REINFORCERS FOR THE TWELVE-MONTH-OLD IN AN OPERANT MANIPULATIVE TASK

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ABSTRACT

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By

Suzanne P. Marshall

Selected auditory and visual reinforcers were compared as to their effect upon responsiveness and color discrimination performance by 12-month-old infants in an operant panel pressing task. The purpose was to find a reinforcer which could maintain responding beyond the seven to 15 minute session typically employed with 12-month-olds. Seventy-two infants (36 boys, 36 girls) were divided into eight groups varying as a function of the color reinforced (blue or green) and the reinforcer received. The types of reinforcement included: (1) a single auditory reinforcer: a stranger's voice; (2) a single visual reinforcer: a red light; (3) a compound auditory-visual reinforcer: a voice and a red light combined; and (4) a variable reinforcer: voice, red light, blinking lights, and chimes, presented singly and in all possible two stimulus auditory-visual combinations. In addition, a pilot group of 19 infants (10 boys, 9 girls) was run to determine what effect increasing the probability of stimulus-response contiguity would have on discrimination performance.

While the major analyses failed to find any differences between the reinforcers, they did reveal: (1) a significant

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decrease in responding and increase in discrimination performance between the fourth and sixth minute of conditioning, independent of any change in experimental manipulations; (2) a significant effect of the color reinforced upon discrimination performance; (3) a significant tendency to respond more to one side than the other; and (4) a suggestion from the pilot data that stimulus-response contiguity may improve discrimination learning by the 12-month-old. All of these findings should be taken into account in designing future studies with 12-month-olds.

Approved Hiram E. Fitzgerald

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Date 8/7/72

REINFORCERS FOR THE TWELVE-MONTH-OLD IN AN OPERANT MANIPULATIVE TASK

By

Suzanne P. Marshall

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ACKNOWLEDGMENTS

As the months of preparation, running, and evaluating of the present study draw to a close, I welcome the opportunity to reflect back upon those times and to offer my thanks to the many individuals whose unique contributions have become so intimately entwined in this final work. Among these individuals the members of my committee Drs. Mark Rilling and Ellen Strommen deserve a special thanks. Dr. Rilling provided a large portion of the programming equipment needed in the present study. Dr Strommen both long before as well as when the present study was conceived spent a great deal of her time listening and constructively evaluating my ideas for infant research. I'd like especially to thank my chairman Dr. Hiram Fitzgerald whose standards of excellence in designing and evaluating one's research both inspired my efforts and guided them in the present study.

In reflecting on the actual preparation and running of the study a number of individuals come to mind. First of all, I am grateful to my husband for the hours he spent helping to build the apparatus and program the equipment. Secondly, I'd like to thank my co-experimenters Beth Matter and Heidi Schwartz, NSF undergraduate research assistants, who each spent hours writing to prospective subjects and helping to run the study when it got underway. And finally my thanks to the 148, 12-month-old infants who came to participate in my task.

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INTRODUCTION

The purpose of the present study was to compare the ability of selected auditory and visual reinforcers to sustain the responsiveness of 12-month-olds in an operant manipulative task. In order to stay within the time limits imposed by the 12-month-old's attention span, such studies have typically employed short sessions lasting on the order of seven to 15 minutes (Hill, 1962, 1965; Lipsitt, 1963; Simmons, 1964; Simmons & Lipsitt, 1961; Weisberg & Simmons, 1966). While simple discriminations have been trained in these sessions (Hill, 1962, 1965; Lipsitt, 1963; Simmons, 1964; Simmons & Lipsitt, 1961; Weisberg & Simmons, 1966), more demanding problems such as oddity discriminations generally have not been mastered (Hill, 1962; Lipsitt, 1963). A methodological factor which may contribute to both the necessity of short conditioning sessions and the difficulty in training more complex problems is the type of reinforcer which has been used. That is, the reinforcers commonly employed may not be powerful enough to maintain the 12-month-old's interest beyond a 15-minute session or over the repeated sessions required for more difficult problems. The characteristics of reinforcing stimuli have been shown to have definite effects on the level of responding by two-to-five-month-old infants (Caron, Caron, & Caldwell, 1971; Koch, 1968).

But the question remains as to which aspects of reinforcement (e.g. modality and familiarity) are most important in maintaining the attention of the 12-month-old.

A comparison of the effectiveness of reinforcers used in past research is confounded by variations in the infants' age and sex; the required response; and the manner of reinforcer presentation. A series of controlled investigations is needed to compare reinforcers and to account for the influence other experimental variables might have on the effectiveness of such stimuli.

The present study was designed to compare selected auditory and visual reinforcers presented to 12-month-olds in an operant panel pressing task. The following review illustrates the diversity of auditory and visual reinforcers that have been used in infant research, and points to the procedural and subject related variables that may have influenced their effectiveness. (See Reese and Lipsitt's (1970) review for a summary of other stimuli that have been used as reinforcers in infant research.)

Auditory reinforcers. Several studies have investigated the infant's response to auditory social stimuli in the form of the mother's or a stranger's voice. Friedlander (1968) found that with increased experience with his Playtest apparatus and increased chronological development, infants ranging from 11-to 15-months-old came to prefer the more novel disguised voice of their mothers over a stranger's or their mothers' bright voices. Koch (1968) using repeated presentations of the mother's face and voice or a stranger's face and voice as a reinforcer for a conditioned orienting response, found higher responding to the more novel stranger as the number of sessions progressed. (Subjects were two-to-five-month-olds and were tested in ten, 12-to 15-minute sessions.) Bank (1968), Wahler (1967), and Weisberg (1963) employed auditory social reinforcers in controlling sucking, smiling, and vocalizing respectively.

Auditory stimuli such as chimes (Lipsitt, 1963; Simmons, 1964; Weisberg, 1963), buzzers (Lipsitt, 1963), tones (Dorman, Watson, & Vietze, 1971; Watson, 1969), and music (Friedlander, 1968; Smith & Smith, 1962) have also been used. Simmons (1964) and Lipsitt (1963) found such reinforcers to be effective in an operant discrimination task with eight- and 12-month-old infants. Friedlander's 13-month-old infant preferred his mother's voice to Bach. Smith and Smith (1962) noted that infants as young as eight months showed a definite interest in music but only one of 10 subjects from four to 22 months learned to touch a plate to activate tape recorded songs. This failure may have resulted from their use of relatively long (two-to three-minute) reinforcement periods which limited the frequency of response-reinforcement pairings. Using a 1000-Hz tone of medium intensity, Watson (1969) demonstrated better operant control over visual fixations in 10- and 14-week-old girls than boys. (Fourteen-week-old boys responded better to a visual reinforcer and 10-week-old boys failed to learn.) Weisberg (1963), using contingent reinforcement with a door chime, failed to condition vocalizations in three-month-old infants.

Visual reinforcers. Various visual reinforcers such as slides of geometric forms, schematic faces, checkerboards, mothers' faces, and pictures of spinning clowns have been given as reinforcers for such responses as headturning, panel and lever pushing, nonnutritive sucking, and visual fixations (e.g. Caron, 1967; Lipsitt, Pederson, & DeLucia, 1966; Rheingold, Stanley, & Cooley, 1962; Siqueland & DeLucia, 1969; Watson, 1969). Lights, while not commonly used as reinforcers have been shown to elicit visual orienting (Cohen, 1969; Levison & Levison, 1967) and have been used by Friedlander (1961) as a reinforcer in a manipulative situation.

Compound auditory and visual reinforcers. Compound auditory and visual reinforcers may prove superior to single modality stimuli in sustaining the infant's attention over a sufficient number of trials for the learning of complex behaviors. Their effectiveness in simple tasks has been demonstrated by Rovee and Rovee (1969) in a conjugate reinforcement study. In their study, increased intensity of kicking resulted in proportional increases in the movement of a mobile eventually causing the parts of the mobile to bang together producing both auditory and visual reinforcement. Using a compound auditory and visual reinforcer, Watson (1969) was successful in conditioning 10-week-old girls but not boys to visually fixate one of two blank targets. Rheingold, Stanley, and Doyle (1964) increased the rates that two-to-five-year-olds touched a ball for a compound sound and motion picture reinforcement. While the reinforcement was successful in maintaining the children's participation during the first session, the children lost interest earlier in a second but otherwise identical session.

