ASSESSMENT OF VISUAL DISCRIMINATION IN INFANTS: COMPARISON OF A CONDITIONING METHOD WITH TRADITIONAL PREFERENCE METHODS

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Elizabeth Anne Cubitt

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EXAMINING COMMITTEE APPROVAL

_____ Dr. Jean Koepke
Senior Supervisor

_____ Dr. L. M. Kendall
Examining Committee

_____ Dr. R. J. C. Harper
Examining Committee

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Abstract

The purpose of the present research was to develop a conditioning procedure with which to assess the visual discrimination ability of infants, and to compare the results of this method with those obtained by traditional visual fixation preference methods.

Infants twelve weeks of age were presented with black and white checkerboard stimuli varying on a physically graded dimension from 4x4 to 20x20 squares. Each stimulus was paired with a 24x24 checkerboard and measures of fixation time, span, and number of looks were recorded relative to each stimulus.

Three groups of Ss were tested by the visual fixation preference procedures. In an effort to establish a procedure that was sensitive to the preferences of individual Ss, the stimulus presentation technique was varied among the groups. The results indicated, however, that the groups did not differ significantly with respect to the number of Ss evidencing discrimination.

An operant conditioning procedure, designed to increase fixation time to one stimulus of a pair by presenting contingent visual stimulation as a reinforcer, was shown to be effective relative to a control procedure in which no reinforcement was administered. In comparison with the visual fixation preference procedure, the experimental procedure was consistently superior in providing evidence of discrimination by individual Ss. In comparisons with the criterion preference procedure, a modified preference procedure, the experimental procedure was usually

superior for finding information about discrimination abilities of individual Ss.

In addition, group results obtained for the preference studies indicated that infants twelve weeks of age most preferred a 10x10 checkerboard stimulus. These results were related to a theory of stimulus selection proposed by Dember and Earl. Both the criterion preference procedure for groups of Ss, and the experimental procedure for individual Ss, indicated that the twelve-week-old infants could discriminate the 16x16 from the 24x24 checkerboard.

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Introduction

The purpose of the present study was to develop an operant conditioning procedure with which to assess the discrimination ability of infants. The usefulness of this index of discrimination was investigated by comparing it with traditional visual fixation preference methods. These latter employ a spontaneous measure of preference which has been widely used in studying infants' perception. The two methods were compared with respect to the number of individual Ss evidencing discrimination at varying degrees of stimulus difference.

Investigators studying infant perception have relied mainly on spontaneous behavioral measures to provide information about the infant's discrimination abilities. The list of response measures is ingenious, considering the limitation of the infant's repertoire, and has included in addition to visual fixation, the most widely used measure, such indices as sucking (Bronschtein, Antonova, Kamenetskaya, Luppova, & Sytova, 1958), smiling and vocalizations (Kagan, Hen-Tor, Levine, & Lewis, 1966), activity level, heart rate and respiration (Lewis, Kagan, & Kalafat, 1966), reflexive eye movements (Gorman, Cogan, & Gillis, 1957), ERG and EEG recordings (see Hershenson, 1967).

Staples (1932) first used visual fixation in studying preference for colours. The potential usefulness of the method was not recognized however, until Fantz (1956) demonstrated the feasibility of using it as an objective method with which to study the percep-

tual abilities of chimpanzees, and subsequently, of infants (Fantz, 1958). Since then, the visual fixation preference method, as it has come to be called, has been the most frequently used vehicle for research in infant perception. It has been used to study pattern perception (Fantz, 1958, 1963; Spears, 1964; Lewis, Meyers, & Kagan, 1963), complexity (Berlyne, 1958; Brennan, Ames, & Moore, 1966; Thomas, 1965; Hershenson, 1965), brightness discrimination (Hershenson, 1964; Berlyne, 1958), acuity (Fantz & Ordy, 1959; Fantz, Ordy, & Udelf, 1962), movement perception (Silfen & Ames, 1964; Ames & Silfen, 1965), depth perception (Fantz, 1961), and the effect of novel stimulation (Fantz, 1964; Caron & Caron, 1968; Saayman, Ames, & Moffett, 1964).

