a large delayed reward while the other alternative (right) led to the large delayed reward only. Once the left alternative had been selected, the immediate reward was chosen on many trials. However, as the time between the initial choice and the terminal choice was increased, preference for the left alternative increased and the children chose the immediate reward almost exclusively. Consequently, while it was apparent that preference could change as a function of time, the variables influencing choice were unclear.

Mischel and Ebbesen (1970) found that children delayed rewards an average of one minute when both immediate less-preferred rewards and delayed (15 minutes) but more-preferred rewards were available. Other experimental conditions revealed that the availability of the reward for attention was a critical variable in determining the amount of time elapsed before the immediate reward was chosen.

Favell and Favell (1972), in a match-to-sample procedure, demonstrated that choice in children could be controlled by conditioned positive reinforcement when reinforcement was immediate for either of two alternative responses. Such a conditioned reinforcer exists in the temporal fading procedure, i.e., the original S+. However, Touchette's (1971) data suggest that delay. of reinforcement was a more powerful variable as the delay of reinforcement increased.

Although the above investigators employed different subjects and procedures, their results indicate that a subject's response to one of two alternative sources of reinforcement can be controlled both by conditioned reinforcers and differential delays of reinforcement. On the basis of their research, it is expected a subject will choose an immediate reinforcer over a delayed reinforcer, even when the delayed reinforcer is larger (Rachlin & Green, 1972) or more preferred (Mischel & Ebbesen, 1970) than the immediate reinforcer.

Consequently, the differential delay of reinforcement between the two stimulus dimensions may account for a subject's transfer from one stimulus dimension to another in the temporal fading procedure. In temporal fading, the alternative sources of reinforcement (immediate vs. delayed) are perfectly correlated with the two different stimulus dimensions.

Inhibitory Stimulus Control

The fourth area of concern is inhibitory stimulus control. Touchette's (1971) procedure may contain inhibitory properties since, in the transfer procedure, the new stimulus display contains an S- element of the original display, i.e., the white background for the new line stimuli.

If the subjects in Touchette's procedure are partially under the control of the white background of the new stimulus display, a question arises as to what effect the S- of the original display being compounded with the new stimulus dimension (lines) has upon the subject's performance.

Terrace (1966), after reviewing considerable research on stimulus control both traditional and errorless, concluded that S- functions as an aversive or inhibitory stimulus when discrimination learning occurs with errors, but functions as a neutral stimulus following discrimination learning without errors. On the other hand, Karpicke and Hearst (1975) produced evidence which indicated that inhibition developed in a nonreinforced stimulus of an errorless discrimination and that a negative correlation between stimulus and reinforcer seemed to be the crucial factor in producing inhibitory stimulus control.

Pigeons were trained to discriminate between a positive stimulus (white key) and a negative stimulus (red or green key) with Terrace's fading procedures. Subsequent generalization tests at four varied wavelengths with intermittent reinforcement for key pecking yielded least responding at the value of the negative stimulus in the most "errorless" birds as well as in birds with errors.

In a similar investigation, Rilling, Caplan, Howard, and Brown (1975) investigated inhibitory stimulus control following discrimination learning with few errors using three different generalization procedures. Pigeons acquired a discrimination between a green stimulus and a vertical or horizontal line through differential auto-shaping on multiple schedules with gradually increasing stimulus durations. Subsequent generalization testing was along a line-tilt continuum. For one group, a resistance-to-reinforcement procedure in which all responses to all line-tilts were reinforced on a variable-interval schedule was employed. For a second group under similar procedures, the lines were superimposed on a green field that formerly served as the positive stimulus. The third group was tested in extinction with the combined stimuli. Remaining control groups had no discrimination training but were non-differentially reinforced for responding to green.

The results showed that both resistance-to-reinforcement groups produced inhibitory gradients around the negative stimulus, while the gradient for the extinction group was relatively flat. Consequently, the authors concluded that the S- of an errorless discrimination is an inhibitory stimulus.

As Touchette (1971) did not control for inhibition, it is possible that the inhibitory stimulus control of the display background is necessary to produce a transfer of stimulus control in a temporal fading procedure. On the other hand, the successful replication of Touchette's procedure by Striefel et al. (1974) without the inhibitory stimulus background suggests that the S- background may either 1) not be necessary, or 2) Striefel's procedure is an additional method of achieving transfer. Striefel's procedure differed from Touchette in that Striefel employed a successive discrimination task rather than a simultaneous discrimination, and verbal and visual stimuli rather than simple visual stimuli. Consequently, the verbal stimuli serving as the new stimulus dimension did not have any components of the original stimulus dimension, i.e., the trainer's motor behavior.

However, it is difficult to ascertain all the features of compound stimulus control that may have occurred in Striefel's successive discrimination procedure, for instance, a lack of motor behavior by the trainer may have had inhibitory properties. Consequently, the current research will control for possible inhibitory stimulus effects and determine their relationship to transfer in a temporal fading procecure.

CHAPTER III

Statement of the Problem

Historically, operant conditioning research has been concerned with fading to produce transfers of stimulus control, and with related matters such as sizes of fading steps, correctional versus noncorrectional fading procedures, and the relatedness of stimulus dimensions. Only recently (Touchette, 1971) has the moment of transfer in a fading procedure been measured.

The measurement of the moment of transfer represents an important step. We cannot begin to manipulate or functionally understand a phenomenon until we can first, define it, and second, measure it (Bachrach, 1962). The current research addressed variables suspected of controlling transfer of stimulus control in temporal fading procedures. Thought to contribute to the moment of transfer are first, the differential delays of reinforcement correlated with each of the stimulus dimensions in a temporal fading procedure; second, inhibitory stimulus control known to be present in other errorlessly formed discriminations; and third, the step constants of temporal delay affecting the point at which transfer occurs.

In view of possible inhibitory stimulus control, the operation of differential delays of reinforcement, and a lack of information regarding the importance of the value of the delay variable, the current research extends our knowledge of the transfer of stimulus control in a temporal fading procedure.

Experiment I will identify whether or not inhibitory stimulus control is a necessary prerequisite to produce a stimulus control transfer in a temporal fading procedure. Experiment II will prevent or produce transfer by manipulating the differential delay of reinforcement between the original and the new stimulus dimensions. Finally, Experiment III will manipulate different step constants of delay to determine if the point of transfer can be controlled.

CHAPTER IV

General Methodology

Participants

Eleven normal and three retarded persons served as participants for three studies. All of the retarded individuals had been institutionalized for some time but none had participated in any prior stimulus control research. Normal participants were from the surrounding community and one had participated in prior research. Parental consent was obtained prior to participation.

Apparatus

Daily sessions were conducted in a dimly lit room approximately 1.5 m by 3.0 m. Participants sat before a 39 cm by 52 cm panel containing two translucent plexiglass keys 4 cm by 6 cm which also served as stimulus displays and manipulanda. Also, two 2.5 cm square lights were adjacent to the keys. The keys were 26 cm apart and 9.5 cm from the base of the panel. Stimuli were presented from the rear by two one-plane IEE projectors. Electromechanical equipment in an adjacent room controlled reinforcement contingencies, stimulus conditions, session length, and recorded latency and response data. M & M reinforcers were dispensed by a Davis Scientific Instrument reinforcement dispenser.

General Procedures

Sessions were generally conducted 5 days a week and each session was terminated after 30 trials. In all experiments, each correct response produced an M & M.

Participants were escorted to and from the experimental area and were free to terminate the experiment at any time. Each participant was given a paper cup at the beginning of each session in which to deposit their M & M's if they chose to save them.

Stimulus Control Baseline

Initially, the experimenter, sitting beside the participant, modeled one or two responses for each participant. Next, the participant was reinforced for a response to one illuminated (S+) key, red or white, for five trials. The illuminated key remained on the same panel during these trials. Each correct response produced an M & M, darkened the key, and initiated a 3-second intertrial interval. Responses to the other, dark key had no effect (correctional procedure) and any responses during the intertrial interval reset the intertrial interval.

Next, the red or white (S+) key randomly alternated position for 5 trials and a response produced an M & M and initiated an intertrial interval. Gradually, the previously dark key (S-) was increased in intensity of white or red light. Each occurrence of a correct response produced an increase in the intensity (via resistance change) of the key. Any errors produced a one-step decrease in the intensity of the key and if no errors were made the S- matched the S+ key in intensity after ten trials. Then ten more trials of red vs. white completed the shaping session. Next, one complete session of red vs. white was conducted to collect baseline latencies from the onset of a trial until a response occurred.

CHAPTER V

Experiment I

The purpose of the first experiment was to systematically replicate Touchette's (1971) study with a control for the possible effect of inhibitory stimuli. As pointed out earlier, Touchette's procedure possibly contains aspects of inhibitory stimulus control and successful transfer may be dependent upon the operation of inhibitory stimulus control. By manipulating the color aspect of the original S+ and S-, it is possible to remove the inhibitory stimulus aspect of the compound stimulus and, instead, substitute the S+ aspect. Also a control for both S- and S+ aspects was employed. A novel and presumably neutral (blue) background accompanied the fading procedure in one condition.

Method

Participants

Five male patients of Woodward State Hospital-School, Woodward, Iowa ranging from 6 years, 3 months, to 20 years, 10 months, classified from mild to moderately retarded, and one six-year old normal female served as participants. The youngest male participant had been institutionalized for less than 3 months, and the remaining male participants had been institutionalized from 2 to 7 years. All subjects had reportedly normal vision, one male had a hearing deficit in one ear, and all had good receptive language abilitites. All but one of the male participants also had well developed expressive language.

Procedure

Initially, each of the six participants experienced the errorless, two-key, simultaneous discrimination procedure described under general methodology. However, for three participants the S+ was white and the S- red, and for three participants the S+ was red and the S- white. Following a baseline session and after ten consecutive trials on which no errors occurred, the subjects proceeded in an ABA fashion, through the following conditions commencing with the next session.

Fading procedure. Superimposed stimuli consisting of vertical (S+) and horizontal (S-) black lines were presented simultaneously with the red and white stimuli on Trial 1. For three participants, the S+ was superimposed on the red key, and the S- was superimposed on the white key. For the other three participants, the S+ was superimposed on the white key and the S- was superimposed on the red key.

Table 1

Stimulus Displays for Participants in Experiment I. (S+ in the new dimension was always a vertical line and S- a horizontal line.)

	New Dimension Background	Original Dimension S+	Original Dimension S-
P1	White	Red	White
P2	Red	White	Red
P3	White	White	Red
P4	Red	Red	White
P5	Blue	White	Red
P6	Blue	Red	White

As the fading progressed, the stimulus backgrounds to the new stimulus dimensions of lines were red for two participants, white for two participants, and blue for the remaining two participants. Thus each pair of participants had a background previously associated with a positive stimulus, negative stimulus, or a neutral stimulus (see Table 1 for experimental conditions).

For participants in Experiment I, a correct response on Trial 1 affected the next trial by delaying the onset of the original S+ 1.0 second. Thus, on Trial 2, both lines were presented and, after a 1.0 second delay, the S+ was added to the correct key. On Trial 3, if the correct response had been made on Trial 2, the S+ was added after 2.0 seconds. On the other hand, an incorrect response terminated the trial and reduced the delay in the subsequent trial by 1.0 second. Intertrial intervals were 3.0 seconds.

For the two control participants, (P5 and P6), original S+ and S- backgrounds were added to the display when the delay terminated. Thus the display changed from vertical and horizontal lines on blue backgrounds, to lines on red and white backgrounds.

The criterion for terminating the fading procedure was a response shift to the new stimulus dimension for at least ten consecutive trials as evidenced by a change in response latencies and the participant's choice of key.

<u>Reversal training</u>. At the start of each reversal sequence, the previously incorrect horizontal line was designated as correct by pairing it with the original S+. Each reversal was accomplished

by reintroducing the original S+ and delaying its onset as before. Again the criterion for terminating each sequence was a shift in stimulus control for at least ten consecutive trials. There was, however a minimum of thirty trials in each reversal to accomodate the usual session length. If those participants having the S+ background did not transfer after 90 trials the fading procedure was terminated.

Results

One pair of participants, P1 and P2, served to replicate Touchette's (1971) study. Latencies from the onset of a trial until a response occurred can be seen in Figures 1 and 2. The temporal fading procedure with an S- background produced a transfer of stimulus control similar to that obtained by Touchette. Response latencies initially increased as the temporal delay to the addition of the original stimulus dimension was increased. At an average of 8 to 9 seconds delay in the presentation of the original stimulus, the response latencies decreased drastically, indicating that the participant was now attending to the new stimulus dimension.

Notably, P1 and P2 made 14 errors over a total of 240 trials. Consequently, their performance was less accurate than that of Touchette's three experienced subjects who made 8 errors over 640 trials.

For the second pair of participants, P3 and P4, the stimulus background during fading was that of the original S+. As can be seen from Figures 3 and 4, this control for inhibitory stimulus effects resulted in a great number of errors and did not produce an errorless

Figure 1. The response latencies in seconds for P1. Latencies are from trial onset to the occurrence of a response and the point at which the original stimulus dimension was introduced is shown in the upper portion of the graph. Solid black lines indicate correct responses and dashed lines indicate errors. The top line steps up or down in correspondence with correct or incorrect responses.