Variable reinforcers. In discussing the decreased responding in their two-to-five-year-old children in the second session, Rheingold et. al. (1964) suggested that variation in reinforcement might have maintained responding for a longer period of time. Research reported by Caron, Caron, and Caldwell (1971); Koch (1968); Siqueland (1969); and Siqueland and DeLucia (1969) speaks directly to this point. Koch compared the effectiveness of a mother's face and voice; a stranger's face and voice; and different noise making toys as reinforcers for conditioned orienting in three groups of two-to-five-month-old infants. As mentioned earlier, infants reinforced by the stranger responded at higher rates over the 10 sessions than those reinforced by the mother. However, the group reinforced by different noise making toys was the most resistant to satiation and therefore produced the highest level of responding. Koch postulated that a familiar repeatedly presented stimulus (the mother) will lose its reinforcing value more quickly than will a novel repeatedly presented stimulus (the stranger). Nevertheless, the infant will in time, also become satiated with a novel stimulus when it is repeatedly presented.

Siqueland and DeLucia (1969) conditioned high amplitude nonnutritive sucking in two groups of 12-month-olds. The groups differed in the amount of reinforcer redundancy. Conditioning involved presentation of slides as reinforcers over two consecutive four-minute sessions followed by two- and three-minute periods of extinction respectively. A "high-redundancy" group saw four slides a total of four times each over the two conditioning phases. A "low-redundancy" group saw eight slides, each presented twice. Slides were changed every 30 seconds. The groups did not differ in responsiveness until the second conditioning phase at which time the high-redundancy group responded at a higher level than the low-redundancy group but also demonstrated a decline in the rate of responding. On the other hand, the response rate for the low-redundancy group was stable. It appears that if conditioning periods were lengthened, the response level of the high-redundancy group may have continued to decline to a level below that of the low-redundancy, stable responding group. That is to say, satiation effects may not be observable in the typical short session used with infant subjects. But if longer sessions were needed for more complex learning tasks, the less redundant reinforcers might prove to be more effective than the repetitive reinforcers frequently employed in infant research. Again it should be noted that in Koch's (1968) study where the changing stimuli did bring higher responsiveness, the infants were undergoing a series of ten, 12-to 15-minute sessions and not one short session as in the Siqueland and DeLucia study.

In 1969, Siqueland reported a study with four-month-olds in which one group of infants was familiarized with the reinforcing stimuli for two minutes prior to eight minutes of conditioning. Results indicated attenuated conditioned responding following familiarization. That is, the group reinforced for high or low amplitude sucking following familiarization, showed a lower rate of the required response than those infants for whom the reinforcers were new. Siqueland (1969) also reported studies with four-month-olds in which novel auditory or visual reinforcements were introduced following five or six minutes of training. Results indicated an increase in conditioned responding by infants reinforced by new stimuli compared with infants who received no change in the type of reinforcer presented over trials.

Caron, Caron, and Caldwell (1971) carried out an extensive investigation of the relative ability of reinforcers varying in redundancy, pattern complexity, and color to maintain an operantly conditioned head turning response in three-and-one-half-month-old infants. Following a period of varying reinforcers, all infants save the control subjects, were exposed to one of several redundant reinforcement conditions. Significant response decrements occurred in those infants receiving simple or complex patterns which either were purely repetitive or alternated only in color. The extent of response decrement was attenuated when reinforcing stimuli alternated in pattern or in both pattern and color. Moreover, reinforcement by continuously changing stimuli was superior to any stimuli in which repetition was involved.

Sex differences. The question of possible sex differences in responsiveness to different reinforcers was raised by Watson's (1969) study in which he conditioned 14-week-old infants to visually fixate one of two blank targets. The infant girls learned better with auditory reinforcement while the boys learned better with visual reinforcement. Watson suggested the possibility of an interaction of sex by modality of reinforcement by the intensity of that reinforcement. Accordingly, Dorman, Watson, and Vietze (1971) varied the intensities of Watson's stimuli adding a higher and lower intensity in each modality. Using a procedure similar to Watson's, they found that only when the medium intensity stimulus (Watson's) was the first to be presented were the findings similar to those in the 1969 study. Lewis, Baumel, and Groch (1971) compared the responsiveness of three-month-olds to stimuli in the auditory and visual modalities. Their findings were analogous to Watson's 1969 study in that girls showed heart rate deceleration more to auditory than to visual stimuli; although boys' decelerations did not significantly differ for the two modalities.

Investigations of the relative attentiveness of infants to novel and familiar stimuli have found sex differences in habituation of attention and in the effects of stimuli varying along a novelty continuum. (Novelty can be defined as the extent of discrepancy from a standard familiarized stimulus or as the degree of uncertainty within and between the components of a stimulus.) If as Kagan (1967) ascertains, learning is a function of both stimulus-response contiguity and attentional involvement of the subject; and if sex differences exist in the factors influencing this involvement, then these differences must be considered in determining the characteristics of an effective reinforcer. Cohen, Gelber, and Lazar (1970); Kagan and Lewis (1965); and Pancrantz and Cohen (1970) found greater incidence of habituation over trials by males than by females in infants ranging from four to 13 months. In particular, Kagan and Lewis found that 13-month-old boys clearly habituated to a matrix of blinking lights and to readings of a paragraph, while girls in both cases were more likely to sustain attention across trials. Caron and Caron (1969) in what appears to contradict the above findings, found that three-and one-half-month-old girls showed steeper decrements in visual fixations to checkerboard patterns than did males. These results were replicated by Caron, Caron, and Caldwell (1971) in their study of redundant and constantly changing reinforcers which is described above.

McCall and Kagan (1970) and Meyers and Cantor (1967) found differential responsiveness in heart rate deceleration to novel and familiar stimuli only in their male subjects (four- and six-months-old respectively). Studies in which the extent of novelty has been varied (Kagan & Lewis, 1965; McCall & Kagan, 1967; Weizmann, Cohen, & Pratt, 1971) have in general found that infant girls respond preferentially to the more novel stimuli. In the Kagan and Lewis study, six-month-old girls preferred jazz music (as determined by heart rate deceleration) whereas boys preferred an intermittent tone. Paragraphs with low meaning, high inflection (i.e. the condition of maximum uncertainty) were more preferred by 13-month-old girls than boys. Weizmann et al.'s (1971) eight-week-old girls responded more reliably to a novel mobile when in a novel bassinet; whereas the eight-week-old boys responded to the novel mobile more reliably when in a familiar bassinet. McCall and Kagan (1967) familiarized infants from their third to fourth month with a standard stimulus and then at four months presented three graded discrepancies from it. Magnitude of cardiac deceleration was an increasing function of discrepancy for girls but not for boys.

Purpose and hypotheses. The purpose of the present study was to compare selected auditory and visual reinforcers in terms of their ability to maintain responding by 12-month-old infants in an operant manipulative task. All subjects participated in a color discrimination task. Groups varied as a function of the discriminative stimulus rewarded and the reinforcer which was given. The following questions were considered:

(a) Would a single auditory or visual stimulus or a combination of these be more effective in maintaining a high level of responding across trials? Although the present study chose an auditory and a visual stimulus, the primary interest was in the particular stimuli and not in the modalities they represented. The same reasoning applied to the social versus nonsocial nature of the reinforcers (i.e. the concern was with the stimuli themselves not the class of stimuli represented).

(b) Would the decrease in redundancy facilitated by a series of different reinforcers, serve to sustain interest and thereby maintain responding more than a single reinforcer?

(c) Would the differential responsiveness of boys and girls to novelty and modality of a stimulus array interact with the reinforcing stimuli in determining the most effective reinforcer?

It was hypothesized that the ability of the reinforcer to maintain a high response level across trials would increase with the number of different stimuli presented within a single and across a number of trials. Although sex differences may emerge both in the extent of sustained responding and as a result of the effects of reinforcers varying in sensory modalities and degree of familiarity, past findings are not clear enough to predict with confidence the direction such differences would take.

METHOD

Subjects. Ninety-one 12-month-old infants (46 boys, 45 girls with a mean age of 11.9 months and a range of 11.4 to 12.6 months) were solicited by mail, newspaper ads, and notices to married students at Michigan State University. Names for those solicited by mail were obtained from newspaper birth announcements. Each family whose name was obtained from the newspaper received a letter explaining the general purpose of the experiment with a postcard to be returned if they were interested. Families were then called, all questions answered, and appointments made. An effort was made to have each infant come to the laboratory at a time when the mother felt he would be most alert and rested. Infants were randomly assigned to the various reinforcement groups within one phase of the study at a time with the restriction that the sexes be as equally balanced as possible across all conditions. The 91 subjects were those remaining from a total of 148 after pilot work was complete and subjects eliminated for failure to meet performance criteria (see explanation below). Five other subjects were eliminated to make the experimental groups more equal in size.

