MATCHING TO SAMPLE IN CHILDREN;
AN EXPLORATORY STUDY

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STATEMENT BY AUTHOR

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"... More I could tell but more I dare not say;

The text is old, the orator too green..."

Venus and Adonis
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ABSTRACT

The purpose of this study was to investigate some of the variables involved in a concept formation task with young children as subjects. A match-to-sample apparatus was designed and constructed to present stimuli, record responses and deliver reinforcement.

Eighteen children aged four through eight were used to investigate the effects of consumable reinforcers on performance in a matching task. Stimulus materials were reproduced from *The Frostig Program for the Development of Visual Perception* (1964) using a photographic technique. The apparatus and procedure are described.

Although this has been an exploratory study, some of the data suggest definite trends usable in future research. Under the non-reinforcement condition (no consumable reinforcer), subjects' rates of responding were found to be statistically significantly higher than under the reinforcement condition (using M&M candies as consumable reinforcers). Although not statistically significant, a trend in the opposite direction was noted for response accuracy. A large intersubject variability was noted in all other data and a chronology of responding is presented for each subject.
Limitations of the present findings are discussed and suggestions are made for future research.
INTRODUCTION

The term "match-to-sample" may refer to a teaching technique or to a device employing this technique. In the first sense, match-to-sample means presenting a stimulus object and asking a subject (S) to choose a response object with a given relationship to the stimulus. For example, a red triangle may be presented as the "sample" and S may have to "match" it by choosing another red triangle from several different stimulus objects.

Psychological concern about the match-to-sample technique is relatively recent as is its application to research but the use of the technique in sub-verbal teaching has a long history. "The method of choice-from-sample was used in a scientific investigation probably for the first time by Itard while training and observing 'The Wild Boy of Aveyron' who was discovered living alone in a forest in 1799" (Weinstein, 1941, p. 196). Itard shaped language behaviors in his "wild boy" by first training him to match primary colors and simple geometric forms by pointing to them. Later he was able to match letters and printed words.

In the second sense of the term, match-to-sample refers to a teaching machine for use with concept formation tasks. This idea of matching-to-sample was originally
formulated by Skinner (1938) several decades ago using infrahuman Ss. Skinner used the principles of operant conditioning to teach pigeons to match two identical visual stimuli, i.e., to indicate by some means which one of the various stimuli was identical to the sample. For example, Skinner (1951) has trained pigeons to look at a given playing card, say, the two of hearts and then choose among three remaining cards the one exactly like the original sample. The pigeon indicates his choice by pecking the card and a correct choice is reinforced by several grains of feed.

In the most basic use of match-to-sample, the original sample is exactly duplicated by one of the matches. Many other designs are possible such as teaching the pigeon to peck one of four labels naming the suit of a given playing card (Skinner, 1951). Responses may be conditioned to different properties of the stimulus such as form, color, texture of size. In this case, the experimenter may decide that when the $S^d$ is blue, the correct choice is the smallest object and when the $S^d$ is yellow, the correct choice is the largest object.

In the above sense, the match-to-sample idea is a method of studying learning in human and animal Ss. A review of recent literature indicates that the term is most frequently employed in the sense of a specific device which is used to present stimuli and record responses. The first
match-to-sample apparatus was developed by Holland and Long (Holland, 1963). This apparatus was designed for use with human Ss and other modifications of this basic device (see for example Bijou, 1965; Ferster & DeMyer, 1961; Zimmerman & Ferster, 1963; Staats et al., 1964) all have common properties. In both human and infrahuman research, visual stimuli are presented on a translucent screen by a technique called "rear projection" in which the projector is located behind the screen and is enclosed by the apparatus. S indicates his choice by pressing on a segment of the translucent screen hinged against a microswitch or by pushing a button directly below the screen segment. The apparatus then reinforces S (positively if correct and negatively if incorrect), records the response, and changes stimulus objects. The machinery may be totally programmed to operate automatically or it may be manually operated by the experimenter (E). The technique of matching-to-sample is testable using means other than the match-to-sample device. For example, Bernstein (1961) used a version of the Wisconsin General Test Apparatus (W.G.T.A.) in testing an oddity problem in monkeys and humans. Martin and Blum (1961), using an oddity task, presented each S with three-dimensional stimulus objects of different size, color, form or spatial orientation. Scherrer and Lyons (1957) presented Ss with line drawings on cards and asked them to
match these drawings with familiar and unfamiliar words presented verbally.

A review of the literature also indicates that matching-to-sample is a more common technique in animal studies than in human research. The technique has been used with fish (Meesters, 1940), pigeons (Berryman, Cumming, & Nevin, 1963), cats (Boyd & Warren, 1957), rhesus monkeys (Young & Harlow, 1943), and chimpanzees (Ferster, 1958). Other authors have even compared humans with monkeys, chimps and an ape (Bernstein, 1961).

In humans the technique is often used where a more conventional verbal teaching paradigm is inappropriate such as teaching language to deaf children (Falconer, 1960), teaching "reading readiness" skills to aphasics (Filby & Edwards, 1963) or teaching form discrimination to autistic children (Ferster & DeMyer, 1961).

In much of the literature, the choice of stimulus objects appears to be one of convenience rather than utility. In a teaching machine program, on the other hand, a great deal of effort usually goes into the ordering of the frames in terms of sequence and the graded difficulty of each step. The only study which could be found in the literature even mentioning this procedure was Staats (1964) and he stated that the frames in his program may have progressed so rapidly as to be aversive to his Ss. In the present study, the Frostig Program for the Development of
Visual Perception (1964) (hereafter referred to as the Frostig Program) was chosen as the source of stimulus objects because of its standardization, application to children of various ages, and because a part of this material lends itself to a match-to-sample presentation. Frostig's program has been thoroughly researched to assure that the frames are presented in a logical and sequential order. Normally, this program is presented to children aged 3-1/2 to 7-1/2 and is used to develop the visual perceptive skills that underlie successful reading. It is often used in conjunction with the Marianne Frostig Developmental Test of Visual Perception (1961) to diagnose children with reading difficulties and to help these children overcome their perceptual impairments. Usually studies using the Frostig program use a standard pencil and paper presentation with a teacher present to mediate reinforcers. The program has been used to test retarded children (Allen et al., 1964), recognize dyslexia (Schiffman, 1962), develop language behaviors in psychotic children (Frostig, 1963) and evaluate perceptual abilities in normal and neurologically handicapped children (Frostig et al., 1961). The present study is the first attempt to use the Frostig material in a match-to-sample presentation or programmed in any way to allow automated presentation.

In the literature on matching-to-sample with human Ss, several studies have relevance to the present work in
that they deal with the general problem of "concept formation." "Concept formation refers to behavior in which the subject learns to respond to one aspect of the stimulus properties of an object while ignoring (inhibiting responses to) all of the others. It is behavior which shows discrimination to one stimulus dimension of an object and generalization of that dimension to other stimulus objects" (Bijou, 1965, p. 75). Martin and Blum (1961) found sex differences in an oddity task where size, color, form and spatial orientation were the relevant stimulus properties. These authors found that with normal Ss, males were significantly better performers than females while the opposite was true in mongoloid Ss. Bernstein (1961) found that human Ss had the same dimensional preferences as macaque monkeys in a visual oddity task. Weinstein (1941) found that monkeys appeared to have higher motivation than children. However, children were able to generalize more broadly and required fewer trials to criterion on the matching task. Despite their better performance, children were unable to verbalize the mechanism involved in their successful responding.

Staats (1964) used a match-to-sample device to teach the reading and pronunciation of phonetic letters to normal children. He established a complex chain of behaviors which involved S pushing a button on the table in front of him, echoing E's pronunciation of the visual
stimulus, pushing the sample window, pushing the one of the three lower windows which matched the sample, pushing another button below the match window to obtain a reinforcer (a marble), and using the marble in a vending-machine apparatus to trade for a trinket. This response chain was shaped using verbal prompts. Staats found that his Ss acquired reading behaviors under reinforcement (S\textsuperscript{R}) conditions but not under non-reinforcement (No S\textsuperscript{R}) conditions. This study is the earliest which could be located in the literature treating matching-to-sample as a free operant response and using a cumulative response recording apparatus to plot the learning curve as is commonly done in animal learning studies.

Staats (1964), being somewhat of a pioneer in the area of match-to-sample research, concludes that, "... an operant conditioning methodology and apparatus ... can be used with children engaged in complex verbal learning to produce learning curves analogous to operant conditioning records obtained with more simple behaviors of children or with simpler organisms" (p. 223).

