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Behavioral Contrast in Children

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BEHAVIORAL CONTRAST IN CHILDREN

by

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ABSTRACT

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The present study was conducted as a systematic replication of earlier work investigating the phenomenon of behavioral contrast. Behavioral contrast has been consistently reported in alternating two component multiple schedules using infra-human subjects. The present study was interested in answering the question, "Does behavioral contrast exist in humans?"

Two experiments were performed which investigated the behavioral contrast and sequential contrast phenomena in children. In both experiments, lever press responses were analyzed using an ABA single-subject design. The children were instructed to press a lever to obtain as many tokens as possible. In Experiment I, six Ss were equally divided into two groups of three subjects each. Group I, the mult VI EXT group began the experiment by responding on an alternating two component multiple variable interval (VI) 20 seconds, extinction (EXT), mult VI EXT, schedule of reinforcement. Following stabilization of response rates on a mult VI EXT schedule, Phase I, the three Ss in this group progressed through Phase II, a mult VI

20 second schedule of reinforcement, and Phase III, a mult VI 20 second EXT schedule of reinforcement. Group II, the mult VI VI group began the experiment by responding on a mult VI 20 second VI 20 second schedule of reinforcement. Following stabilization of response rate on the mult VI VI schedule, Phase I, the three Ss in this group progressed through Phase II, the mult VI 20-sec EXT schedule of reinforcement, and Phase III, a mult VI 20 second VI 20 second schedule of reinforcement.

Behavioral contrast, in an alternating two component multiple schedule, defined as an increase in response rate in one component accompanying a decrease in response rate in the alternate component was observed in Experiment I. Regardless of the sequence of exposure to the multiple schedule, all Ss showed similar response patterns under the same multiple schedules. For example, an increase in response rate in the unchanged VI component was observed in all Ss when the response rate in the alternating EXT (previously VI) component decreased (positive behavioral contrast). A decrease in response rate in the unchanged VI component was also observed in all Ss when an increase in response rate in the alternating VI (previously EXT) component occurred (negative behavioral contrast).

The appropriate change in response rate in the second component of a multiple schedule appeared to be prerequisite for the occurrence of behavioral contrast whether it be a decrease in responding when the second component programmed EXT or a stable response rate when the second component programmed a VI 20 second reinforcement schedule.

In Experiment II, three Ss were exposed to a mult VI 20 second EXT schedule of reinforcement the components of which were presented in a random sequence. Sequential contrast, defined as a greater reponse rate during S+ when an S+ is preceded by an S- component than when S+ is preceded by other S+ components was not consistently observed in the present experiment. One of three subjects exposed to the sequential contrast experiment showed a consistently higher rate of responding during S+ components that followed an S- component than when an S+ component followed another S+ component, but the other two Ss in the experiment failed to emit response patterns characteristic of sequential contrast.

(90 pages)

Introduction

"A multiple schedule of reinforcement consists of two or more alternating schedules of reinforcement with a different stimulus present during each" (Ferster and Skinner, 1957). In a multiple schedule, an organism may be trained to engage in several different kinds of behavior. Each behavior is preceded by a different stimulus which can be presented one at a time in a regularly or randomly repeating series (Herrnstein and Brady, 1958).

Reynolds (1961a) observed that a pigeon's rate of key pecking in the first component of a multiple schedule may be altered by changing only the schedule of reinforcement associated with the second component schedule. This change in responding, Reynolds observed, brought about by changing the schedule associated with the alternate component of a multiple schedule is called an interaction. In a two component multiple schedule, when the change in rate of responding in the presence of one stimulus is in a direction away from the rate of responding generated during the presentation of the other stimulus, this change in rate of responding is called contrast or behavioral contrast.

Behavioral contrast was first described by Pavlov (1927). He wrote:

> The secretory effect was increased almost 50 per cent when the positive conditioned stimulus was applied immediately after the termination of the inhibitory stimulus, and the latent period of the reflex was definitely shortened (p. 189).

Pavlov suggested this increase in amount of salivation during the positive conditioned stimulus that followed an inhibitory stimulus trial was a consequence of inhibition that had been evoked during the inhibitory stimulus. He referred to this phenomenon as "positive induction." Skinner later referred to positive induction as "contrast" (Skinner, 1938) and included in this concept certain changes in response rate to a discriminative stimulus during the acquisition of a discrimination. Results similar to those found by Pavlov (1927) and Skinner (1938) have been reported by Smith and Hoy (1954), Herrick, Myers, and Korotkin (1959) and more recently Reynolds (1961a), who referred to this phenomenon as "behavioral contrast." Behavioral contrast is commonly observed in a two component multiple schedule. In such a schedule, two alternating stimuli are correlated with independent schedules of reinforcement.

Behavioral contrast has been observed after a change in frequency of reinforcement in the second component of a multiple schedule using positive reinforcement (Finley, 1958; Herrick, Myers, and Korotkin, 1959; Reynolds, 1961a, b, c, d; Schuster, 1959; and Smith and Hoy, 1954); when the second component of a multiple schedule was under the control of an aversive stimulus (Azrin, 1960; Azrin and Holtz, 1961; Brethower and Reynolds, 1962; and Wertheim, 1965); in concurrent schedules (Alfano, 1969; Catania, 1961; and King, 1970); in chained variable interval (VI) schedules (Wilton and Gay, 1969); and in a double chained schedule (Bloomfield and Russell, 1970).

The present study is a systematic replication of behavioral contrast in an alternating two component multiple schedule using children as subjects. This study was conducted because the presence of behavioral contrast in an alternating two component multiple schedule, using humans as subjects, remains largely open to question.

Review of the Literature

Defining the Area

Behavior is seldom found in isolation and behavior emitted by an organism in the presence of one stimulus might be quite different from the response made when another stimulus is added (Catania, 1963). The behavior of an organism in a complex situation cannot be predicted on the basis of the behavior which was emitted in a simple situation. A simple one to one relationship between behavior under simple and complex situations does not seem to exist. This is one reason why a study of behavior in a complex situation is necessary.

Within the framework of operant conditioning, a type of complex stimulus situation is found in a multiple schedule. When an organism is exposed to a multiple schedule, two independent stimuli set the occasion for different consequences to be programmed. Each independent schedule of the multiple schedule, when presented comes to control the behavior of the organism. For example, in a multiple schedule consisting of FI and FR (mult FI FR) the FI component would be expected to produce typical FI responding followed by typical FR responding. However, in addition to the schedule of reinforcement in effect, the preceding schedule of reinforcement may also acquire some control over behavior. Reynolds (1961a) defined this combined effect of two independent schedules of reinforcement as an interaction.

Reynolds (1961b) set forth a useful classification for interactions which may occur between the components of a multiple schedule. In this system, changes in response rate are classified in terms of direction of change with respect to both components. With respect to the component in which the change in response rates is observed, an interaction is called positive if the response rate increases and negative if the response rates decreases. With respect to the other component, an interaction is called induction if the change in rate is toward the rate prevailing in the other component, and contrast if the change in rate is away from the rate prevailing in the other component. It is the second type of schedule interaction (contrast) which is under the investigation in this study. Behavioral contrast is defined in this paper as an increase in the response rate during one component of a multiple schedule (S+) accompanying a decrease in the response rate in the alternate component of a multiple schedule (S-).

Contrast was first reported by Pavlov (1927, p. 188) as "positive induction." Skinner (1938, p. 175) later referred to this phenomenon as "contrast" and Reynolds (1961a) added the term behavioral to complete the term as it is most commonly used today, behavioral contrast. Prior to Reynold's investigation of behavioral contrast, induction or generalization was viewed as the predominant type of interaction in discrimination learning (Mash, 1969). Contrast, according to Skinner (1938, p. 175), "is a temporary phenomenon appearing at only one stage of discrimination learning . . . it is doubtful whether contrast is a genuine process comparable with induction."

Hilgard (1956) also considered generalization as the only major interaction involved between two stimuli. Thus when the early work of Reynolds (1961a, b, c, d), brought to the fore the reliability of the behavioral contrast phenomenon some of the basic theoretical ideas of discrimination learning had to be reexamined. Thus even though behavioral contrast was reported earlier by Pavlov and Skinner, only recently has it been investigated as an independent behavioral phenomenon by Reynolds (1961 a, b, c).

Extinction in the Second Component

The systematic investigation of behavioral contrast has primarily been restricted to a free operant procedure where the dependent measure was the response rate of the subject. Behavioral contrast has consistently been observed during discrimination training using various multiple schedules of reinforcement. Behavioral contrast has been reported where the first component of a multiple schedule has been variable interval (VI) (Reynolds, 1961a; variable ratio (VR) (Reynolds, 1961b); fixed ratio (FR) (Reynolds, 1961c); and fixed interval (FI) (Reynolds and Catania, 1961); and the second component of the multiple schedule was extinction.

Two reinforcement schedules often used in a multiple schedule are VI and EXT. On a VI schedule, reinforcement is delivered for the first response following a given interval of time, with the interval varying about a mean time, from one reinforcement to another. Hence, a VI 1-min schedule is programmed to deliver a reinforcer for the first response following a mean interval of one minute.

Smith and Hoy (1954) observed that during the development of an operant discrimination the total number of daily responses remained relatively constant. They attributed this consistency to an increase in responding to the S+ as the response rate during S- decreased. Herrick, Myers and Korotkin (1959) found that when a VI schedule of reinforcement, in the presence of one stimulus, was alternated with a stimulus, in whose presence responding was not reinforced, i.e., a multiple VI EXT schedule (mult VI EXT), the total number of responses in the VI component almost doubled the initial response rate. Each of the two above mentioned experiments are examples of behavioral contrast since an increase in response rate in the VI component was reported in conjunction with a decrease in the response rate in the alternating EXT component.

Reynolds (1961a) trained pigeons to peck a key on a two component multiple schedule of reinforcement in which both components of the multiple schedule were initially correlated with identical VI schedules of reinforcement (mult VI VI). When performance had stabilized in both components, the second component was changed from VI to EXT. When this change occurred, the pigeon's response rates in the unchanged VI component increased as the response rate in the EXT component decreased (behavioral contrast). Reynolds also altered the reinforcement schedule in the second component by introducing a time out (TO) during which the experimental chamber was darkened and no reinforcement delivered. The first session after the change in the second component from VI to TO, all birds showed contrast. The response rate in

TO was near zero, while the rate of responding in the first component (the one correlated with the unchanged VI schedule) increased. Reynolds called this increase in responding in the unchanged component positive behavioral contrast. When the TO component was changed back to VI, responding in the first VI component decreased as the response rate increased in the second, now, VI component. Reynolds labeled this negative behavioral contrast. The response rates in this mult VI VI schedule were approximately equal to the level originally maintained by the mult VI VI schedule. In a subsequent study, Reynolds (1961b) found when mult VI VI or mult VR VR was replaced by extinction in the second component of a multiple schedule, performance maintained by reinforcement in the unchanged VI or VR component increased, and when extinction was replaced by VI or VR in the second component of a multiple schedule, responding in the unchanged component decreased. Reynolds and Catania (1961) discovered that behavioral contrast would occur when other schedules comprised the first component of a multiple schedule with EXT still programmed in the second component. This increase in response rate was observed in three different first component schedules including VI, FI and differential reinforcement of low rates (DRL). The DRL schedule accomplishes the differential reinforcement of low rates by reinforcing a response only if there has been no other response within the preceding specified time interval (Sidman, 1960). Reynold's (1961b) and Reynold's and Catania's (1961) findings are both additional instances in which behavioral contrast has

been observed when one component consisted of a reinforced stimulus and the alternate component consisted of EXT.

Reinforcement Delivered in Both Components

Finley (1958) demonstrated that contrast occurred in a multiple schedule even when reinforcement for responding was delivered in the second component. Finley (1958) and Schuster (1959) using a mult VI 6-min VI 6-min schedule of reinforcement showed that the rate of responding on the VI 6-min schedule of reinforcement in the constant component of a multiple schedule increased when the other component was a VI with a mean interval greater than six minutes. In later studies, Reynolds (1961c) observed behavioral contrast when a VI 3-min schedule of reinforcement was alternated with VI 1.5-min and VI 3-min schedules of reinforcement.

When Reynolds (1961a) programmed a mult VI DRO schedule, called differential reinforcement of other behavior (DRO), he failed to observe behavioral contrast. In a DRO schedule, reinforcement occurs after a fixed time interval has elapsed since the last response. No bar press responses are required for reinforcement and the frequency of reinforcement is inversely related to the rate of responding. A change from VI to DRO, therefore, can result in a decrease in the rate of responding in one component but no decrease in the frequency of reinforcement. When Reynolds changed the second component of a mult VI VI schedule from VI to DRO, he observed no change in

response rate in the first component, even though this change from VI to DRO decreased the rate of responding in the second component.

Nevin (1968) and Reynolds and Limpo (1968) later observed behavioral contrast in a mult VI DRO schedule and pointed out that the rate of reinforcement correlated with the second component in Reynolds (1961a) mult VI DRO schedule increased as much as four fold in the DRO component, during the discrimination training. The increase in the number of reinforcers delivered during the DRO component might have accounted for the absence of an increase in rate of responding during the VI components.

Weisman (1969) maintained equal reinforcement densities when he changed a mult VI VI schedule to a mult VI DRL. Weisman maintained the density of reinforcement in both components and still observed behavioral contrast. Weisman (1970) later investigated a mult VI DRO schedule and found behavioral contrast when he changed a mult VI VI schedule to a mult VI DRO schedule. These findings are in conflict with Reynolds (1961a) but as has been pointed out by Nevin (1968) and Reynolds and Limpo (1968) the number of reinforcers delivered in the DRO component was somewhat different. These experiments have shown that no change, a reduction, or a complete discontinuation of reinforcement in the second component of a multiple schedule can produce behavioral contrast.

Catania (1963) using a concurrent schedule found that varying the magnitude as well as frequency of reinforcement had identical effects i.e., they both produced contrast. Shettleworth and Nevin (1965) discovered

behavioral contrast when they varied the magnitude of reinforcement in a mult VI VI schedule of reinforcement; and more recently, Mariner (1967) has produced contrast in a mult VI 1-min VI 1-min schedule by varying the duration of access to the grain hopper in the first VI component of a multiple schedule. Mariner found that the response rate in the first VI component increased and the response rate in the second VI component decreased when the access to the grain hopper was varied. Gay and Wilton (1969) using the mult VI 1-min VI 1-min schedule also observed behavioral contrast when the magnitude of reinforcement was varied.

Aversive Control

In an early discrimination study conducted by Dinsmoor (1952), it was concluded that punishment may produce induction instead of contrast. DeArmond (1966) failed to obtain a contrast effect when she used a mult FR FR schedule with punishment superimposed on response requirements in both components. The fact that punishment can change a response's topography by reducing rate of responding was offered as a possible reason for her failure to obtain contrast.