Apparatus. The infant's responses were made to a three panel apparatus with a 24 X 15½ inch front surface. The apparatus was made of wood and painted flat black. Its front face sloped 30° from the vertical away from the infant. Each 6 X 4 inch panel was composed of four pieces of plexiglas (clear, white, and two frosted from top to bottom) with a 1½ inch diameter hole in the center of the white piece through which blue or green stimulus lights could be seen. The panels and discriminative stimulus lights were the same in the first two phases of the study. During the third phase which was essentially pilot in nature, a new set of lights was used and a hole was cut in the top layer of the plexiglas directly above the stimulus lights. This gave an additional dimension to the panels which it was hoped would draw the subjects' attention to the discriminative stimuli and increase the likelihood of stimulus-response contiguity.[1] In all phases of the study, six small circles were found equally spaced around the larger hole and 5/8 inch from it. Through these six spaces neon blinking reinforcer lights could be seen. Each panel was above a microswitch that was triggered when the infant depressed the panel. The apparatus was wired such that a response to the positive stimulus could not be recorded while a response was being made to the negative panel and vice versa.

A speaker, 3 inches in diameter, was located below each

[1]Several investigators (Jeffrey & Cohen, 1964; Murphy & Miller, 1959; Ramey & Goulet, 1971) have demonstrated that children ranging in age from 41 months to 11 years have considerable difficulty solving discrimination problems when the discriminative stimuli and locus of response are spatially separated. The present pilot work was an attempt to determine the applicability of these findings to 12-month-olds.

panel. A small red light protruding approximately ½ inch from the front surface of the box, was found centered above each panel. The speakers and red lights provided the auditory and single light reinforcers (see below). The use of three speakers, three red lights, and three sets of blinking lights was to maximize the probability that the infant would associate the reinforcement with a given discriminative stimulus and not with the entire experimental situation (Friedlander, 1966).

Presentation and timing of the stimulus lights and reinforcers and counting of the subject's responses to each panel was controlled from the experimenter's unit located in an adjoining room. A tape recorder used in playing a female stranger's voice saying "that's good; you're doing fine", and chimes from the Sound of Music, was placed with the experimenter's unit.

Testing for all infants with the exception of a few pilot subjects took place in a 6½ X 5½ X 5½ foot sound-attenuated room with an ambient noise level of 30 db. The only sound other than that coming from the apparatus, the infant, or his parent was produced by a fan in the ceiling above the test box. This sound was 30 db above the ambient level. The room was dimly lit so that the discriminative stimuli and reinforcing lights would be maximally visible. The lighting was not however so dim as to possibly upset the infant.

Procedure. A period of five to 10 minutes was set aside at the beginning of each session to talk to the parent and to enable the parent and the infant to become comfortable in the situation in the absence of the experimenter. At the beginning of this time the parent was given a further explanation of the study; asked to sign a permission form; and asked not to interact with the infant during the actual experiment unless it was necessary to comfort him. (Most subjects were accompanied by their mothers although several fathers stayed with the infants during the session.) The parent was informed that the experimenter would be able to hear what was happenning and would terminate the session should the infant become upset during testing. It was explained to the parent that after he and the infant were alone in the situation for a few minutes and when the infant seemed at ease, the experimenter would turn on the stimulus lights. The parent was instructed to direct the infant's attention to the lights and to demonstrate by pushing each of the two outer panels twice. Following the demonstration, the lights would be turned off momentarily. This was to signify to the parent that from that point on, he was to refrain from directing the infant in any way. During the study the parent positioned himself in a location which would be to the rear of the infant whenever he was playing with the apparatus. The parent sat either on the floor or on a chair whichever was preferred. The parent was however encouraged to sit on the floor because in this position the infant was less likely to want to climb on his parent's lap which would be several feet from the experimental apparatus. During pilot work an attempt was made to have infants remain seated in front of the apparatus, but the protests which ensued led to a change in procedure which would allow the infant to move freely around the sound-attenuated room.

The experimental design is summarized in Figure 1. The first two phases of the study were alike with the exception of the stimulus which was rewarded. Subjects in the first phase were reinforced for responding to the blue light while those in the second phase were reinforced for the green light. Within each positive stimulus group, subjects were divided into four additional groups varying only with regard to the kind of reinforcement received. Each blue positive reinforcement group was composed of 10 infants (five girls, five boys) and each green positive group had eight infants (four girls, four boys). The four reinforcement groups were as follows:

Group I (single auditory reinforcer) subjects were rewarded by a three-second tape recording of a cheery female stranger's voice saying, "that's good; you're doing fine".

Group II (single visual reinforcer) subjects saw three seconds of a red light presented above the positive stimulus.

Group III (compound auditory-visual reinforcer) subjects saw three seconds of the light and heard the voice simultaneously.

Group IV (low redundancy, variable reinforcer) subjects

Group	S^+	Subjects	Reinforcement	Periods (Same for all)
I	Blue	5 male 5 female	3 sec. voice of stranger	Baseline: two, 15 sec.periods two, 5 sec.timeouts Conditioning: six, 60 sec.periods six, 5 sec.timeouts Extinction: two, 60 sec.periods two, 5 sec.timeouts Reconditioning: six, 60 sec.periods six, 5 sec.timeouts Final Extinction: four, 60 sec.periods three, 5 sec.timeouts
	Green	4 male 4 female		
II	Blue	5 male 5 female	3 sec. red light	
	Green	4 male 4 female		
III	Blue	5 male 5 female	3 sec. voice plus red light	
	Green	4 male 4 female		
IV	Blue	5 male 5 female	3 sec. presentations, 1 stimulus for 30 sec.: voice; red light; voice & red; blinking lights; voice & blinking; chimes; chimes & red; chimes & blinking	
	Green	4 male 4 female		
Pilot Flat	Blue	5 male 5 female	Same as Group IV	
Pilot Hole	Blue	5 male 4 female	Same as Group IV	
Total: 91 subjects				18 minutes, 30 sec. with lights; 1 minute 35 sec. timeout

Fig. 1. Design of the experiment.

received eight different reinforcers: stranger's voice; red light; voice plus red light; blinking lights; blinking lights plus voice; chimes; chimes plus red light; and chimes plus blinking lights. The order of these stimuli was randomly determined within blocks of eight with the stipulation that the same stimulus could never be the last in one block and the first in the next. The order of presentation of the three randomized eight stimulus blocks was also randomized across subjects. All reinforced responses in a given 30 second period received the same reinforcer.

The general experimental paradigm was the same for all groups: 30 second baseline[2]; six minutes conditioning; two minutes extinction; six minutes reconditioning; and four minutes final extinction. In all phases the stimulus lights were turned off after every minute for a five second timeout. After each 30 second interval, the experimenter recorded the cumulative responses to each panel and to the positive and negative stimuli and changed the reinforcing stimulus for Group IV. After each minute the experimenter also changed the position of the stimulus lights according to a predetermined random position sequence. Each subject received one of six orders of stimulus light presentation with each light appearing half the time on the right and left sides. (It

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[2]One subject in each green positive group received one minute of baseline. A t-test performed on the total responses of these versus the remaining green positive subjects did not reveal a significant difference (t = .879, df = 30).

should be noted that the center panel was never used in the present study.) During the baseline period the lights were on but no reinforcement was given. Following the first 15 seconds of the baseline, the position of the colored stimulus lights changed. Baseline data was originally deemed necessary to determine the existence of color or position preference as well as the operant level of responding. It was however too short to be used for anything but color preference testing. (Some subjects did not respond at all during this time; but color preference could only be tested prior to reinforcement of responding.) Position preference was determined with data from the entire session. A longer baseline used in pilot work was shortened because it appeared to extinguish the subjects' interest in the apparatus. Subjects received continuous reinforcement throughout all conditioning periods. However, the apparatus was set up such that responses occurring during a reinforcement were recorded on the counters but did not lead to another reinforcement. Subjects therefore frequently responded more than once for each reinforcement. During extinction the stimulus lights remained on (except during timeouts) and changed as required at the end of one minute periods. No reinforcement was given during extinction except at the end of the first extinction period in order to regain the subject's attention to the box prior to the reconditioning phase. Reconditioning and final extinction followed the same format as original conditioning and extinction . If during the first conditioning period the subject stopped responding for more than three minutes or if any time after first extinction responding ceased for greater than two minutes, the session ended. Also, if at any time during the session the infant refused to continue (e.g. by crying) the session was terminated. Subjects had to remain in the study at least through the first extinction period in order for their data to be considered.