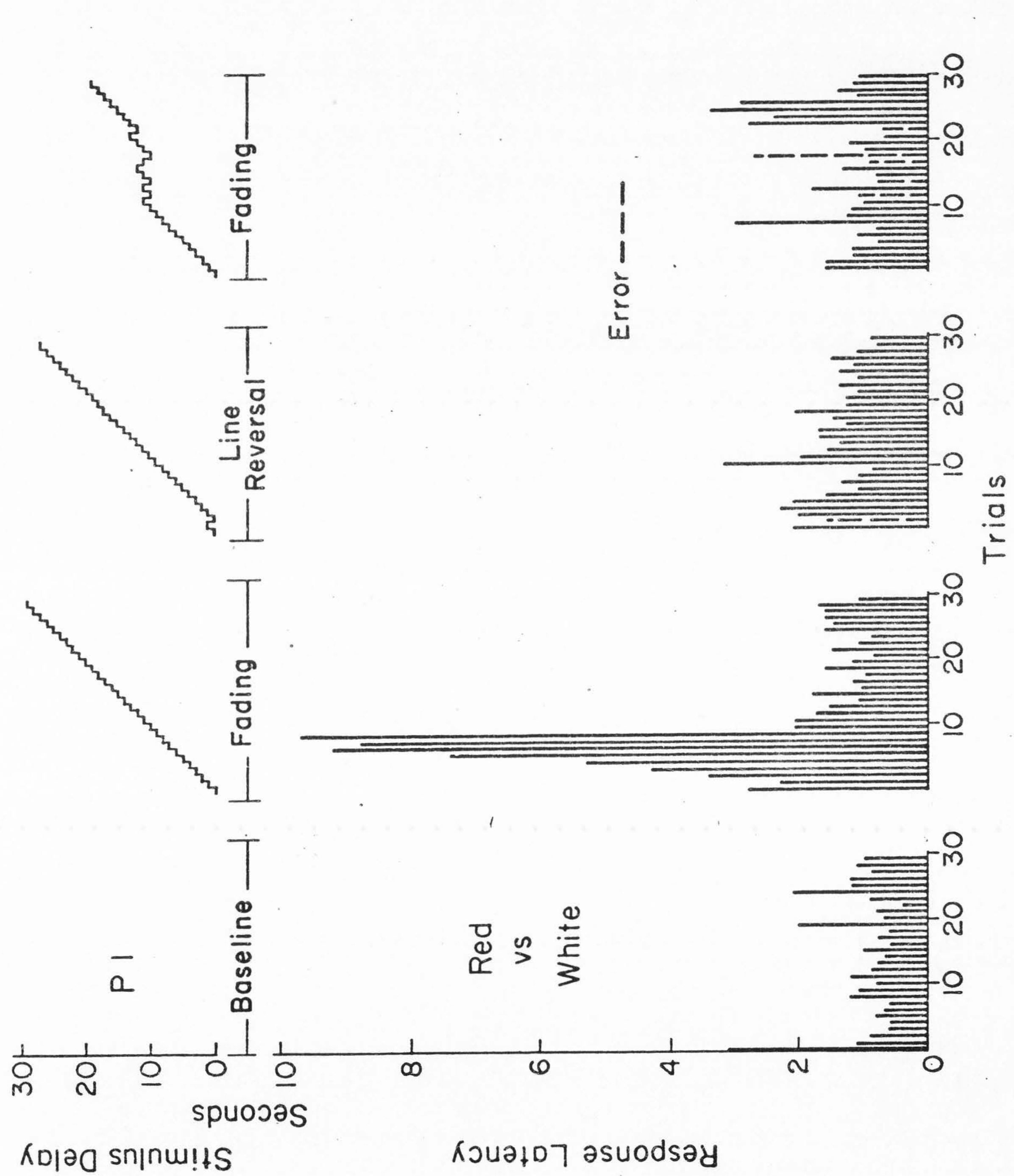

P 1
Stimulus Delay
Seconds
Response Latency
Baseline
Fading
Line Reversal
Fading
Red vs White
Error
Trials

Figure 2. The response latencies in seconds for P2. Latencies are from trial onset to the occurrence of a response and the point at which the original stimulus dimension was introduced is shown in the upper portion of the graph. Solid black lines indicate correct responses and dashed lines indicate errors. The top line steps up or down in correspondence with correct or incorrect responses.

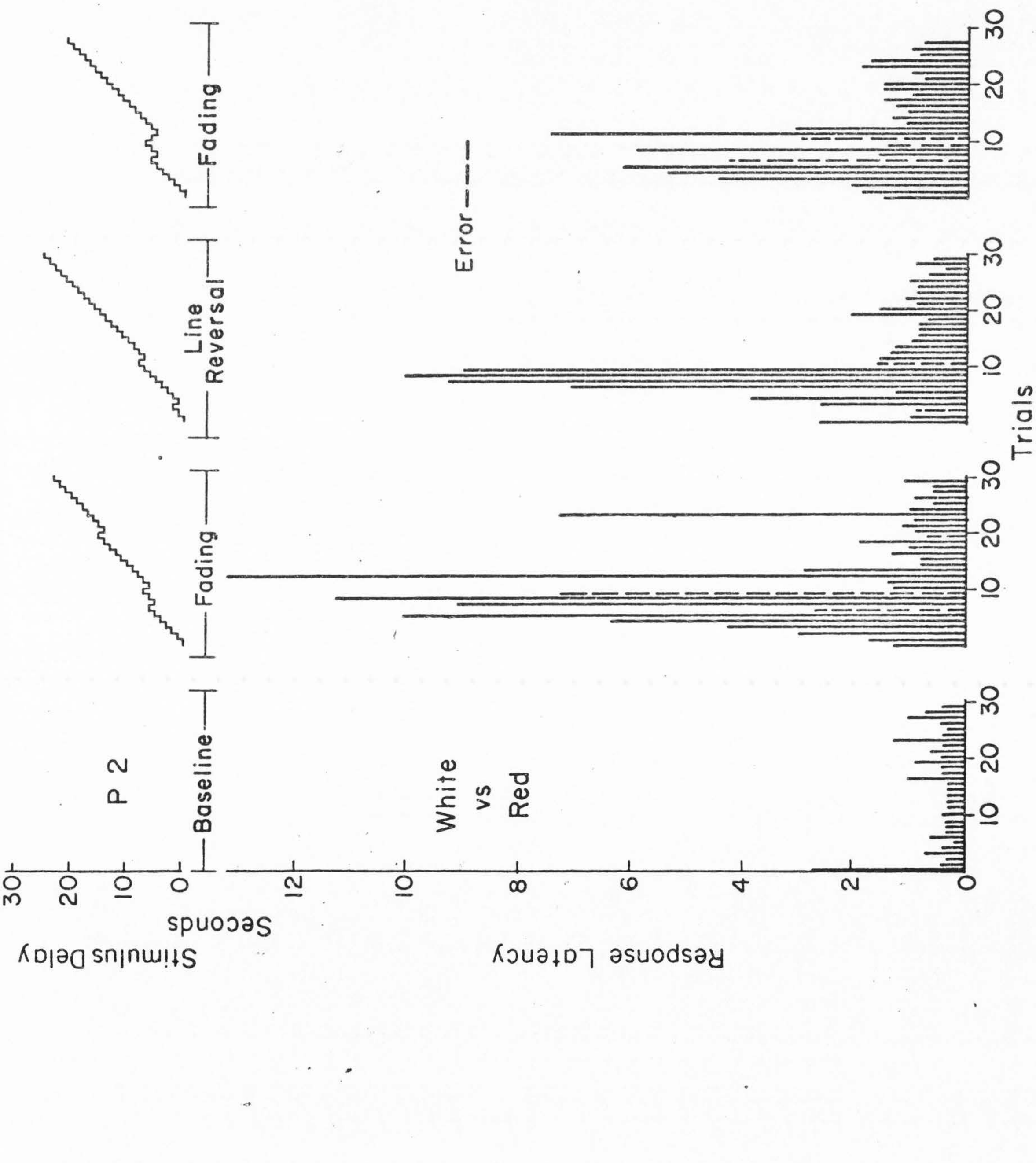
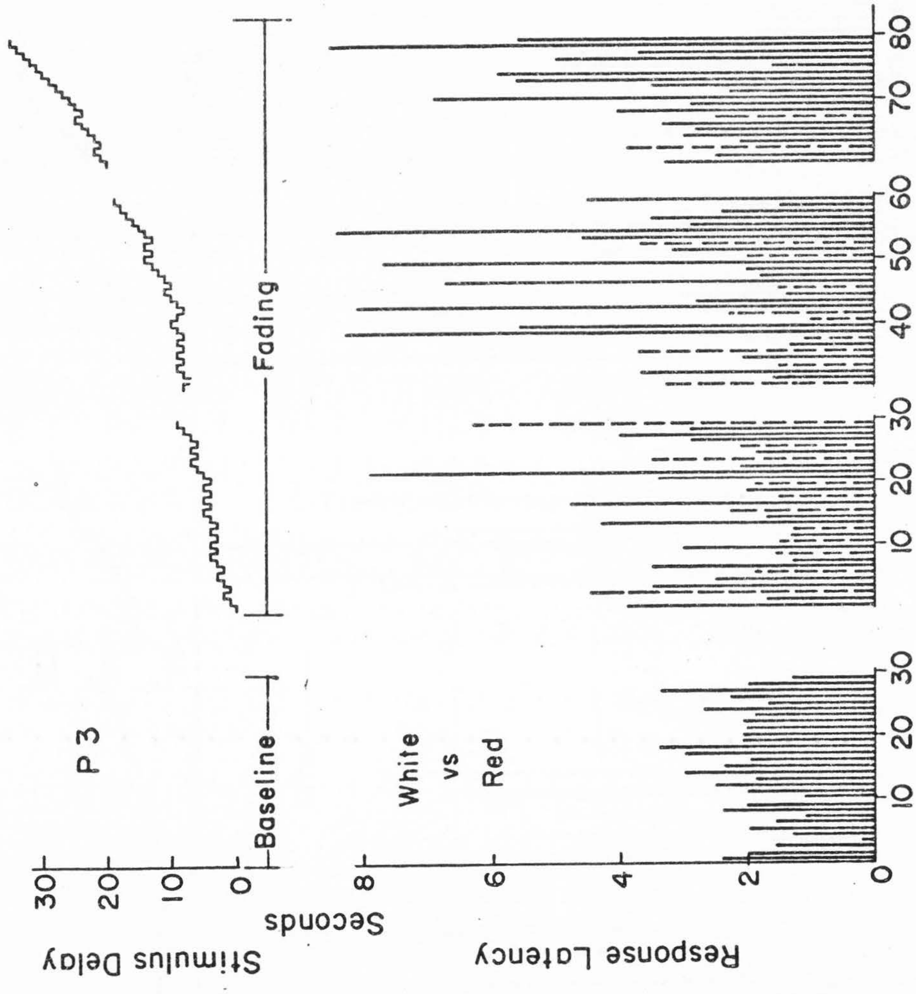

P 2
Baseline
Fading
Line Reversal
Fading
White vs Red
Error
Trials
Stimulus Delay
Seconds
Response Latency

Figure 3. The response latencies in seconds for P3. Latencies are from trial onset to the occurrence of a response and the point at which the original stimulus dimension was introduced is shown in the upper portion of the graph. Solid black lines indicate correct responses and dashed lines indicate errors. The top line steps up or down in correspondence with correct or incorrect responses. Page 35 is the continuation of P3's experience.


P 3
Baseline
Fading
White vs Red
Stimulus Delay
Seconds
Response Latency
Trials
0
10
20
30
40
50
60
70
80
2
4
6
8