Azrin (1956) used two intermittent schedules of reinforcement with immediate and delayed punishment during the first component of a warning stimulus which alternated with the second component, a background stimulus. He observed an increase in response rate during the presentation of the background stimulus when the response rate in the alternating warning stimulus

decreased due to punishment. These effects were greatest when the punishing stimulus was immediate, but Azrin reports that the compensatory increases in response rate during the background stimulus were neither sizeable nor completely consistent for a given subject.

Brethower and Reynolds (1962) reinforced responding on a mult VI VI schedule until a stable response rate was established. Following stabilization, punishment, in the form of shock, was delivered following each response emitted in the second component. A decrease in response rate was observed during the punishment component and an accompanying increase in response rate was observed during the non-punishment component. The contrast effects reported appeared to be a function of shock intensity. Terrace (1968) has also obtained contrast effects following punishment for responding in one component. In both of these studies the frequency of reinforcement was not altered.

Wertheim (1965) investigated behavioral contrast in a multiple schedule with free operant avoidance responding in both components. He found that increasing the response-shock (R-S) interval in the variable component resulted in a decrease in response rate in that component and an accompanying increase in response rate in the unchanged component. Wertheim recorded these effects as contrast.

Conditions Necessary for the Occurrence of Behavioral Contrast

Guttman (1959) and Reynolds (1961d) both concluded that a necessary condition for the occurrence of contrast is differential reinforcement, but not

necessarily extinction, in the presence of two or more discriminative stimuli. Terrace (1963b) proposed that a necessary and sufficient condition for contrast seems to be the advent of responding to S- (a component where no reinforcement is delivered) during the formation of a discrimination. He based his inference upon the fact that no contrast was observed when pigeons were trained using a special training procedure known as "errorless" training (Terrace, 1963a). In "errorless" training, Terrace found "errors" (responses to S-) were not necessary to the formation of a color discrimination. The absence of responding to the S- component was accomplished by first having the S- available for a short duration, differing in both color and brightness from the S+. Brightness and duration were then gradually faded in until the only difference in the S+ and S- was the color. This fading procedure eliminates both errors and behavioral contrast. Terrace (1966) further stated that a sufficient condition for behavioral contrast is the reduction of responding to one component of an alternating multiple schedule whether accomplished by nonreinforcement, punishment, or a reinforcement contingency requiring a low rate of responding. Reynolds (1961c) and Catania (1961) proposed that a change in the relative rate of reinforcement in each component of a two component multiple schedule produced contrast, but Reynolds and Limpo (1968) later concluded that rate and relative frequency of reinforcement are only weak variables that influence behavioral contrast. Reynolds and Limpo (1968) found that four times as many reinforcers were needed to prevent the occurrence of contrast when the second component of a multiple schedule was DRO, than

when it was a VI. Weisman (1970) later confirmed this fact when he observed behavioral contrast in a Mult VI DRO schedule with an equal number of reinforcers present in each component.

Bloomfield (1967) and Nevin (1968) found the frequency of reinforcement in the second component of a two component multiple schedule controlled response rate in the first component thus producing behavioral contrast. Equivalent changes in the frequency of reinforcement resulted in similar effects in response rate in S+ either when the S- schedule produced high rates of responding as in FR or low rates of responding as in DRL or DRO. All of the controlling variables involved in the production of behavioral contrast have not yet been specified, however, the results of the previously reported studies indicate that certain variables are involved in the production of behavioral contrast. Some of the conditons consistently present when behavioral contrast has been observed are differential reinforcement in the presence of two or more stimuli (Guttman, 1959; Reynolds, 1961a); responding during the S- component (Terrace, 1963a) and reduction of responding in one component (Terrace, 1963b).

Use of Multiple Schedules with Human Subjects

Bijou and Orlando (1961), Long (1962) and Staats (1968) have all used multiple schedules with children. Long (1962) states:

> Anyone who has ever run both pigeons and children on a multiple fixed interval-fixed ratio schedule cannot help being impressed by the relative ease with which the pigeon is brought

> under stimulus control and the great difficulty encountered by the child (p. 455).

Despite the difficulty apparent in working with children, Staats (1968) obtained appropriate results from children, in response to multiple schedules in the acquisition of reading. Bijou and Orlando (1961) were successful in obtaining appropriate responding from two mentally retarded children. While these three experiments have used multiple schedules, no attempt was made to ascertain if behavioral contrast occurred. O'Brien (1968) first attempted analysis of behavioral contrast in humans but did not obtain it. However, he reported atypical response rates during S- components in that:

> The multiple schedule used in the study did not produce stimulus control with human subjects. . . (Although) S+ response rates were greater than S- response rates in all sessions . . . the rate of responding in S- was greater than is generally demonstrated in studies with other animals (p. 17).

O'Brien's procedure consisted of presenting each subject with a multiple VI 1-min EXT schedule. The components were five minutes in duration and presented in a random sequence. He attributed his failure to obtain behavioral contrast to the fact that one S had previous training on a mult VI EXT schedule and since contrast is transient, any effects may have already subsided with experience. The other subject showed an increase in responding in the VI component for five consecutive sessions (Sessions two through six) but no decrease in response rate was observed during the EXT component.

Following only one session of exposure to a mult VI VI schedule, Mash (1969) changed the second component of the former mult VI VI schedule

to EXT and analyzed 10 second intervals within his two minute extintion component for behavioral contrast. No behavioral contrast was observed under these conditions or under threat of shock conditions which were presented in the second VI component of a mult VI VI schedule two days later. Mash's experiment lasted only five days with one day's exposure to a mult VI EXT schedule. During the experiment, Mash was unable to obtain a discrimination with his subjects during the mult VI EXT portion of his experiment. Reinforcers in Mash's experiment were points accumulated on counters. It is likely that either the reinforcement delivered or number of sessions given to the subjects in Mash's experiment were inadequate to produce behavioral contrast.

Alfano (1969) and King (1970) have both reported behavioral contrast in humans when they used a two key apparatus to deliver reinforcement under two different concurrent schedules. Both Alfano and King used points accumulated on counters as reinforcers for their college student subjects.

In summarizing experiments which have attempted to demonstrate contrast in humans, it can be stated that behavioral contrast occurs in concurrent schedules (Alfano, 1969, and King, 1970), but behavioral contrast in an alternating two component multiple schedule has neither been reported nor adequately investigated in human subjects.

Sequential Contrast

Jenkins (1961) outlined an alternate method for obtaining an operant discrimination. This alternate method calls for the presentation of the S+ and S- stimulus in a randomly occurring order instead of alternating the S+ and S- stimuli. Jenkins further suggested that the response rate on a mult VI EXT schedule in which the components were presented in a random order did not resemble the response rate of mult VI EXT schedules where the VI and EXT components were simply alternated. Terrace (1966) also presented the S+ and S- stimuli of a two component multiple schedule in a random order. He observed that the response rate in an S+ component which followed another S+ component was lower than the response rate of an S+ component which followed an S- component. Terrace (1966) defined this difference in response rate as sequential contrast.

O'Brien (1968) found similar results with two mentally retarded subjects. The sequential contrast reported by O'Brien occurred in his subjects without evidence of the formation of a discrimination. O'Brien reported an increase in response rate during S+ for five sessions but no decrease in response rate was reported during the S- components. Furthermore, since the S+ and S- were presented in a random order, there is no way of determining from his paper whether the increase in response rate followed an S+ or an S- component or if in fact the increase in response rate constitutes a transition similar to that reported by Long, Hammack, May and Campbell

(1958). They reported that most subjects, when responding on a VI schedule, showed drops in response rates by the third session and then stabilized at this rate for the next several sessions suggesting a transition in the early sessions. Thus, by 1968, sequential contrast had been reported in humans but behavioral contrast had not.

A review of the literature to date does not suggest that behavioral contrast in a two component multiple schedule should be limited to infra-human subjects. The results of experiments which have attempted to produce behavioral contrast with human subjects are not clear. The length of Mash's (1969) experiment might have been a reason for his inability to obtain contrast. In addition, neither Mash (1969) nor O'Brien (1968) obtained a discrimination in their attempts to produce contrast. This might also have prevented the appearance of such. Furthermore, since behavioral contrast was not apparent but sequential contrast was (O'Brien, 1968), it would appear that the two might be functions of different variables. The present paper is written to examine both behavioral contrast and sequential contrast using children as subjects.

Statement of Problem

Bijou and Orlando (1961), Long (1962) and Staats (1968) have all used multiple schedules with children, but did not attempt a systematic analysis of behavioral contrast. O'Brien (1968) failed to find behavioral contrast in two hospitalized mentally retarded adolescents. He attributed this failure to previous experience for one S, and lack of stimulus control for the other S. According to hospital records subject EH had previous training in the experimental room on a variant of the multiple schedule used by O'Brien.

Mash (1969) failed to find behavioral contrast using an alternating two component multiple schedule with college students as subjects. Mash's experiment lasted only five days with but one day's exposure to a mult VI EXT schedule. In addition to the short length of Mash's experiment, both O'Brien and Mash found that their experimental extinction procedures were ineffective in producing extinction. Alfano (1969) and King (1970) have reported behavioral contrast in college students using concurrent schedules of reinforcement, varying the schedules and magnitude of reinforcement respectively.

Sequential contrast defined as a greater S+ response rate when an S+ component is preceded by an S- component than when preceded by an S+ component, has also been observed in rats (Jenkins, 1961; Terrace, 1966) and O'Brien (1968) has reported sequential contrast in children. O'Brien's

findings came from subjects with previous multiple schedule training but with little evidence of stimulus control.

The present study will constitute a systematic replication of two phenomena, i.e., behavioral contrast in an alternating two component multiple schedule and sequential contrast. Behavioral contrast has previously been reported in infra-human subjects and with human adults, the latter under the special procedures of a two-key concurrent schedule of reinforcement. At the writing of this paper, there is no evidence that behavioral contrast exists in an alternating two component multiple schedule in children, yet this case is the most common case reported in the infra-human literature (Bloomfield, 1967; Reynolds, 1961a; Reynolds and Catania, 1961; Terrace, 1963; and Weisman, 1970). The present study investigated how response rates of children are controlled and affected by alternating components in a two component multiple schedule using a single response manipulandum. A demonstration of behavioral contrast in human subjects would be a significant extention of the behavioral contrast phenomenon to different organisms.

Sequential contrast has been reported in infra-human subjects by Jenkins (1961) and Terrace (1966) and O'Brien has reported sequential contrast in two mentally retarded subjects. O'Brien reported, however, the response rates of his two subjects were "atypical" in that the response rate in the EXT component did not show a decrease. It is not clear that O'Brien's results are valid since stimulus control was not obtained in his study. An investigation of sequential contrast in normal human subjects

who come under control of the multiple schedule would extend the information in the area of sequential contrast .

Experiment I

Method

The first experiment was conducted to discern the existence of behavioral contrast in an alternating two component multiple schedule. In particular, human subjects were run long enough to allow their behavior to come under multiple schedule control. An investigation of the behavioral contrast phenomenon in the present experiment is one of the first such investigations of it's kind using human children as subjects.

Subjects

A total of eight, five, six, seven and eight-year-old boys and girls were recruited from the Logan, Utah area for use in this experiment. Three subjects were assigned to each of two groups. The two groups were labeled: (1) mult VI EXT group and (2) mult VI VI group.

One girl (five years, six months) and one boy (six years, six months) did not complete the experiment. The girl failed to reach criterion (see below) on the first mult VI VI sequence and asked to terminate. The boy also asked to terminate following 17 days in the second phase of the experiment. The second phase of the experiment consisted of a mult VI EXT schedule. During the 17 days that the boy was exposed to Phase II of the experiment, no evidence of formation of a discrimination was observed.

Mult VI EXT group. This group was exposed to a two component multiple schedule in the following sequence: mult VI EXT, mult VI VI and mult VI EXT. One boy and two girls comprised this group and all three subjects completed the entire experiment. The ages of Ss in this group ranged from seven years, four months to eight years, three months, with an average age of seven years, nine months.

Mult VI VI group. This group was exposed to a two component multiple schedule in the following sequence: mult VI VI, mult VI EXT, mult VI VI. Two boys and one girl comprised this group. The age range for Ss in this group was from seven years, two months to seven years, ten months with an average of seven years, seven months.

Apparatus

The Child Experimental Laboratory was located in Room 406 of the Education Building, Utah State University, Logan, Utah. Subjects, who were awaiting their turn, stayed in this room. Around the periphery of the room were displayed various backup reinforcers, i.e., small toys, stuffed animals, dolls, race cars, etc. Each toy was marked with the number of tokens required for it's purchase. Three small candy dispensers with plastic fronts contained assorted candy, i.e., small malt balls and chocolate balls, bubble gum, jaw breakers, red hots and boston baked beans. The candy dispensers could be operated with a token. Two other dispensing machines with display windows contained other assorted candies and small trinkets with the number of tokens required for each purchase designated above the item. A soft drink

machine was located in one corner, where several flavors of soft drinks were available. A bank made of plexiglass was mounted on one wall where subjects could save their tokens for the larger items if they so desired. The value of each token was set at approximately one-half cent. The tokens could be exchanged for various back up reinforcers after the session terminated or could be saved and cashed in at some later date.

Along two walls of the waiting room were four small experimental rooms in one of which was contained the experimental console. Mounted on the face of the console were three response levers, and six stimulus lights. Two levers and four stimulus lights were covered from the subjects' view. Red and blue stimulus lights located approximately one and one-half inches above the remaining response lever were the stimulus lights that were used in the present experiment. Each light was separated by two inches. The console housed a Davis Universal Feeder #310 which delivered reinforcers i.e., tokens (five centavo pieces) through a small opening in a three and one-half inches square plate on the face of the console into a tray to the right of the lever. Centered one-half inch above the tray was a yellow light which flashed for 3 seconds in conjunction with the delivery of each reinforcer. In addition to the flashing light, the noise of the feeder operation accompanied delivery of the reinforcer.

Scheduling of the experimental program was controlled by standard electromechanical programing equipment located in an adjoining room. Each lever response was recorded on an electronic impulse counter and a Gerbrands

cumulative recorder. Responses were defined as switch closures requiring 34 grams of force through one-sixteenth inch on a standard Gerbrands lever.

Procedure

All subjects in each of the two groups were exposed to experimental training sessions, Monday through Friday. The experimental procedure consisted of an ABA single subject design. The use of three subjects in each group was not designed for evaluation using group statistical methods of analysis, but rather to add to the reliability of the results by demonstrating that each subject produces the same basic response pattern when he comes under control of the appropriate stimulus.

A multiple schedule of reinforcement was used in which each component of the multiple schedule was two minutes in duration and cued by two stimulus lights. When the red light (always designated S+) was illuminated, a VI 20-sec schedule of reinforcement was in effect. When the blue light was illuminated, either VI 20-sec or EXT was programmed in the second component. The red and blue lights alternated every two minutes until the session ended. When the schedule of reinforcement programmed a mult VI EXT schedule, five S+ and five S- components defined the session. The average time between reinforcers during VI components was 20 seconds and an average of 30 reinforcers were programmed during these sessions. When the mult VI VI schedule was programmed 30 reinforcers defined the session length. A three second DRO protection contingency was placed at the end of the EXT components to insure that responding in the last three

seconds of the EXT component would not accidently be reinforced by the appearance of the next VI component. Thus, any response in the last three seconds of the EXT component would prevent the next VI component from appearing for at least three more seconds.