The third phase of the study was run primarily to collect pilot data concerning the importance of stimulus-response contiguity in the discrimination performance of 12-month-olds. As noted previously, evidence gathered with older children (e.g. Jeffrey & Cohen, 1964) indicated that discrimination was severely retarded when the discriminative stimuli and the required response were not spatially contiguous. The question was therefore raised as to whether 12-month-olds could discriminate better if they pressed the panel directly at the stimulus light. It was noted during the first two phases that the infants were particularly attracted to any part of the box that protruded or indented from the remaining portions. It was hoped that if the panel were indented only at the light itself, this might prompt responding at the discriminative stimuli. Therefore, a hole was made in the top piece of the plexiglas panels directly over the stimulus lights. Five male and four female subjects were run in the blue positive, variable reinforcement condition with the indented panels. A comparison group of five males and five females had a flat panel and was also run under the blue positive, variable condition. However, the two groups were not completely comparable because the first had a 30 second and the second a one minute baseline. Nevertheless, the data was worth considering for information applicable to possible future research.

RESULTS

To determine the effects of the reinforcement conditions on total responding as well as their effects on discrimination, two basic measures of each subject's performance were used in the analysis: total number of responses and discrimination ratios, $\frac{S^+ - S^-}{S^+ + S^-}$. The former measure consisted of merely counting the responses made to each stimulus during each minute of testing. The latter measure examined the relative number of responses to the positive (S^+) and negative (S^-) stimuli during each minute and thus limited the effect of large individual differences in the amount of responding. The possible discrimination ratios range from -1 indicating that the subject responded only to the negative stimulus, through 0 representing equal responding to both stimuli, to +1 indicating responding only to the positive stimulus.

Total responding. No differences were found in the total number of responses made by subjects in each of the four reinforcement groups in either the blue or green positive stimulus conditions (Figures 2A & 2B). A three factor mixed design with repeated measures on one factor ($\text{Reinforcement}_4 \times \text{Sex}_2 \times S^+S^-_2$) performed within each positive stimulus condition (blue and green) yielded a significant

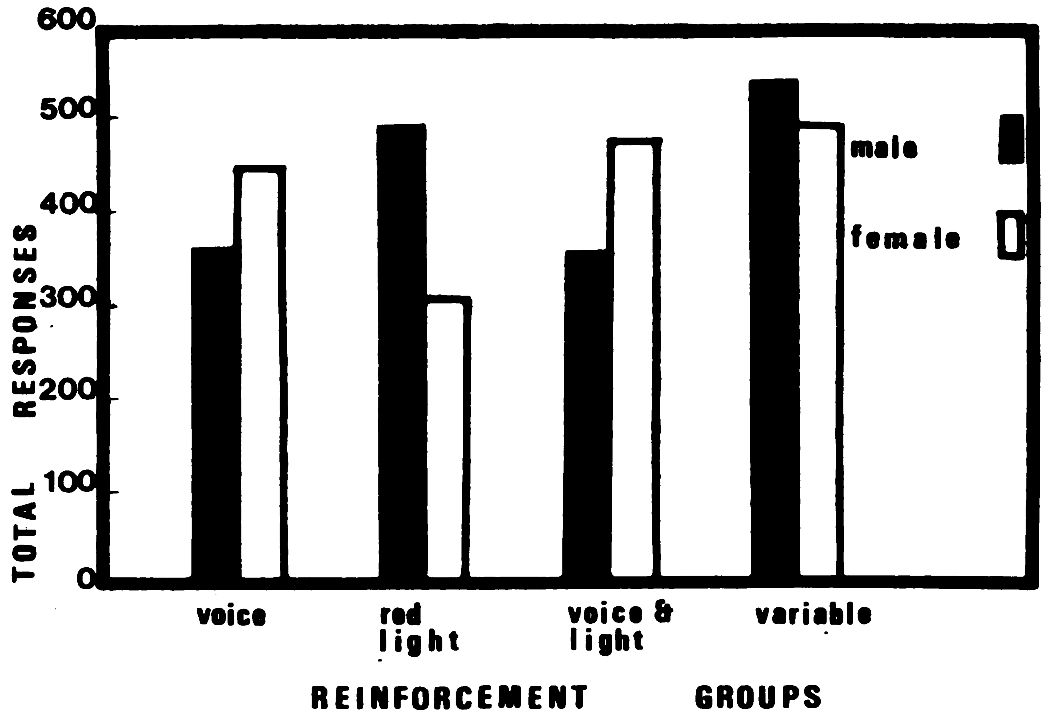

Fig. 2A. Total responses in blue positive, male and female reinforcement groups. N = 5 per column.

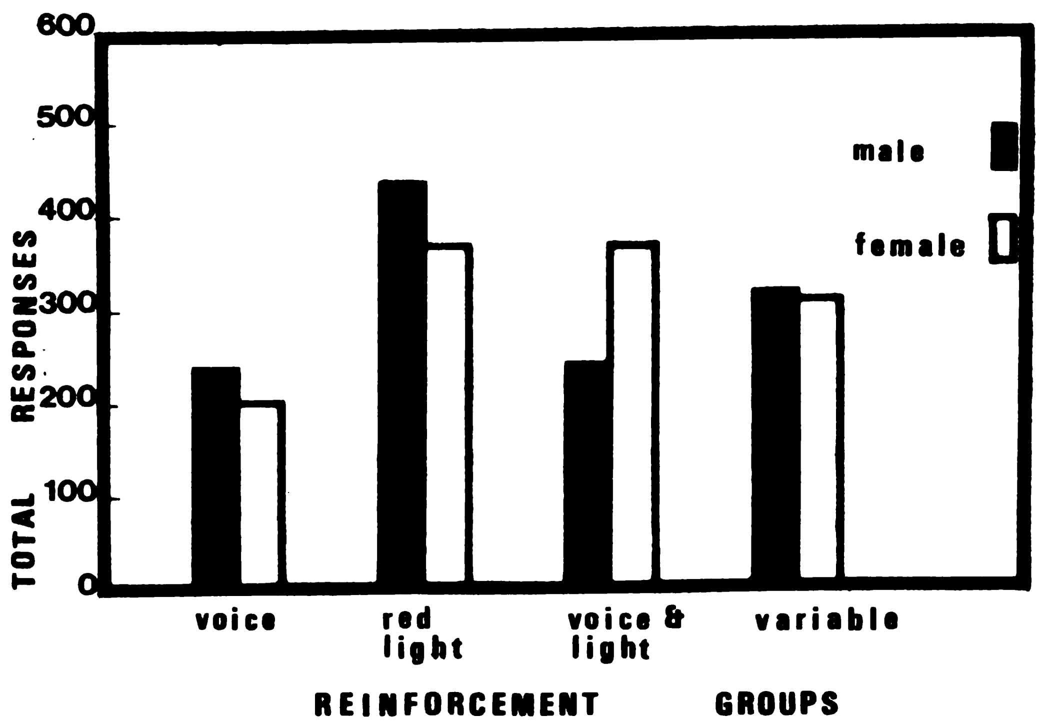

Fig. 2B. Total responses in green positive, male and female reinforcement groups. N = 4 per column.

difference in total responding to the positive and negative stimuli (Blue: $\underline{F} = 6.44$, $\underline{df} = 1/32$, $\underline{p} < .025$; Green: $\underline{F} = 8.2$, $\underline{df} = 1/24$, $\underline{p} < .01$) (All analysis of variance tables yielding significant results may be found in the Appendix.)