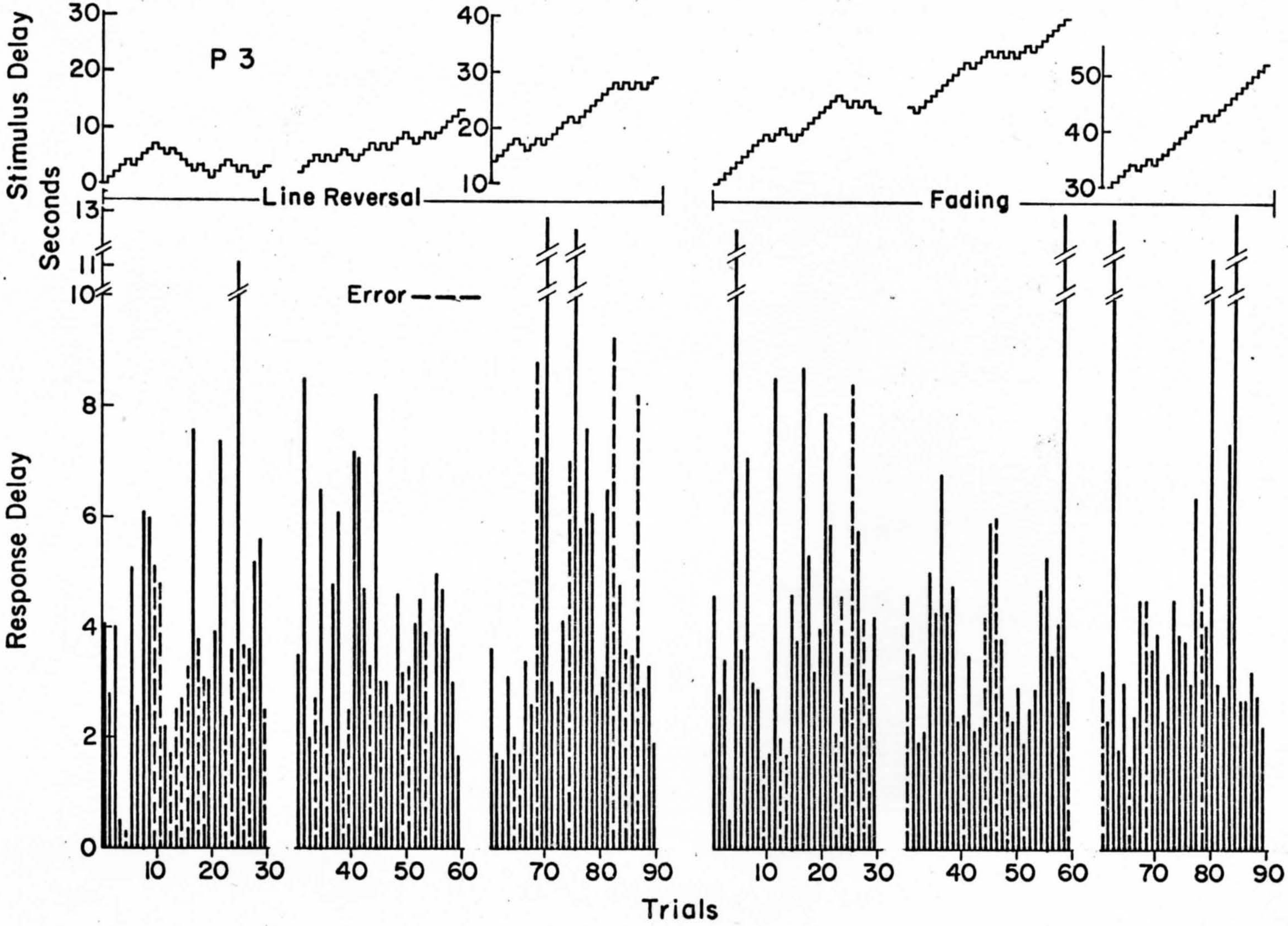
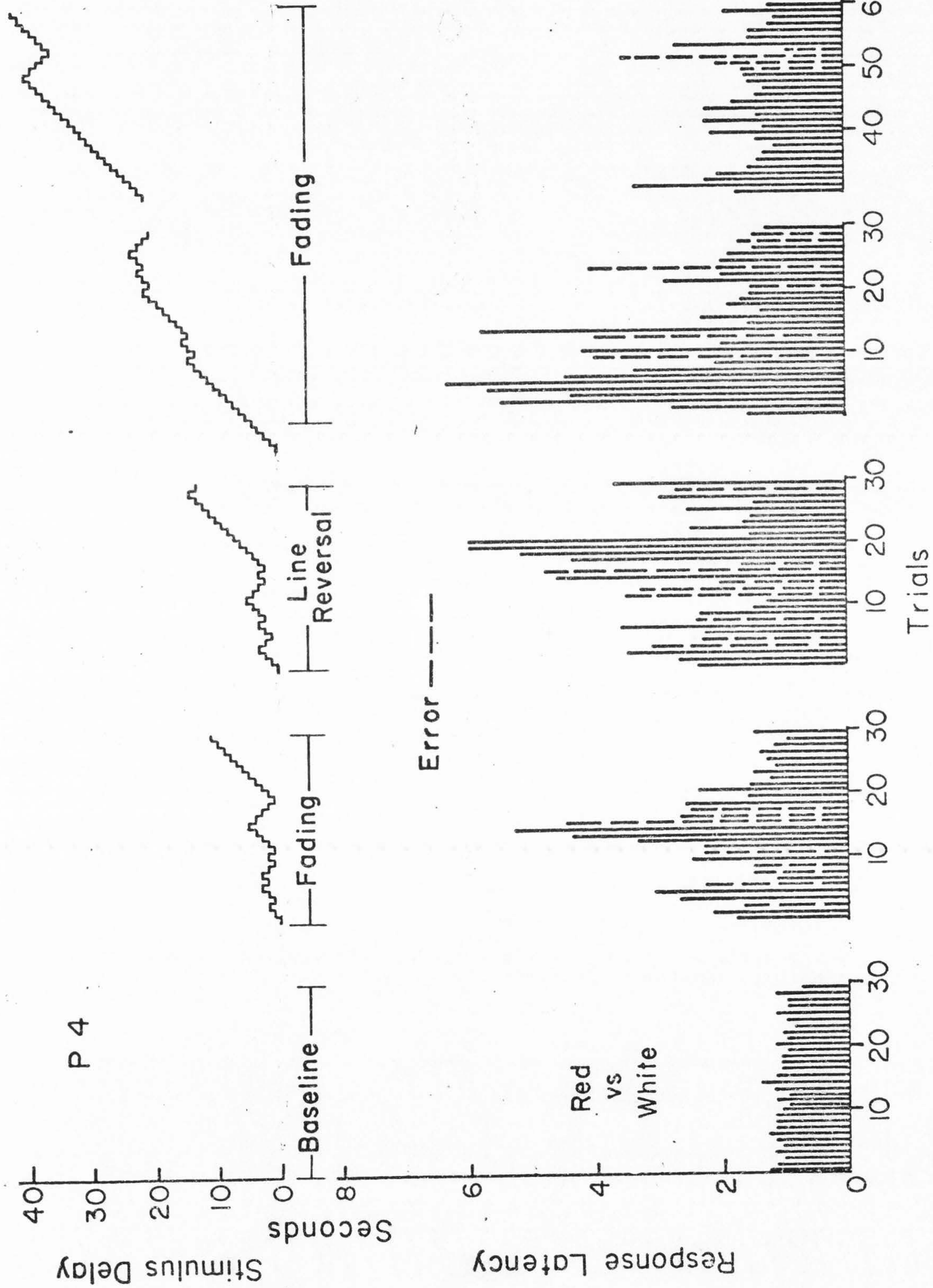

P 3
Stimulus Delay
Seconds
Response Delay
Line Reversal
Fading
Error
Trials
0
10
20
30
40
50
60
70
80
90

Figure 4. The response latencies in seconds for P4. Latencies are from trial onset to the occurrence of a response and the point at which the original stimulus dimension was introduced is shown in the upper portion of the graph. Solid black lines indicate correct responses and dashed lines indicate errors. The top line steps up or down in correspondence with correct or incorrect responses.


P 4
Stimulus Delay
Seconds
40
30
20
10
0
Baseline
Fading
Line Reversal
Fading
Red vs White
Error
Response Latency
8
6
4
2
0
10
20
30
40
50
60
Trials

discrimination transfer. Participants did not delay their response until an S- was added to the display, which was a necessary strategy to render the discrimination possible, but rather, the subjects would respond to one or the other of the S+ backgrounds. A great number of errors occurred before either participant attained stable performance.

The final pair of participants, P5 and P6, had a fading procedure employing a neutral stimulus background. One of the participants, P6, essentially replicated the performance of the first two participants. However, it was necessary to fade out the original stimulus dimension in 2-second steps as one session of fading in 1-second steps simply produced longer and longer response latencies. For the other participant, P5, the transfer of stimulus control occurred very early and the participant consistently emitted latencies much shorter than P6 (note differing ordinates in Figures 5 and 6).

Discussion

The temporal fading procedure employed by Touchette (1971) did not control for the possible effects of inhibitory stimuli. As Karpicke and Hearst (1975) and Rilling, Kaplan, Howard, and Brown (1975) have demonstrated that the S- in errorless discrimination can be an inhibitory stimulus that can suppress responding, the current experiment included controls for possible inhibitory effects.

The present experiment indicated that inhibitory stimulus control while perhaps sufficient, is not necessary to produce an errorless transfer. This conclusion is brought about by the fact

Figure 5. The response latencies in seconds for P5. Latencies are from trial onset and the point at which the original stimulus dimension was introduced is shown in the upper portion of the graph. Solid black lines indicate correct responses and dashed lines indicate errors. The top line steps up or down in correspondence with correct or incorrect responses.

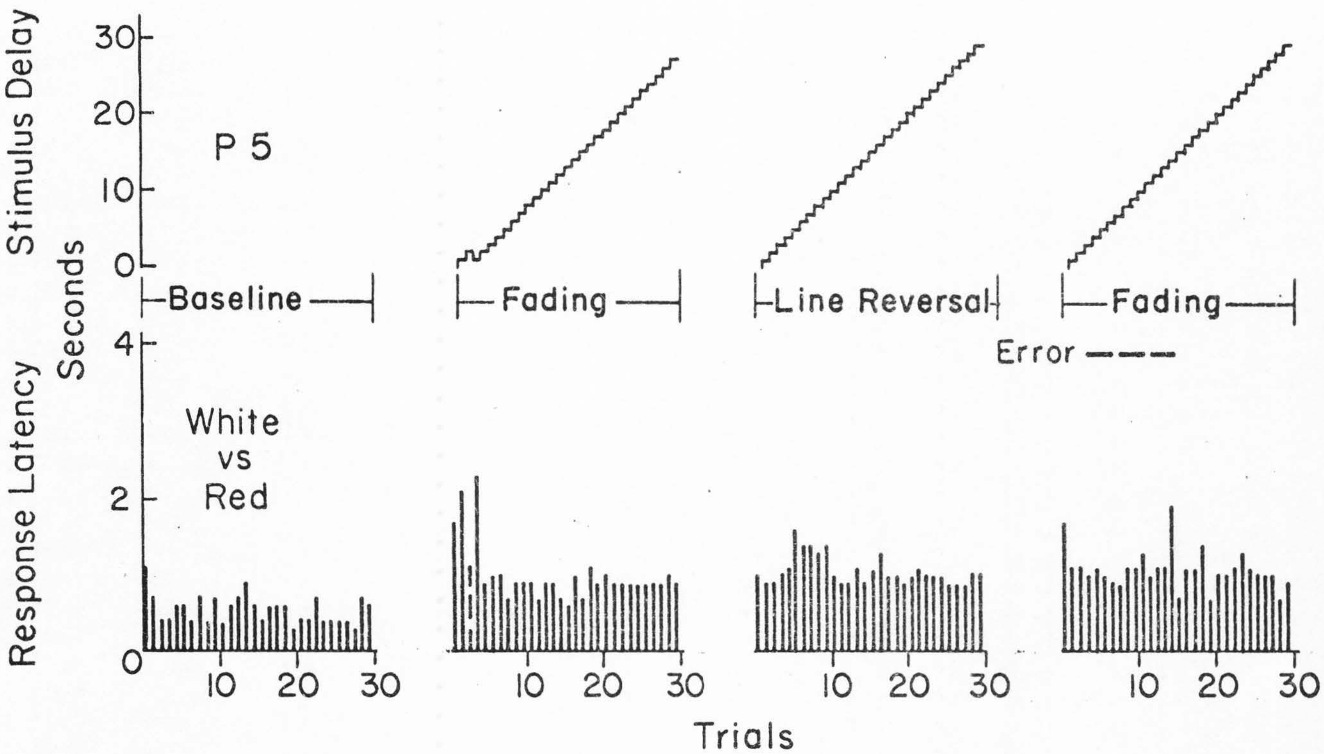
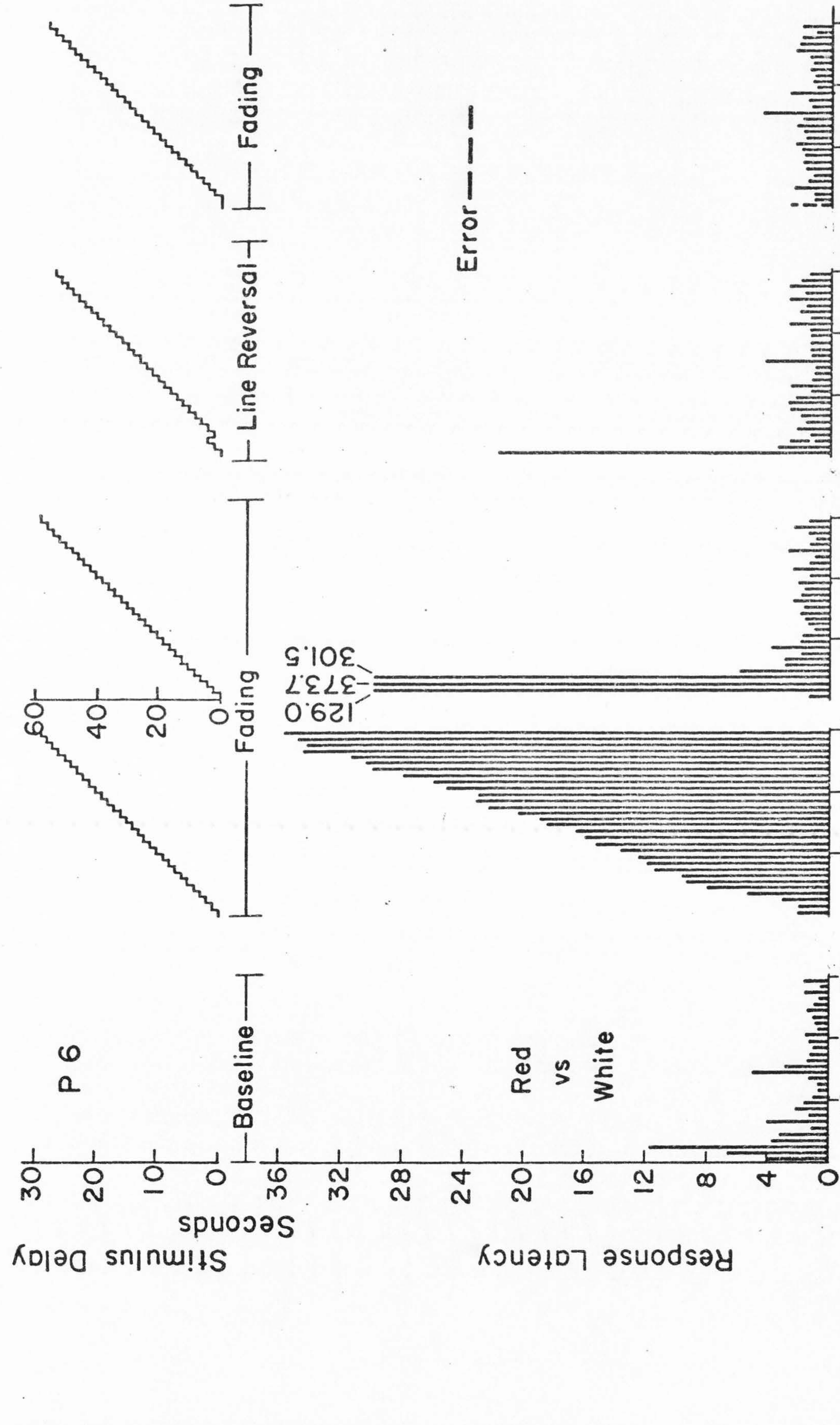

Stimulus Delay
Seconds
Response Latency
P 5
White
vs
Red
Baseline
Fading
Line Reversal
Fading
Error
Trials
30
20
10
0
4
2
0
10
20
30

Figure 6. The response latencies in seconds for P6. Latencies are from trial onset and the point at which the original stimulus dimension was introduced is shown in the upper portion of the graph. Solid black lines indicate correct responses and dashed lines indicate errors. The top line steps up or down in correspondence with correct or incorrect responses. Note that the ordinate scale differs from previous figures.