Most of the studies in the literature employing a match-to-sample apparatus used either two or three windows to display the matches. The most sophisticated apparatus reported in the literature employed five windows for matches and a totally programmed apparatus in the sense of operating automatically without requiring E to manipulate
reinforcers, record responses, or change stimulus objects (Bijou, 1965). In the Bijou apparatus, a chime and a flashing light were used to indicate that a correct response had been made. The presentation of stimuli was made by a modified 35 mm. slide projector which automatically advanced after a correct response and backed up after an incorrect response. The stimulus objects used by Bijou were geometric forms which were oriented 3/5 vertically and 2/5 horizontally in terms of total area. Some of these stimuli had mirror-image possibilities and could be used to test for rotation of figures in space. Ss were shaped into correct responding by utilizing only three matches in the early part of the program and by making all three matches identical to the sample at first and gradually fading into a larger number of choices.

Bijou (1964) employed 100 normal Ss and 100 retarded Ss in several programs of varying difficulty and he found that retarded Ss did not require any special training to learn the match-to-sample task. However, degree of progress in his program appeared negatively related to amount of retardation. He suggests that a match-to-sample program is a useful way to approach both diagnosis of perceptual disabilities and subsequent perceptual training and even in working with language difficulties in aphasics. Bijou also suggests the use of a match-to-sample presentation with children who have,
"... academic problems which seem to be related to 'perceptual' difficulties (including dyslexia)" (p. 78).

The apparatus used in the present study is basically similar to that used by Bijou in that both employed a stimulus presentation device manufactured by Grason-Stadler Co. and the equipment in the present study was designed from a schematic wiring diagram obtained from Bijou in a personal communication to Dr. Ralph J. Wetzel. Major changes in the apparatus include the addition of a dispenser for consumable reinforcers, the addition of an auditory stimulus (buzzer) to indicate an incorrect response, provision for interrupting reinforcers if $S$ backed up in the program, and the installation of the apparatus in a trailer to allow "on location" testing of $S$s.

Since no studies could be found in the literature using the Frostig material in a programmed sequence and no studies could be found using consumable reinforcers with a match-to-sample apparatus using human $S$s, it was decided to implement an exploratory study in this area to see if some critical variables could be identified for further study. Another reason for undertaking the present study is to test the match-to-sample apparatus to find how best to adapt it to a wide range of experimental problems.
METHOD

Subjects

The 18 Ss employed in this study were all "normals" ranging in age from 4 yrs. 0 mo. to 7 yrs. 11 mo. (See Table 1 for descriptive data on all Ss.) Eleven of the Ss were male and seven were female. Six of the Ss were obtained on loan from professors in the Psychology Department of the University of Arizona, the remaining twelve through the cooperation of a local day nursery. No attempt was made to equate Ss on the basis of intelligence, perceptual ability or previous experience with concept formation tasks. Of the 18 Ss, only one (S14) was noted to have any difficulties in adjusting to the school situation and his difficulties did not center around academic tasks but, in the words of his nursery school teacher, he is "socially introverted." All of the Ss were told something about the nature of the task before being introduced to the experimental situation and each S was given a chance to say no if he didn't wish to participate. This was done to eliminate Ss who might be frightened by the experimental setting since there would be no adult or other child immediately present in the experimental room to provide social comfort. Of all the would-be-Ss contacted, only one (a 4 year-old male) declined to participate.
Laboratory Facilities

The match-to-sample apparatus used in the present study is located on the grounds of the University of Arizona in a three-room "mobile home" type trailer specially made for the University of Arizona Department of Psychology by Sportcraft of Arizona. (For a list of manufacturer and model number of the apparatus used in data collection for this thesis, see Appendix A.) The middle room of the trailer houses the apparatus and contains one-way mirrors to allow E to view S's behavior in either of the two experimental rooms. For the present study, the room not being used in the experimental procedure was well stocked with toys and was used as a playroom for Ss awaiting their turn at the apparatus. Since the trailer was reasonably well sound-proofed, intercom units are installed in the two end rooms to allow recording Ss' verbalizations if desired. The intercom in the playroom end of the trailer was used whenever Ss were "on deck" so that E could visually attend to the experimental S through the one-way mirror and still keep track of the interactions between Ss in the playroom.

The temperature in the experimental rooms was maintained at approximately 75° by a built-in thermostatic refrigeration system. In the experimental room were two small chairs and a table. The outside windows were covered
with blinds and curtains and the glass in the door was frosted to minimize distractions to S.

On either side of the match-to-sample presentation window is a 24" by 18" one-way mirror. These allow viewing S while he is attending the program without being seen by him. In an earlier study (Vogler, 1966) using a different apparatus in the playroom of the trailer, some difficulty was encountered with Ss becoming distracted from the task and attempting to look through the one-way mirror into the apparatus room. If S were to place his forehead against the glass and cup his hands around his eyes, there was enough light in the experimental room for him to see in.

To eliminate this difficulty in the present study, hardboard blinds were hinged to cover E's side of the one-way mirrors. Cabinet door catches were used to hold the blinds up out of the way when they were not needed. When S approached the one-way mirror and shielded his eyes to try to see in, the blind would be dropped until he resumed responding.

**Stimulus Materials**

The stimulus materials were chosen from the Frostig Program because of their standardization and their adaptability to the match-to-sample technique. The Frostig Program consists of five separate sections, each designed to train a child in some particular aspect of visual
perception related to reading. These sections are:

- perception of position in space
- perception of spatial relationships
- perceptual constancy
- visual-motor coordination
- figure-ground perception

Frostig (1961) has also developed a paper and pencil test to determine a child's level of perceptual development and in actual practice, the Frostig Program is generally used in conjunction with the Frostig Test to train children in those areas which have been singled out as visual-perceptual handicaps by the Frostig Test. In the present study, the perception of position in space section of the Frostig program was chosen because it appeared to lend itself to a programmed presentation without changing the nature of the task. (The stimulus materials used in this study may be seen in the Frostig Program Worksheets, 1964)

Frostig (1964) defines perception of position in space as, "... perception of the relationship of an object to the observer" (p. 16). Although the pencil and paper training program taps only a limited portion of the child's orientation to position in space, the actual training program begins with a series of body exercises in which the child develops awareness of the tactile sensations of his body. For example, at the direction of the teacher, he duplicates positions of children in drawings, touches different parts of his body, completes partially drawn figures, and differentiates left from right in
drawings of the human body. Only after completing these general orientation exercises is the child given the pencil and paper program. No attempt was made in the present study to duplicate these exercises or control for their effect. In fact, there is a large difference between the Frostig Program per se and the task employed in the present research in that a teacher is always present during the administration of the program to verbally mediate reinforcers and give directions. Another difference is that the last 10 tasks in the position in space section were not used because they were not programmable on the apparatus. The present author does not claim that the use of this part of Frostig's Program as stimulus objects in any way equates the present task with Frostig's task but only that the stimulus objects have been shown to be useful to identify perceptual differences in young children.

The Frostig Program is published on 8-1/2" by 11" sheets of paper, usually with four or five tasks per page. There are two basic types of task in the position in space section, a match-to-sample task in which only one of the matches is identical to the sample and an oddity task in which there are four identical stimulus objects and one different one. In all cases, the stimulus objects are represented two-dimensionally and in the same bluish color. In the match-to-sample section, the number of matches per
frame varies between three and five but not in any apparent order.

Reproductions of the Frostig material were made using a photographic technique with the actual Frostig materials which were cut out and fastened to a white background. The frames were made using Kodak 35 mm. film in a Voigtlander camera with a Porta-3 close-up lens at a distance of 13-1/2" from the subject matter. Two photos-flood-1 bulbs were used for illumination and the camera was set at f.11 at 1/15 second for all reproductions.

The total program consisted of 67 frames as originally presented in the Frostig sequence. According to the Frostig Teacher's Guide (1964), the materials in each sub-section of the program are progressively ordered in terms of difficulty and for this reason they were presented in their original order in the 67 frame program. The first 30 frames were of the match-to-sample variety, the next ten oddity, the next ten matching, 12 oddity, and the five match-to-sample. The two pilot Ss and the next six Ss were all presented with the entire 67 frame program. An analysis of their cumulative records indicated that several Ss were progressing through the first 30 frames relatively well and then extinguishing on the first few oddity slides. (For purposes of this study, extinction is operationally defined as leaving the room or five straight minutes without a response.) For the following 10 Ss, all
of the oddity frames were removed from the program reducing it to 45 frames of matching. This was done since it would be difficult to use verbal instructions to prompt Ss into correct responding in the oddity task (as is done in the usual administration of the Frostig Program). The cumulative records for the last 10 Ss appeared more consistent after the removal of the oddity items.

**Stimulus Presentation Apparatus**

The frames (35 mm. slides) were displayed by a Kodak Carousel projector onto the back side of the match-to-sample presentation window. This window is divided into two sections, the top (sample) section being all one piece of translucent plexiglas and the bottom (match) section being divided into five separate segments of the same material. Each section of window is hinged at the top and presses against a microswitch at the bottom. S registers his response by pressing against the window (pushing on the stimulus picture) and closing the microswitch. (For a block diagram of the inter-connections of the apparatus, see Fig. 1.)