In order to examine the change in total responding per minute (i.e. trial) a three factor mixed design with repeated measures on one factor (Reinforcement$_4$ X Sex$_2$ X Trial$_8$) was performed separately within the blue and green positive conditions. Only the six minutes of the first conditioning and the two minutes of the first extinction were examined because of the small number of subjects completing the remaining portions of the study. Results within the blue positive condition indicated a significant trials effect ($\underline{F} = 9.32$, $\underline{df} = 7/224$, $\underline{p} < .001$). A Neuman Kuels (Winer, 1962) performed on this effect revealed a significant difference ($\underline{p} < .01$) between trials one through four and six through eight. It should be noted that trial six which is part of conditioning was significantly different from trials one through four of conditioning but not from trials seven and eight which composed extinction (see Figure 3A). That is, responding decreased prior to the implementation of the extinction phase. Results within the green positive condition also revealed a trials effect ($\underline{F} = 9.45$, $\underline{df} = 7/168$, $\underline{p} < .001$). In addition a Reinforcement $\underline{x}$ Sex $\underline{x}$ Trials interaction was also found ($\underline{F} = 2.35$, $\underline{df} = 21/168$, $\underline{p} < .005$). A Neuman Keuls performed on the trials effect found trials seven and eight (i.e. extinction) to be significantly

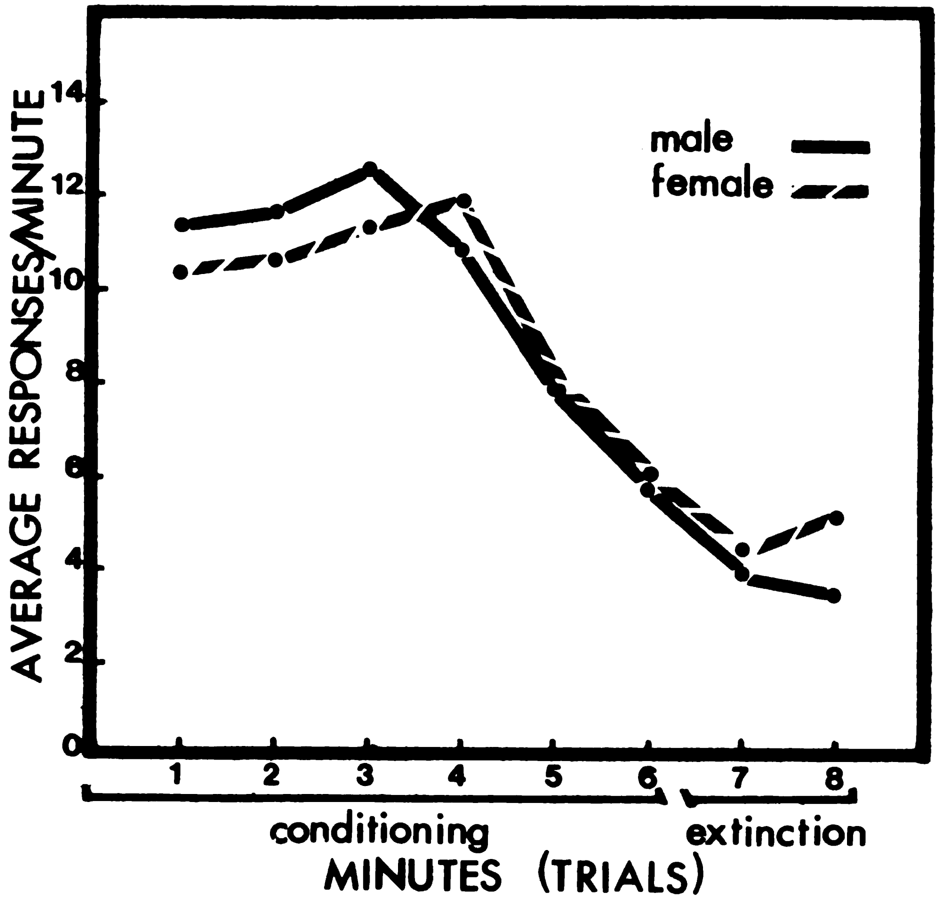

Fig. 3A. Average responses per minute for male and female subjects across blue positive groups.

different ($p < .01$) from trials one through four but not from trials five and six; trial five was significantly different from trials one and two; six was also different from one. Note that here again, responding in the last trials of conditioning did not significantly differ from responding during extinction (see Figure 3B).

In a three factorial design ($\text{Reinforcement}_4 \times \text{Sex}_2 \times \text{Color Reinforced}_2$), no difference was found in total responding as a function of the color which was rewarded.

Discrimination performance. Discrimination ratios were used in a three factor mixed analysis ($\text{Reinforcement}_4 \times \text{Sex}_2 \times \text{Trials}_8$) performed separately for the blue and green positive stimulus conditions. Within the blue condition a significant trials effect was found ($F = 2.2$, $df = 7/224$, $p < .05$) as well as trends toward Reinforcement x Trials; Reinforcement x Sex; and Reinforcement x Sex x Trials interactions ($F = 1.51$, $df = 21/224$, $p < .07$; $F = 2.46$, $df = 3/32$, $p < .09$; $F = 1.56$, $df = 21/224$, $p = .05$; respectively). A Neuman Keuls performed on the significant trials effect yielded a significant difference ($p < .05$) between trials four and five (see Figure 4). It should again be noted that this difference lies within the conditioning trials. As seen in the figure, discrimination during trial five was better than in trial four. No significant differences or trends were found in the comparable analysis for the green positive subjects. It should also be noted that no significant differences were found in discrimination performance between reinforcement groups

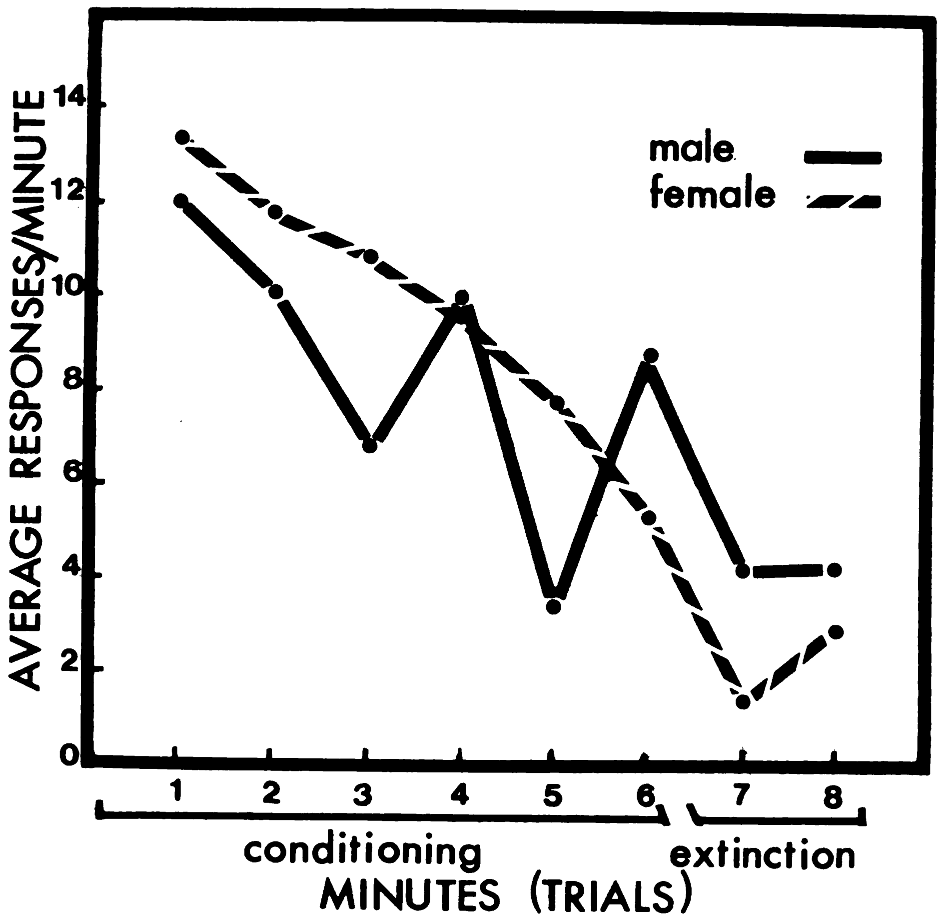

Fig. 3B. Average responses per minute for male and female subjects across green positive groups.