P 6
Stimulus Delay Seconds
Response Latency
Baseline
Fading
Line Reversal
Fading
Red vs White
Error
129.0
373.7
301.5
Trials

that the subjects under the condition of a presumably neutral stimulus background also transferred from the original to the new stimulus dimension without errors and with response patterns similar to that obtained by Touchette and P1 and P2. The neutrality of the blue background is assumed since it had no experimental history of pairing with either S+ or S- conditions.

The experimental condition which employed a positive stimulus background produced a great number of errors for both participants and did not result in performances similar to any other participants. Both subjects, P2 and P3, emitted many errors upon the introduction of the fading procedure and continued to make errors throughout the experiment. Their disrupted performance is easily predicted considering the prior function of the stimulus background, i.e., it formerly served as a discriminative stimulus for reinforcement. Also, P2 and P3's performance suggests that the S- background served to suppress errors in P1 and P2's performance.

But at the same time, the stimulus background which had S- associations in the original discrimination may not have been an inhibitory stimulus. Since no independent test of inhibitory properties was conducted it is possible that the S- in the current experiment may simply have been a neutral stimulus since those participants with a neutral stimulus background also achieved an errorless transfer.

In conclusion, the first experiment indicates that inhibitory stimulus control is not necessary, but may be sufficient, to produce a transfer of stimulus control. However, it appears necessary that the stimulus background does not have S+ properties in the original discrimination as such a procedure greatly disrupts performance. Finally, it is sufficient for the stimulus background to be neutral, a procedure which produces performance similar to procedures employing inhibitory stimulus control.

CHAPTER VI

Experiment II

As pointed out in the introduction, the temporal fading procedure may be viewed as presenting two routes to reinforcement i.e., the original and new stimulus dimensions. If the transfer of stimulus control is, in fact, a function of the differential delay of reinforcement between the original and new stimulus conditions, then it should be possible to prevent a transfer of stimulus control by making the delay of reinforcement constant and equal for both the new and the original stimulus dimensions.

In order to better understand the effects of delay of reinforcement alone in a simultaneous discrimination task, a control condition of the original red vs. white discrimination with delayed reinforcement was also employed. This condition enabled the response latencies under delayed reinforcement for a simultaneous discrimination to be compared to the latencies produced by a temporal fading procedure without a differential delay of reinforcement between stimulus dimensions. To accomplish these goals, Experiment II employed a fixed trial duration.

Method

Participants

Three male and one female patients of Woodward State Hospital-School, Woodward, Iowa ranging from 10 years, 6 months to 43 years in age and classified from mild to severely retarded, served as participants. Two had been institutionalized for over 5 years and the remaining two for less than 3 months. All four had fairly good receptive language and two of these also had expressive language.

Procedure

Initially, each of the four naive participants experienced the errorless discrimination procedure described earlier. After a baseline session and ten consecutive trials of immediate reinforcement with no errors, two participants proceeded through the delayed reinforcement condition and temporal fading procedure, and two participants proceeded through the delayed reinforcement condition only.

Delayed reinforcement and temporal fading. Trials lasted 10 seconds for the first 5 trials, 20 seconds for the next ten, 30 seconds for ten, and then 40 seconds for the last 5 trials of the first session. A trial began with the new stimuli present, and the original stimuli were added after a temporal delay as in Experiment I. The temporal delays started at 0.0 seconds and increased by 1.0 second steps on each trial. When a response to either key was made, the keys darkened, an adjacent white light went on, and the display remained dark until the trial elapsed. Responses to the dark keys had no effect. Upon completion of the trial, a reinforcer was dispensed if a correct response had occurred, and a three-second intertrial interval began. If an incorrect response occurred, no reinforcer was delivered prior to the intertrial interval. If no response occurred, the trial conditions repeated, however this did not occur.

The increasing delay of the original stimulus onset was in the same temporal direction as Touchette (1971). If the participant did not transfer his response after the delay in the onset of the original stimuli had reached 30 seconds, the next condition was initiated after 30 additional trials occurred. If the participant transferred his responding, the next condition was initiated after 10 consecutive responses to the new stimulus dimension had occurred.

Delayed reinforcement. The red and white stimuli were present throughout the duration of the trial; however, when a response to either key was made, the display darkened, an adjacent white light went on, and remained until the trial elapsed. Upon completion of the trial, a reinforcer was dispensed if a correct response had occurred, and a 3-second intertrial interval began. Responses to the dark keys had no effect and if an incorrect response occurred, no reinforcer was delivered prior to the intertrial interval.

The response latencies were recorded sequentially and an analysis of their temporal position within the trial was made. The two participants in this condition were yoked to the first two participants for a determination of the number of trials to occur.

Immediate reinforcement. Following the delayed reinforcement conditions, for all four participants, reinforcement was immediate for a correct response. For the two participants under delayed reinforcement, reinforcement for a correct response was no longer delayed. For the two participants under delayed reinforcement plus temporal fading procedure, reinforcement became immediate for a correct response to either the new or the old stimulus dimension.

Trial length was again increased as in the second condition and the new stimulus dimension was temporally faded for the two participants who experienced the delayed reinforcement and temporal fading procedure (see Table 2).

Table 2

Experimental Conditions for P7, P8, P9, and P10

		Immediate S^{R+}	Delayed S^{R+}		Immediate S^{R+}	
TEMPORAL FADING	P7 & P8	R vs. W Response Terminates Trial	40" – 10"	40"	40" – 10"	40"
			TRIAL LENGTH			
CONTROL	P9 & P10	R vs. W Response Terminates Trial	40" – 10"	40"	40" – 10"	40"

Results

Participants 7 and 8 were exposed to the S+ fading procedure with delayed reinforcement. During the second delay of reinforcement session, the delay remained at 40 seconds. For both subjects, it can be seen in Figures 7 and 8 that their response latencies lengthened to await the onset of S+ both in the delayed reinforcement and in the subsequent immediate reinforcement series. None of the participants made a transfer to the new stimulus dimension as in Experiment I. For all four participants, the delays between responses and subsequent reinforcers can be found in the appendix.

P7 omitted quite a few responses in the first and second sessions of immediate reinforcement following the delayed reinforcement series. Also, his latencies became more variable in the delayed reinforcement condition. A few responses were made to the new stimulus dimension and one error was made. For P8 this was not the case. P8's latencies were extremely uniform throughout the sessions and P8 always based his response on the original stimulus dimension.

Participant 9 was yoked to P7 in terms of number of trials under delayed reinforcement and immediate reinforcement conditions. As can be seen in Figure 9, P9's response latencies did not lengthen as the delayed reinforcement was increased to 40 seconds, but rather latencies became variable and a few responses were omitted. When P9 was returned to immediate reinforcement, the response latencies stabilized during the second session. During a 6th session P9's latencies again became variable under an immediate reinforcement and variable trial length condition. However, no errors were produced by P9 in any sessions.

Participant 10 who was yoked to P8, produced a performance similar to P9. Response latencies under the delayed reinforcement conditions did not increase as the reinforcement delay increased, but instead became more variable. P10's performance essentially replicated that of P9, with the exception that P10 made one error during the 4th session (Figure 10).

Figure 7. The response latencies in seconds for P7, with delayed reinforcement. Response latencies are from trial onset and the point at which the original stimulus dimension was introduced and trial length is shown in the upper portion of the graph. Solid black lines indicate correct responses and dashed lines indicate errors. The top line steps up or down in correspondence with correct or incorrect responses. Phase a denotes variable trial length and immediate reinforcement.

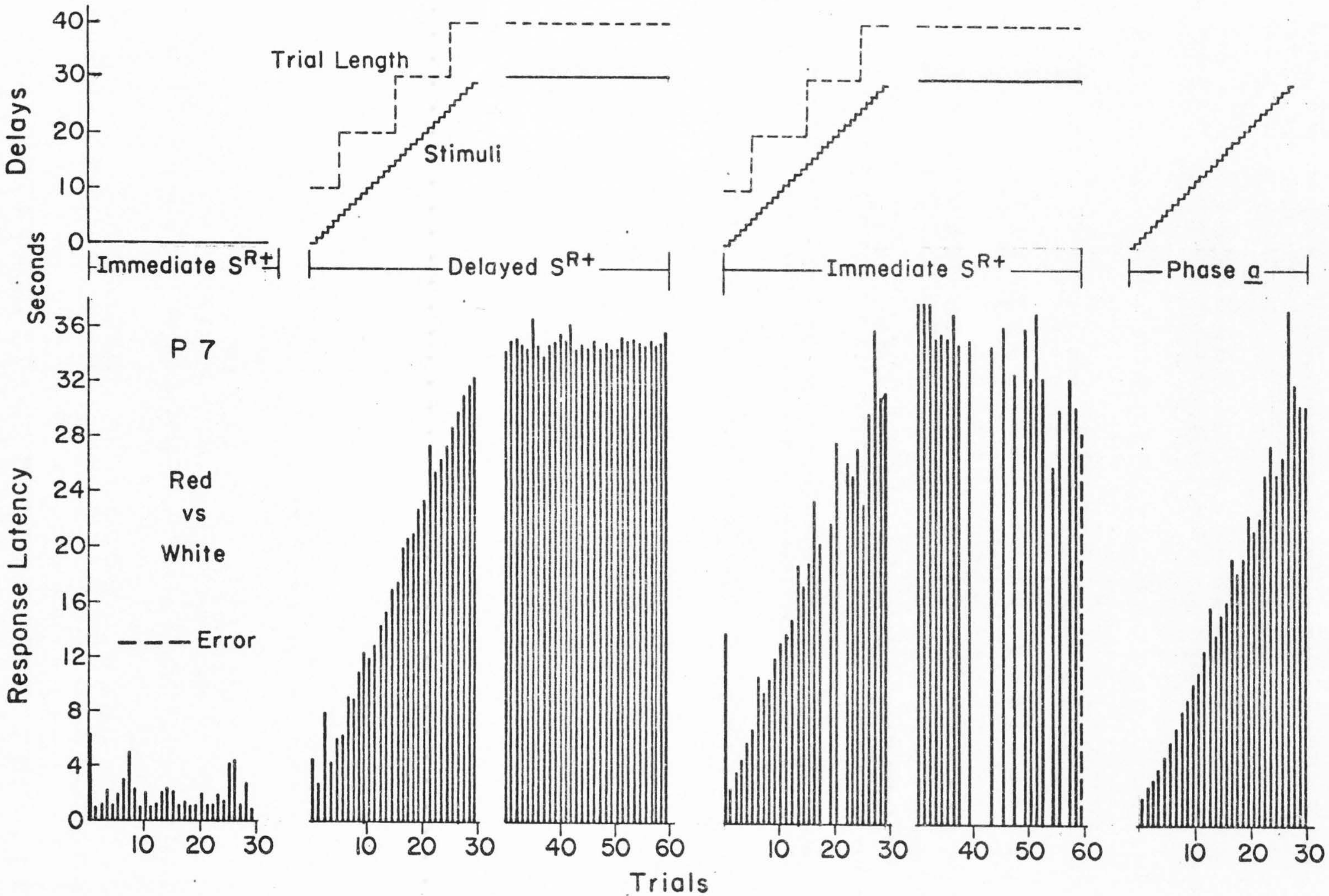

Trial Length
Stimuli
Delays
Seconds
Immediate S^{R+}
Delayed S^{R+}
Immediate S^{R+}
Phase a
P 7
Red
vs
White
Error
Response Latency
Trials

Figure 8. The response latencies in seconds for P8, with delayed reinforcement. Response latencies are from trial onset and the point at which the original stimulus dimension was introduced is shown in the upper portion of the graph. Solid black lines indicate correct responses and dashed lines indicate errors. The top line steps up or down in correspondence with correct or incorrect responses.