An electrically operated shutter is located between the projector and the window such that the sample portion of the frame can be displayed without displaying the matches. S was required to press the sample each time the program changed frames so that the shutter would drop and
Fig. 1. Block diagram of match-to-sample apparatus.
he could see the matches. Since pressing the match windows before the shutter was lowered did not operate the equipment, S had to see the matches before he could respond.

When less than five matches were utilized in a given frame, they were arranged around the center window and the unused windows were left blank. In any given frame, only one match was correct and it always differed in terms of position or rotation in space. Since it is necessary to vary the position of the correct match to keep from developing a response set, the presentation device must have some way to "tell" the programming equipment which response is the correct one for any given frame. This was done using five small photocells, one centered above each match. Each frame was coded using a modified Davis slide punch to place a small hole in the cardboard mount. Light from the projector bulb passed through the hole in the mount and hit the photocell above the correct response closing a relay in the apparatus. When S pressed the match directly below the activated photocell, the "correct" circuit was energized and a positive reinforcer was given and when he pressed any of the other four matches, the "incorrect" circuit was energized and a negative reinforcer ensued.

It was necessary to build several "foolproofing" circuits into the apparatus to keep S from outwitting the
program. Fifteen of the 3PDT relays were used to keep $S$ from being reinforced for pressing more than one response at a time. These relays were wired such that if multiple responses were tried, all the circuitry was turned off and nothing happened. It was also necessary to induce $S$ to hold a given response for .2 seconds to keep him from running his finger along all five response windows like a boy dragging a stick along a picket fence. Without this "hold" circuit, $S$ would be reinforced for this "fence dragging" response or for a very rapid poke at one of the windows. This .2 second interval was chosen after watching college student $S$s perform in a previous program. An interval timer was used in an AAB sequence such that, if $S$ didn't hold a given window for .2 seconds, nothing happened and he had to repeat his response.

Whenever a correct response was made, the projector automatically advanced one frame and when an incorrect response was made, it backed up one frame. Thus, if $S$ was incorrect, he had to respond correctly on the previous frame to get another try at the one he just missed. This circuitry made it possible for $S$ to back up in the program by making a series of incorrect responses.

All of the relays used in the programming apparatus were mounted in relay racks and connections were made using patch cords and NuWay snap connectors. This was done to facilitate changes in the circuitry to make the apparatus
more flexible so that it could be quickly changed to another program.

**Reinforcing Systems**

Several different reinforcers were presented in the present study, probably too many to unequivocally study the effects of one given reinforcer. The apparatus was programmed to present a chime (pleasant tone), and red flash of light and sometimes a consumable reinforcer (an M&M candy) for a correct response. For an incorrect response, it provided a buzzer (aversive tone). It is also assumed from the data that progress in the program (seeing new frames) was positively reinforcing and that backing up (seeing an old frame again) was negatively reinforcing.

Voltage to the chime and buzzer were adjustable with rheostats and they were set so that the chime presented a single soft tone whereas the buzzer presented a loud, long noxious tone that would startle S. None of the Ss complained about the chime but several voiced a dislike for the buzzer and one (S3) placed his fingers in his ears when responding and pushed the match windows with his elbow after wincing to the buzzer several times.

The consumable reinforcers were delivered by a Davis dispenser through a tube into a tray below the response windows. The chime, light and buzzer followed S's response immediately (following the .2 second "hold"
interval) but the M&M required approximately one second to fall down the tube and reach S. S was allowed to eat the candy when it fell into the tray or to keep it in a plastic bag (provided by E) to take home and eat later.

There were also several secondary reinforcers available to S. Whenever he pressed a response window, the clicking of the relays, timer, recorders, shutter and projector could be heard faintly through the walls. A more prominent sound was provided when the M&M dispenser was operated. This caused a distinct "thud" and also a rattling noise as the candy fell down the "gooseneck" metal tube into the tray. The effect of these secondary reinforcers was not investigated.

A sequence alternator relay with position indicating lights was used in conjunction with a microswitch on a long cord to allow E to change the reinforcement condition from any point in the apparatus room. Two reinforcement conditions were employed; No S<sup>+</sup> condition in which a correct response was reinforced by a flash of light, a chime, and an advance in the program, and S<sup>+</sup> condition in which these reinforcers were supplemented by the consumable reinforcer. In both of these conditions, an incorrect response was followed by the buzzer and the program backing up one frame.
Recording Apparatus

Two recorders were employed in this study to keep track of S's performance. The primary record was provided by a cumulative recorder which was connected to the slide projector. Each time S was correct, the projector advanced one frame and each time he was incorrect, it backed up one frame so this recorder kept a running account of S's progress in the program over time. The reinforcement pen was wired to provide a slash mark on the cumulative record each time S received a consumable reinforcer. In this way, the cumulative recorder also kept track of which reinforcement condition S was in and how much time he spent in each condition. This recorder was originally operating at 3"/min. but the rate of 1-1/2"/min. was selected after the pilot study as being more convenient for the present design.

A 20 channel event recorder was also used to keep track of the temporal sequence of responses, position fixations, multiple responses, responses of too short a duration to operate the equipment (less than .2 seconds), number of positive and negative reinforcements administered, and rate of responding under each reinforcement condition. Channels one through five recorded responses on the five match windows, channel six recorded responses on the sample window, channel seven monitored correct responses, channel eight incorrect responses, and channel nine recorded
consumable reinforcers. This recorder operated independently of the programming equipment such that any response on one of the windows would be recorded as to time and duration of response regardless of whether or not it operated the equipment. The event recorder was also adjusted to operate at 1-1/2"/min. to allow a direct comparison with the cumulative record but in actuality, there was a slight disparity between the operating speeds of the two recorders such that a direct comparison was not possible.

Whenever S did something worth noting, E wrote it down on a blank portion of the cumulative record such that its approximate time of occurrence was noted.
PROCEDURE

A pilot study was conducted with two Ss (S1 & S2) to determine the most effective procedure to use and to get the "bugs" out of the apparatus. The instructions were standardized on these two Ss and several other changes were made in the apparatus as the result of the pilot study such as recorder speed, consumable reinforcer delivery method, and the scheduling of the $S^r$ reinforcement condition.

Each S was asked, before being placed in the experimental setting, if he liked M&M candies and if he would like to play a game to earn some. The answer to both these questions was affirmative in all Ss. Ss were usually brought to the trailer in E's car in groups of two or three and were allowed to play in the playroom while E started the equipment functioning and ascertained that everything was working.

Ss were taken into the experimental room one at a time and were read the standardized instructions while the apparatus was demonstrated by E. The instructions stated:

This is a game you can play. When you press the top picture (demonstrating), you see some more pictures down here. When you press the right bottom picture (demonstrating), this light flashes, this bell rings and you get a new picture on top. When you press the wrong picture (demonstrating), this buzzer buzzes.
Sometimes when you are right, a candy will fall into this tray (dropping an M&M into the tray by hand). You can eat the candies now or put them in this bag (handing S a "Baggie") and save them until later.

You see which way this top one points. You have to choose one on the bottom which points exactly the same way (demonstrating a correct response on the pre-Frostig frame).

Okay, now you try. Be sure to choose one on the bottom that is exactly the same.

If S responded correctly, E said, "That's right."

If S responded incorrectly, E said, "Try again."

If S persisted in the same error, E said, "Try a different one."

If S asked a question that could be answered by repeating a part of the instructions, it was answered and otherwise it was ignored. After S had correctly responded to the first frame, E left the room to monitor the equipment and change the reinforcement condition. The recording equipment was started just before taking S into the experimental room but S's cumulative record was considered to begin at his first response.

S was left alone in the experimental room until he completed the program or until his responding extinguished. Extinction was arbitrarily defined as S's either leaving the experimental room or going five straight minutes without a response.

Altogether, there were five schedules of reinforcement employed in this study but these were variations of three basic schedules, CRF (continuous reinforcement), NRF
The only reinforcer which changed from one schedule to another was the consumable reinforcer, the chime, light, buzzer, and progress or back-up in the program remained consistent throughout. More specifically, these schedules were: $\text{CRF}_1$ ($S_1$ & $S_2$) in which each correct response was reinforced with an M&M, $\text{CRF}_2$ ($S_3$, $S_4$, & $S_5$) in which the first correct response on any given frame was reinforced with an M&M, $\text{NRF}$ ($S_6$ & $S_7$) in which no M&Ms were dispensed, $\text{MRF}_1$ ($S_8$, $S_9$, $S_{11}$, & $S_{12}$) in which M&Ms were available for the first correct response on frames 1-20 alternating with no M&Ms in subsequent groups of 20 frames, and $\text{MRF}_2$ ($S_{10}$, $S_{13}$, $S_{14}$, $S_{15}$, $S_{16}$, $S_{17}$, & $S_{18}$) in which an M&M was available for the first correct response on frames 1-10 and then this was alternated with no M&M in subsequent groups of 10 frames.