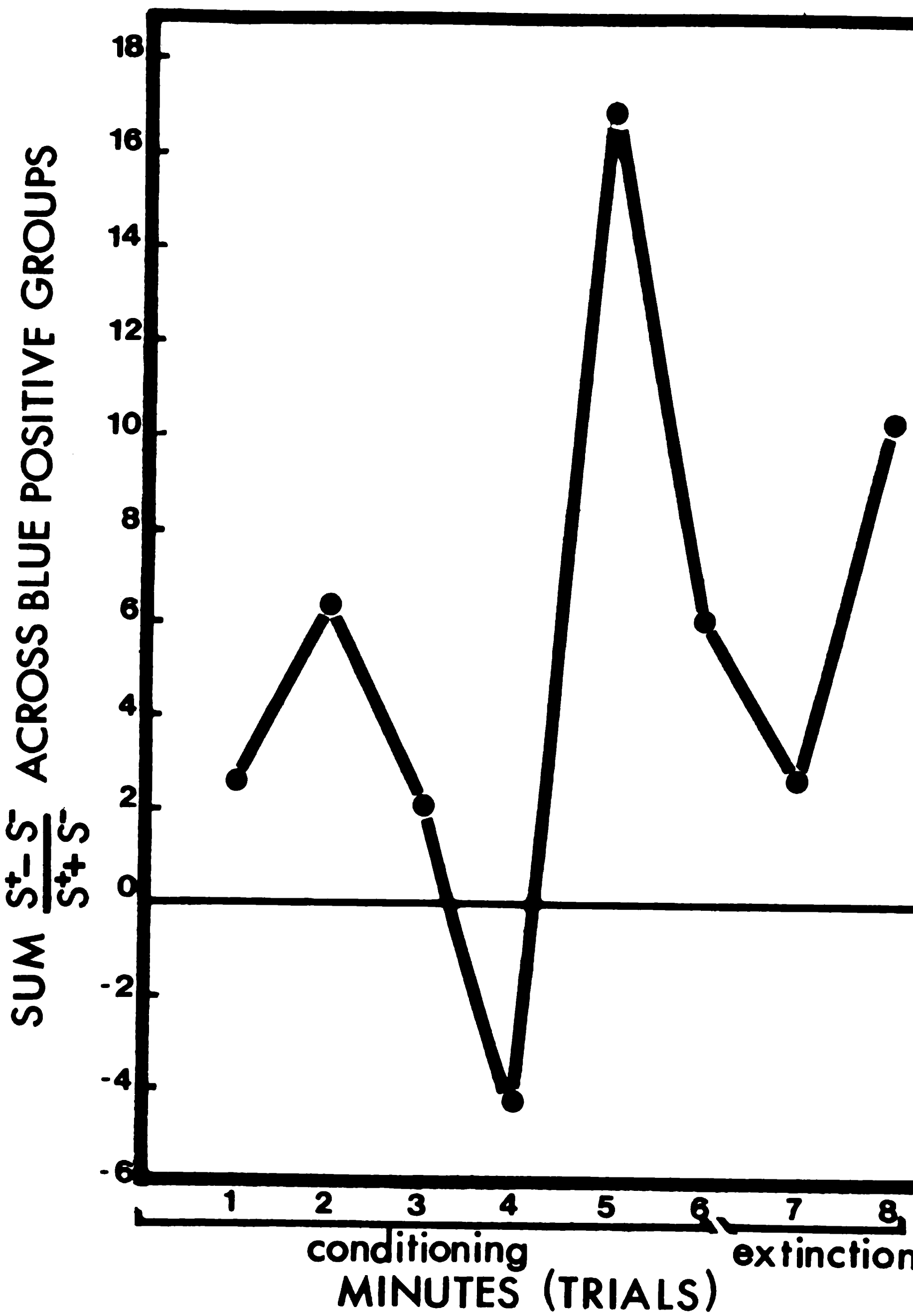

Fig. 4. Discrimination ratios across trials in blue positive groups. The line at 0 indicates equal responding to the positive and negative stimuli.

(see Figures 5A & 5B). While the figures suggest possible differences, the results of any post hoc testing should be viewed sceptically. A two by two analysis (Reinforcement$_4$ X Sex$_2$) performed within the blue positive voice and red light groups did yield a significant Reinforcement x Sex interaction ($F = 10.16$, $df = 1/16$, $p < .01$).

Average discrimination ratios across the first eight minutes (first conditioning and first extinction) were calculated for each subject. These ratios were then employed in a three factorial analysis (Reinforcement$_4$ X Sex$_2$ X Color Reinforced$_2$) to determine the relative effects of the two positive stimuli on discrimination performance. A significant color effect and Reinforcement x Sex x Color interaction were found ($F = 5.90$, $df = 1/56$, $p < .025$; $F = 2.79$, $df = 3/56$, $p < .05$, respectively). As illustrated (Figures 5A & 5B), performance was superior in the blue positive condition.

__Relationship between total responding and discrimination performance__. Spearman rank order correlations were performed with each subject's total responses and average discrimination ratio within each positive stimulus condition. The purpose of this analysis was to find the degree of the linear relationship between amount of responding and discrimination performance. Correlations of .019 within the blue positive and .26 within the green positive both demonstrated the lack of a significant relationship between these two measures. A high degree of responding by subjects within a given

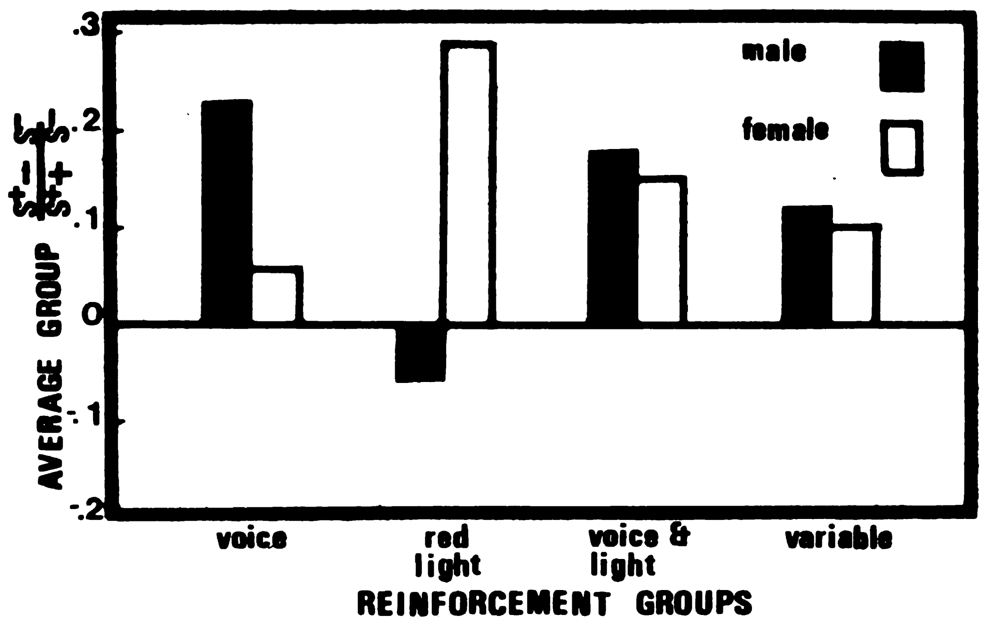

Fig. 5A. Average reinforcement group by sex discrimination ratios in the blue positive condition. The line at 0 indicates equal responding to the positive and negative stimuli.

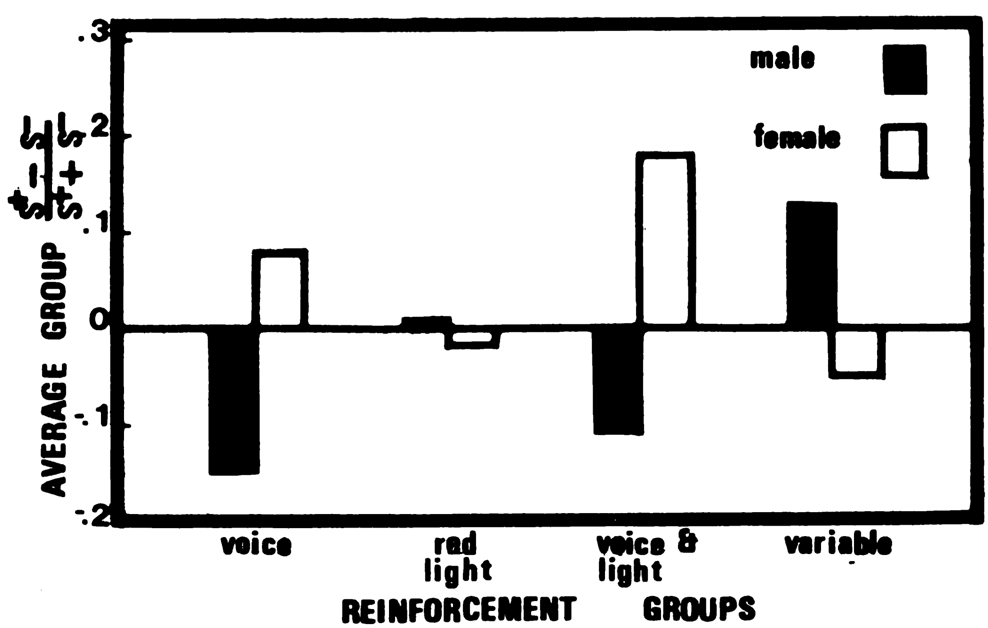

Fig. 5B. Average reinforcement group by sex discrimination ratios in the green positive condition. The line at 0 indicates equal responding to the positive and negative stimuli.

reinforcement group is not therefore a good predictor of high discrimination performance. One of the more extreme examples within the present data is the performance of males in the blue positive red light reinforcement group. In this case, total responses were the second highest of all blue positive groups but the average discrimination ratio was only -.06. That is, while male subjects responded well, they actually chose the negative more often than the positive stimulus (Figures 2A & 5A).