The instructions given to each subject regardless of the group assigned him were identical. Prior to the first session all Ss were shown the reinforcers and the dispensing devices and told that they could earn tokens to operate the devices and purchase what they wished. Ss were shown the console and the experimenter (E) said, "Watch what I do." The response lever was then pushed by E at an approximate rate of one response per sec until a token was dispensed. E then said, "You can get tokens by pushing this lever. Now you push it and see how many tokens you can get. You will not get a token every time and I will let you know when to stop." Following this brief introduction E left the room. In the first session, all subjects were initially exposed to S+. S+ was programmed to deliver reinforcement on a mult VI 20-sec schedule of reinforcement for each S on their initial exposure to the experiment. This assured the delivery of a reinforcer within the first few seconds that the S was in the room and provided three or four more reinforcers before an EXT component was first introduced. If S left the room during the first extinction component to question if the equipment was functioning properly E answered all questions by saying, "Do what you think is best, I will let you know when to quit." No problems were encountered after the initial exposure to Ss first EXT component.

Mult VI EXT group. The sequence of exposure to the multiple schedule conditions outlined for each subject in the mult VI EXT group progressed through three phases of the experiment. Phase I consisted of a mult VI 20-sec EXT schedule. In Phase II a mult VI 20-sec VI 20-sec reinforcement schedule was in effect and in Phase III a mult VI 20-sec EXT schedule of reinforcement was in effect. Five VI components alternated with five EXT components which defined a daily session during Phase I. After the 10 two minute components had been presented the equipment and stimulus lights automatically turned off, terminating the session. The room was then entered by E who told S, "That completes the experiment for today." The S was then allowed to cash in his tokens or put them in his bank after which time he was taken home.

The criteria required before progressing to the next phase were established a priori and required evidence that a discrimination had been formed. A discrimination was defined as an average of less than 10 per cent of the total responses in the session occurring during EXT components for at least three consecutive days. For example, Ss were shifted from a mult VI 20-sec EXT schedule to a mult VI 20-sec VI 20-sec schedule when an average of less than 10 per cent of the total lever presses emitted occurred during EXT components for a minimum of three consecutive days.

In the second phase (mult VI VI) the Ss were reinforced on a VI 20-sec schedule of reinforcement in the presence of both stimulus components. In this phase, reinforcers were delivered during both the red and blue

stimulus lights which alternated every two minutes until a total of 30 reinforcers had been accumulated for that session. When the 30 tokens had been delivered, the equipment and stimulus lights were automatically turned off at which time the Ss were informed that the session was completed for that day. Ss remained in Phase II until their response rates on the two VI components had stabilized. Stabilization was established a priori and defined as an average of less than 10 per cent variation in response rates between the two VI components over a daily session for two consecutive days.

Following stabilization in the second phase of this experiment, the third phase was introduced. In Phase III the same conditions that existed in Phase I were once again in effect, i.e., a mult VI EXT schedule of reinforcement.

The experiment was terminated after the criteria in Phase III were met. No time requirement was imposed as to the maximum number of sessions required for each subject to complete the experiment.

Table 1 is a summary of the procedures which defined the order prescribed for Ss in the mult VI EXT group.

Mult VI VI group. The procedures outlined for Ss in the mult VI VI group differed from those outlined for the Ss in the mult VI EXT group only in the sequence of the presentation of the multiple schedules. The criteria required for progressing from one phase to the next were identical to the respective phases in the mult VI EXT group. The five Ss in the

TABLE 1

Summary of Procedures for the Mult VI EXT Group in Experiment I

Phase	Object	Condition	Criteria
Phase I	Establish stimulus control and stable responding on a mult VI 20-sec EXT multiple schedule	Red VI 20-sec and blue EXT stimulus lights alternate every 2 minutes.	Average of less than 10% of the responses made in the EXT component for a minimum of three consecutive days.
Phase II	Determine if behavioral contrast can be obtained in children.	Mult VI 20-sec VI 20-sec schedule of reinforcement in effect.	Exposure to mult VI 20-sec VI schedule of reinforcement until the response rate deviated less than 10% within both sessions for two consecutive days.
Phase III	Determine if behavioral contrast can be obtained in children.	Mult VI 20-sec EXT schedule of reinforcement in effect.	Exposure to mult VI 20-sec EXT schedule of reinforcement until the criteria required in Phase I are met.

mult VI VI group were exposed first to a mult VI VI schedule followed by a mult VI EXT schedule, and a mult VI VI schedule again.

Table 2 is a summary of the procedures which defines the order prescribed for Ss in the mult VI VI group.

Results

The response rate accumulated in each daily session for both red and blue stimulus conditions was averaged and reported as the average number of responses emitted during two minute components.

Mult VI EXT group

Figure 1 represents the mean number of responses emitted in two minutes for the three Ss in the mult VI EXT group. The graph is divided into three major sections each section representing one phase of the experiment.

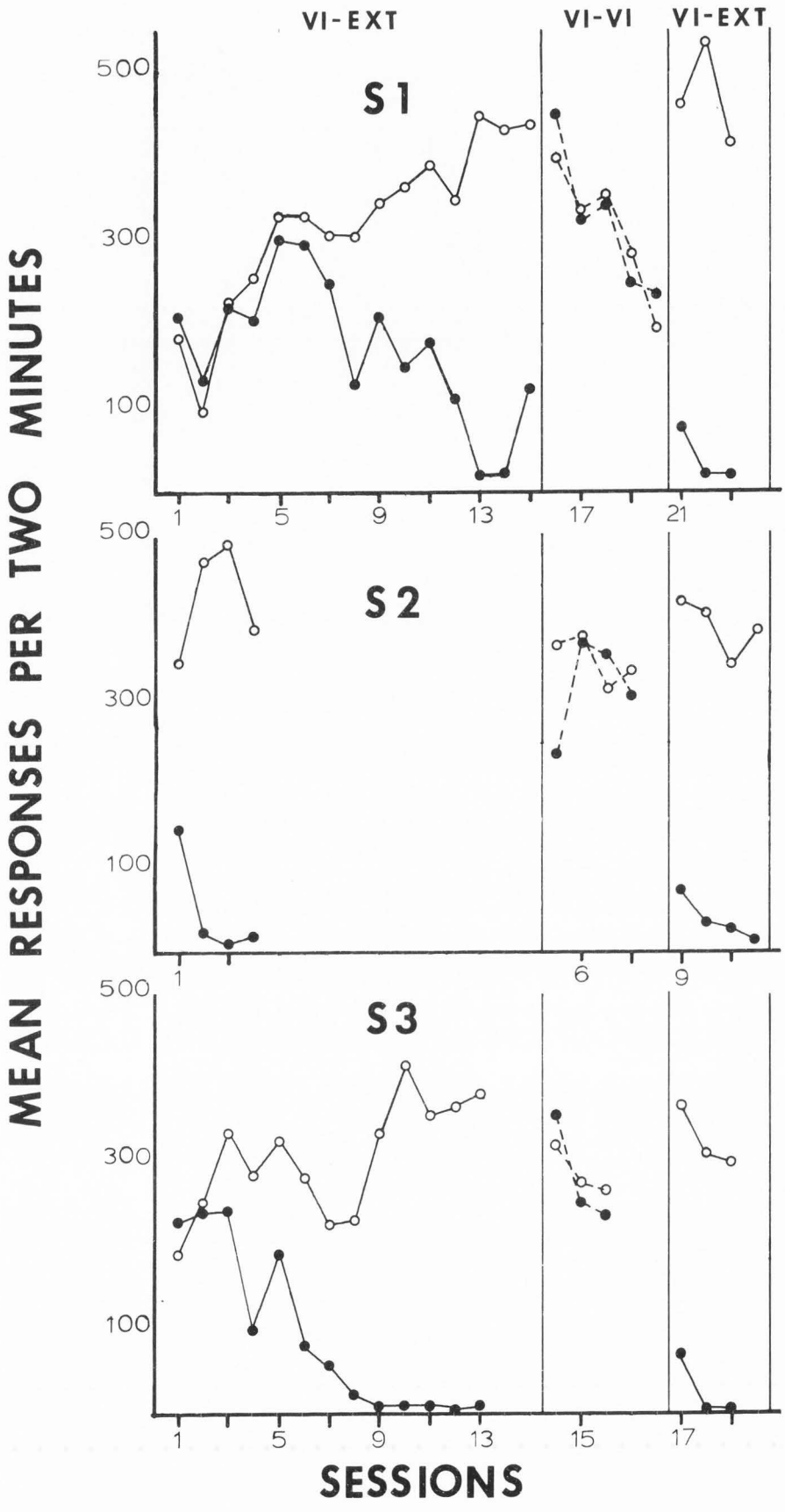
Phase I. Phase I or the first mult VI EXT condition illustrated in Figure 1 shows the development of the discrimination for all Ss. The number of daily sessions required for the acquisition of the discrimination varied from one (S2) to nine (S1) days. As the response rate in the EXT component decreased a concomitant increase was observed in the VI components, but the number of reinforcers received remained the same. The response rate in the VI component in the first phase of the experiment continued to increase until the response rate in the EXT component decreased to approximately 10 per cent of the total responses emitted within the session.

TABLE 2

Summary of Procedures for the Mult VI VI Group in Experiment I

Phase	Object	Condition	Criteria
Phase I	Establish stimulus control and stable responding in a mult VI 20-second VI 20-second multiple schedule.	Red and blue stimulus lights alternate every 2 min with VI 20-sec schedules of reinforcement in effect in each component.	Exposure to mult VI 20-sec VI 20-sec schedule of reinforcement until the response rate deviated less than 10% within sessions for two consecutive days.
Phase II	Determine if behavioral contrast can be obtained in children.	Mult VI 20-sec red EXT blue schedule of reinforcement is in effect.	Average of less than 10% of the responses made in the EXT component for a minimum of three consecutive days.
Phase III	Determine if behavioral contrast can be obtained in children.	Mult VI 20-sec VI 20-sec schedule of reinforcement is in effect.	Exposure to a mult VI 20-sec VI 20-sec schedule of reinforcement until criteria required in Phase I are met.

Figure 1. The average number of responses per two minute components for both stimulus conditions plotted for each daily session. The graph represents the three Ss in the mult VI EXT group. Session numbers are listed on the abscissa. Note that the total number of sessions in each condition for Ss was different. The three phases of the experiment are listed at the top of the graph and represent the multiple schedule condition in effect. The open circles represent responding during the red stimulus light condition and the closed circles represent responding during the blue stimulus light condition.


VI-EXT
VI-VI
VI-EXT
S1
S2
S3
500
300
100
1
5
9
13
17
21
6
15
MEAN RESPONSES PER TWO MINUTES
SESSIONS

S1 showed an overall increase in response rates for the first five sessions at which time the response rates began to separate and were deviating progressively by the ninth session. By the 13th session the response rate in the VI component was approximately double that during the early sessions. The response rates emitted by S3 paralleled those of S1 but she required fewer sessions to meet the maximum deviation in response rate between the VI and EXT components. The discrimination began to form in the initial session for S2. However, a general increase in VI responding along with a decrease in extinction responding was observed over the next three sessions (see Figure 1).

Following the formation of the discrimination the responses that were made in the EXT component were mainly carry over responses from the VI components. In the VI components, as many as four responses per second were being emitted at the end of the S+ component. It was, therefore, not uncommon that 10 to 20 responses were emitted before the subject discontinued responding when the schedule changed from the S+ to the S- component.

Phase II. When a change was made to the second phase, mult VI VI, an immediate increase in the response rate during the previous EXT components occurred (see Figure 1). High rates of responding appeared immediately following the first reinforced response delivered in what was previously the EXT component. The response rate in both VI components became stable, even within the first session for S1 and S3 and in the second

session for S2. A gradual decrease over the next several sessions was observed as the response rate in both components approached the rate of responding observed in the VI component of the early sessions of Phase I. Individual differences in response rates are apparent but similiar patterns of responding were present for all Ss.

Phase III. Visual inspection of Figure 1 shows marked changes in the response rates in both components at the beginning of this phase. The response rate in the unchanged VI component increased as the response rate in the alternating EXT component decreased. The change in response rate occurred for all Ss within the first session following the change in the second component from VI to EXT. The variation among Ss that occurred in the initial formation of the discrimination in Phase I was not present in Phase III. Following exposure to the first EXT component the response rate during the EXT component decreased to near 10 per cent of the total responses emitted for the session.

Phase I. Figures 2, 3, and 4 show the cumulative records produced by three Ss over four different daily sessions. Cumulative record "A" was an early session from Phase I. Moving from "A" to "B" in Phase I, a distinct increase in response rate during the red components can be observed in all three figures. Accompanying the increase in response rate in the red components one can observe an increase in pausing, represented by the plateaus in record "B" during the blue stimulus conditions.

Figure 2. Cumulative records represent S1's performance. Two cumulative records were taken from Phase I and one cumulative record each from Phase II and Phase III. The cumulative record "A" in Phase I was Session 10 and "B" was Session 13. The cumulative record representing Phase II was Session 19 and the cumulative record representing Phase III was Session 20 . The bottom line represents the stimulus condition in effect. In the down position the red stimulus light was illuminated and in the up position the blue stimulus light was illuminated. The small "a" located on the time line was added to call the reader's attention to the difference in slope of the response lines for the four cumulative records.