$\text{CRF}_1$ schedule was abandoned and $\text{CRF}_2$ adopted after the pilot study which indicated that Ss who were reinforced for every correct response learned that it was to their advantage to back up in the program every now and then because they were reinforced for correct responding on frames they had already learned as well as new frames. In the $\text{CRF}_2$ schedule, Ss were unable to receive more than one consumable reinforcer per frame which made it necessary to keep learning new frames in order to get M&Ms. One S in the pilot study cycled back and forth between frame 2 and
frame 3 for 65 straight responses, pressing the correct response on frame 2, receiving a consumable reinforcer, pressing an incorrect response on frame 3 (the same one every time), backing up to frame 2, and receiving another M&M for the same correct response he had made previously. The CRF₂ schedule may have brought about earlier extinction in some Ss, but it is felt this change was necessary for Ss to learn the conceptual task.

In the NRF schedule, S got one M&M in the demonstration as did all other Ss but no consumables were administered for the duration of the experimental period. At the end of this period (after S finished all the frames or responding extinguished), the projector was turned back near the beginning of the program and S was placed on a CRF₁ condition so that he would be able to earn some M&Ms. No given amount of time was allowed but S was allowed to continue until he had what looked to E like about as many M&Ms as the other Ss in the playroom had earned previously.
RESULTS

Possibly the most striking resultant of the present study is the amount of intersubject variability. Progress in the program varied from 4 to 67 frames correctly responded to, total time spent in the experimental room varied from 7-1/2 to 43 minutes, rate of responding varied from 1.2 to 11.6 presses per minute and the percentage of correct responses varied from 45.4% to 100%. (For summary data for all Ss, see Table 1).

Due to this intersubject variability a brief chronology of results will be reported for each S individually. All 18 Ss were run between May 20 and June 11, 1966 in the late morning or early afternoon.

S1

S1 is a male who was 5 yrs. 11 mo. of age when he participated in the experiment. He was part of the pilot study and was on the CRF schedule. His rate of pressing was very high throughout the program as was his amplitude of response (not measured by the equipment but judged by the amount of noise created when he pounded on the response windows with his fists). The event recorder shows that S1 made frequent responses of too short a duration to operate the equipment and when this happened, he was often observed
Table 1

Summary Data for All Subjects

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age/yr.</th>
<th>Condition</th>
<th>Frames in Program</th>
<th>Total Responses</th>
<th>Time in Program</th>
<th>Time Responses</th>
<th>Frames Completed</th>
<th>Responses per Minute</th>
<th>% Correct</th>
<th>Extinction</th>
</tr>
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<tbody>
<tr>
<td>1 Timmy</td>
<td>M, 5/11</td>
<td>CRF1</td>
<td>67</td>
<td>255</td>
<td>22</td>
<td>161</td>
<td>94</td>
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<td>195</td>
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<td>111</td>
<td>84</td>
<td>111</td>
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<td>56.9</td>
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<tr>
<td>3 David</td>
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<td>CRF1</td>
<td>67</td>
<td>84</td>
<td>17</td>
<td>75</td>
<td>9</td>
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<td>17.1/2</td>
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<td>35</td>
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<td>7.8</td>
<td>74.5</td>
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<tr>
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<td>74</td>
<td>15.1/2</td>
<td>59</td>
<td>15</td>
<td>45</td>
<td>4.8</td>
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<td>92</td>
<td>45</td>
<td>0</td>
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<tr>
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<td>45</td>
<td>48</td>
<td>16.1/2</td>
<td>40</td>
<td>8</td>
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<td>70</td>
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<td>NRF</td>
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<td>75</td>
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<td>M, 6/4</td>
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<td>93</td>
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<td>NRF</td>
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<td>33</td>
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<td>25</td>
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<tr>
<td>16 John</td>
<td>M, 5/3</td>
<td>NRF</td>
<td>45</td>
<td>186</td>
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<td>7.5</td>
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<tr>
<td>17 Richard</td>
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<td>100.0</td>
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</tbody>
</table>
striking the window harder rather than holding his response for a longer period. This greater amplitude of response was probably shaped by accident since S1 tended to hold the response window longer when he hit it harder.

At several points in the program, S1 cycled back and forth between two frames, receiving a consumable reinforcer for every other response. For example, between minute 3 and minute 8-1/2, S1 went back and forth between frames 9, 10, and 11. Between minute 11 and minute 13, S1 cycled between frames 30 and 31. At minute 16 and thereafter, S1's cumulative record shows several points at which he was incorrect on several frames in a row and backed up in the program, for example, from frame 55 to frame 51. Overall, S1's progress through the program was relatively constant including the oddity items and he completed the program in 22 minutes receiving a total of 161 M&Ms. He appears to have learned the conceptual task since he completed all 67 frames.

S2

S2 is a 4 yr. 2 mo. old male and the brother of S1. He was a part of the pilot study and was on CRF schedule. His rate and amplitude of response were much less than S1's and he only completed 33 of the 67 frames in the 28-1/2 minutes he was in the experimental room.
After 9 minutes, S2 hadn't progressed beyond frame 2 so E went into the experimental room and repeated the portion of the directions emphasizing the direction in which the right triangle stimulus "pointed." After one correct response on frame 3, S2 cycled back and forth between frames 1 and 2 between minute 10 and minute 14. At minute 18, S2 responded correctly for 7 frames in a row and then began cycling again until minute 22 when he ceased responding for about one minute. S2's last response was made (to oddity frame 30 although he had been as far as frame 33) at minute 23-1/2 and, after an incorrect response, he wandered around in the experimental room without any further responding until, at the end of 5 minutes, E came in to let him out.

S2's rate of responding was relatively consistent over the 33 frames except when he ceased responding at minute 22 but his accuracy of responding was highly variable. The oddity portion of the program begins at frame 31 and it didn't appear that S2 caught on to the nature of the oddity task since, after correct responses on frames 31 and 32, he backed up to frame 30 and cycled between 30 and 31 for the last minute of responding. From his cumulative record, it may be concluded that S2 probably learned the nature of the matching task but probably didn't learn the oddity task.
S3

S3 is a 5 yr. 8 mo. old male who was on CRF schedule. S3 completed the 67 frame program in 17 minutes with a high accuracy of responding; over the whole program he made only 9 errors and most of those occurred early in the program.

From the first response, S3's rate of responding was relatively constant for the first 6 minutes at which point he ceased responding for just over 2 minutes. This break in the response rate occurred at the first oddity frame but it isn't known if this change in the program brought about his lack of responding. After minute 8, his response rate was relatively constant until the end of the program.

At about frame 20, S3 developed an interesting method of responding which persisted throughout the program. At frame 20 he had made 4 errors altogether, and he was observed to startle when the buzzer sounded. At this point, he placed his fingers in his ears and pushed the response windows with his elbow for many subsequent responses. It is possible that this "elbow pushing" response was maintained by the programmed reinforcers since S3 was observed to push the match window with his finger for less than .2 seconds duration at which he would use his elbow and, meeting the .2 second criterion, be reinforced. It therefore seems possible that S3's behavior
was shaped by the .2 second response duration requirement and that placing his fingers in his ears constituted a superstitious response. Not enough information is available to know whether S3's mode of responding was a superstitious response, was done purely to avoid the S-delta, or both. It does appear that S3 learned the conceptual task involved in the matching and oddity sections of the program.

S4

S4 is 7 yrs. 2 mo. of age and the sister of S3. She was on CRF2 schedule with the 67 frame program for 17-1/2 minutes at which time she completed frame 67. Her rate of responding was higher than that of S3 but her responding was less accurate.

For the first 4 minutes, S4 made 46 responses without being correct on frame 2. She persisted in making the same error on frame 2 and, at the end of 4 minutes, ceased responding for 1 minute. During this period, E entered the experimental room and repeated the instructions. After this procedure, S4 finished the remaining frames at a relatively constant rate with the exception of 1/2 minute pauses at minutes 8-1/2 and 11. She made several errors when the first oddity frames were presented and backed up 3 frames at that point but then she continued through the remaining frames with only 4 errors.
S4's rate of responding in the program is actually very high after minute 5 when she appeared to catch on to the task. She went from frame 3 to frame 67 in 12-1/2 minutes with only 12 errors, so, after an initial period of low accuracy, S4's responding rate and accuracy matched that of any other S. The same instructions were read to S4 at minute 4 that were read at the beginning of the experimental period so it is not known what brought about the great change in her performance. The most likely explanation is that S4 was not attending to the instructions when they were read the first time and that she responded correctly when E said, "Okay now you try" either by imitating E or by chance. However, it does appear that S4 learned both the matching and oddity tasks since she finished the program.

S5

S5 is a female, 5 yrs. 1 mo. of age. She was on CRF2 schedule in the shorter 45 frame program (with the 22 oddity frames removed). She completed the program in 15-1/2 minutes with a moderate rate of response and accuracy throughout.