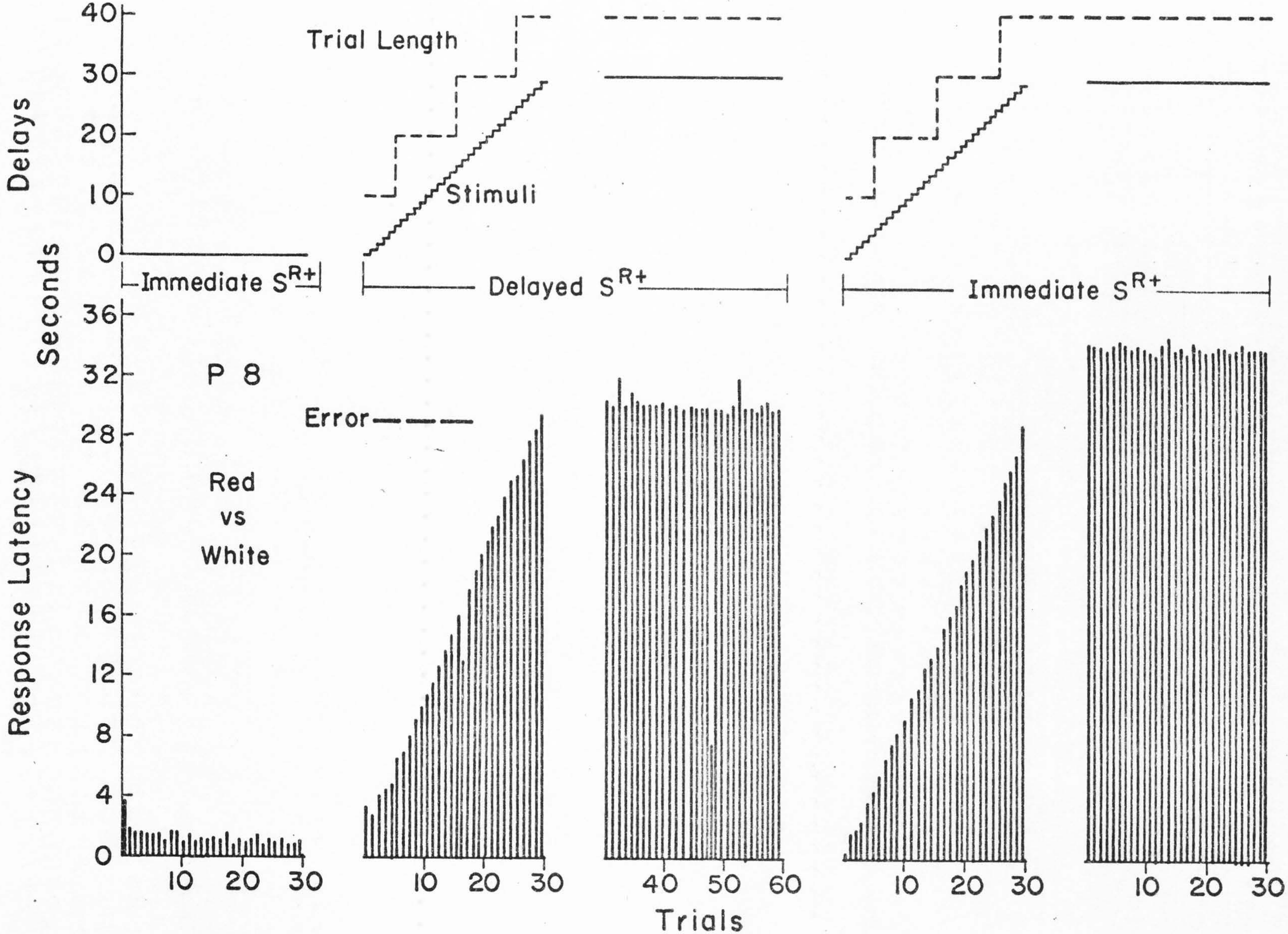

Delays
Seconds
Response Latency
Trial Length
Stimuli
Immediate S^{R+}
Delayed S^{R+}
Immediate S^{R+}
P 8
Red
vs
White
Error
Trials
0
10
20
30
40
0
4
8
12
16
20
24
28
32
36
10
20
30
10
20
30
40
50
60
10
20
30
10
20
30

Figure 9. The response latencies in seconds for P9, control subject. The point at which the original stimulus dimension was introduced is shown in the upper portion of the graph. Solid black lines indicate correct responses and dashed lines indicate errors. The top line steps up or down in correspondence with correct or incorrect responses. Phase _a_ indicates added session.

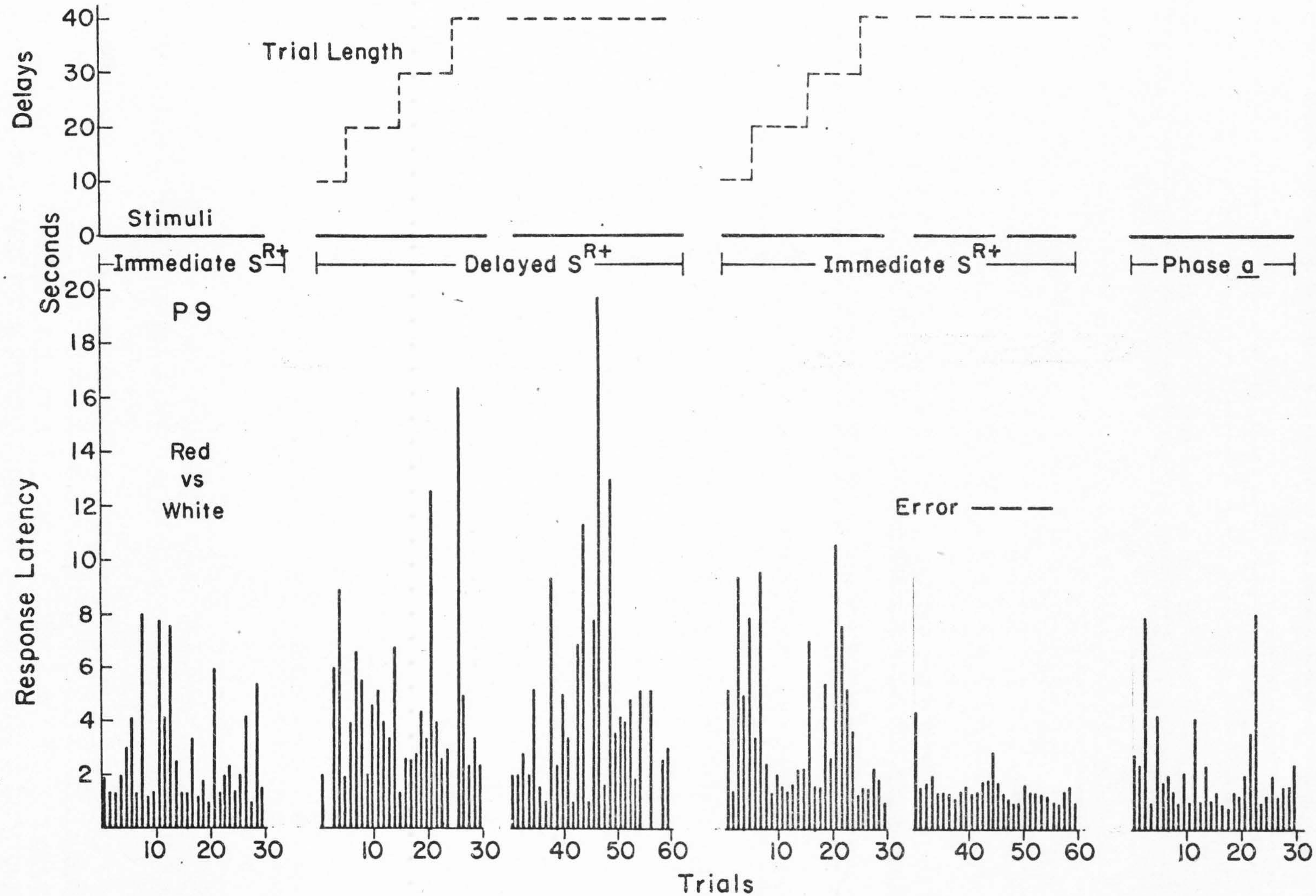
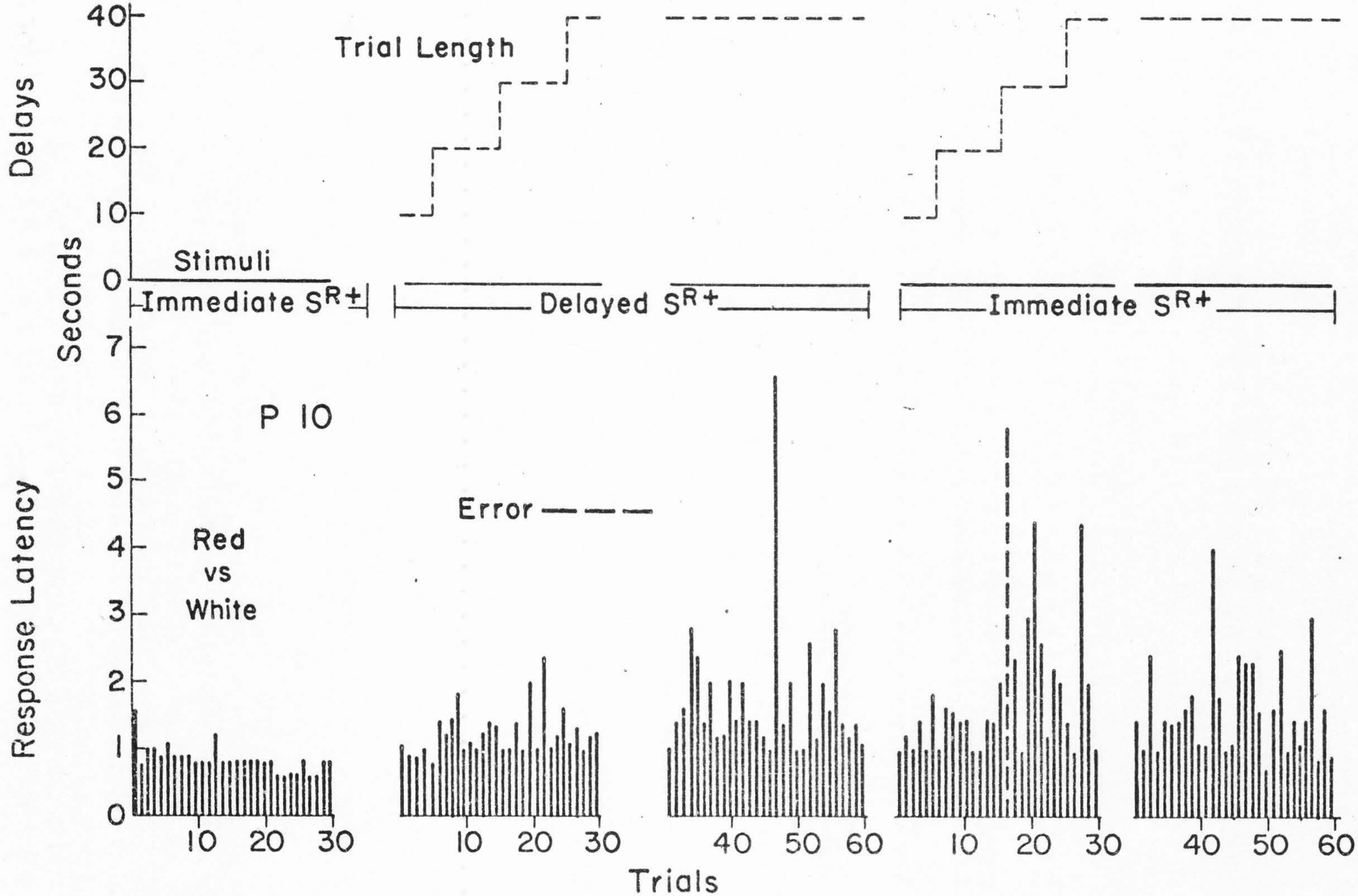

Delays
Trial Length
Stimuli
Seconds
Immediate S^{R+}
Delayed S^{R+}
Immediate S^{R+}
Phase a
P 9
Red vs White
Error
Response Latency
Trials

Figure 10. The response latencies in seconds for P10, control subject. Response latencies are from trial onset and the point at which the original stimulus dimension was introduced is shown in the upper portion of the graph. Solid black lines indicate correct responses and dashed lines indicate errors. The top line steps up or down in correspondence with correct or incorrect responses.


Trial Length
Delays
Seconds
Stimuli
Immediate S^{R+}
Delayed S^{R+}
Immediate S^{R+}
P 10
Error
Red
vs
White
Response Latency
Trials

Discussion

The two participants, P7 and P8, who were exposed to delayed reinforcement and a temporal fading procedure did not transfer their responding to the new stimulus dimension. Their response latencies increased as the delay of the original S+ presentation increased and their latencies remained over 30 seconds for 30 trials. The delays of reinforcement experienced by the participants varied as the delay itself was increased. The performance of these two participants indicates that the relative delay of reinforcement engendered by Touchette's temporal fading procedure may be a necessary component for producing a transfer in stimulus control.

Interestingly, when P7 and P8 were subsequently placed on immediate reinforcement and a temporal fading procedure, they still did not transfer their responding to the new stimulus dimension, but instead responded to the original stimulus dimension. This indicates that the training under the delayed reinforcement condition increased the control by the original S+ as well as taught the participant to tolerate delays of reinforcement from the onset of each trial. This result indicates that the success of the temporal fading procedure may rely on the participants not having developed a stable performance under conditions of delayed reinforcement. In other words, the relative delay of reinforcement between the two stimulus dimensions becomes irrelevant if the participant has had prior training to accept delays of reinforcement.

Johnson and Cumming (1968) and Ray (1969) offered evidence that the immediate history of a subject is very important in determining attention within a compound display. Touchette (1971) also suggested that immediate history was important in the facilitation of the transfer of stimulus control. The failure to obtain transfer in Experiment II may, according to these researchers, be a function of the immediate history of delayed reinforcement that each participant brought to the immediate reinforcement condition.

On the other hand, since P7 and P8 had a history of long latencies being reinforced, the failure to transfer under the immediate reinforcement condition may simply indicate a tendency to behave in the fashion previously reinforced. This interpretation would however, require the assumption that the subjects were insensitive to the difference between immediate and delayed reinforcement in the fading series.

Participant 7 was exposed to immediate reinforcement and temporal fading with variable trial length following the completion of the scheduled experimental sessions to determine if a variable trial length would produce a transfer (Fig. 7, Phase a). This was unsuccessful.

The control participants, P9 and P10, under delayed reinforcement displayed no characteristic performance other than increased variability in response latencies upon introduction of delayed reinforcement. Both participants continued responding under the delayed reinforcement condition.

Overall, Experiment II indicates that the delay of reinforcement engendered by the temporal fading procedure is apparently a necessary condition to produce a transfer of stimulus control but Experiment

II also indicates that relative delay of reinforcement alone is not sufficient. In the case where prior conditions train a tolerance for delayed reinforcement, participants may not be sensitive to changes in relative delay of reinforcement and therefore may not transfer.