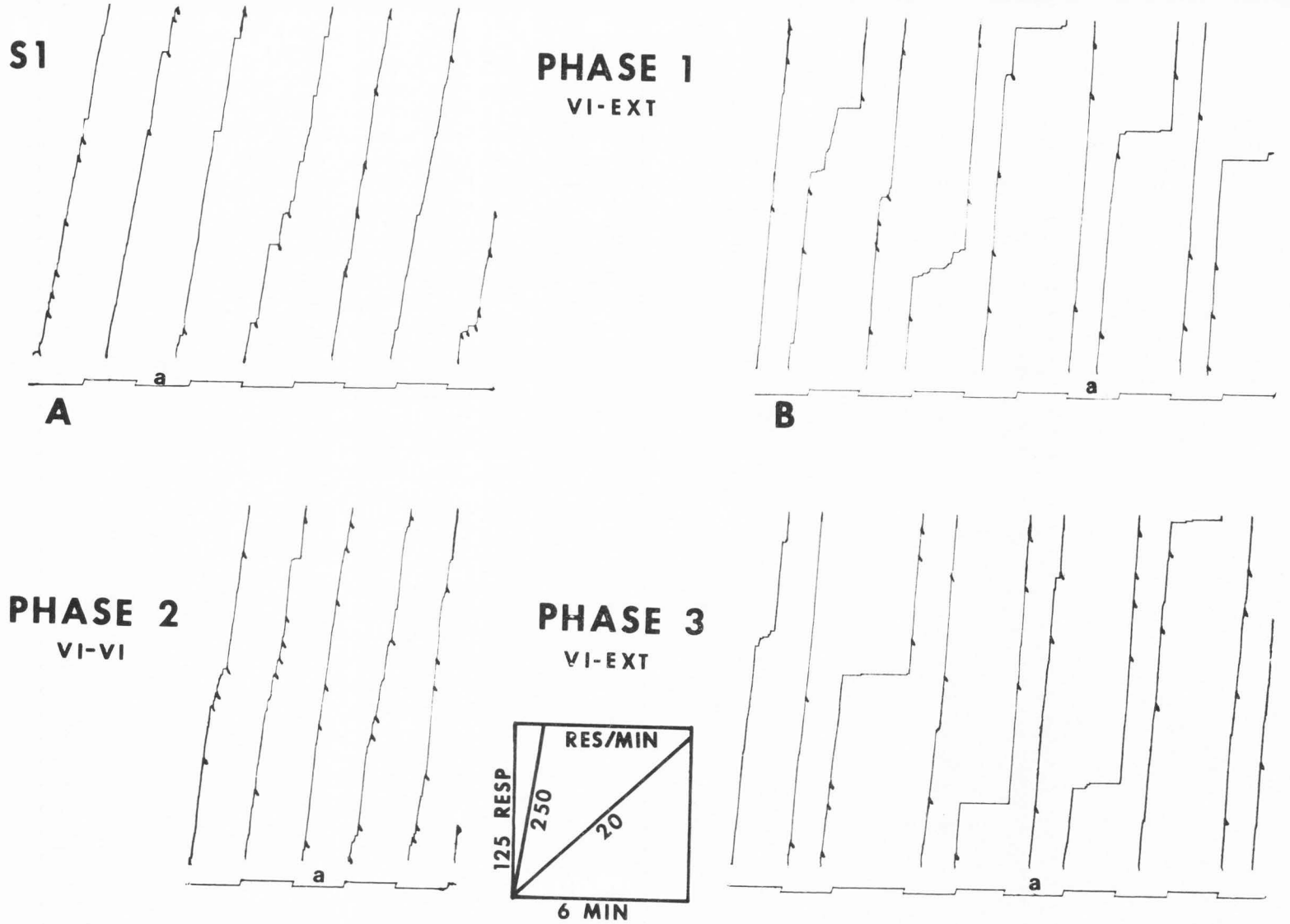
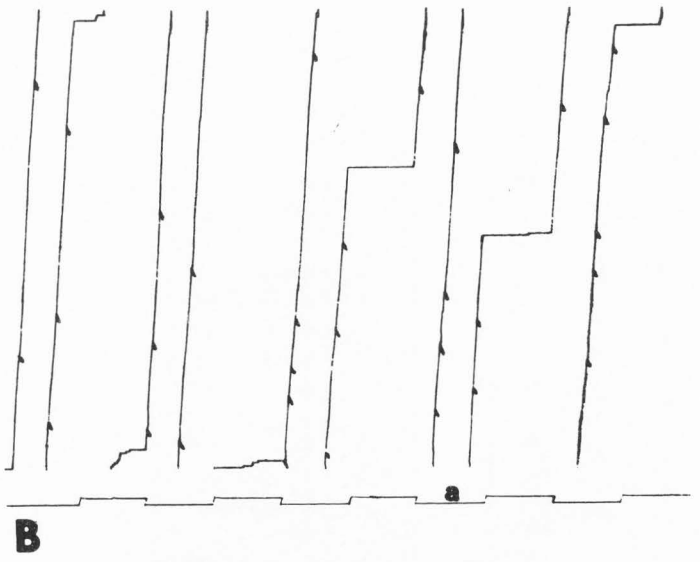
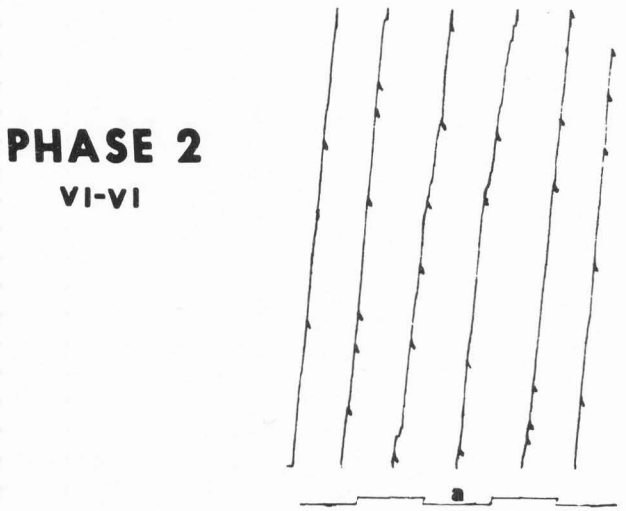

S1
a
A
PHASE 1
VI-EXT
a
B
PHASE 2
VI-VI
a
PHASE 3
VI-EXT
RES/MIN
125 RESP
250
20
6 MIN
a

Figure 3. Cumulative records represent S2's performance. Two cumulative records were taken from Phase I and one cumulative record each from Phase II and Phase III. The cumulative record "A" in Phase I was Session 1 and "B" was Session 3. The cumulative record representing Phase II was Session 8 and the cumulative record representing Phase III was Session 9. The bottom line represents the stimulus condition in effect. In the down position, the red stimulus light was illuminated and in the up position the blue stimulus light was illuminated. The small "a" located on the time line was added to call the reader's attention to the difference in slope of the response lines for the four cumulative records.


S2
a
A


PHASE 1
VI-EXT
a
B


PHASE 2
VI-VI
a

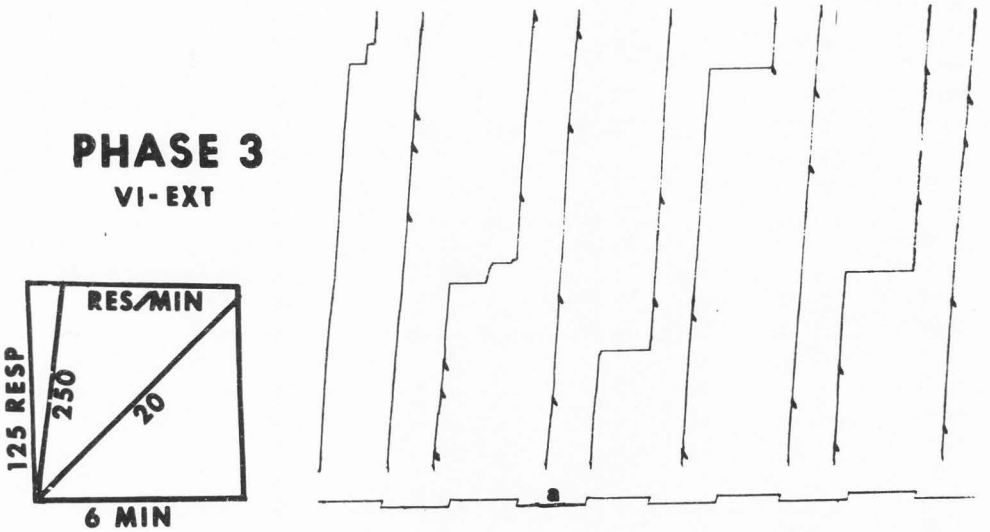
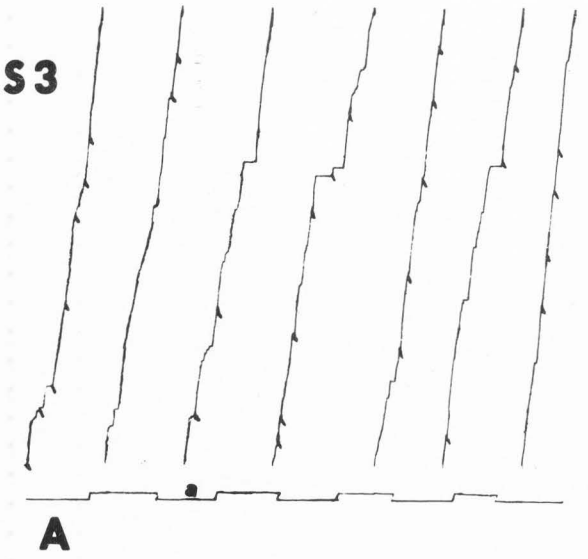
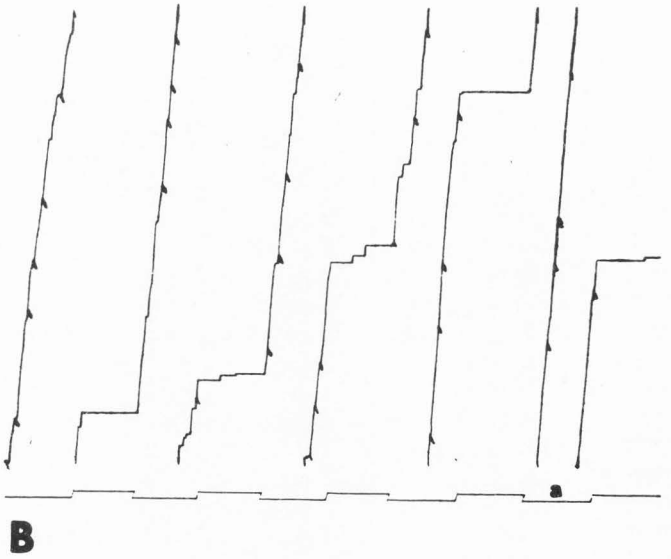

PHASE 3
VI-EXT
RES/MIN
125 RESP
250
20
6 MIN
a

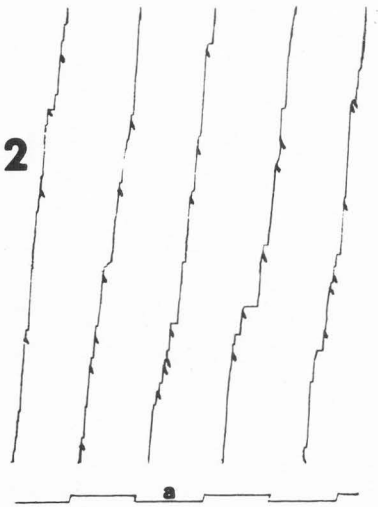
Figure 4. Cumulative records represent S3's performance. Two cumulative records were taken from Phase I and one cumulative record each from Phase II and Phase III. The cumulative record "A" in Phase I was Session 4 and "B" was Session 11. The cumulative record representing Phase II was Session 16 and the cumulative record representing Phase III was Session 17. The bottom line represents the stimulus conditions in effect. In the down position the red stimulus light was illuminated and in the up position the blue stimulus light was illuminated. The small "a" located on the time line was added to call the reader's attention to the difference in slope of the response lines for the four cumulative records.



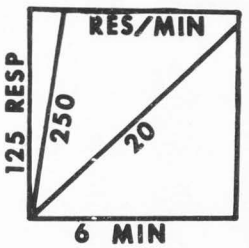
PHASE 1
VI-EXT

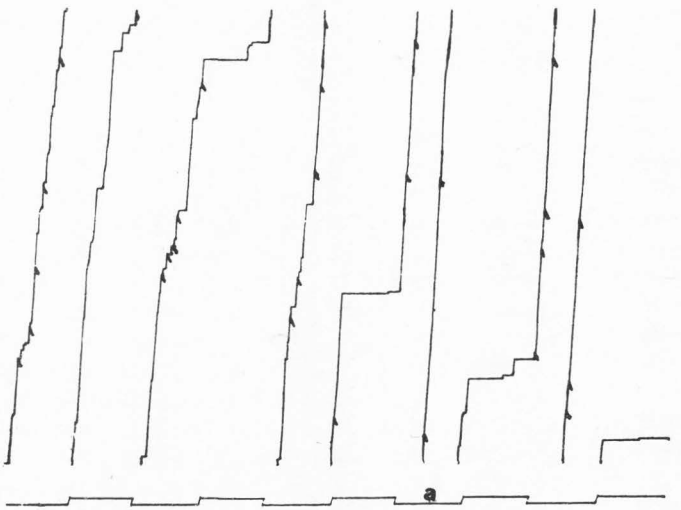


PHASE 2
VI-VI



PHASE 3
VI-EXT





Phase II. In Phase II, the cumulative records shown in Figures 2, 3, and 4 illustrate the change in response rates when the multiple schedule was changed to mult VI VI. By referring to the slope of the response line at the small "a" on the time line of the cumulative record one can observe the response rates in the red, VI components of Phase II are less than the response rate in the red VI components in Phase I. When the last session in Phase I is compared with the first session in Phase II the average response rate per two minute components in the red VI component for S1 decreased from 437 responses in the last session of Phase I to 398 responses in the first session of Phase II. The average decrease in the response rate per two minute components for S2 was from 388 responses in the last session of Phase I to 267 responses in the first session of Phase II. The change in response rate for S3 during the same period was from 382 to 321. The average response rate in the red VI component during Phase II continued to decrease throughout the phase. The average response rate per two minute components for S1, S2, and S3 in the last session of Phase II was 195, 338, and 267 responses, respectively. The pauses during the blue component in Phase I cumulative record "B" are easily observed but these pauses were eliminated in the blue component in Phase II.

When the last session in Phase I is compared with the first session in Phase II, the average response rate per two minute components in the blue EXT component for S1 increased from an average of 124 responses in the last session of Phase I to 449 responses in the first session in Phase II.

In Phase II, the blue component, previously EXT in Phase I, programmed a VI 20 second schedule of reinforcement. The average increase in response rates per two minute components for S2 was from 19 responses in the last session of Phase I to 238 responses in the first session of Phase II. The change in response rate for S3 during the same period was from 10 to 355.

Phase III. The cumulative records of Phase III as seen in Figures 2, 3, and 4 show responses returned to a pattern very similar to that represented in the cumulative record "B" of Phase I. The response rate in the first blue component was initially high, but began to break up even within that very component. When the last session of Phase II is compared with the first session of Phase III a change in the average response rate per two minute component was observed. The response rate in the red VI component for S1 increased from an average of 195 responses in the last session of Phase II to 461 responses in the first session of Phase III. The average increase in response rate per two minute components for S2 was from 388 responses in the last session of Phase II to 422 responses in the first session of Phase III. The change in response rate for S3 during the same period was from 267 to 367. The increase in response rate in the unchanged component can be detected by observing the change in slope of the response lines at point "a". When the response rate in the second component of the last session of Phase II was compared with the response rate in the second component of the first session of Phase III (EXT) a change in the average response rate per two minute components was observed. The response rate in the EXT component

for S1 decreased from an average of 240 responses in the last session of Phase II, to 77 responses in the first session of Phase III. The average decrease in response rate for S2 was from 308 responses in the last session of Phase II to 75 responses in the first session of Phase III. The change in response rate for S3 during the same period was from 236 to 69.