For the first 5 minutes, S5 responded rapidly and without error. When she reached frame 17 (after minute 5 and 1 error), she began cycling between frames 16 and 17 for over .5 minutes. During this 5 minute period, she made
only 21 responses and she spent most of the time talking to herself, walking around, and trying to look out the frosted window. The last 1-1/2 minutes of this 5 minute period were spent at the window without any attention being given the apparatus.

At minute 9-1/2, S₅ spontaneously began responding again and continued through the remaining frames at a consistent rate making only 4 errors. If the 5 minute period of cyclical responding were removed from S₅'s record, her performance throughout the program would show a high rate and a high accuracy when compared with other Ss. No hints can be found in the cumulative record to indicate why S₅'s responding dropped off during that 5 minute period. Up until that time, she had received 17 consumable reinforcers most of which had been placed in the plastic bag and they were left on a chair and not attended to during the 5 minute period.

It appears that S₅ learned the conceptual task since she finished the program.

S₆

S₆ is a male, 5 yrs. 10 mo. in age. He was placed on the NRF schedule and he completed the 45 frame program in 22-1/2 minutes with a great deal of variability in response rate and accuracy.
For the first 5 minutes, S6 cycled between frames 1, 2, and 3. From minute 5 to minute 10-1/2, he went from frame 1 to frame 7 and then back down to frame 1. During this period his rate of responding was relatively constant but his accuracy was variable. It appeared that most of S6's errors were made in choosing the mirror image of the correct figure and then fixating on that particular choice.

At minute 13, S6 was still on frame 7 but from that point on, his accuracy increased greatly and he completed the program with only 6 additional errors. No changes in external stimulation were noted by E but, for some reason, there were two plateaus in S6's responding at minutes 15 and 16-1/2 when he stopped responding for about 1/2 minute and then built up to his previous rate.

S6 sometimes winced at the sound of the buzzer and it appeared to be very aversive to him but it is not known if this S-delta initially suppressed his response rate or had any other effect on his performance.

Since S6 completed the program without any consumable reinforcers, it is apparent that consumable reinforcement is not a necessary condition for the learning of this conceptual task but the amount of intersubject variability in this study makes any other conclusions tenuous.
S7

S7 is a 6 yr. 0 mo. old male. He was placed on NRF schedule in the 45 frame program. He did not complete the program but extinguished after 11-1/2 minutes of responding.

S7 made two correct responses during the first minute of the program and then poked at the matching windows for less than .2 seconds for the next 1-1/2 minutes. He then held the correct response window long enough to be reinforced on frame 3 and again poked at the windows for 2 minutes. He went into the experimental room and repeated the instructions and at that point, S7's rate of responding and accuracy increased greatly. For the next 5 minutes, S7 responded consistently and advanced to frame 34 with 7 errors.

At minute 11-1/2, S7 began to look around the experimental room and to talk to himself. He spent the next 5 minutes wandering around without attending to the apparatus (constituting extinction). He had responded correctly to the last 4 frames in a row before leaving the apparatus on frame 34.

S7 had a very low overall rate of responding (although his response rate was high from minute 5 to minute 10) but his overall response accuracy was high, some 88.3% correct. Since the extinction criterion of 5 minutes without a response had been arbitrarily chosen before running Ss, it was followed in this case. It is not known
whether S7 would have gone back to the apparatus if more time had been allowed and it is not clear what maintained his performance from minute 5 to minute 10 but, as is the case with S6, it appears that consumable reinforcers are not necessary to bring about learning in this particular task. From his cumulative record, it is difficult to say whether or not S7 learned the task but his performance from minute 5 to minute 10 gives some indication that he did.

S8

S8 is a 6 yr. 3 mo. old male who was on the MRF schedule. He had the 67 frame program but he extinguished on frame 32 after 38 minutes of responding.

For the first 7-1/2 minutes, S8 did not get past frame 4. After minute 7-1/2, he walked around the room for 3 minutes and so E returned to the experimental room and repeated the instructions. S8 emitted 7 more responses in the next 3 minutes but again did not get past frame 4. At minute 14-1/2, S8's response rate and accuracy increased (for no apparent reason) and he responded to frames 4 through 20 without error in 3-1/2 minutes.

The reinforcement schedule was changed (from CRF to NRF) on frame 20 and S8 cycled between frames 20 and 21 for 1-1/2 minutes. He then progressed from frame 21 to frame 30 in 2 minutes while making 1 error. The oddity task
began at frame 31 and S8 spent the next 15-1/2 minutes cycling between frames 30, 31, and 32 before extinguishing.

S8's rate of responding was variable throughout the experimental session and he often looked at the apparatus for up to 1 minute before making several quick responses in a row. His response rate was higher during the No $S^r$ condition but his accuracy was greater during the $S^r$ condition. Thus, it appears with S8 that consumable reinforcers may have maintained accuracy of responding but that they have a negative effect on response rate. However, the lower response rate may be an artifact because S8 picked up each M&M individually and placed it in the plastic bag at the time it was received (as did many Ss) and so he may have spent a greater portion of his time attending to the apparatus during the No $S^r$ condition.

From S8's cumulative record, it appears that he may have learned the matching task but that he probably didn't learn the oddity task.

S9

S9 is a female 4 yrs. 6 mo. of age and the sister of S8. She was on the MRF schedule for the 67 frame program. She extinguished on frame 31 after 31-1/2 minutes of responding.

After reading the instructions and demonstrating the apparatus, E left the experimental room. After the
instructions, "Okay, now you try," S9 had responded correctly to frame 1. Two minutes after E had left the room, S9 hadn't responded successfully. She was pressing the match windows which were blank since she had not pushed the sample window. E returned to the room and reread the instructions at this point and S9 began responding correctly.

After seven straight correct responses, S9 cycled between frame 7 and frame 8 for 3-1/2 minutes and backed up to frame 5. She then responded without error to frame 20 in 3-1/2 minutes and the reinforcement schedule changed. She progressed to frame 30 in 3 more minutes with 3 errors and began the oddity frames.

S9 responded in bursts for the next 18 minutes, cycling between frames 27 and 31 without any consumable reinforcers. At minute 22-1/2, she chose the same incorrect response to frame 31 9 times in a row before backing up to 29. Then she progressed to 31 again and chose the same wrong window 5 more times.

After minute 29-1/2, S9 sat down for 2 minutes and then got up and made 1 final response before sitting for the next 5 minutes. S9, like S8, was more accurate under the $S^r$ condition but responded at a higher rate under the No $S^r$ condition. She also fixated on a particular incorrect response several times and continued to repeat that response even though it was always negatively reinforced.
From her cumulative record, it appears that S9 may have learned the matching task but she did not learn the oddity task.

S10

S10 is the oldest S in this study, 7 yrs. 11 mo. She was also the most accurate in that she made no errors in the 45 frame program under the MRF2 reinforcement schedule. S10 was only in the experimental room for 7-1/2 minutes before finishing the program. She received 25 consumable reinforcers but, unlike other Ss, didn't pick them up each time they fell into the tray. In fact, she appeared to be much more interested in the stimulus objects than in the reinforcers.

S10 looked at the apparatus for her first 1/2 minute in the experimental room and then correctly responded to the first 10 frames in 1-1/2 minutes. After the first No Sr frame (frame 11), she paused for 1/2 minute and looked around the room before resuming responding. She then progressed to frame 45 in 5 minutes at a high response rate without any more plateaus even when the schedule changed.

Response rate under condition No Sr was higher for S10 than under condition Sr as is true of most Ss but response accuracy was the same (100%) under both conditions. During the last 5 minutes of responding, the rate for both
conditions was very high but it was somewhat higher under the No \( S^r \) condition. Unlike other \( S_s \), \( S_{10} \) did not handle the candies while responding and so her greater response rate without consumable reinforcers does not appear to be an artifact of time spent manipulating the candies.

Comparing \( S_{10} \) with the other \( S_s \), it appears as though performance in the program is a function of age but there are confounding variables in her case. According to her father, \( S_{10} \) does a great deal of reading and she had reading-readiness exercises in school which were much like the materials in the Frostig program.

\( S_{11} \)

\( S_{11} \) is a female whose age at the time of this study was 5 yrs. 9 mo. She was on reinforcement schedule \( CRF_1 \) in the 67 frame program. During 40-1/2 minutes in the experimental room, she emitted 315 responses before extinguishing on frame 60. This is the largest number of responses emitted by any \( S \).

For the first 12-1/2 minutes in the program, \( S_{11} \) did not get past frame 4 and she had a consistently low rate of responding. At minute 13, for no apparent reason, her response rate increased greatly and she progressed from frame 4 to frame 20 with 8 errors. After the schedule changed at frame 21, she cycled between 17 and 21 for the next 3 minutes. At minute 20-1/2, her response rate
increased rapidly again and she responded correctly to frames 20-31 in 1 minute.