<u>Length of time responding</u>. Since the purpose of the study was to find reinforcers which would maintain responding, a two factorial (Reinforcement$_4$ X Sex$_2$) analysis of the length of time subjects continued to respond was performed within each positive stimulus condition. No significant differences between reinforcement groups were found in either analysis. On the average, subjects continued to respond for 10.7 minutes. This does not include time in the baseline period or the time following the last response during which subjects continued to remain under the experimental conditions.

<u>Position preference</u>. In order to determine the existence of position preference as an error factor in the present study, each subject's total response data was converted into the absolute value of the ratio $\frac{\text{Right - Left}}{\text{Right + Left}}$. The resulting values could fall between 0 and 1 indicating responding equally to both sides and responding to only one side respectively. A two factorial (Reinforcement$_4$ X Sex$_2$) analysis within each positive stimulus condition found no significant

differences in the amount of position preference in the various reinforcement groups. However, failure to find a difference here does not mean that responding was not highly influenced by position preference but merely that no differences were found as a function of the reinforcement groups. A $\underline{t}$ test was performed within each positive stimulus condition to determine if the mean ratio was significantly greater than a ratio of 0 which would be predicted if no position preference existed. The $\underline{t}$ within both positive stimulus groups was highly significant indicating the strong prevalence of responding more to one side than the other (Blue: $\underline{t} = 9.77$, $\underline{df} = 39$, $\underline{p} < .0005$, one-tailed; Green: $\underline{t} = 9.66$, $\underline{df} = 31$, $\underline{p} < .0005$, one-tailed).

Nonparametric tests. Kruskal-Wallis one way analyses of variance (Siegel, 1956) performed on portions of the data yielded results similar to those found above using parametric analysis of variance designs. That is, no significant differences were found in total responses in each group-by-sex cell in both blue and green positive conditions; nor were there any differences in group-by-sex cells using average discrimination ratios for each subject. The presence of great individual differences between subjects suggested the possible use of the median test (Siegel, 1956) to see if those subjects who discriminated better responded differently as a function of the reinforcement group. This test requires that no more than 20% of the cells have an $N \leq 5$. This assumption could not be met in blue and green reinforcement group comparisons. While it could be met in both blue and green sex comparisons, the results were not significant.

Stimulus-response contiguity. A t test was performed on the pilot data collected to determine the effect of increasing the probability of contiguity between the discriminative stimuli and the infant's response. A one-tailed test of the data using average discrimination ratios in the indented versus flat panel groups found a trend at the .06 level ($t = 1.69$, $df = 17$, $p < .06$).

DISCUSSION

The main findings may be readily summarized. First, in the major analyses there were no significant effects of sex or reinforcement groups on length of participation, total responses, or discrimination performance in either the blue or green positive condition. Second, infants showed a significant change in both their rate of responding (blue and green conditions) and discrimination performance (blue only) between the fourth and sixth minute of conditioning independent of any major changes in the experimental conditions. And finally, while more responding to the positive than to the negative stimulus was found, performance (a) was significantly influenced by the color of the positive stimulus; (b) had to overcome strong tendencies to respond more to one side; and (c) could possibly have been enhanced by an apparatus in which the probability of stimulus-response contiguity was improved.

<u>Sex and reinforcement groups</u>. The intent of the present investigation was to find reinforcing stimuli which could maintain the interest of 12-month-olds in an operant, manipulative task longer than the typical seven to 15 minute session. Past studies (Caron, Caron, & Caldwell, 1971; Koch, 1968) had demonstrated the effectiveness of changing reinforcers but unfortunately most of the previous work had been done

with two- to five-month olds. In general, these young infants are more accepting than 12-month-olds of the restrictions an experimenter might impose on their activities. Nevertheless, while the restless character of the 12-month-old makes experimentation more difficult, it also provides an excellent preparation for testing the power of the reinforcing stimuli to maintain interest in the task. This is particularly true in the framework of a free operant study where the subject can change the rate of responding and in this way inform the experimenter of the effectiveness of his stimuli. Such effectiveness may also be measured in terms of the length of time the subjects respond, the amount of responding, and the quality of responding in terms of the experimental contingencies. In all these measures (responses per minute, time, total responses, and discrimination ratios) the reinforcing conditions in the present study brought statistically equivalent results. After a few minutes of responding, subjects preferred to examine the experimental room, climb on the chair, and turn to their parents for stimulation. During pilot work subjects were at first seated in a car seat, and in a later modification merely restricted to a playpen. Both situations brought such strong protests that the final design was adopted in which subjects were allowed relative freedom within the confines of the 6½ X 5½ X 5½ foot sound-attenuated room.

When the experiment was designed it was thought that "variable reinforcement" composed of four basic stimuli, presented singly and in all possible two stimulus auditory-visual arrays, would have the equivalent effect of Siqueland and DeLucia's (1969) eight stimulus "low-redundancy" reinforcement. That is, it would maintain a stable rather than a declining response rate characteristic of their four stimulus "high-redundancy" group. It is possible, however, that the new combinations of stimuli in the present study were seen by the infants as repetitions of old stimuli. If this were the case then the "variable reinforcement" would have an effect similar to Siqueland and DeLucia's high-redundancy group. This similarity did in fact occur. If the variable group did not lack redundancy then it is logical that differential effects of reinforcement groups did not occur in this dimension. Hypotheses dealing with the relative effects of the novelty of the reinforcer would also be affected by this interpretation. Specifically, differences based on the preference of females for novelty could not occur if the stimuli were not sufficiently variable.

Although the study was primarily concerned with specific reinforcers, the fact that both visual and auditory modalities were represented permitted investigation of sex differences in responsiveness to the two modalities. It was acknowledged that any results that could arise would be confounded by such factors as the social nature of the voice and the additional tactual modality inherent in the red light reinforcer. In addition to investigating the effects of the reinforcer's modality, the recording of each subject's responses per minute allowed for a crude measure of sex differences in habituation to the task. Previous studies had found more orienting and better learning by three-month-old females under auditory and males under visual reinforcement (Lewis, Baumel, & Grooh, 1971; Watson, 1969). Such results had been tempered by a failure to replicate except when medium intensities were used (Dorman, Watson, & Vietze, 1971). Work relating to the question of habituation has usually been done with very young infants, however; one study which did test 13-month-olds (Kagan and Lewis, 1965) found greater habituation in their male subjects.

In the major analyses of the present study, all significant results involving sex took place in three way interactions (Blue, discrimination ratios: Reinforcement x Sex x Trial, $p = .05$; Green, responses per minute: Reinforcement x Sex x Trial, $p < .005$; Discrimination ratios: Reinforcement x Sex x Color Reinforced, $p < .05$). Graphical representations and a survey of the data itself indicated that the effects were due either to particular subjects whose responses grossly deviated from the others in their group (Green responses per minute) or to so many differences across trials, sex, reinforcement, and color reinforced cells that as a whole no consistent pattern of relationships could be found.

With regard to habituation, graphical representation of the data (Figure 3A) indicated approximately equal patterns of responding per minute by males and females in the blue positive condition. In the green positive condition (Figure 3B) females showed a more consistent decrease in response rate although no significant Sex x Trials interaction occurred.

The general findings at least as they appear graphically, are contrary to those of Kagan and Lewis (1965). The findings with the green positive subjects are however congruent with Caron, Caron, and Caldwell's (1971) data with three- and one-half-month-old infants. In the latter study, habituation was determined by a response rate measure; while in the former cardiac deceleration and visual fixation were used. The discrepant results of these two studies may be a function of the different measures employed. Conclusions based upon such measures are likely to vary when general phenomena such as habituation are considered.

The difficulties in interpretation of the three way interactions and interest in possible sex by modality interactions in the voice and red light groups prompted the post hoc two factorial analysis in the blue positive condition. The significant Reinforcement x Sex interaction reflected the failure of the males in the red light condition and females in the voice condition to discriminate between the positive and negative stimuli. In contrast to these findings, males on the average earned ratios of .23 and females earned ratios of .29 in the voice and red light groups respectively (see Figure 5A). These results contradict the previous findings of greater attentiveness and superior performance by three-month-old females under auditory and males under visual reinforcement (Lewis, Baumel, & Groch, 1971; Watson, 1969). Nevertheless, they serve to emphasize the warning of Dorman, Watson, and Vietze (1971) that the nature of sex by modality interactions is a function of the intensity of the particular stimuli and the context of stimulation in which they occur. It is also likely that the differences in the task itself (i.e. visual fixation versus panel pressing) and the age of the subjects (three versus 12 months) confounds any predictions from one study to the next. In contrast to the above results using discrimination ratios, if one compares total responses under the voice and red light reinforcement groups in the blue positive condition (see Figure 2A) then the results comply at least graphically with those expected from previous research. That is, females respond more (although not significantly more) in the auditory and males in the visual reinforcement groups.