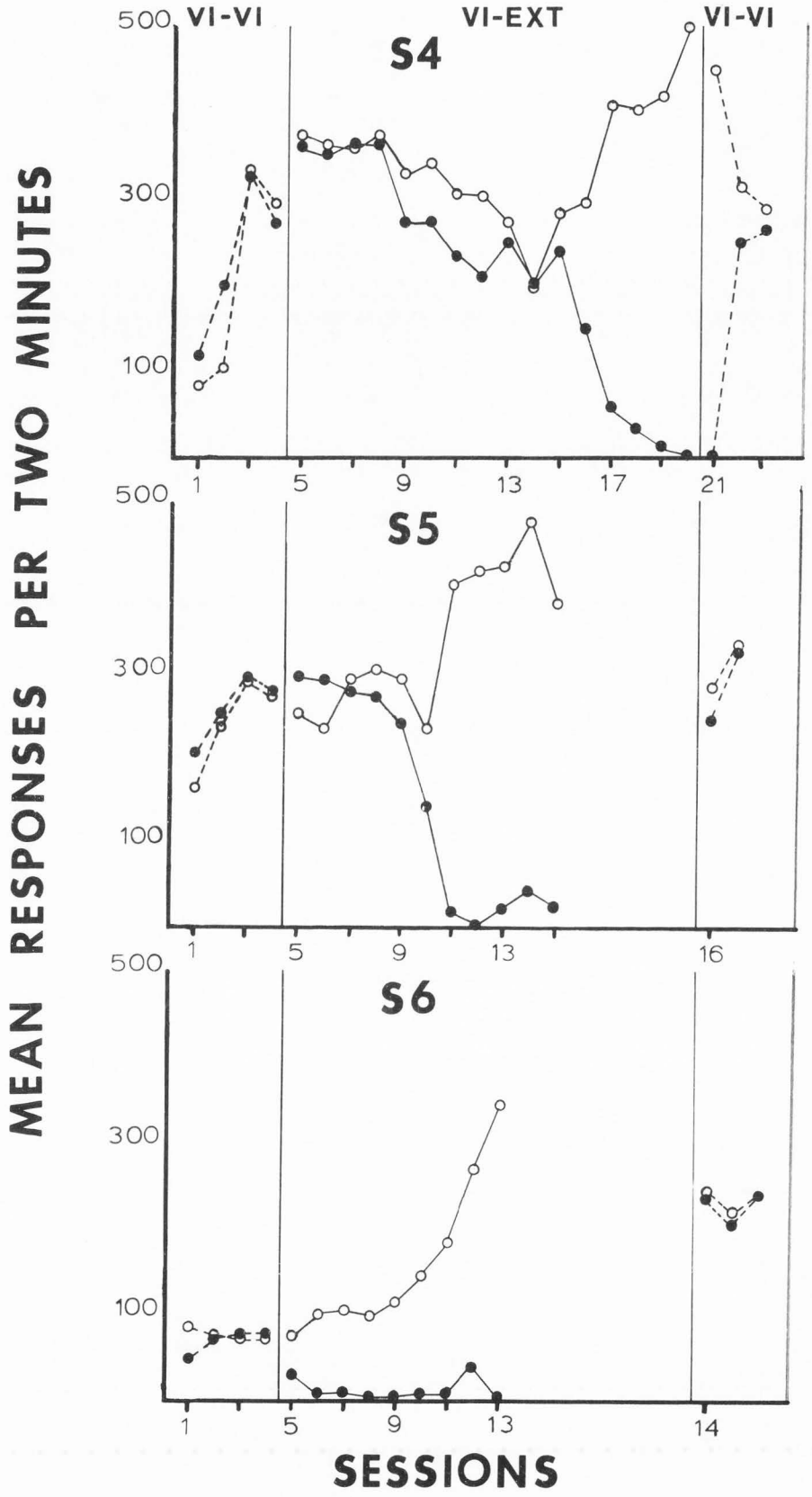
Mult VI VI Group

Figure 5 shows the mean number of responses emitted during the two minute components across daily sessions for the mult VI VI group.

Phase I. Phase I or the first mult VI VI condition illustrated in Figure 5 shows the stability of response rates which existed for the three Ss early in the experiment. The number of responses emitted varied among Ss (see Figure 5, S4 and S6) but stable patterns of responding were established for all three Ss. The response rates across mult VI 20-sec VI 20-sec sessions generally increased for Ss 4 and 5 but remained relatively constant for S6. Nevertheless, the stability criteria were still met by all Ss. The mult VI VI schedule began to control response rates even in the initial session as evidenced by the stable response rates across subjects (see Figure 5, Phase I).

Phase II. When the multiple schedule was changed to Phase II, mult VI EXT, from mult VI VI, the stable behavior in the two components of Phase I was disrupted. All Ss showed a gradual decrease in response rates in the blue, EXT, components along with a gradual increase in response rates in the unchanged VI component. The time required for the

Figure 5. The average number of responses per two minute components for both stimulus conditions plotted for each daily session. The graph represents the three Ss in the mult VI VI group. Session numbers are listed on the abscissa. Note that the total number of sessions in each condition for Ss was different. The three phases of the experiment are listed at the top of the graph and represent the multiple schedule condition in effect. The open circles represent responding during the red stimulus light condition and the closed circles represent responding during the blue stimulus light condition.


VI-VI
VI-EXT
VI-VI
S4
S5
S6
500
300
100
1
5
9
13
17
21
16
14
MEAN RESPONSES PER TWO MINUTES
SESSIONS

discrimination to form varied among the three Ss, but the response patterns across sessions paralleled each other. The number of daily sessions required for the acquisition of the discrimination varied from 2 (S6) to 12 (S4). The maximum number of responses made in the unchanged VI component was observed when the response rate in the alternating, EXT component was at a minimum. The lowest mult VI VI response rate of the three subjects was emitted by S6. Her response rate in the VI component of the mult VI EXT schedule approximately tripled over the rate in the same component of the mult VI VI schedule by the final session of Phase II (see Figure 5). Rates for Ss 4 and 5 were nearly double. The increase in response rate in the VI component occurred with no corresponding increase in the number of reinforcers.

Phase III. During this phase, the schedule was again changed to mult VI VI. Visual analysis of Figure 5 shows a decrease in response rate in the unchanged VI component as the response rate in the alternate VI component increased from what it was during the EXT component in Phase II. The decrease in the response rate in both VI components continued over several sessions, approaching the average response rate in Phase I.

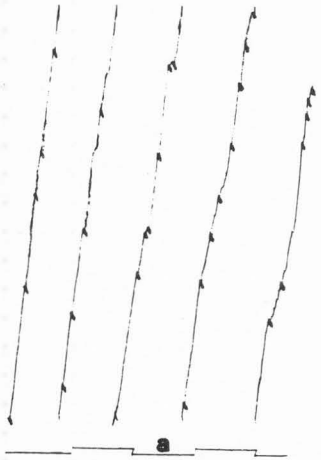
Figures 6, 7, and 8 are cumulative records for S4, S5, and S6. Four cumulative records are presented for each subject. All cumulative records were selected because they were representative of Ss' response rate.

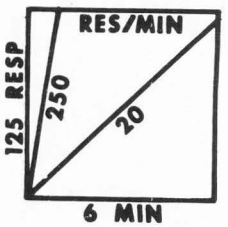
Phase I. Figures 6, 7, and 8 show the cumulative records produced by three Ss in the mult VI VI group over four different daily sessions. Little

Figure 6. Cumulative records represent S4's performance. Two cumulative records were taken from Phase II and one cumulative record each from Phase I and Phase III. The cumulative record in Phase I was Session 4. Cumulative record "A" in Phase II was Session 15 and "B" was Session 20. The cumulative record representing Phase III was Session 23. The bottom line represents the stimulus condition in effect. In the down position the red stimulus light was illuminated and in the up position the blue stimulus light was illuminated. The small "a" located on the time line was added to call the reader's attention to the difference in slope of the response lines for the four cumulative records.

S4

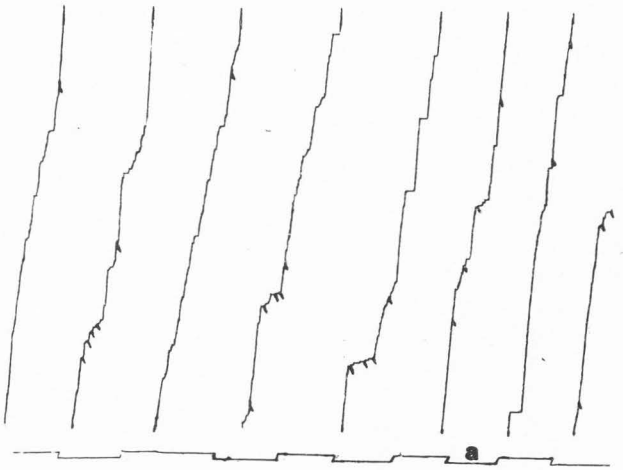
PHASE 1
VI-VI



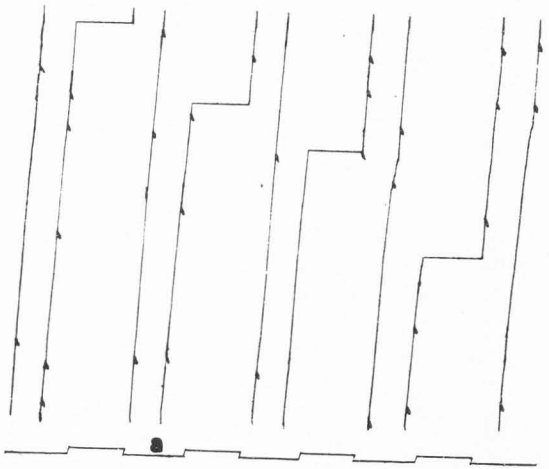


PHASE 2
VI-EXT

A



B



PHASE 3
VI-VI

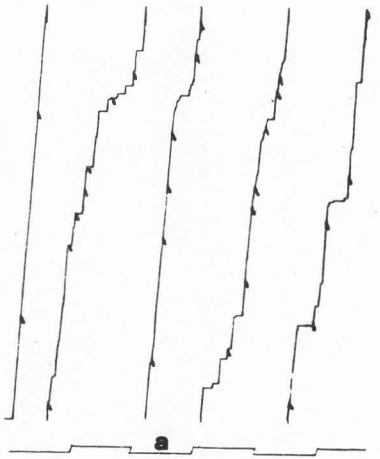
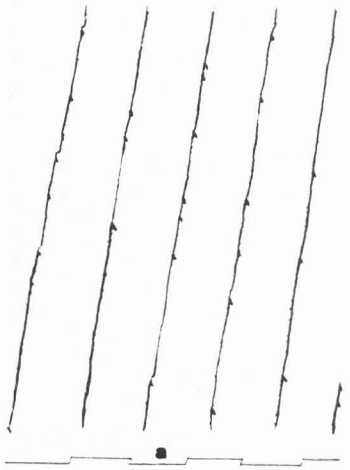
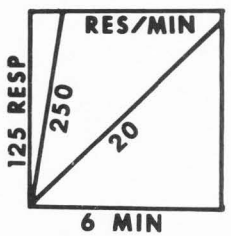


Figure 7. Cumulative records represent S5's performance. Two cumulative records were taken from Phase II and one cumulative record each from Phase I and III. The cumulative record in Phase I was Session 2. Cumulative record "A" in Phase II was Session 10 and "B" was Session 14. The cumulative record representing Phase III was Session 16. The bottom time line represents the stimulus condition in effect. In the down position, the red stimulus light was illuminated and in the up position the blue stimulus light was illuminated. The small "a" located on the time line was added to call the reader's attention to the difference in slope of the response lines for the four cumulative records.

S5

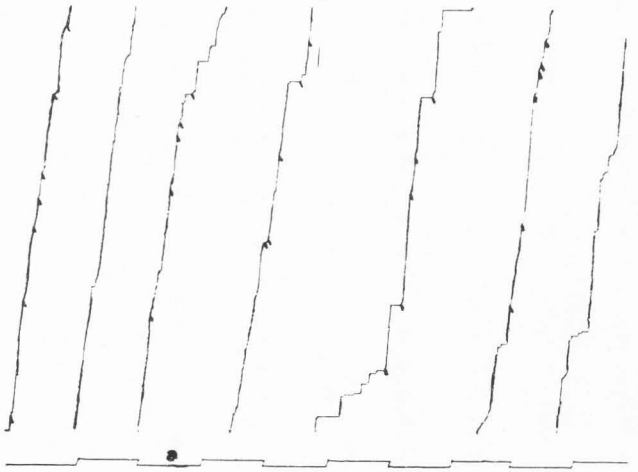
PHASE 1
VI-VI





PHASE 2
VI-EXT

A



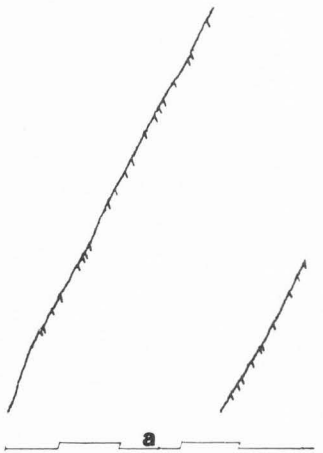
B

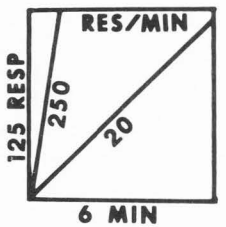
PHASE 3
VI-VI

Figure 8. Cumulative records represent S6's performance. Two cumulative records were taken from Phase II and one cumulative record each from Phase I and III. The cumulative record in Phase I was Session 2. Cumulative record "A" in Phase II was Session 7 and "B" was Session 13. The cumulative record representing Phase III was 15. The bottom line represents the stimulus condition in effect. In the down position, the red stimulus light was illuminated and in the up position the blue stimulus light was illuminated. The small "a" located on the time line was added to call the reader's attention to the difference in slope of the response lines for the four cumulative records.

S6

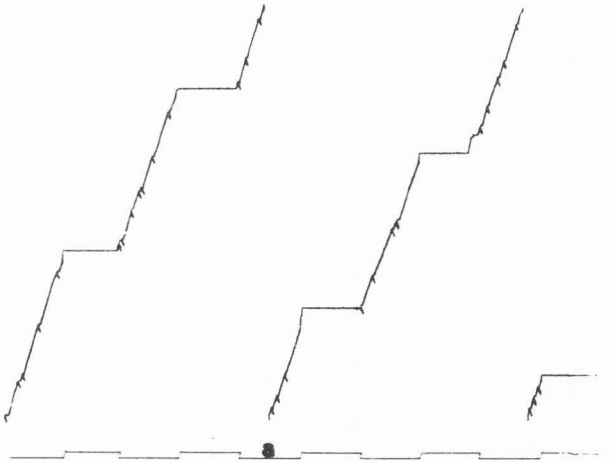
PHASE 1
VI-VI





PHASE 2
VI-EXT

A



B

PHASE 3
VI-VI

variation in response rate for the Ss of this group occurred within the first few sessions.