At frame 31, the first oddity frame, S11 spent the next 5 minutes backing up and then getting back to 31 again. After progressing to frame 36, she began cycling again, this time from 33 to 36 for 4 minutes. From the beginning of the session, S11's response rate had generally increased to this point. After reaching frame 40, the $S^R$ condition was reinstituted and her response rate dropped. After 2-1/2 minutes of the $S^R$ condition, it was necessary for E to leave the apparatus room for 6 minutes (to take S12 to the toilet). S11 was told that E would be back soon and that she should keep "Playing the game" but in fact, she did not respond at all until E arrived back at the trailer. The apparatus was left on $CRF_1$ condition during E's absence but since no responses were made, this did not affect S11's performance. It is not known what S11 did for these 6 minutes or what effect the break had on her overall performance.

S11 resumed a high response rate for 2-1/2 minutes after E's return to the trailer. Accuracy was not high during this period but she did progress as far as frame 60. During the next 5-1/2 minutes, she backed up as far as frame 53 (although still under $S^R$ condition) and then her responding extinguished on frame 54.
In general, as with most Ss, S11's response rate was higher under No S condition and her response accuracy was greater with consumable reinforcers. She appeared to lose interest in the program during the last 5-1/2 minutes of responding and several times she pressed responses without looking at them. From the cumulative record and from her progress to frame 60, it could be concluded that S11 learned the conceptual tasks involved but there is a great deal of variability in her responding as well as some indication of difficulty with the early oddity items. After the experimental session, S11's father (a Ph. D. psychologist) experimented with a match-to-sample task using triangularly shaped stimulus objects (Tortilla chips) which also served as the consumable reinforcers. When S11 matched correctly, she was allowed to eat the "match." S11 was able to respond in this task and a similar oddity task without error and thus, it appears that she did learn the concept formation task.

S12

S12 is a 4 yr. 0 mo. old male, the brother of S11 and the youngest S in the present study. He was assigned to the 67 frame program under reinforcement condition MRF. S12 went only as far as frame 4 in his 20 minutes in the experimental room although he made 75 responses. His overall accuracy of response was low (52.0%) and he only
received 4 M&Ms for his participation in the program. Later, he was given a few more "free" candies so that he would have some to carry home with him.

S12 began by responding correctly to the first 4 frames in his first minute in the experimental room. Then he cycled back and forth from frame 1 to frame 4 for the next 19 minutes. His responding was variable and he would respond for 2 or 3 minutes and then look at the apparatus for a while. His pauses became more frequent near the end of the experimental period and he finally extinguished on frame 2.

S12 participated in the same match-to-sample task that S11 had done using Tortilla chips, providing some measure of his learning in the present program. According to his father, S12's performance appeared to be near the chance level even when he was given each correct "match" to eat. Thus, it appears that S12 did not learn the conceptual task involved in the present research and that his progress through the first 4 frames may have been due to chance.

S13

S13 is a female, 5 yrs. 1 mo. in age. She was run on the MRF2 schedule in the 45 frame program. S13's responding extinguished after progressing through 10 frames in 17 minutes. S13 had the greatest difference in accuracy
between $S^r$ and No $S^r$ conditions of any $S$ tested; 100% correct with consumable reinforcers and 49.2% without.

$S_{13}$ progressed to frame 10 in 6 minutes of responding with no errors. Although the reinforcement schedule changed at that point, she never correctly responded to frame 11 and therefore had no way of knowing of that change. $S_{13}$ cycled between frames 9 and 11 for the next 6 minutes, always pressing the same incorrect response on frame 11 (some 27 times). Frame 11 does not appear to differ in any great way from the previous frames and it is not known why $S_{13}$ persisted in the same incorrect response.

After 12 minutes of responding, $S_{13}$ sat down in the chair and looked around the experimental room for 5 minutes (constituting extinction). $S_{13}$ was noted wincing at the buzzer several times during her responding (as did several other $S$s) but she is the only $S$ who visibly jumped at the sound of the chime. Both auditory stimuli may have been aversive to this $S$ and this may have extinguished response differentiation. She picked up the M&Ms as they fell into the tray and put them into the plastic bag but she was not observed to eat any while responding. Possibly the auditory stimuli were so aversive to $S_{13}$ that the consumable reinforcers were not positive enough to maintain responding, although the great difference in response accuracy between the two conditions indicates that the M&Ms were having some effect on her performance.
It is difficult to state whether or not SI3 learned the conceptual task but it is probably safer to conclude that her early extinction indicates that she did not.

SI4

SI4 is a 6 yr. 4 mo. old male who was placed on schedule MRF2 in the 45 frame program. He completed the program in 18 minutes receiving 25 consumable reinforcers. His responding was variable throughout the experimental session and he tended to respond in bursts and then look around the room for a while.

For the first 3 minutes, SI4 responded correctly to the first 7 frames without error. Then he began cycling between frames 6, 7, and 8 for the next 4-1/2 minutes at which time he left the apparatus for 2-1/2 minutes. During the 2-1/2 minute period he played with the door for a time (without opening the door) and then began what looked to E like a "snuffling" sort of crying. E went into the experimental room and repeated the instructions (not knowing what else to do) and SI4 stopped "snuffling" and began to respond again.

For the next 18 frames, this S responded without error, pushing at a much higher rate during the No S condition. He cycled between frames 26 and 27 a few times (4) and then finished the program with one additional error on frame 44. At minute 15, he stopped responding for 1
minute to play with the flexible pipe that dispenses the M&Ms into the tray.

S14 is the only S whose response accuracy was greater during the No Sr reinforcement schedule. Most of his errors were made in the 4-1/2 minute period when he was cycling between frames 6, 7, and 8 and, although he didn't receive any M&Ms during that time, he was on the Sr condition until frame 10. Since about 3/4 of S14's errors were made during this 4-1/2 minute period, this greatly lowers his accuracy for the Sr conditions of the schedule. It is not known whether S14 understood the instructions before they were re-read but his 7 correct responses previous to that time would indicate that he did. No differences could be observed by E between frames 6 and 7 that would cause the difficulty that S14 had progressing past that point in the program. There is no direct indication whether this S was "snuffling" because of frustration with the program, discomfort at being left alone, or some other variable.

It might be hypothesized that this kind of problem could be minimized by having a non-interactive adult present in the room with each S to comfort those Ss who have a fear of being left alone. This adult could sit quietly reading or knitting or some similar activity in a part of the room removed from the apparatus and would answer S's questions by "reflecting" them. No good evidence is available but it is felt that S14 would not
have begun "snuffling" with an adult present since he stopped after re-read the instructions.

S15

S15 is a 5 yr. 7 mo. old female who was on MRF schedule in the 45 frame program. She extinguished after 21 minutes in the experimental room during which time she progressed as far as frame 18. Her rate of responding was moderately rapid at the beginning of the experimental session and gradually her response rate dropped until she left the apparatus and played with the door for her last 5 minutes in the room.

S15 responded to the first 10 frames in 5 minutes while making 1 error. She correctly responded to the next 6 in a row and then began cycling between 16, 17, and 18 at a low rate of response for 8-1/2 minutes. At minute 16, this S left the apparatus after an incorrect response to frame 18.

This is the only S whose response rate was higher during the S\textsuperscript{R} condition. She is also the only S whose response rate and accuracy clearly dropped off after the consumable reinforcers were discontinued (which was expected in all Ss). It is not known whether her responding would have increased again with the reintroduction of the S\textsuperscript{R} condition because she did not reach frame 20. It appears that response rate and accuracy were maintained in this S.
by the consumable reinforcers but it would have been necessary to reintroduce the $S^r$ condition to really demonstrate operant control. With $S_{15}$, it is probably safest to assume that she did not learn the conceptual task.

$S_{16}$

$S_{16}$ is a male aged 5 yrs. 3 mo. He was on schedule MRF$_2$ in the 45 frame program and his responding extinguished after 20-1/2 minutes in the experimental room. His progress in the program was less consistent than that of any other $S$ and he backed up in the program all the way to frame 1 three different times.

After an initial error on frame 2, $S_{16}$ progressed through frame 9 without further error. He cycled between 8 and 9 for 2 minutes and then backed up to frame 1 in 8 straight errors. During this period of backing up, this $S$ chose the match with no stimulus object pictures if there were fewer than 5 matches on that frame. He cycled between frame 1 and frame 2 for 1 minute and then progressed to frame 9 without error. After 3 identical errors on frame 9, $S_{16}$ rapidly progressed to frame 16 without error. After cycling between 15 and 16 for a minute, $S_{16}$ began a gradual 3-1/2 minute backup to frame 1. After cycling between 1, 2, and 3 for 2 minutes, he progressed to frame 9 again and
then backed up directly to frame 1 again. During most of this time, his response rate was high and relatively consistent.

During his last 3 minutes of responding, S16 cycled between frames 1 and 4 and eventually opened the door and left the experimental room with the apparatus on frame 1. His response accuracy was the lowest of any S due to the many times when he backed up in the program. It looked to E as though the backing up were a conscious effort to be incorrect as S16 would carefully look at the matches in each frame and usually choose the blank one if they did not all contain stimulus objects.