CHAPTER VII

Experiment III

Experiment III examined the effect of different rates of temporal delay on the moment of transfer in the fading procedure. If the differential delay of reinforcement between stimulus conditions is responsible for transfer in a temporal fading procedure, then the step size at which that delay increases should be an important variable in determining the point at which the subject transfers his responding. The current experiment examined the effect of three step values upon the moment of transfer.

Method

Participants

Two patients of Woodward State Hospital-School, Woodward, Iowa ages 6 years, 3 months, and 17 years who functioned in the mild and moderate ranges of retardation participated. A third participant, P13, was a normal 10-year-old female and a fourth participant, P12, was a normal 7-year-old male. All were experimentally naive except P13 who participated in previous match-to-sample research.

Procedure

Each of the four participants experienced the errorless discrimination procedure described under general methodology. After ten consecutive trials on which no errors occurred, the participants proceeded through the following conditions.

Fading. The fading procedure with red and white backgrounds was as described in Experiment I, with the following changes.

For P11 and P12, a correct response on Trial 1 affected the next trial by delaying the onset of the red stimulus 0.1 seconds. Thus, on Trial 2 both figures were presented and after 0.1 seconds delay, the red was added to the S+ figure. On Trial 3, if the correct response had been made on Trial 2, the original S+ was added after 0.2 seconds. On the other hand, an incorrect response terminated the trial and reduced the delay in the subsequent trial by 0.1 seconds. This delay was programmed for the first 30 trials. The delay was then .5 seconds for the next 30 trials, and 5.0 seconds for the last 30 trials. The result of these steps was a slightly curvilinear progression in delay. This was necessary because of equipment limitations. Intertrial intervals were 3.0 seconds.

Two participants, P3 and P4, in Experiment I proceeded with the temporal variable set at 1.0 seconds. The data from that experience is referred to in this experiment again for comparison purposes. The third pair, P13 and P14, proceeded with the temporal variable set at 10.0 seconds.

The criterion for terminating the fading procedure was a response shift to the new stimulus dimension for at least 10 consecutive trials as evidenced by a change of response latencies and the participant's choice of key or the completion of 90 trials under one condition.

Reversal training. A discrimination reversal was arranged using the fading procedures described above. At the start of each reversal sequence the previously incorrect figure (horizontal line) was designated as correct by pairing it with the S+ (red or white) background. Each reversal was accomplished by reintroducing the original S+ and delaying its onset according to the temporal parameters specified above. Again the criterion for terminating each sequence was a shift in stimulus control for at least 10 consecutive trials. There was, however, a minimum of 30 trials in each reversal in order to accomodate the usual session length.

Fading. After each reversal was accomplished, the participant was returned to the prior fading procedure with the same criterion applying.

Results

Figure 11 shows the relationship between the trial on which transfer occurred and the step of delay to which each participant was exposed. For each participant, the number of trials was averaged across the three fading series that he experienced. The point of transfer ranged from Trial 14 to Trial 51 for P11 and from Trial 16 to 41 for P12. For P1, the point of transfer ranged from Trial 3 to 10 and for P2, from Trial 9 to 13. Participants 13 and 14 always transferred on Trial 2 of each fading sequence. As can be seen, there is an inverse relationship between the step of delay and the number of trials until transfer occurs. Figures 12 and 13 show the experimental experiences for P11 and P12 respectively. For P11, it was necessary to run 90 trials in the first fading series to meet criterion. The discrepancy in the slopes of the increasing response latencies in the first and second sessions of the fading series is due to a change in the temporal delay parameter. Due to limitations in the equipment available, it was necessary to program .1 sec. steps for the first 30 trials, and then for the next session to start at 3 sec. and increase in .5 sec. steps. This same procedure was necessary for P12 during the reversal series, where P12 did not meet criterion in the first reversal session.

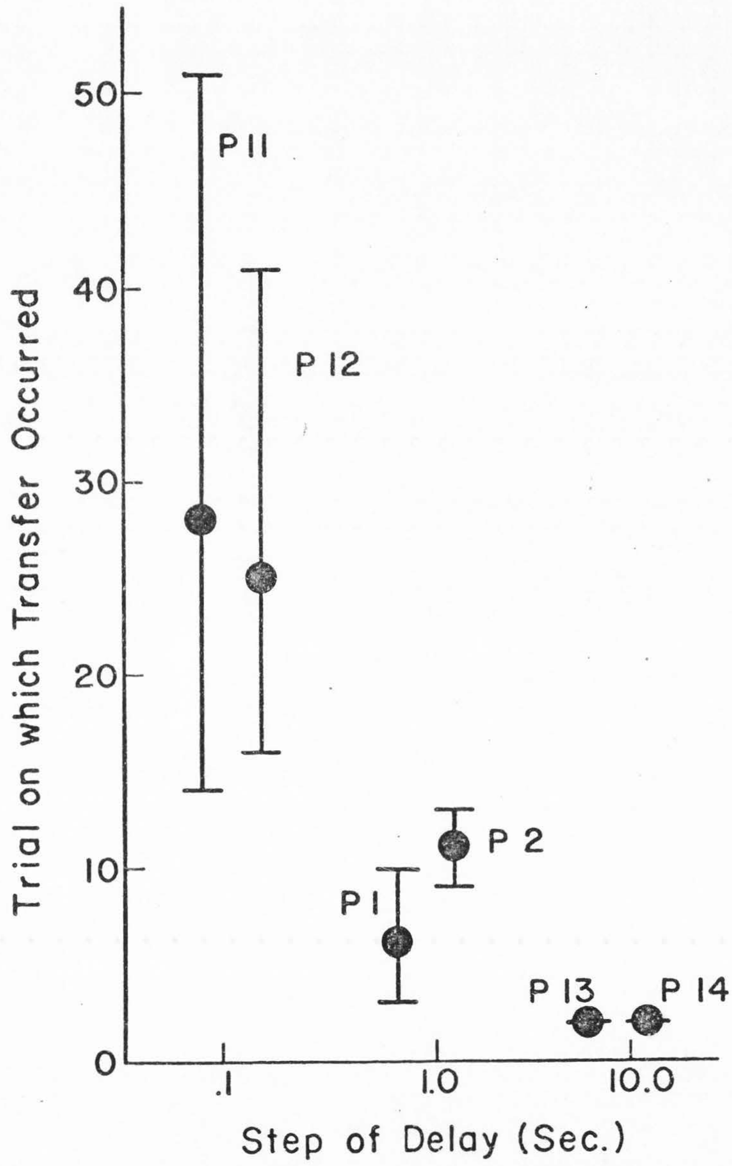
P13 and P14 proceeded with the temporal delay variable set at 10 secs. In each of the three fading series that P13 and P14 experienced, they transferred on the second trial of the fading program. As a result, P13 and P14 did not show the customary gradual increase in response latencies but instead demonstrated relatively stable performances with longer latencies occurring only during the first few trials of the first fading series.

The accuracy of participants P11, P12, P13, and P14 was much better than that of P1 and P2. Only four errors out of 600 trials occurred for these participants. The four errors were emitted by P11 (Figure 12). Two occurred at the beginning of the reversal series and two occurred at the beginning of the second fading series.

Discussion

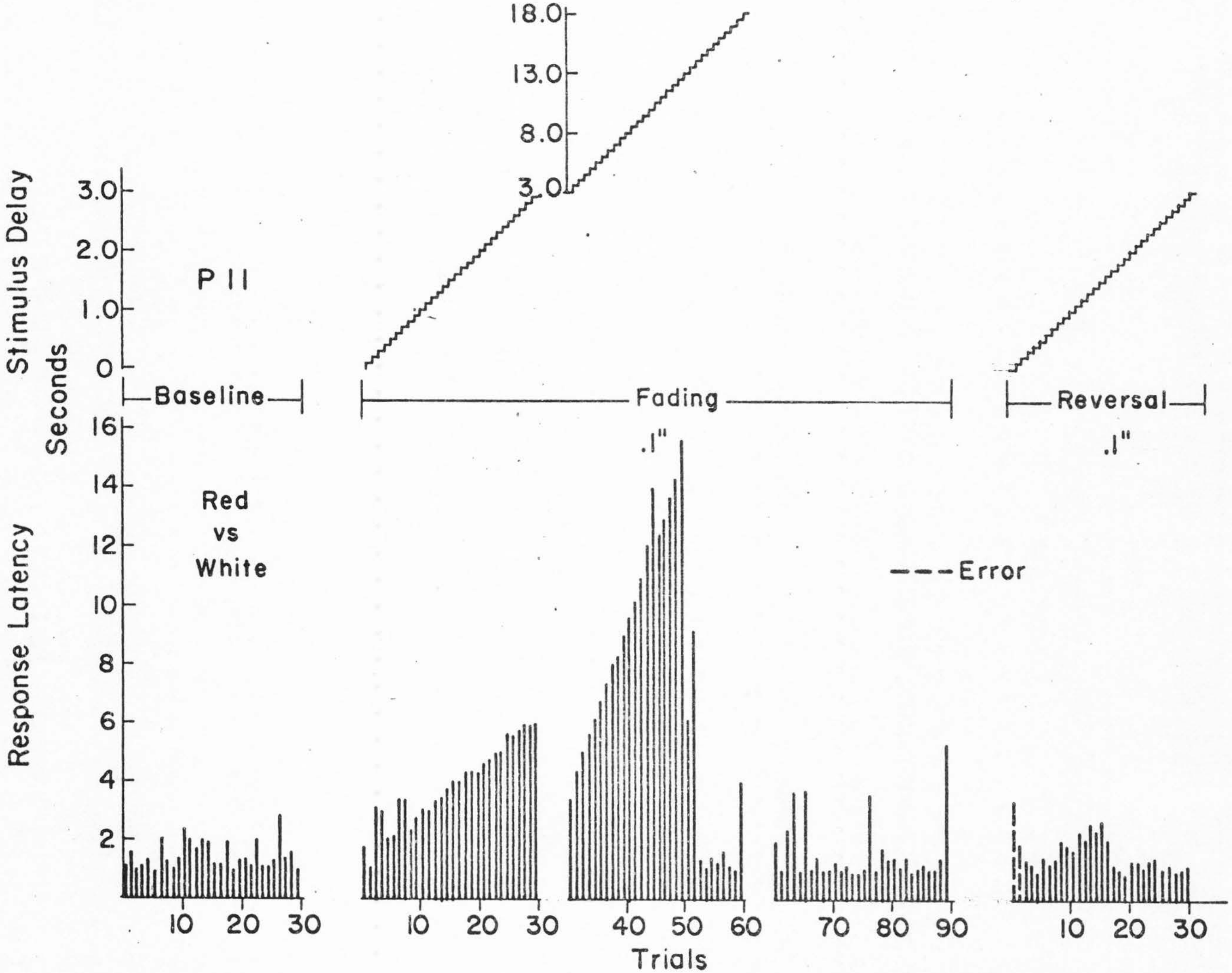
The results of Experiment III indicate that the step of delay in the temporal fading procedure is an important factor in determining the point at which a transfer of stimulus control occurs. High steps of delay engender rapid transfers, while very low steps lead to transfers late in a fading program.

Figure 11. Steps of delay and points of stimulus control transfer. Data for each subject were averaged over three fading sequences. Range is indicated by horizontal bars.



Trial on which Transfer Occurred
50
40
30
20
10
0
P 11
P 12
P 2
P 1
P 13
P 14
.1
1.0
10.0
Step of Delay (Sec.)

Figure 12. Response latencies for P11, with .1 sec. delay step. Response latencies are from trial onset and the point at which the original stimulus dimension was introduced is shown in the upper portion of the graph. Solid black lines indicate correct responses and dashed lines indicate errors. The top line steps up or down in correspondence with correct or incorrect responses. Page 69 is the continuation of P11's experience.