Phase II. In Phase II the response rate changed when the multiple schedule was changed to mult VI EXT. One difference observed in the early sessions of Phase II that was not found in Phase I was an occasional short pause in responding during the EXT component. No immediate change in response rate was observed when the experiment progressed from Phase I to Phase II. However, during Phase II the discrimination began to form as seen in the later sessions of Phase II represented by cumulative record "B". An increase in response rate in the unchanged VI component can be seen by referring to the slope of the response line at point "a" cumulative record "B" (see Figures 6, 7, and 8). The response rate in the unchanged VI component increased as the response rate in the EXT component decreased.

The average increase in response rate per two minute components in the unchanged, VI component, continued through Phase II. When the average response rates in the first and last sessions in Phase II are compared an increase over sessions is apparent. The average response rates in the first session of Phase II for S4, S5, and S6 were 376, 256, and 76 respectively. In comparison the average response rates during the final session of Phase II for S4, S5, and S6 were 451, 381, and 346 respectively. The response rate in the first blue, EXT, component was initially high but began to decrease even within the first blue component. The average response rates in this component for S4, S5, and S6 in the first session of Phase II

were 362, 298, and 11 respectively. In comparison, the average response rates during the final session of Phase II for S4, S5 and S6 were 5, 25, and 5 respectively.

Phase III. The schedule of reinforcement in effect during this phase was again mult VI VI. A close observation of the individual cumulative records in Phase III shows that they closely parallel the cumulative records in Phase I. The response rates in the red, VI, components were less than the response rates in the red, VI components in Phase II. When the last session of Phase II is compared with the first session of Phase III, a change in the average response rate per two minute components can be observed for S5 and S6. A similar change in response rate can be seen for S4 except the change was not present until the second session of Phase III.

In the first session in Phase III, S4 made no responses in the blue component that were reinforced. The response rate in the red, VI, components for S4 decreased from an average of 500 in the last session of Phase II to 314 in the second session of Phase III. The average decrease in response rates for S5 was from 384 in the last session of Phase II to 282 in the first session of Phase III. The change in response rate for S6 during the same period was from 346 to 245.

The pauses during the blue component in Phase II, are easily observed but these pauses were eliminated in the blue component in Phase III. When the last session of Phase II is compared with the first session (second session for S4) of Phase III a change in the average response rate per two

minute components can be observed. The response rate in the blue VI (previously EXT) component for S4 increased from an average of four responses in the last session of Phase II to 251 in the second session of Phase III. The average increase in response rate for S5 was from 25 responses in the last session of Phase II to 243 in the first session of Phase III. The change in response rate for S6 during the same period was from 5 to 233.

Discussion

The results of the present research demonstrate the presence of behavioral contrast in children. All six Ss who responded differentially on a mult VI 20-sec EXT schedule produced an increase in the number of responses emitted during the VI components as their response rates during the EXT components decreased.

Mult VI EXT Group

Figure 1 and the individual cumulative records in Figures 2, 3, and 4 for S1, S2 and S3 illustrate the development of behavioral contrast. If the rate of responding in the unchanged component increases, the interaction is called positive; thus the change in rate of responding during the VI component in Phase I was positive behavioral contrast. If the rate of responding in the unchanged component decreases, the interaction is called negative; thus in Phase II the change in rate of responding during the VI components in Phase II was negative behavioral contrast. When the schedule of reinforcement was

changed to Phase III, mult VI EXT, the response rate in the VI component increased which is positive behavioral contrast.

Mult VI VI Group

Figure 5 and the individual cumulative records, Figures 6, 7, and 8 for Ss 4, 5, and 6 illustrate the development of behavioral contrast. Stable response rates under a mult VI VI schedule of reinforcement can be observed in Figure 5, Phase I. In Phase II positive behavioral contrast can be observed and negative behavioral contrast was produced in Phase III.

Experiment II

Method

The second experiment was conducted to determine the presence of sequential contrast in children. The subjects were exposed to a mult VI 20 second EXT schedule of reinforcement with the VI and EXT components presented in a random sequence. Sequential contrast which is defined as a greater response rate during S+ when an S+ is preceded by an S- component than when S+ is preceded by other S+ components, was under investigation in the present experiment.

Subjects

Three, seven and eight-year-old children were recruited from the Logan, Utah area for use in this experiment. One boy and two girls comprized this group. All three Ss completed the entire experiment. Their ages ranged from seven years, two months to eight years, two months with an average of seven years, nine months. One boy and one girl in this experiment had had previous multiple schedule training. The boy was S5 in the mult VI VI group reported in Experiment I. The girl was S2 in the mult VI EXT group reported in Experiment 1. The third subject in this group, a girl, S7 had no previous multiple schedule training.

Apparatus

The physical layout and apparatus were the same as those used in Experiment I.

Procedure

The three Ss in this experiment were given training sessions Monday through Friday, of 20 minutes in duration. A two component multiple schedule, mult VI 20-sec EXT was used with the VI and EXT components presented randomly. The stimulus components were selected in pairs so an evaluation of the S+ component could be analyzed. Each day the S+ and S- components were arranged randomly by drawing small discs from an urn. The rates in the two minute components of an S+ stimulus which followed another S+ component were compared with the rates of an S+ stimulus which followed an S- component. The maximum number of S+ or S- components that could appear in succession was limited to two.

The instructions given to S7 on how to operate the console were identical to the instructions given to all Ss in Experiment I. No additional instructions were given to S5 and S2. They were never informed of any change in the experiment. The DRO protection contingency during the last three seconds of EXT components was in effect throughout the experiment. A session consisted of five, two minute VI 20 second components and five, two minute EXT components and lasted approximately 20 minutes. Following approximately 20 minutes of session time, the equipment and stimulus lights were automatically turned off and Ss were informed that the session was

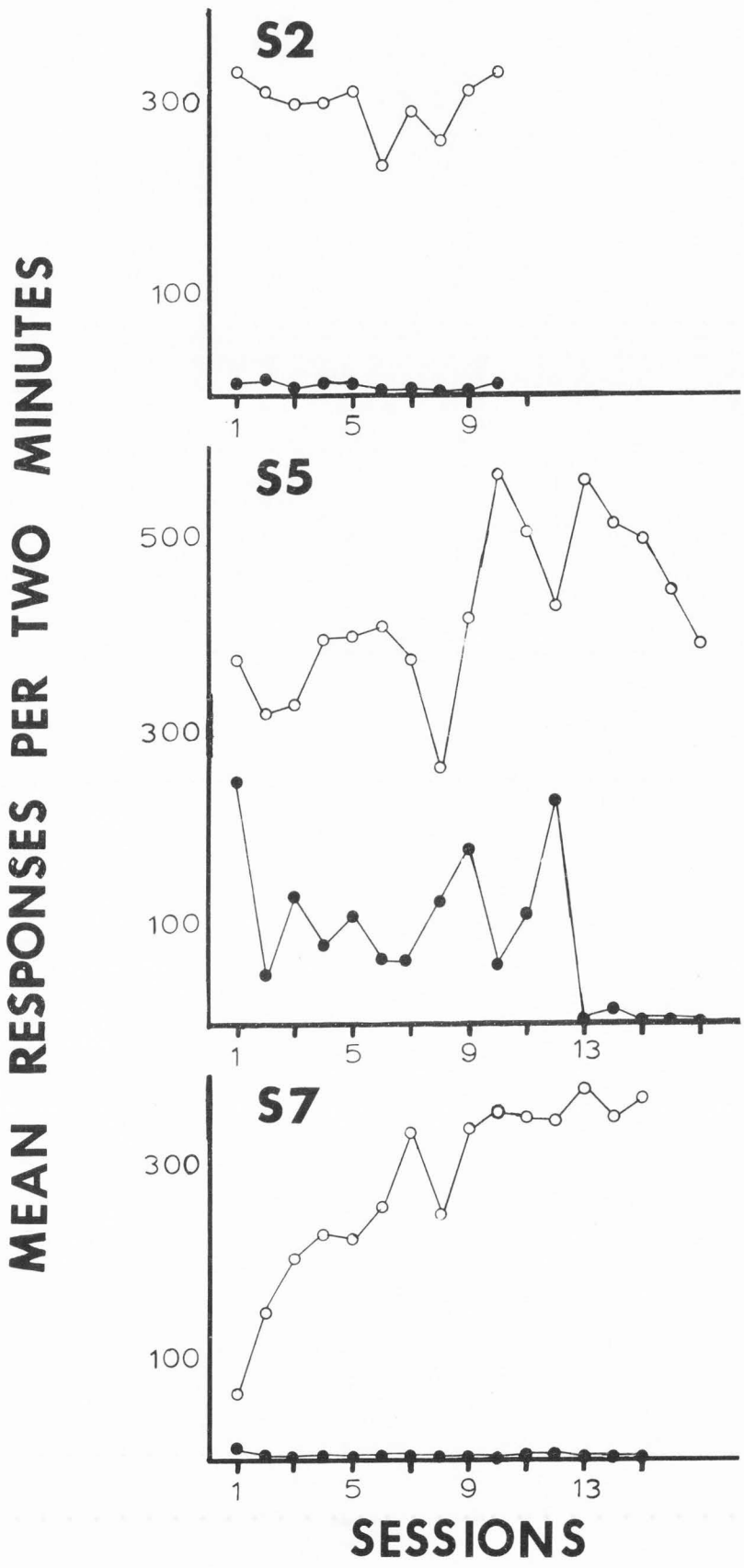
completed for that day. The criteria used for evidence of a discrimination were established a priori and were defined as an average of less than 10 per cent of the total responses in the session occurring in the EXT components for at least three consecutive days. During each daily session an average of 30 tokens was delivered. In the first session, S7 was initially exposed to an S+ component to assure delivery of a token within the first few seconds that the S was in the room.

Results

Figure 9 shows the average number of responses emitted in the S+ (VI component) and the S- (EXT component) components. It also illustrates that the average response rates in the S+ components were always much higher than the average number of responses emitted during the S- components.

S5 showed the greatest variability in his response rates throughout the experiment. No stable response pattern was evidenced in either S+ or S- components until the 13th session of this experiment. At this point, his response rate during the S- components decreased and remained constant. A decreased rate of responding was also produced during the S+ component. When S5 began this experiment, he had received 17 days of previous training on a multiple schedule. Seven of these days were on a mult VI VI schedule of reinforcement with two sessions immediately preceding Experiment II on a mult VI 20-sec VI 20-sec schedule.

Figure 9. Average responses per two minutes for both S+ and S- components are represented for each daily session. The S+ components in which reinforcers were delivered on a VI 20 second schedule are represented by the open circles. The S- components during which no responses were reinforced are represented by closed circles. Two minute components of S+ and S- were presented in a random sequence.


S2
300
100
1
5
9
S5
500
300
100
1
5
9
13
S7
300
100
1
5
9
13
MEAN RESPONSES PER TWO MINUTES
SESSIONS

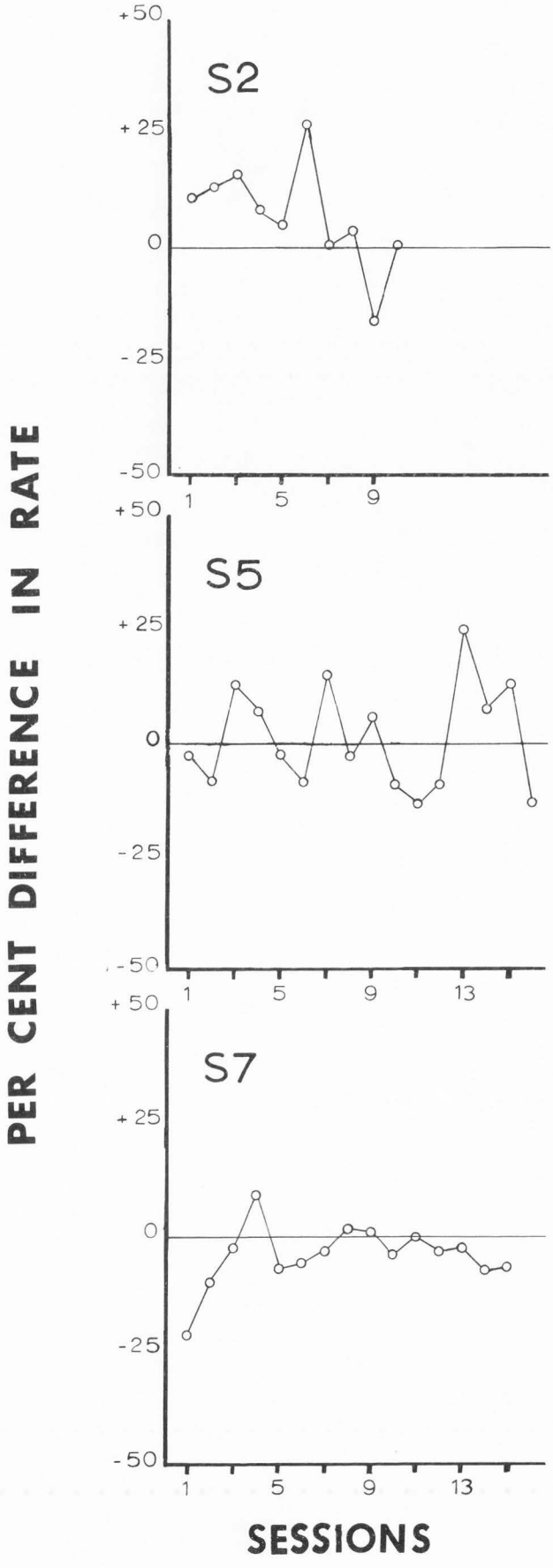
S2 also had previous multiple schedule training. The response rates during the S- components for S2 were at a low rate during the initial sequential contrast session and remained at that rate throughout the experiment. Response rates during the S+ component were more variable especially during sessions 6, 7, and 8, but with these three exceptions remained relatively constant. S2 had received 12 days of previous multiple schedule training with four sessions immediately preceding Experiment II on a mult VI 20-sec EXT schedule.

S7 was a naive subject in terms of previous multiple schedule training. The resonse rates during VI and EXT components for this S soon began to diverge and after the first few sessions very few responses were emitted in the S- component. This S showed the least amount of variability in rate of responding in the S- components of the three Ss in the experiment. The response rate for S7 gradually increased during S+ components until more than three times as many responses were emitted than during the initial S+ sessions (see Figure 9).

Figure 10 is a representation of the per cent difference in S+ components which followed other S+ components from S+ components which followed S- components. The open circles represent the per cent difference in rate emitted during the S+ components that followed S- components as compared with S+ components that followed other S+ components.

Per cent difference between response rates during the S+ components that followed S- components (viz., S+ S-) and the response rates during S+

Figure 10. A representation of the per cent difference between response rates during S+ components that followed S- components and response rates during S+ components that followed other S+ components. The per cent difference was calculated by subtracting S+S+ from S+S-, dividing the answer by S+S+, and multiplying by 100.