S16's response rate was higher during the No Sr condition and his accuracy was greater during Sr condition but it is hard to know how to interpret these data with his many reversals. It is possible that control over the frames (being able to go forward or backward at will) was more reinforcing to this S than any of the other reinforcers and that his behavior was maintained by being able to go forward or backward whenever he chose. He is the only S that backed up for long distances and it is not felt that reinforcement control was gained with this S. It is exceedingly difficult to say whether or not this S learned the conceptual task but there is evidence that he learned a different conceptual task, control of the direction of the projector.
S17

S17 is a male 4 yrs. 8 mo. in age. He was placed on MRF₂ schedule in the 45 frame program. He remained in the experimental room for 32 minutes before extinguishing on frame 17. His rate of responding gradually slowed after the last consumable reinforcer with the exception of three periods of rapid pressing.

S17 started responding immediately after E left the room and proceeded to frame 10 with 7 errors in 6 minutes at a slow rate of response. He then proceeded on the No Sᵣ condition to frame 17 with 6 more errors and, after reaching frame 17, cycled between 14 and 17 for the next 18-1/2 minutes before leaving the apparatus for 5 minutes. His errors on frame 17 were mostly choosing the same wrong response which was a mirror image of the correct response. S17's response rate was variable during the last 18-1/2 minutes and he often paused for 1/2 minute to look around before responding rapidly for 1 or 2 minutes.

As with most of the Ss, S17's response rate was higher during the No Sᵣ condition but his response accuracy was greater during the Sᵣ condition. It is not known what maintained his responding during the time he cycled between frame 14 and frame 17 for the last 18-1/2 minutes of responding but, as with other Ss, just seeing some change in the stimulus objects may have been sufficiently reinforcing to maintain pressing. Even when cycling between 2
frames, each S was still being reinforced for each correct response by the chime and the flash of light and these reinforcers may have been better behavioral maintainors in some Ss than in others.

Sl8

Sl8 is a male aged 6 yrs. 8 mo. He was assigned to the MRF schedule on the 45 frame program. His overall response accuracy was very high and he completed the program in 8-1/2 minutes while making only 3 errors.

After E left the experimental room, Sl8 made 4 rapid correct responses and then began playing with the M&M dispensing tube (as Sl4 had done). After about 1/2 minute of playing, he resumed rapid responding until he reached frame 12. His response rate slowed for a short time after he reached the No S condition and, generally, his response rate appeared more stable in the S condition although it was higher at times in the No S condition. Immediately after the two times when the program changed from S to No S, Sl8's rate of responding decreased momentarily and then increased to a higher rate than it had been under the S condition.

Sl8's response rate was higher under the No S condition and his response accuracy was higher under the S condition. He did not make any errors while he was being
reinforced by M&Ms but he made only 3 errors in the other condition.

S18's performance indicates that he learned the conceptual task and he is one of the only Ss that did not do any cycling between frames. He was never wrong on any given frame more than once, a datum shared only by S18 and S10. However, the cumulative record does not clearly indicate whether this S's behavior came under reinforcement control.

Statistical Analyses

Several trends are evident in the data that appear to be consistent across Ss despite the great intersubject variability. Various dependent variable measures were tried to ascertain the best way to present the data. Among those tried were ratio of correct to incorrect responses, time in each reinforcement schedule, correct and incorrect responses per minute, etc. The two measures which seem to best describe the data are response rate (in responses per minute) and response accuracy (in percentage of responses which were correct). These two measures reflect the changes in responding that accompany changes in the reinforcement schedule.

Ten of the 18 Ss, Ss 8, 9, 10, 11, 13, 14, 15, 16, 17, and 18, responded under both the S^R and No S^R conditions and consistent trends were noted under these two
conditions. With one exception (SI5), the response rate was always higher under the No S condition and with one exception (SI4), response accuracy was greater under the S condition. It was decided to attempt a statistical analysis of these trends to see if they were significant across Ss.

A correlated t test was employed to test the mean differences across Ss for the variables rate and accuracy under the two reinforcement conditions. (For a summary of these data, see Table 2.) There was a significant difference between rate of responding under the two conditions at the .05 level of confidence (t = 2.30). The difference observed in accuracy of response under the two conditions was not significant at the .05 level of confidence, however, it was significant at the .10 level (t = 1.98) indicating the presence of a definite trend. From these two statistics, it may be concluded that for the 10 Ss who participated in both reinforcement conditions, a significantly higher rate of responding was noted in the No S condition but response accuracy was greater during the S condition although not significantly so.

Trends in the Data

Other trends of a descriptive nature appear across Ss. For example, 3 of the 8 Ss who participated in the complete 67 frame program extinguished on one of the first 3 oddity frames. It was felt that this was too large an
Table 2

Differences Between Reinforcement Conditions in Response Rate and Response Accuracy for Ss 8, 9, 10, 11, 12, 14, 15, 16, 17, and 18

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean for Sf cond.</th>
<th>Mean for No Sf cond.</th>
<th>d.f.</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response rate</td>
<td>4.9/minute</td>
<td>6.4/minute</td>
<td>9</td>
<td>2.30**</td>
</tr>
<tr>
<td>Response accuracy</td>
<td>77.9%</td>
<td>65.8%</td>
<td>9</td>
<td>1.98*</td>
</tr>
</tbody>
</table>

*p < .10
**p < .05

increment in the program and that, without using additional instructions at the point of change, it was best to eliminate the oddity items which resulted in the shorter 45 frame program.

One important trend is the tendency for older Ss to be better performers than younger ones. All 4 of the Ss under 5 years of age (S2, S9, S12, and S17) reached extinction without completing the program whereas none of the Ss over 6-1/2 years (S4, S10, and S18) extinguished. The Ss under 5 years of age averaged 55.1% correct responses while the Ss over 6-1/2 years averaged 89.53% correct. Thus, there is some evidence that behavior in this particular concept formation task is a function of age.
No real trends were noted in terms of sex differences. Males averaged 67.6% correct while females averaged 71.5%, not a significant difference. Response rate and total time in the program also appeared relatively equal between males and females. Both males and females averaged 22-1/2 minutes in the program. Fifty-four per cent of the males in this study extinguished whereas 57% of the females reached extinction.

With several Ss (S2, S4, S8, S9, and S14), it was necessary for E to go back into the experimental room and repeat the instructions. This was done when S did not progress beyond the first few slides in the program and did not appear to understand the conceptual task (except with S14 where it was done mostly to reduce his discomfort). With these 5 Ss, the task may have differed significantly due to E's intervention but the data do not reveal any obvious differences.

Another behavior which appeared in nearly all Ss (all but S3, S7, S10, and S18) was some form of cycling back and forth between 2 or 3 frames. Usually, S would consistently choose the same wrong response on a given frame. Since the cycling response was so common, it may be suggested that the positive and negative reinforcers were not specific enough to bring about progress in the program and that the change in stimulation as the frames changed was enough reinforcement to maintain cycling.
DISCUSSION

The present research is an exploratory study undertaken to determine some of the critical variables involved in a match-to-sample conceptual task with young children. The rather complicated apparatus, which was used for the first time in this study, worked well after a few initial "bugs" were removed. The match-to-sample technique appears to be an effective way to present a reading-readiness program like Frostig's. Intersubject variability was great in this study but, despite that fact, certain trends were observed and analyzed which held up rather well across Ss.

In comparing the results of this study with those cited in the literature, some differences may be noted. For example, Martin and Blum (1961) found significant sex differences in an oddity task using three-dimensional stimulus objects differing in terms of size, color, form, and spatial orientation. In normal Ss, males were better performers in this particular oddity task. In the present study, no significant sex differences were noted, however, the stimulus objects were two-dimensional and were different in the spatial orientation dimension only. The differences in the perceptual task in these two studies could have caused the differences noted here and, in a culture where an early emphasis is placed on boys manipulating
objects such as in sports or building things, the Martin and Blum findings are not surprising.

Staats (1964) found that his Ss acquired basic reading behaviors (a concept formation task) under reinforcement conditions but did not learn to read under a No Sr condition. Staats recorded his Ss progress in the program with a cumulative recorder and he drew his conclusions on the basis of response accuracy rather than rate of responding. Taking the accuracy variable alone, the results of the present study are in accord with those of Staats in that Ss appear to learn the conceptual task more readily under a reinforcement condition. However, Ss in the present study did learn the task under the NRF schedule and, in fact, responded at a higher rate under this schedule than when they were receiving consumable reinforcers. There are several factors which make a comparison of the present data with those of Staats tenuous. In the present study, condition No Sr is not a removal of all reinforcers but only of the consumable reinforcer. In the NRF schedule, Ss still saw a flash of light, heard a chime, and saw the program advance when they responded correctly and so it is not surprising to discover that learning took place even without M&Ms.