Trials. The finding of a significant decrease in response rate during the conditioning session is not completely without precedent in the literature of manipulative responding by the 12-month-old. In a study of the effects of conjugate reinforcement on panel pushing by 12-month-olds, Lipsitt, Pederson, and DeLucia (1966) found a significant difference in the rate of responding between the first and the fourth but not between the first and fifth minute of conditioning. In the present study in the blue positive condition (see Figure 3A) responding increased gradually during the first three to four minutes of conditioning and then decreased rather abruptly resulting in a significant difference between the the fourth and sixth minute of conditioning. The sixth minute was not significantly different from the rates in minutes seven and eight which composed extinction. This is similar to the Lipsitt et al. data in that it appears that extinction had begun around the fifth minute of the study independent of a change in experimental contingencies. Rate of responding in the green positive condition began at a higher level than in the blue and decreased as the study progressed (see Figure 3B). For female subjects this decrease was a gradual one but for males occasional rises in response rate interrupted the decline. Here again a change around the fifth minute is evident, responding per minute being significantly less than in minutes one and two but not differing from minutes seven and eight of extinction.

The writer knows of no other free operant manipulative discrimination study with 12-month-olds in which conditioning was carried beyond four minutes. There is thus no comparison available for the significant rise in discrimination performance from minute four to five in the blue positive group. Perhaps the decrease in responding per se at this time facilitated recognition of the experimental contingencies but the rapid onset of extinction prevented maintaining this level of performance across succeeding trials.

Color. The current finding of a significant difference in discrimination performance in the blue and green positive groups is somewhat analogous to the superior discrimination ratios of red versus blue groups in Simmons' (1964) study. Simmons found an initial preference for red in her baseline data to which she attributed differential performance in the two groups in the remaining phases of the study. In the present study analysis of the 30 second baseline data yielded no such preferences. The mean responding to the blue and green stimuli in the blue positive baseline was 3.87 and 4.25 responses and in the green positive baseline was 4.5 and 4.4 responses respectively. Original preferences do not therefore seem to account for the significantly better discrimination under the blue positive versus the green positive condition. Studies by Chase (1937) and Spears (1966) have shown that blue and green can be discriminated and at least in Spears' data with four-month-olds, there is no evidence of a significant preference between them. Brightness differences could have influenced the results since this variable was not rigidly controlled. An attempt was made to keep the lights as equivalent as possible as judged by the adult eye within the grave limitations of the present apparatus. As noted by Simmons (1964), this brightness dimension may be of crucial importance in regulating the discrimination performance of 12-month-olds.

Position preference. Position preference as defined in the present study means that the subject had tendencies to respond more to one side than the other. Whether this was a function of hand preferences that the subject brought with him to the study or a tendency to continue responding to the previously reinforced side is not determined. Analyses by Simmons (1964) of baseline data in a similar study did not find preferential responding. Weisberg and Simmons (1966) using a modified Wisconsin General Test Apparatus did however find definite tendencies to respond to the previously reinforced side. Analyses in the present study concerned all the responses the subject made and thus included both initial and task produced biases. The significant results of position preference testing serve to emphasize the necessity of developing techniques to eliminate such biases in an operant task. Weisberg and Simmons (1966) found it necessary to spend 20 to 40 trials, or approximately one session, to eliminate the perseverative tendencies. An initial session of this sort in which such tendencies were weakened might improve subsequent performance. Modification of the task so as to require only one panel (successive rather than simultaneous discrimination) would also eliminate such biases. If either of these measures were taken, subjects perhaps could learn simple as well as more complex discriminations more quickly before they habituated to the task.

Stimulus-response contiguity. When the apparatus used in the present study was designed, contiguity of stimulus and response was facilitated by placement of the discriminative stimuli in the center of the manipulanda. During the course of the investigation it became apparent that infants frequently were pushing the panels without regard to the stimuli. For example in the red light group, an infant could be touching the red light which protruded above the panel while pushing on the panel with the base of the hand. The infant could in this manner keep the light on while ignoring the discriminative stimulus. Personal communication with Dr. Lipsitt (1971) who used a similar apparatus, brought out the point that in his apparatus the stimulus light was somewhat indented from the remainder of the panel. In the present study the panel was flat. An observation frequently made during the major portion of the study was that infants liked to feel any portion of the box which showed three-dimensional contour (e.g. a screw). Perhaps by indenting the stimuli (i.e. cutting a hole in the top layer of plexiglas) the infants, because they were attracted to contour, would be more likely to press the panel directly on top of the discriminative stimulus. In this way the probability of stimulus-response contiguity would be improved. However, it would not be assured because the infants could still press the panel at any other location and the response would be rewarded. With this limitation, the trend at the .06 level for a significant $\underline{t}$ indicating a difference in performance between subjects with the original and modified panels is very encouraging. The results are congruent with studies concerning older children (Jeffrey & Cohen, 1964; Ramey & Goulet, 1971). Discrimination was better for the group with the modified panels.

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APPENDIX

TABLE 1

Analysis of Variance:
Total Responses to S^+ and S^- in the Blue Positive Condition

Source	df	MS	F
Reinforcement (R)	3	602.18	
Sex (S)	1	8.45	
R X S	3	928.58	
Error Between	32	1803.15	
S^+S^- (D)	1	2101.25	6.44*
R X D	3	180.98	
S X D	1	6.05	
R X S X D	3	171.98	
Error Within	32	326.49	

*$p < .025$

TABLE 2
Analysis of Variance:
Total Responses to S^+ and S^- in the Green Positive Condition

Source	*df*	*MS*	*F*
Reinforcement (R)	3	1407.43	
Sex (S)	1	4.52	
R X S	3	458.81	
Error Between	24	1579.79	
S^+S^- (D)	1	3291.89	8.20*
R X D	3	450.93	
S X D	1	.76	
R X S X D	3	453.89	
Error Within	24	401.68	

*$p < .01$

TABLE 3
Analysis of Variance:
Responses per Minute in the Blue Positive Condition

Source	df	MS	F
Reinforcement (R)	3	59.96	
Sex (S)	1	.11	
R X S	3	97.12	
Error Between	32	158.08	
Trials (T)	7	420.51	9.32*
R X T	21	62.24	
S X T	7	10.38	
R X S X T	21	31.63	
Error Within	224	45.14	

*$p < .001$

TABLE 4
Analysis of Variance: Responses per Minute in the Green Positive Condition

Source	df	MS	F
Reinforcement (R)	3	175.66	
Sex (S)	1	11.39	
R X S	3	66.40	
Error Between	24	197.10	
Trials (T)	7	391.38	9.45**
R X T	21	42.11	
S X T	7	65.09	
R X S X T	21	97.26	2.35*
Error Within	168	41.42	

*$p < .005$
**$p < .001$

TABLE 5
Analysis of Variance:
Discrimination Performance in the Blue Positive Condition

Source	*df*	*MS*	*F*
Reinforcement (R)	3	.05	
Sex (S)	1	.09	
R X S	3	.96	2.46*
Error Between	32	.39	
Trials (T)	7	.99	2.20**
R X T	21	.68	1.51*
S X T	7	.34	
R X S X T	21	.70	1.56*
Error Within	224	.45	

*$p < .10$
**$p < .05$

TABLE 6
Analysis of Variance:
Discrimination Performance in the Blue Positive
Voice and Red Light Conditions

Source	*df*	*MS*	*F*
Reinforcement (R)	1	.01	
Sex (S)	1	.04	
R X S	1	.34	10.16*
Error	16	.03	

*$p < .01$

TABLE 7
Analysis of Variance:
Discrimination Performance as a Function of the Color Reinforced

Source	df	MS	F
Reinforcement (R)	3	.01	
Sex (S)	1	.05	
Color Reinforced (C)	1	.29	5.90**
R X S	3	.06	
R X C	3	.03	
S X C	1	.01	
R X S X C	3	.14	2.79*
Error	56	.05	

*$p < .05$
**$p < .025$