P 11
Stimulus Delay
Seconds
3.0
2.0
1.0
0
18.0
13.0
8.0
3.0
Baseline
Fading
Reversal
.1"
.1"
Response Latency
16
14
12
10
8
6
4
2
Red
vs
White
---Error
10
20
30
10
20
30
40
50
60
70
80
90
10
20
30
Trials

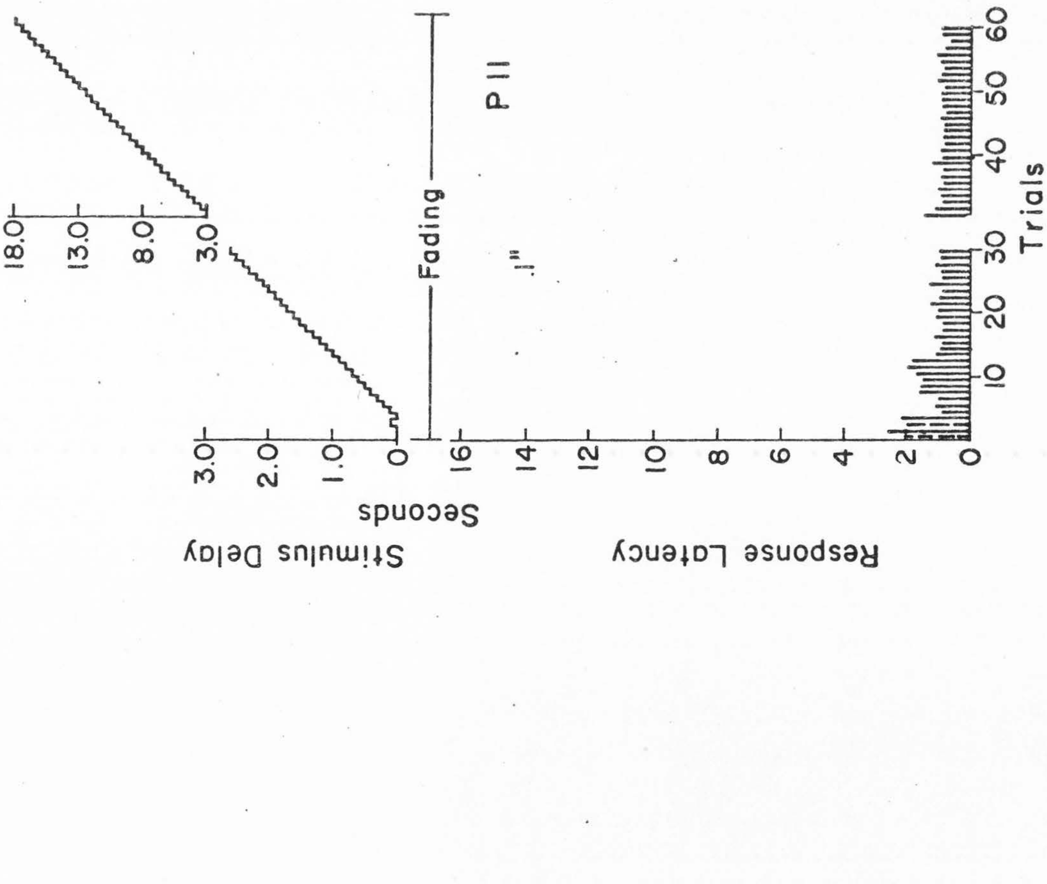
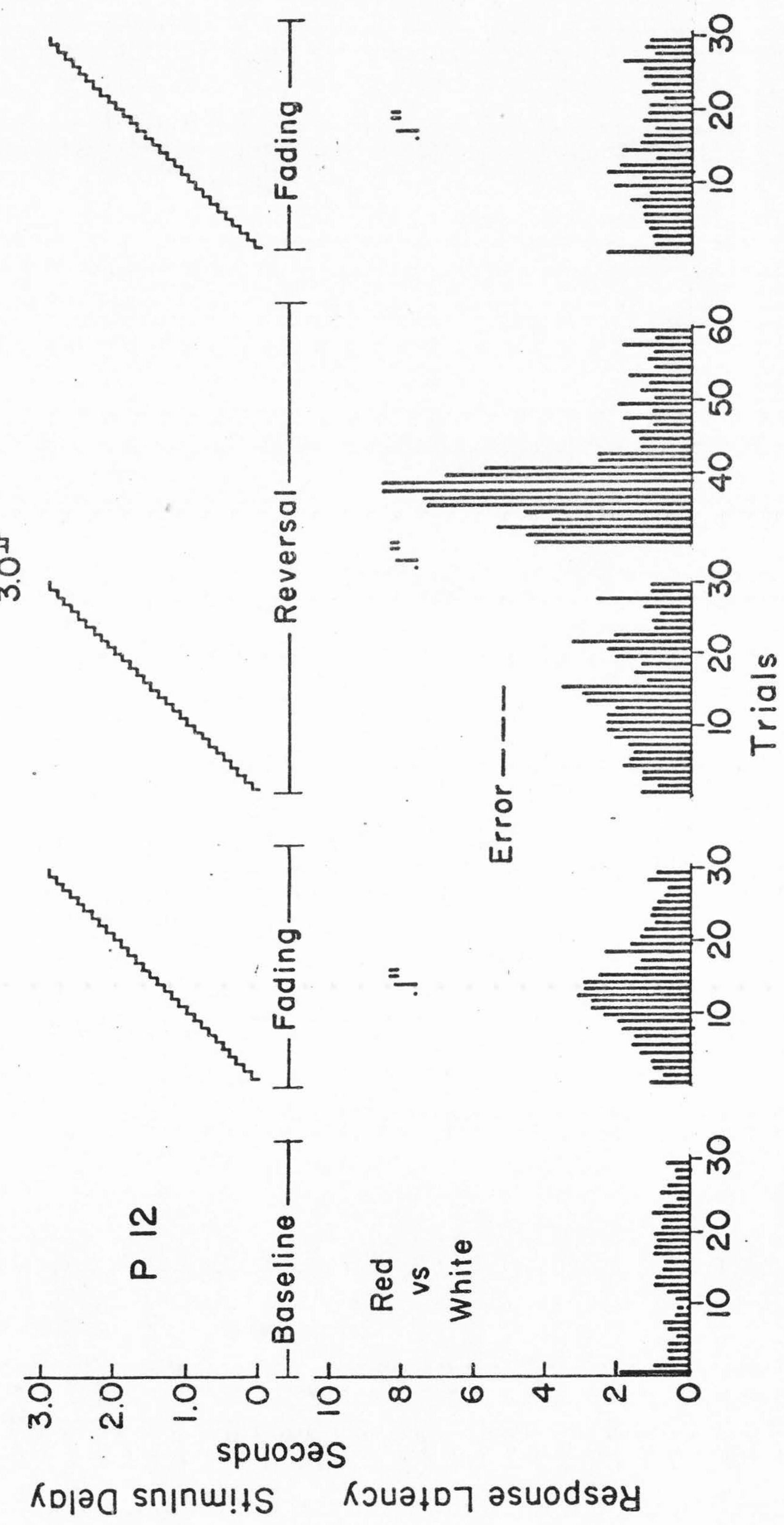
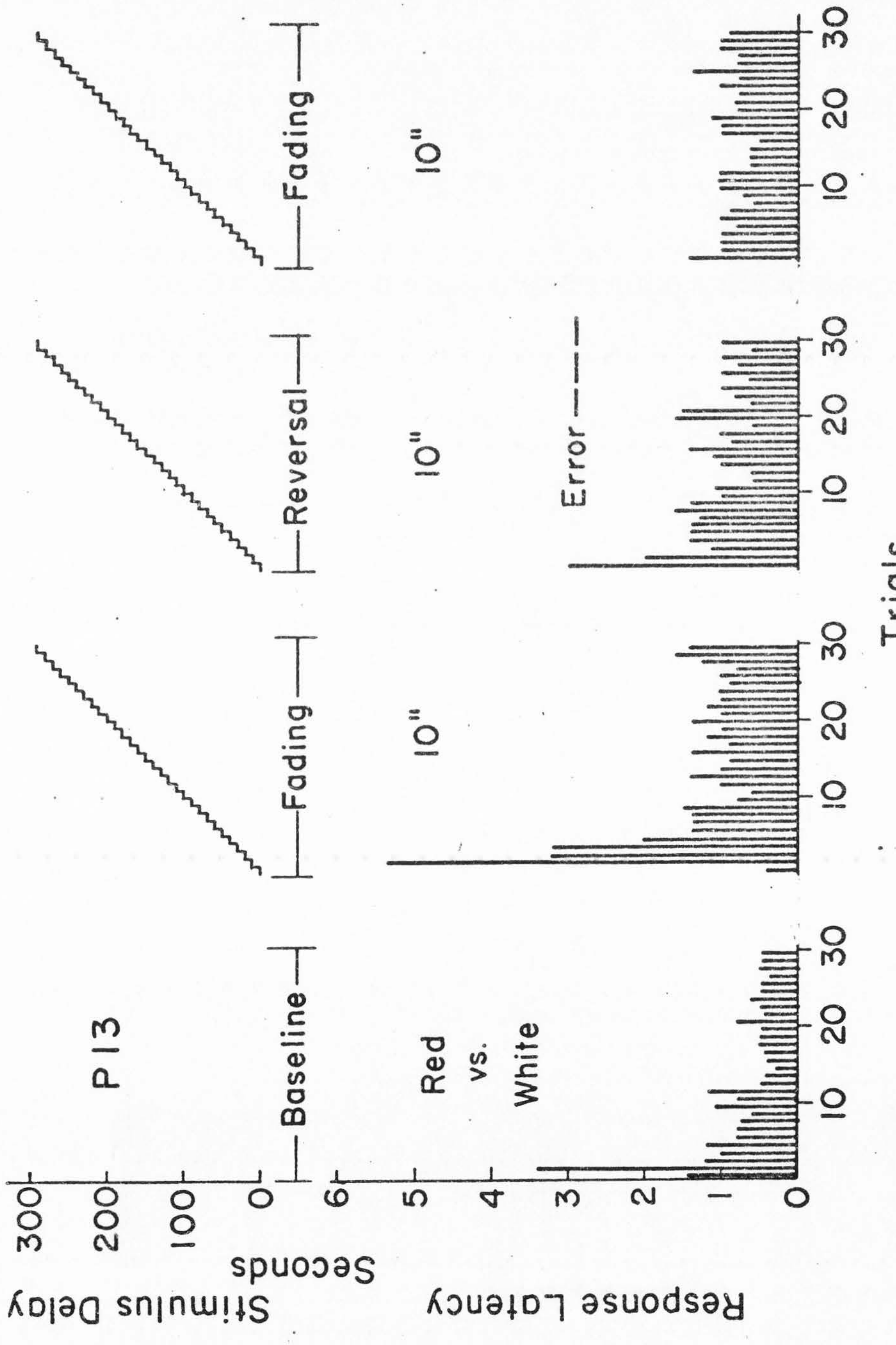

Stimulus Delay
Seconds
3.0
2.0
1.0
0
18.0
13.0
8.0
3.0
Fading
P 11
Response Latency
16
14
12
10
8
6
4
2
0
10
20
30
40
50
60
Trials

Figure 13. Response latencies for P12, with .1 sec. delay step. Response latencies are from trial onset and the point at which the original stimulus dimension was introduced is shown in the upper portion of the graph. Solid black lines indicate correct responses and dashed lines indicate errors. The top line steps up or down in correspondence with correct or incorrect responses.



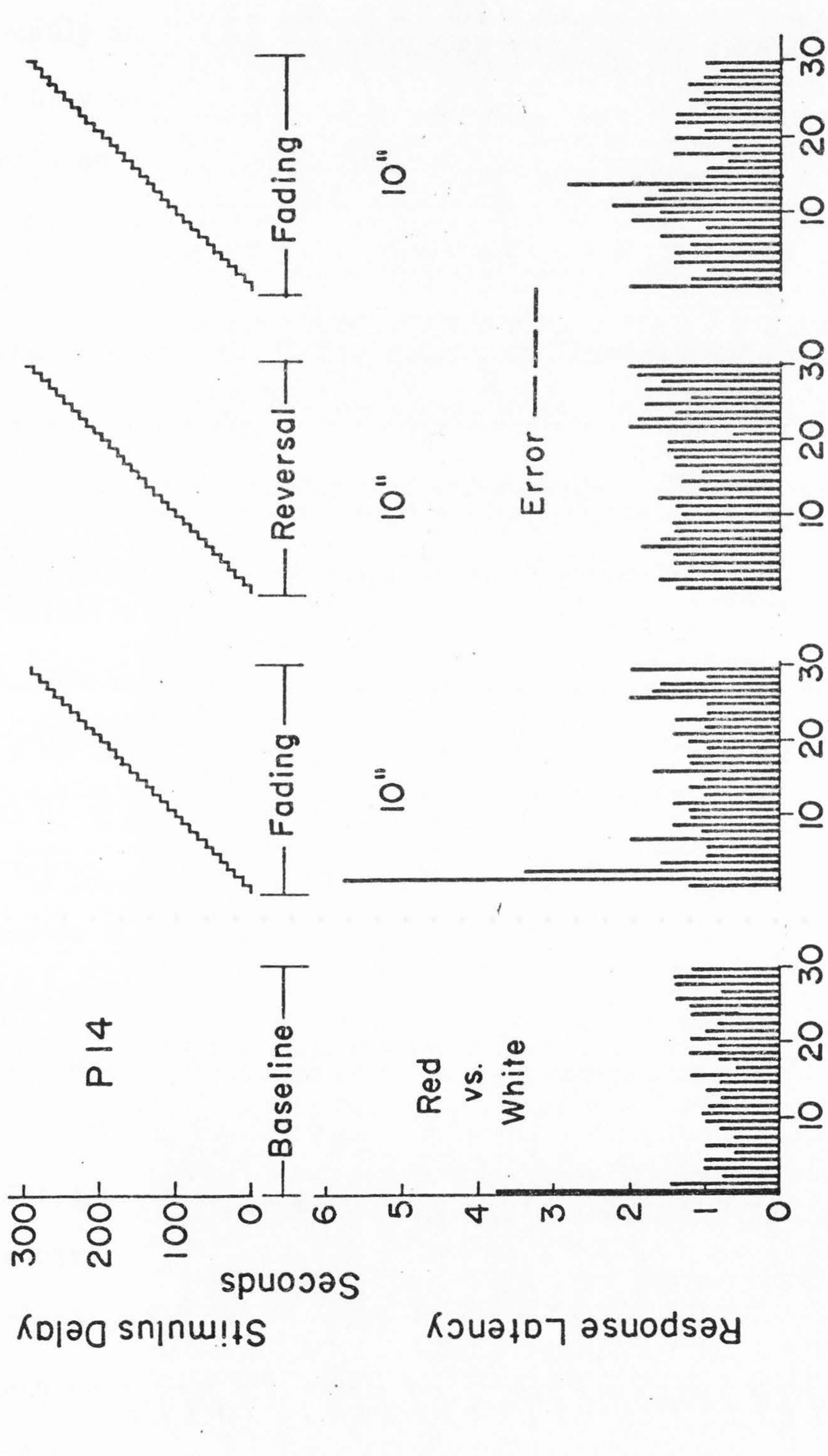
P 12
Stimulus Delay
Seconds
Response Latency
Stimulus Delay
3.0
2.0
1.0
0
10
8
6
4
2
0
18.0
13.0
8.0
3.0
Baseline
Fading
Reversal
Fading
Red
vs
White
Error
.1"
.1"
.1"
10
20
30
10
20
30
10
20
30
40
50
60
10
20
30
Trials

Figure 14. Response latencies in seconds for P13, with 10 sec. delay step. Response latencies are from trial onset and the point at which the original stimulus dimension was introduced is shown in the upper portion of the graph. Solid black lines indicate correct responses and dashed lines indicate errors. The top line steps up or down in correspondence with correct or incorrect responses.