Staats also mentioned a problem in using a cumulative record as a response measure, a problem which also occurred in the present study. The cumulative record
cannot be treated as a measure of a free operant when $S$ obtains a consumable reinforcer (or token in Staats' study) because he will then spend a certain amount of time manipulating or consuming this reinforcer. This behavior brings about an artificially lower rate of responding under the reinforcement condition but the actual rate may be the same or higher if "reinforcer manipulating behavior" could be removed from the cumulative record. Staats quotes Long (1962) as having mentioned the same problem in an operant study.

One possible solution to this problem would be to place a transparent cover such as a clear plastic lid over the reinforcer tray such that $S$ could see the reinforcers but not manipulate them. At the end of each experimental session, the cover could be removed and $S$ would be allowed to collect all the reinforcers at once. A procedure similar to this was followed by Bijou (1955) in an early operant child study where $S$s obtained "trinket" reinforcers by dropping rubber balls into an apparatus.

In a study by Donaldson (1959), logically equivalent positive and negative information did not appear to be psychologically equivalent in a matching task. In Donaldson's study, 14 year old children were unable to use negative information as effectively as positive information in matching. This finding has implications for the present study in that $S$s were negatively reinforced (negative
information) for incorrect responses and positively reinforced (positive information) for correct responses. Positive and negative information were not logically equivalent in the present study in that a correct response gave specific information whereas an incorrect response still left S with a choice of 4 possible correct responses. In the present study, it appears that Ss receiving more negative information are more likely to extinguish before completing the program, but this conclusion is confounded by many other untapped variables such as ability to perform in the concept formation task and level of motivation. If less negative information had been used in this study, for example, turning off the buzzer or having the program remain on a given frame until the correct response was made instead of backing up, it appears from Donaldson's results that fewer Ss would have reached extinction.

Ss were also given many different kinds of positive reinforcement in the present design. In the NRF schedule, S saw a flash of light, heard a chime, and progressed to another frame for each correct response. In the CRF schedule, S also received an M&M for each correct response. There may be too many modes of positive reinforcement in this study for S to effectively use all of the positive information available. It is suggested that this variable be tapped in future research by using the reinforcers singly and in different combinations to ascertain the most
effective reinforcement technique to use for the behavior under study.

Several limitations to the conclusions of the present study have implications for future research in the area. Although a trend toward more accurate responding at a lower rate was noted in the $S^r$ condition, this finding may be confounded by a procedural variable. All 16 Ss who were responding under the $S^r$ condition at some time in the program were placed on that schedule first. This was done to maximize interest in the task in order to discourage early extinction. This procedure may have depressed the response rate in the $S^r$ condition since most Ss began responding at a low rate until they caught on to the nature of the task. In future research, Ss could be assigned to the initial condition randomly to control for this effect and to see if the higher response rate under the No $S^r$ condition is an artifact of the procedure in the present study.

Another limitation may be noted in the application of the Frostig Program to the present task. The present use of this material cannot be equated with Frostig's pencil and paper presentation where a mediator (teacher) is always present to verbally prompt each child. Frostig (1964) states that the material becomes progressively more difficult in each subsection of her program and that the steps between frames are small enough that the child will
not have difficulty with the continuity of items. However, in the present use of the Frostig material, there was no mediator present to provide verbal prompts and so the steps between frames may have been too great for some Ss without some specific instructions. Some indication of this problem is given by the fact that 3 of the 8 Ss who participated in the 67 frame program (including the oddity task) extinguished on one of the first 3 oddity items and most of the other 5 Ss had a plateau in their cumulative record when the oddity task began. It is felt that specific verbal instructions at this point would have minimized this difficulty since the Frostig Teachers Manual (1964) states that the child is verbally directed to pick the "different one" by the teacher. The removal of the oddity items appeared to reduce the problem of early extinction in the program but it is not known how this change affected the continuity of the material.

Frostig's manual also states that the program is applicable to children from 3-1/2 to 7-1/2 years but in the present use of the Frostig material, the age range should probably be raised somewhat due to the difference in the conceptual task. In the present research, children over 6-1/2 seemed to perform well even when the program changed to oddity items. Children under age 5 did not perform accurately regardless of the reinforcement condition. A similar problem was noted by Staats (1964) who had
difficulty maintaining matching behavior in his 4 year old Ss. It is felt that an age range of 5 to 8 years would be more suitable to study concept formation in the present programmed use of the Frostig material.

In her Teacher's Guide (1964) Frostig states, "Within each set of work sheets the exercises for a particular type of training begin with the easiest and progress through those of medium difficulty to those that are most difficult. This order should be strictly adhered to in the sense that an easier exercise should always precede a more difficult one" (p. 99). The present study offers evidence that the logical order of the Frostig Program is not in the materials as she implies but is dependent on the skill of the administering teacher. In the 67 frame program, the cumulative records of all Ss showed some change with the first oddity item (frame 31) and 3 of the 8 Ss who participated in this program extinguished on one of the first oddity frames. When these items were removed, there was less difficulty with Ss extinguishing early in the program despite the fact that 22 frames had been removed from the middle of Frostig's material. This would give some indication that the most difficult matching items are not as difficult as the easiest oddity items. The Teacher's Guide also states that, "Specific needs of individual children must also be taken into consideration as you plan the amount and range of work
to be done" (p. 99), so it is evidently up to the teacher to tailor the materials to each child using sufficient verbal prompts to help him understand the nature of the task.

In the present research, a great deal of inter-subject variability was noted. Although this is a characteristic of operant research, a more meaningful analysis of Ss' performance in the Frostig program might be gained by matching Ss in terms of conceptual ability by using the Frostig test. Small groups of Ss matched for age and perceptual ability could then be run under different reinforcement conditions, giving a somewhat less confounded analysis of the differences between conditions. The Frostig test could also be used as a pre- and post-experimental measure to ascertain the amount of learning that took place as S went through the program. In this sort of design, it would also be necessary to use a control group without any specific concept formation practice between the pre- and post-test to control for improvement in performance that did not result from the program (such as remembering some of the items from the pre-test).

Another limitation to the findings of the present study is that some Ss may have felt uncomfortable in the experimental setting since they were put into an unfamiliar room by an unfamiliar person and they were shut in that
room for an unspecific time. Some Ss in the present study showed some signs of hesitancy in entering the experimental room whereas others barged right in and appeared eager to begin the task. Some control over this variable might be obtained by having an adult seated in a corner of the room doing some "busywork" task or reading. This observer could remain non-interactive if approached by S by "reflecting" his questions or comments. For example, if S were to ask the observer if the equipment were broken (when he was not getting M&Ms), the observer could say, "You think maybe the equipment is broken." This sort of non-interaction should extinguish question-asking and commenting and it is felt that, in time, S would come to ignore the presence of the observer.

There is a methodological limitation to the observations in the present study. When the reinforcement schedule was changed from CRF to CRF, a sequence alternator relay was installed in conjunction with a microswitch on a long cord to allow E to change the condition from S to No S from any point in the apparatus room. This apparatus was used when the MRF schedule changed from one condition to the other or when S backed up in the program. In order to keep track of when S was backing up in the program, E had to attend to the cumulative recorder and the frame indicator (on the projector) and this limited giving attention to S and keeping notes on his behaviors. In
future work, it is suggested that an assistant be employed to take care of this task or that it be automated by the equipment using an add-subtract counter. In addition to the add-subtract counter, a stepping relay added to the present sequence alternator relay would allow programming the changes in the reinforcement schedule. Thus, S could pre-set the program to change every 10th or 20th frame from \( S^R \) to No \( S^R \). These two additions to the present apparatus would make its operation totally automatic and would free E for behavioral observation or other tasks.
APPENDIX A

EQUIPMENT CATALOG

Trailer—Specially made to order for Dr. Ralph J. Wetzel by Sportcraft of Arizona.

Match-to-sample presentation window--Ralph Gerbrands Co.

Power supply--28 v.d.c. Grason-Stadler model E783DA.

Cumulative recorder--Gerbrands C-3 factory modified for use with Kodak Carousel projector.

Event recorder--Esterline-Angus 20 channel model AW.

Projector--35 mm. Kodak Carousel model 550.

Interval timer--Grason-Stadler model E1100H.

Shutter--2 segment, 110 v.a.c. specially made by Ralph Gerbrands Co.

M&M dispenser--Davis model MMD-1.

Sequence alternator relay--Foringer 1186-M1.

Cumulative recorder control--Foringer 1193-M1.

Camera--Voigtlander Ultramatic 35 mm.

S^F light--#93 bulb in red lens, voltage adjusted by rheostat to 16 v.d.c.

S^F chime--Household doorbell type, voltage set at 12 v.d.c.

S-delta buzzer--Household doorbell type, voltage set at 20 v.d.c.
Switching relays--Advance and P&B 3PDT types with 5 amp contacts (3/4 used).

Latchng relays--P&B K817D 24 v.d.c.
LIST OF REFERENCES