PER CENT DIFFERENCE IN RATE
+50
S2
+25
0
-25
-50
1
5
9
+50
S5
+25
0
-25
-50
1
5
9
13
+50
S7
+25
0
-25
-50
1
5
9
13
SESSIONS

components that followed another S+ component (viz., S+S+) were calculated by subtracting the response rate of S+S+ from S+S- for each session. The difference was divided by S+S+ and multiplied by 100 to obtain the per cent difference: viz.,

$$\frac{(S+\ S-) \quad - \quad (S+S+)}{(S+S+)} \quad X\ 100.$$

A positive per cent difference indicates sequential contrast and the magnitude of the difference indicates the magnitude of sequential contrast (O'Brien, 1968).

Figure 10 represents the per cent difference in rates for the three Ss in Experiment II. A considerable amount of variability in the per cent difference can be seen for all Ss in this experiment. The record for S2 indicates a positive per cent difference in rate for the first eight sessions. The consistent pattern of responding emitted by S2 was not found for either of the other Ss in the experiment. The per cent difference in rates for both S5 and S7 vacillated between positive and negative values throughout the entire experiment. S5 spent 16 sessions on the sequential contrast experiment. During these sessions, the percent difference in rate was negative nine days and positive for seven days. The maximum number of positive per cent sessions that appeared in succession was three during Sessions 13, 14, and 15. Subject 7 spent 15 sessions on the sequential contrast experiment. In these sessions, the per cent difference in rate was negative 11 days and positive only three days with the remaining session being zero. The

maximum number of positive per cent sessions that appeared in succession was two during Sessions 8 and 9 (see Figure 10).

Figure 11 contains two cumulative records each for S2 and S5. "A" represents an early session for each S and "B" represents a late session for each S. The cumulative records were selected because they are representative of S's response rates.

Response rates for S2 remained relatively constant in both the early and late sessions. The response rates were consistent and relatively rapid when the red light (VI 20-sec) was illuminated, but few responses were emitted during the presentation of the blue (EXT) components. Response rates for S5 were different for the early and late sessions with more responding during the S- components in the early sessions. In the late sessions, represented by cumulative record "B", S5's response rates paralleled S2's response rates and were consistent and relatively rapid when the red light was illuminated, but few responses were emitted during the presentation of the blue (EXT) components. The decrease in response rate for S5 during the S- components can be seen by looking at the pauses during the S- components in cumulative record "B" when compared to the pauses in record "A" (see Figure 11).

Figure 12 contains three cumulative records for S7. The cumulative records therein illustrate the development of rapid responding during the VI components for S7. By comparing the three cumulative records for S7 an increase in response rates in the red, VI component can be observed. This

Figure 11. Cumulative records represent both S2's and S5's performance. Two cumulative records were selected for each S. The cumulative records labeled "A" were Sessions 1 and 4 for S2 and S5 respectively. The cumulative records labeled "B" were Sessions 7 and 15 for S2 and S5 respectively. The bottom line represents the stimulus condition in effect. In the down position the red stimulus light was illuminated (VI) and in the up position the blue stimulus light was illuminated (EXT).

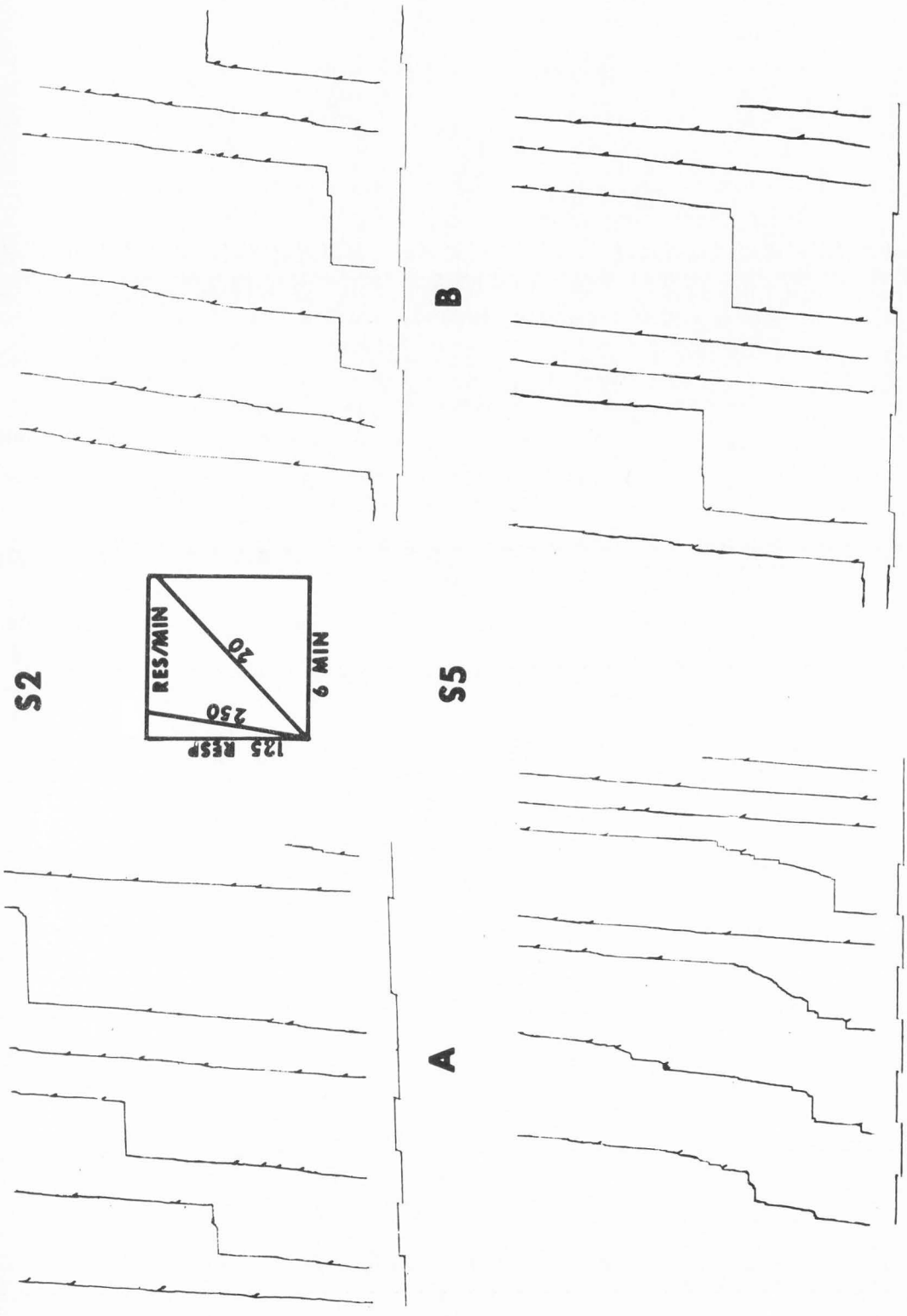
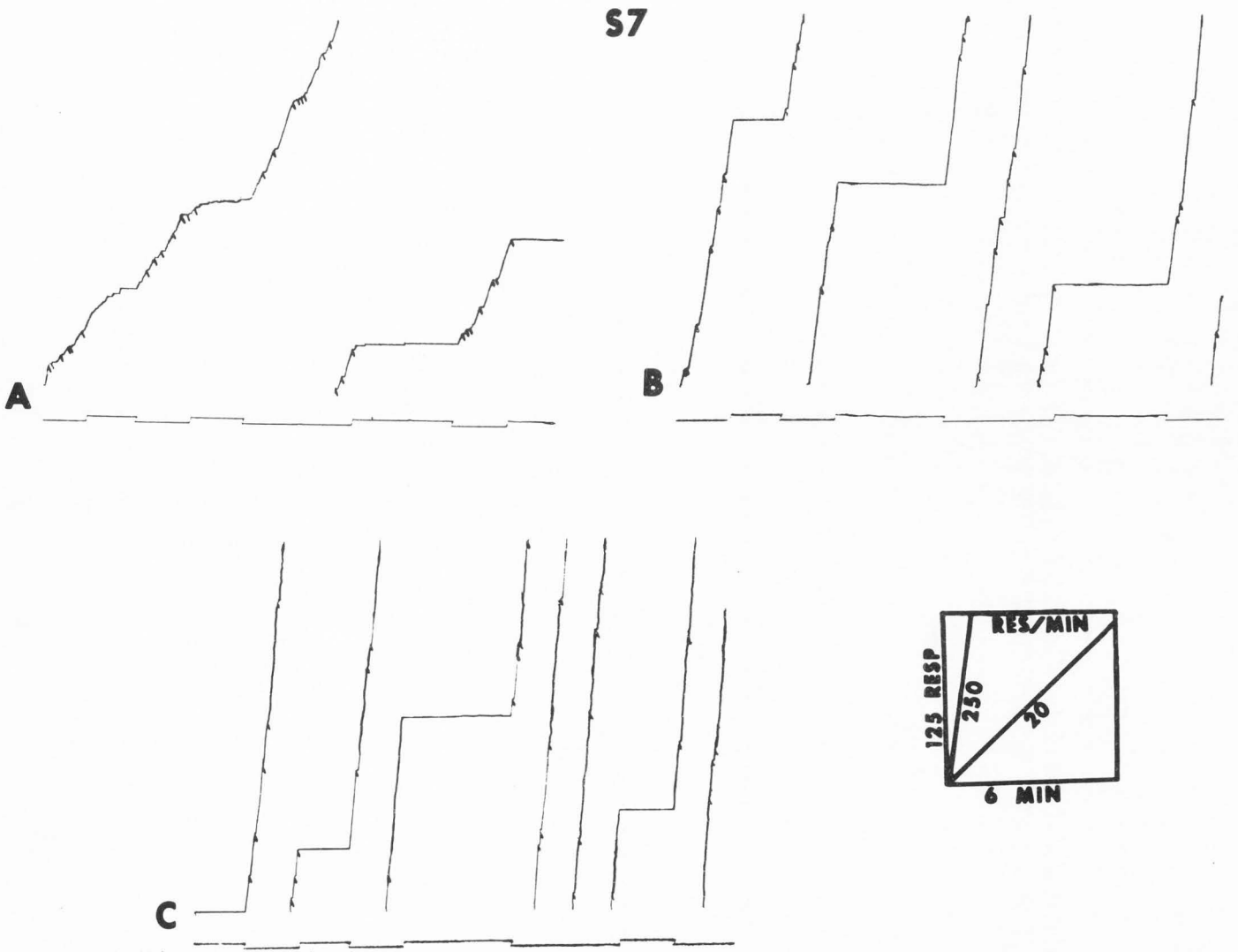

S2
S5
A
B
RES/MIN
70
250
125 RESP
6 MIN

Figure 12. Cumulative records represent S7's performance.

Three cumulative records are presented in Figure 12. The cumulative record labeled "A" was Session 1; the cumulative record labeled "B" was Session 4; and the cumulative record labeled "C" was Session 15. The bottom line represents the stimulus condition in effect. In the down position the red stimulus light was illuminated (VI) and in the up position the blue light was illuminated (EXT).


S7
A
B
C
RES/MIN
125 RESP
250
30
6 MIN

increase is depicted by the increase in the slope of the response line during the red stimulus condition. When "A", "B", and "C" cumulative records are compared, the change in the slope of the response line is easy to detect. The pauses during the blue, EXT component began to form in the first session as seen in record "A" and were well established in records "B" and "C". Visual inspection of this figure reveals that a difference in responding parallels the different stimulus conditions. A rapid rate of responding as indicated by the slope of the response line was emitted during the red, VI stimulus condition and a low rate of responding was emitted during the blue, EXT stimulus condition.

Discussion

Three Ss were exposed to a mult VI 20-sec EXT schedule of reinforcement presented in a random sequence (see Figure 9). Only one of the three subjects (S2) emitted a response pattern characteristic of sequential contrast. The discrimination was formed in all three subjects in the experiment which was not surprising for Ss 2 and 5 since they both had had previous multiple schedule training. The previous training which each S had is reflected in Figures 9 and 11. Subject 2's record of average responses was fairly stable with not much variation over sessions. Subject 2 had 12 day's experience on a multiple schedule with four days on a mult VI VI schedule and eight days on the mult VI EXT schedule. The four days immediately preceding exposure to Experiment II, S2 had been exposed to a mult VI EXT schedule. Thus, the responses made during the S- stimulus

condition had not been reinforced frequently or recently. As one might predict S2 made few responses during the S- condition. The response rate during the S+ was also fairly consistent.

In comparison with S2, S5 had had 17 days of previous multiple schedule experience. Seven of the 17 days of previous experience were on a mult VI VI schedule. The last two days immediately preceding exposure to Experiment II S5 was exposed to a mult VI VI schedule. The response rates of S5 were much less stable than those for S2 (see Figure 11). The two days preceding exposure to the random schedule might have had some effect on the behavior of this S. Responding during the S- condition occurred sporadically for the early session in Experiment II (see Figure 11, cumulative record "A"), but stabilized at a low rate after Session 10. This increase in response rates in the S+ component emitted by S7 was characteristic of behavioral contrast for all Ss in Experiment I during mult VI 20-sec EXT conditions (see Figures 1 and 5).

The only S that produced response rates characteristic of sequential contrast was S2 (see Figure 11). Neither S5 or S7 emitted response patterns which provided a consistent positive per cent difference in the rate which is characteristic of sequential contrast (O'Brien, 1968).

In summary, sequential contrast was not consistently observed in the present experiment.

General Discussion

Behavioral Contrast

In an alternating two component multiple schedule, behavioral contrast is reported as a change in response rate during the presentation of one stimulus in the direction away from the response rate prevailing during the presentation of the alternating stimulus. In the present experiment, behavioral contrast was observed with humans and the effects were remarkably similar to the effects reported in pigeons by Reynolds (1961a, b). In both groups, an increase in rate of responding in one component was always accompanied by a decrease in response rate in the alternate component. When the initial schedule of reinforcement was mult VI VI, the Ss soon established very stable response rates in both VI components. That is, the differences in response rates between the two VI components varied less than 10 per cent even though the overall response rates may have varied from day to day. When the mult VI VI schedule was changed to a mult VI EXT schedule, the response rates of the Ss were disrupted for several days (see Figure 5, Phase II), but as the schedule began to take control, as evidenced by a reduction in response rate during the EXT component, an increase in response rate in the unchanged VI component was observed.

The group of Ss that began the experiment on a mult VI EXT schedule (see Figures 2, 3, and 4, Phase I) showed response patterns very similar to the response patterns of the mult VI VI group (see Figures 6, 7, and 8, Phase II). The formation of the discrimination during the first phase of the mult VI EXT group and the second phase for the mult VI VI group appeared to be a critical point in the experiment. The first session in which Ss were exposed to the mult VI EXT schedule they began to verbalize their discontent about the "blue light" which was associated with the extinction component. The report of discontent, however, did not initially affect the rate of responding during the EXT component. Only two subjects (S2 and S6) of the six initially emitted differential response rates during VI and EXT components. When responding continued throughout the EXT component the responding postponed the appearance of the following VI component due to the protection contingency used.

In the present study, discrimination formation might have been facilitated by the use of the DRO contingency during the EXT components. Bijou and Orlando (1961) found it was advantageous to use a pause building technique (DRO) to lengthen pauses during EXT components. O'Brien does not state in his work if he used a protection contingency at the end of the EXT component. The absence of a protection contingency could also account for O'Brien's inability to obtain stimulus control in his subjects thus preventing behavioral contrast.