P 13
Stimulus Delay
Seconds
300
200
100
0
Response Latency
6
5
4
3
2
1
0
Baseline
Fading
Reversal
Fading
Red
vs.
White
10"
10"
10"
Error
10
20
30
Trials

Figure 15. Response latencies in seconds for P14, with 10 sec. delay step. Response latencies are from trial onset and the point at which the original stimulus dimension was introduced is shown in the upper portion of the graph. Solid black lines indicate correct responses and dashed lines indicate errors. The top line steps up or down in correspondence with correct or incorrect responses.


P 14
Stimulus Delay
Seconds
300
200
100
0
Baseline
Fading
Reversal
Fading
Response Latency
6
5
4
3
2
1
0
Red
vs.
White
10"
10"
10"
Error
10
20
30
Trials

Several conditions created by the different steps of delay may be responsible for these variances in performance. First, the extremely short delay, i.e., .1 sec., presents the subject with a display where the new stimulus dimension is available alone very briefly on the first few trials. In this respect, the fading program resembles an errorless discrimination procedure where an unreinforced stimulus is introduced briefly and gradually increased in duration. As the temporal delay increased to the point of a participant's response latencies during baseline, the participants began to delay their responses further. This process slowly continued until the discrepancy between when a reinforcer was obtained and was available was relatively great, i.e., approximately 15 secs. for one subject. Then transfer occurred.

On the other hand, the participants who experienced 10 sec. step of delay were confronted on the first trial with the two dimensions, old and new, and on the second trial with only the new dimension for 10 secs. Both participants emitted latencies of approximately 1 to 2 secs. during baseline, and responded to the new dimension on the second trial within 6 secs. and within 3 to 4 secs. on the third trial. Subsequent response latencies were even shorter and closely resembled that obtained during the red vs. white baseline. Both P13 and P14 transferred errorlessly throughout their experimental experience, indicating that on the first trial of each fading series, they attended to both stimulus dimensions, a necessary prerequisite for transfer of stimulus control according to Ray and Sidman (1970). On the second trial when confronted apparently with only the new dimension, both participants responded to it appropriately.

CHAPTER VIII

Discussion

The current research demonstrates that temporal fading procedures are a reliable, although complexly controlled, method of achieving a transfer of stimulus control from one dimension to another. Of interest is the implication some of the current findings have regarding the nature of a stimulus control transfer in a fading series.

The current research supports the findings of Fields, Bruno, and Keller (1976) who demonstrated that new stimuli acquire dimensional control in two sequential stages. First, the combined original stimulus and the new element control responding and second, the new stimulus alone controls responding. A similar process has been suggested by Ray and Sidman (1970) as controlling stimulus-response relationships.

The current research would indicate that the two-stage process can occur in as few as two trials. For example, in Experiment III two participants had a 10-second delay prior to the onset of the original stimulus dimension on the second trial of each fading series. The first trial consisted of the original and new stimulus dimension presented simultaneously. On the second trial of each fading series, both subjects transferred, i.e., six transfers out of six series. In this case, the participants apparently attended to both dimensions on the first trial, and then based their responding solely on the new dimension on the second trial with no errors.

The literature (Fields, et. al., 1976; Touchette, 1971) and the current research suggests that many steps of a fading program may be superfluous, in that only two trials are necessary to achieve an errorless transfer. However, difficulty arises in attempting to specify the critical trials in a fading procedure. The subjects may vary widely in their point of transfer in the fading program and consequently the critical trials for any one subject may be impossible to predict prior to his experience with the program.

Experiment II indicated that the aspect of a temporal fading procedure that produces a transfer of stimulus control may be the relative delay of reinforcement between two stimulus dimensions. De Villiers (1977) in reviewing work on choice and concurrent schedules criticized Chung and Herrnstein's (1967) study on the grounds that the pigeons' choice may have been influenced more by rate of reinforcement than by relative delay of reinforcement per se. Overall rate of reinforcement may be an important variable as density of reinforcement increases when the subject transfers to the new stimulus dimension.

The current research demonstrated that when overall density of reinforcement is controlled and equal delays of reinforcement are imposed locally for a response to either stimulus dimension, transfer of stimulus control does not occur. In addition, when one participant, P7, was placed on the usual variable length trial with immediate reinforcement to either stimulus dimension, he did not transfer but instead remained with the original stimulus dimension as he had done in the two prior conditions. P7's last experience was accompanied by an increase in overall reinforcement density as the length of trials was not fixed. However, this was not sufficient to produce transfer.

The current research defined delays for reinforcement in terms of the delay from the onset of a trial, when reinforcement is available, to the occurrence of a response which produced the reinforcer. Shimp (1969) systematically replicated Chung and Herrnstein's study and placed a response requirement after the delay blackout to obtain reinforcement. His results showed that two of the three pigeons still matched relative response rates to the relative reciprocal of delay. However, since there was no time interval imposed between the last peck and food presentation, Shimp argued that delay of reinforcement was not the critical variable in Chung and Herrnstein's experiment.

A similar criticism could be made of the current research if delay of reinforcement only denoted delays between a response and its subsequent reinforcer. In the temporal fading procedure there was no delay of reinforcement in this sense as a correct response was always followed by a reinforcer. Consequently, the differential between the two stimulus dimensions, i.e., a delay from the onset of a trial to the availability of a reinforcer, appears to be a controlling variable in determining a transfer of stimulus control. Delays of reinforcement between response and reinforcer did occur for the subjects in Experiment II under the delayed reinforcement condition (see Appendix 1). However, these delays were a result of a fixed trial length which was employed to remove the differential delay between the original and the new stimulus dimension.

Whether or not inhibitory stimulus control enters into the process of producing a transfer in stimulus control remains questionable. The current research (Experiment I) demonstrated that while sufficient, inhibitory stimulus control is not necessary to produce transfers. When presumably neutral stimulus backgrounds were employed in a temporal fading procedure subjects transferred readily and without errors. At the same time, the neutrality of the stimulus backgrounds in Experiment I may be questioned. No independent demonstration that the blue stimulus functioned as a non-aversive stimulus was conducted and an appropriate conclusion may be that the blue background was just as aversive as the original S- dimension since the results were similar.

Overall, the current research points to the relative delay of reinforcement from the onset of a trial as being the primary determinant of the transfer of stimulus control in a simultaneous visual discrimination task. The step by which the delay increases is an important factor in determining the point at which a participant will transfer in a fading series and the use of very high steps of delay offers evidence supporting a two-stage analysis of stimulus control transfer.

Future research should examine the possibility of two trial transfer in physical fading procedures, employing superimposition of old and new stimulus dimensions for only one trial. Also, the present research indicates that further research is needed to more fully understand performance under fixed delays of reinforcement versus relative delay of reinforcement in simultaneous discrimination tasks.

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Appendix

Table 3

Delays of reinforcement incurred by P7 during fading conditions.

Session #2		Session #3	
5.4		4.2	
7.3		4.9	
2.4	10 sec	5.2	
5.6		5.0	
4.1		5.3	
13.9		5.0	
11.0		4.7	
11.0		4.9	
9.1		4.7	
7.6	20 sec	5.4	
8.1		5.4	
7.0		5.0	
5.7		5.4	40 sec
4.4		4.9	
3.0		5.3	
12.4		5.2	
11.3		5.4	
9.3		3.6	
9.0		4.9	
7.3	30 sec	4.4	
6.4		5.1	
2.6		5.3	
4.6		5.9	
3.9		5.2	
2.7		3.3	
11.3		5.4	
10.3		5.3	
8.9	40 sec	4.6	
8.3		4.9	
7.6		5.7	

Table 4

Delays of reinforcement incurred by P8 during fading conditions.

Session #2

Session #2	
6.7	
7.2	
6.0	10 sec
5.7	
5.2	
13.4	
13.1	
12.0	
10.9	
10.1	20 sec
9.2	
8.4	
7.2	
6.1	
5.2	
14.1	
17.0	
12.2	
11.1	
10.1	30 sec
9.0	
8.1	
7.2	
6.0	
4.9	
13.6	
12.5	
11.2	40 sec
10.5	
9.4	

Session #3

Session #3	
8.6	
8.9	
7.0	
8.9	
8.0	
8.9	
9.1	
9.1	
9.1	
9.1	
9.1	
9.1	
9.1	
9.1	
9.1	40 sec
9.2	
32.6	
9.2	
9.1	
9.1	
8.8	
7.0	
9.1	
9.1	
9.1	
9.2	
9.1	
9.2	
9.2	

Table 5

Delays of reinforcement for P9 in the control condition of Red vs. White.

Session #2		Session #3	
8.1		37.9	
No Response		37.9	
4.0	10 sec	37.2	
1.1		38.0	
8.0		34.9	
16.1		38.4	
13.4		39.0	
14.5		30.7	
17.9		37.6	
15.4	20 sec	35.0	
14.9		36.6	
16.1		39.0	40 sec
16.6		33.1	
13.2		28.4	
18.7		39.6	
27.4		32.2	
27.4		15.9	
27.2		38.4	
25.7		26.7	
26.7	30 sec	36.4	
17.5		35.9	
26.0		36.1	
27.4		35.2	
27.1		38.1	
No Response		34.9	
23.7		No Response	
35.1		34.9	
37.7	40 sec	No Response	
36.6		37.6	
37.7		37.1	

Table 6

Delays of reinforcement for P10 in the control condition of Red vs. White.

Session #2	
9.0	
9.1	
9.1	10 sec
9.0	
9.3	
18.7	
18.9	
18.7	
19.1	20 sec
18.9	
19.0	
18.9	
18.6	
18.6	
29.1	
29.0	
28.7	
29.0	
28.0	30 sec
29.0	
27.6	
29.6	
28.9	
28.4	
38.9	
38.7	
39.0	40 sec
38.9	
38.9	

Session #3	
39.0	
38.6	
38.4	
37.3	
37.6	
38.6	
38.0	
38.9	
38.9	
38.1	
38.7	
38.0	
38.6	
38.7	
38.9	40 sec
39.0	
33.4	
38.7	
38.1	
39.1	
39.1	
37.4	
38.9	
38.0	
38.4	
37.2	
38.6	
38.9	
38.6	
37.7	

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B.A., 1969	Eastern Washington State College Cheney, Washington	1967-1969
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Experience:

January 1975 to August 1977. Director, Department of Psychology at Woodward State Hospital-School serving approximately 750 mentally retarded persons. The department of psychology consists of nineteen positions, ranging from technician to journeyman psychologist positions, including both Masters and Ph.D. psychologists. Also, an internship program is shared with Drake University for four graduate interns each semester. The department is responsible for providing psychological services to the Treatment Program Areas (4), the Diagnostic Evaluative Clinic, and the Short Term and Respite Care Unit, along with the Traveling Team. Services include routine assessments of intellectual and adaptive behavior functioning levels; program design, implementation, and maintenance for individuals, wards, buildings, or Treatment Program Areas. Treatment is primarily based on principles of applied behavior analysis.

From April thru August, 1976, I served as an acting Treatment Program Administrator, in addition to regular duties. The position is one of functional supervision over a wide range of professionals comprising an inter-disciplinary treatment team including social workers, psychologists, M.D., RN's, LPN's, as well as direct care staff (approximately 150) and other specialized positions. The Treatment Program Areas are the major service units for residents and assume responsibility for resident services and welfare.

Committee work: Chairman, Research Review Committee (WSHS); Member, Human Rights Committee (WSHS); Chairman, Division of Mental Health Resources Committee on Aversive Conditioning. Developed the Division's current policy on use of aversive conditioning in MR and MH institutions in Iowa.

September 1974 to December 1974. Acting Director, Department of Psychology and Diagnostic-Evaluative Clinic Psychologist. During this time the department duties were the same as described above. The Diagnostic-Evaluative Clinic responsibilities include providing intellectual and adaptive behavior assessments for clients of the Diagnostic-Evaluative Clinic, usually 3-4 per week, and developing recommendations for programming and placement within the community as well as follow-up on previous placements from the Short Term and Respite Care Unit.

September 1973 to September 1974. Diagnostic-Evaluative Clinic Psychologist and Programming Consultant, Short Term and Respite Care Unit (STTRC). The D-E duties were as described above. The STTRC duties include individual program design for behavior problems, ward, school, and home settings, parental consultation and training for control of behavior problems during visitation periods and subsequent to discharge. The STTRC unit serves the communities in the northern half of Iowa for intensive programming needs and respite care on a one to three month basis.

January 1973 to June 1973. Intern, Manpower Development Service (one-half time). Duties included conducting analysis of manpower and employee-employer relationship problems in various industries and recommending and/or implementing programs for behavioral change.

July 1972 to January 1973. Manager, Human Behavior Lab, Utah State University (one-half time). Supervised research with children, maintained electro-mechanical, solid state and digital computer programming equipment (under the direction of Dr. J.G. Osborne, USU).

September 1970 to June 1972. Research Assistant, Animal Behavior Research Lab, Utah State University (one-half time). Conducted research on social schedules of reinforcement, taught classes in psychological instrumentation and managed programming equipment (under the direction of Dr. R.B. Powers, USU).

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Increasing Work Behavior in Retarded Adolescents. Paper presented at Minnesota Association for the Advancement of Behavior Therapy, Brainard, September 1974, with Makarowski, L.M., and Mundy, J.A.

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Self-Government of Mealtime Behavior with the Mentally Retarded. Paper presented at Midwestern Association of Behavior Analysis, Chicago, May 1976, with Scott Parker and Susan Goodwin.

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