Mash (1969) failed to obtain behavioral contrast using college students as subjects, however, Mash's experiment only lasted five days. Furthermore, the second day of his experiment was the only day that a mult VI EXT schedule of reinforcement was in effect. Behavioral contrast in the present experiment did not begin to appear in the subjects the initial day of exposure to a mult VI EXT schedule, but required several days for the formation of the discrimination to take place. This would suggest that the duration of Mash's (1969) experiment was inadequate to produce behavioral contrast.

In all Ss, when the multiple schedule called for identical VI reinforcement schedules in both components, stable rates of responding were established within each session but often not between sessions. The characteristic rapid rate of responding in the VI component when the previous phase had been mult VI EXT began to decrease as Ss began to respond in the VI, previously EXT, component (see Figures 1 and 5). This decrease in response rate accompanying an increase in response rate in the alternating component is characteristic of negative behavioral contrast (Reynolds, 1961b).

The three phases through which each group progressed, illustrated behavioral contrast at each change in the schedule of reinforcement. For example, in Phase I the mult VI EXT group reached a high rate of responding in the VI component as the response rate in the EXT component decreased. When Phase II, a mult VI VI schedule, was initiated, a decrease in response

rates in the unchanged VI component accompanied an increase in response rate in the other VI component. This change in response rate is negative behavioral contrast. Positive behavorial contrast occurred again as an increase in response rate was observed in all Ss in this group the first session following a change to Phase III, a mult VI EXT schedule (see Figure 1).

The mult VI VI group stabilized in Phase I (mult VI VI schedule). This was followed by positive behavioral contrast when Ss were changed to Phase II (mult VI EXT schedule). The response rates in the VI components near the end of the Phase II were higher than response rates in the same components at the beginning of Phase II and greater than the response rates in Phase I. Their increased rates of responding during VI components paralleled decreased response rates in the EXT components.

Negative behavioral contrast in going to Phase III (mult VI VI schedule) was observed as the response rates in the VI components for S5 and S6 decreased in the initial session following the change to Phase III. S4 showed a similar change in the second session of Phase III. This delay in changing from Phase II to Phase III for S4 may have been due to the alternation of the two components. No manipulations were made to determine the nature of controlling stimuli and S4 may have been under control of the alternation of the components, the stimulus lights themselves, or both conditions. Whatever the controlling stimuli might have been, the decreases in response rates during the EXT components were associated with concomitant increases in the response rates in the other VI component, previously EXT, for all Ss.

The factor that consistently preceded the appearance of behavioral contrast was evidence of the formation of a discrimination, i.e., differential responding in the presence of the two stimulus conditions. For example, in the mult VI EXT condition, an increase in response rate in the VI component did not occur until an accompanying decrease in response rate appeared during the EXT components. The Ss reported that they were receiving no reinforcers in the EXT component and that they had discontinued responding before they actually did. Neither the Ss' verbal report of not receiving tokens during the EXT component nor their false report about discontinuation of responding during the EXT component had any effect upon a change in response rate or the appearance of behavioral contrast. It was not until the response rates in the presence of the two stimuli became separated that behavioral contrast appeared.

The results of the present experiment suggest that appropriate responding to two different stimuli might be the most important factor associated with behavioral contrast. The present experiment was not designed to investigate the factors which produce behavioral contrast but the results do provide some information which suggests that not all of the important variables involved in the production of behavioral contrast have been considered. Reynolds (1961c) first proposed that the change in relative frequency of reinforcement was the major factor producing behavioral contrast. Reynolds and Limpo (1968) and Weisman (1970) later began to question the fact that relative frequency of reinforcement was the predominant factor

which produced behavioral contrast. The present results would concur with the views of Reynolds and Limpo, and Wilton in that the relative frequency of reinforcement is not the most significant variable that produces behavioral contrast. The basis for this view is the delay in the appearance of behavioral contrast until the discrimination is formed. If the relative frequency of reinforcement was the critical variable, then behavioral contrast should appear as soon as the relative frequency of reinforcement changed. This would be at the first schedule change to a mult VI EXT schedule and not several sessions (for S4 as many as 12 sessions) later when the discrimination began to form. Once the discrimination began to form, behavioral contrast appeared. This finding is consistent with previous research reported by Terrace (1963b).

Bloomfield (1967) suggested that emotionality is the factor which produces behavioral contrast, but the emotionality produced by an EXT component should (and usually does) occur at the first introduction of the EXT component, thus behavioral contrast should be seen rapidly. Behavioral contrast did not immediately appear in the present study when the EXT component was first introduced but appeared several sessions later.

Two other conditions reported previously as being consistently present during the occurrence of behavioral contrast were also present in this experiment. They include differential reinforcement in the presence of two or more stimuli (Guttman, 1959; Reynolds, 1961a) and responding during the S- component (Terrace, 1963a).

The present experiment also suggests why behavioral contrast has not previously been reported in human subjects. O''Brien (1968) first attempted to obtain behavioral contrast using two mentally retarded teenagers. The procedures used by O'Brien were not sufficient to produce stimulus control. Mash's (1969) failure to produce behavioral contrast might be accounted for by the short length of his experiment.

The results of the present experiment permit several inferences: (1) That the reinforcement schedule may affect the production of behavioral contrast and (2) that the component length of the multiple schedule may affect the production of behavioral contrast. There are two bases for these inferences. The first stems from O'Brien's failure to obtain behavioral contrast using a VI 1-min reinforcement schedule and five minute components. The present experiment used a VI 20-sec reinforcement schedule and two minute components. In the present experiment, as compared with O'Brien's experiment an average of three times as many reinforcers were delivered each minute the S was in the VI component. This difference in number of reinforcers per minute may have helped Ss in the present experiment form the discrimination. That is, because the Ss in this experiment received a reinforcer on the average every 20 seconds it may have been easier for them to discriminate the absence of reinforcement (EXT) than it was for O'Brien's subjects.

The second basis for inferences about reinforcement scheuldes and component lengths stems from the length of time required for the discrimination to form in the initial mult VI EXT phase of each experiment. It may be that a

different component length would speed up the formation of the discrimination. In experiments where the component length was five minutes (O'Brien, 1968) a greater delay exists between S+ components than in the present experiment where the components were two minutes. This may have had an effect upon the formation of the discrimination since meeting a low response criteron during EXT components of five minutes may be more difficult than meeting the same criteron in two minutes.

Alfano (1969) and King (1970) both reported behavioral contrast using a two key concurrent schedule of reinforcement with college students as subjects. The results of the present experiment would suggest that an investigation of behavioral contrast in humans would be more easily accomplished under a concurrent schedule of reinforcement than an alternating two component multiple schedule of reinforcement. The reason that it may be easier is that the S has something to do that can be reinforced at all times under a concurrent schedule. One strategy may be for the S to select the stimulus which produces the maximum number of reinforcers and respond accordingly. In a single response multiple VI EXT schedule, however, he must do two things, i.e., select the stimulus which produces the maximum amount of reinforcement and respond accordingly, and also select an alternate response pattern which is incompatible with lever pressing that can be emitted during the alternate S- component.

Superstitious behavior was reported to E by Ss as to "what turns off the blue light." The report that "kissing the blue light turns it off," was made by S5. Another S, S1, reported that "turning off the ceiling lights" produced a change in the stimulus condition. Other behaviors eventually began to appear

during the EXT component which were incompatible with responding. Most common among these was the counting of the tokens which had been received to that point in the experiment. An extreme case of behavior emitted during the EXT component by S4 was correcting his school work while the blue light was on.

A thorough investigation of reinforcement schedules and lengths of components would be a significant contribution to the area of behavioral contrast.

Sequential Contrast

One of three subjects exposed to the sequential contrast experiment emitted a consistently higher response rate during S+ components that followed an S- component than when an S+ component followed another S+ component. The remaining two Ss (S5 and S2) failed to emit response patterns characteristic of sequential contrast. S2 showed a consistently higher rate of responding in the first eight sessions during S+ components which followed S- components than S+ components which followed other S+ components. This consistent response pattern is characteristic of sequential contrast. However, there is no way to identify sequential contrast from S2's cumulative records (see Figure 11). Behavioral contrast, however, was easily identified on the cumulative records in Experiment I (see Figures 2, 3, 4, 6, 7, and 8).

The random presentation of VI and EXT components in Experiment II failed to produce sequential contrast in S5 and S7. The response rates of S7 during S+ components gradually increased over the first several sessions (see Figure 9). This increase in response rate parallels the response patterns seen

earlier in Ss 1, 2, and 3 in Experiment 1 (see Figure 1, Phase 1). Sequential contrast did not, however, develop consistently in S7.

It is not readily apparent why the results in this experiment are inconsistent with O'Brien's (1968) earlier research. Some possible reasons that could account for the difference in results between this experiment and O'Brien's experiment include: (1) A different reinforcement schedule (O'Brien used a VI 1-min reinforcement schedule in his S+ components and a VI 20-sec reinforcement schedule was used in the present experiment); (2) the component lengths were also different. O'Brien used five minute components in his experiment and two minute components were used in the present experiment; (3) subjects in the present experiment all formed discriminations while O'Brien's subjects did not; and (4) O'Brien used a TO between components while the present experiment did not.

In a VI 20-sec reinforcement schedule an average of three times as many reinforcers are delivered each minute than in a VI 1-min reinforcement schedule. This difference might account for some difference in response rates in the present experiment when compared with O'Brien's experiment.

Component length might also have accounted for a difference in response rates when an S+ component followed one or two S- components. For example, in O'Brien's experiment if an S+ component followed an S- component the temporal difference between the time the S was exposed to the EXT component until he had an opportunity to respond and be reinforced would be five minutes. This time length exceeds the time that any S in the present experiment ever spent in an EXT component or combination of EXT components. Meeting a low response rate criteron during

EXT components of five minutes may be more difficult than meeting the same criteron for two minutes.

The formation of a discrimination might also be a factor which affects sequential contrast as it was well established in the present experiment but absent in O'Brien's experiment. The difference in procedure between the two experiments included a .5 sec. TO between each component in O'Brien's experiment and no TO between components in the present experiment. The above suggestions, as to what might have contributed to the differences between the present experiment and O'Brien's experiment are only possible suggestions which might account for differences between the two experiments. These differences do not, however, account for the difference among Ss in the present experiment.

The final factor which may be responsible for the differences in acquisition of sequential contrast may be related to the patterns of responding produced by S5 and S7. The formula used to calculate the per cent difference which is used to indicate the presence or absence of sequential contrast is a very critical measure which can be affected by variables other than those apparent in cumulative records. One variable observed in the present experiment that seems to affect the rate difference was the response patterns as seen in S5 and S7. Each of these Ss began each session responding at a lower rate than their terminal rate. The response rates gradually increased as the session progressed. Thus, calculation of per cent differences was determined to a certain extent by where the S+ S+ occurred in the session. For example, if S+ S+ occurred early in the session the response rate in the second S+ component of the S+ S+ pair would be low in comparison

with the average S+ response rates for that session. This would produce a positive per cent difference in rate between S+ S- and S+ S+ and thus reflect a high magnitude of sequential contrast. If on the other hand, the S+ S+ sequence appeared late in the session the S+ response rate which followed another S+ component was usually high in comparison with the average S+ S- components. This would lead to a negative value in the difference between S+ S+ and S+ S- when the per cent difference in rate was being calculated. A negative per cent difference is reflected as negative evidence for sequential contrast. In view of the fact that the formula used to calculate per cent differences in rate is susceptible to small changes in patterns of response rate, it is felt by the author that perhaps an alternate method of measure might be devised. Such a measure should provide a consistent method that would reflect true differences in response rates when calculating sequential contrast.

Some of the reasons which might account for sequential contrast in S2 and not in the other two Ss might include: (1) different histories of reinforcement on a multiple schedule and (2) the response patterns of Ss 5 and 7. S2 was a member of the mult VI EXT group thus her exposure to the multiple schedule was different than the other two Ss. When S2 began the sequential contrast experiment (Experiment II), her response rates were stable from the last phase in the behavioral contrast experiment (Experiment I) and no schedule change was made. This could have set the occasion for stable response patterns throughout the sequential contrast experiment. In contrast, S5 was exposed to an abrupt schedule change from a mult VI VI schedule whose components regularly alternated (the last session of Experiment I) to a mult VI EXT schedule whose components randomly alternated

(the first session of Experiment II). This change may have disrupted S5's responding (compare Figures 5 and 9). Initial exposure to a mult VI EXT schedule whose components randomly alternated may not have facilitated stable response patterns for S7. The latter S was the only S to experience this condition only.

In summary, the results of Experiment II are inconclusive as to the presence of sequential contrast in children. One of three Ss produced response patterns which suggest the presence of sequential contrast, but this pattern was not present in the other two subjects used in this experiment.

SUMMARY

When a change in behavior during the presentation of one stimulus is brought about by changing the schedule of reinforcement associated with a different stimulus an interaction is said to have occurred (Reynolds, 1961a). One type of interaction is called contrast. Behavioral contrast in an alternating two component multiple schedule is defined as an increase in response rate in one component accompanying a change in the reinforcement schedule and rate of responding in the alternate component. Eight children ages five to eight years of age were exposed to multiple schedule training. Two groups of Ss were exposed to a different alternating sequence of VI 20-sec and EXT components of a multiple schedule. Group 1 was exposed to multiple schedules in the following order: mult VI 20-sec EXT, mult VI 20-sec VI 20-sec, and mult VI 20-sec EXT. Group II was exposed to multiple schedules in the following order: mult VI 20-sec VI 20-sec, mult VI 20-sec EXT and mult VI 20-sec VI 20-sec. A three second protection contingency was included at the end of each EXT component that specified any response made during the last three seconds of any EXT component postponed the appearance of the next VI component for three seconds. The schedule components were of two minutes in duration and simply alternated. Regardless of the sequence of exposure to the multiple schedule six Ss showed an increase in response rate in the unchanged VI component when the response rate in the alternate EXT component decreased (positive behavioral contrast). A decrease in response rate in the unchanged VI component was also observed when the alternate component of the multiple

schedule was changed from EXT to VI reinforcement and the response rate in the VI (previously EXT) component increased (negative behavioral contrast). The factor most closely associated with the occurrence of behavioral contrast was responding which indicated that the S had formed a discrimination. The results reported above are the first reported results of behavioral contrast in a two component multiple schedule using children as subjects.

Sequential contrast, defined as a greater response rate during S+ when an S+ is preceded by an S- component than when S+ is preceded by other S+ components was not consistently found in the present experiment. Three children, seven and eight years old were exposed to VI 20-sec and EXT components of a multiple schedule. The VI and EXT components were presented randomly. Only one of the three subjects exposed to the sequential contrast experiment showed a consistently higher rate of responding during an S+ component that followed an S- component than when an S+ component followed another S+ component. From the above results one cannot conclude that sequential contrast was demonstrated in the present experiment.

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