When this method is used, conclusions regarding the infant's behavior depend on whether or not he responds differentially to the stimuli presented. If an infant fixates significantly longer, or more frequently, on one of two stimuli, he is said to prefer that stimulus and also to be able to discriminate it from the other. If he looks equally at both, he is said to have no preference. However, since lack of preference does not necessarily indicate lack of discrimination, an equal looking time does not provide clear information regarding an infant's ability to discriminate. Thus, investigators concerned with inferences regarding the discrimination abilities of infants have of necessity been concerned with factors influencing the emergence of preferences.

After initial findings indicated that infants preferred to fixate particular patterns, investigators became interested in the determinants of these preferences. Complexity was one of the

dimensions hypothesized to mediate preferences (Hershenson, 1964; Hershenson, Munsinger, & Kessen, 1964; Brennan, Ames, & Moore, 1966; Thomas, 1965; Berlyne, 1958; Spears, 1964). The first few investigations of complexity suggested that infants preferred to look at the more complex of two patterns, but this conclusion had to be qualified when Hershenson (1964) reported that newborns preferred the least complex (as defined by fewer squares) of a series of checkerboard patterns.

In an attempt to reconcile these findings, Brennan, et al (1966), investigated the effect of age on preferences for black and white checkerboard stimuli differing in complexity, as defined by number of squares varying from 2x2 to 24x24. They found that preferences for these stimuli changed from the least complex at three weeks to the most complex at fourteen weeks of age.

Ames (1966) attempted to account for this change of preference with age, in terms of the theory of stimulus selection proposed by Dember & Earl (1957) and Earl (1961), as well as by Sackett (1965) in what he called complexity dissonance preference hypothesis. Basically these theories state that, in a free choice situation, responses to stimuli are determined by the complexity of the stimuli and the complexity of the individual. Just as a stimulus has a complexity level, each individual has a psychological complexity level depending on his past experience with stimuli. His "capacity" for any particular stimulus is termed his "ideal complexity". He prefers (will give maximum response to) a stimulus of complexity slightly greater than his ideal level. Such a stimulus, optimally more complex than the ideal, is called the

pacer. For a given S the ideal complexity level, as well as the complexity of the pacer stimulus, increases with experience.

Thus, the finding that developing infants prefer increasingly more complex stimuli could be explained in terms of an ideal complexity level and pacer stimulus which increase with experience or age (Ames, 1966). Furthermore, the theory proposes that on a unidimensional complexity continuum, responses to stimuli other than the pacer would be expected to decrease with their distance from the pacer. This is exactly the finding reported by Brennan et al (1966) for groups of infants three, eight, and fourteen weeks of age.

The implications of this theory are important in considering the usefulness of preference measures as indices of discrimination. For one thing, the theory implies that while a younger infant might respond differentially to a given pair of stimuli, an older infant with an ideal complexity level beyond either of the stimuli might not. Thus, the paradox could arise in which an older infant having no preference for stimuli less complex than his ideal level would indicate no discrimination of stimuli which would be discriminated by younger infants. Exactly this paradox occurred in a study by Brennan (1965): three-week-old infants preferenced, and thus discriminated a 2x2 from an 8x8 checkerboard, while five-week-olds did not; eight-week-old infants discriminated an 8x8 from a 24x24 checkerboard, while ten-week-olds did not.

A second paradox implied by the theory is that if stimuli equidistant on either side of the pacer were presented, preferences for the two would be equal, thus providing no indication of

discrimination. However, if either stimulus were presented in combination with the pacer stimulus, preference for the pacer would provide evidence of discrimination. Paradoxically then, preference measures would indicate that a small difference between two stimuli could be discriminated, while a larger difference could not. In line with this prediction, Hershenson et al (1964) found that newborns differentiated between a five-turn and a ten-turn figure, but did not differentiate a five-turn from a twenty-turn figure.

Thus, both the theory of stimulus selection and the data supporting it (for additional confirmation see Sackett, 1965, 1966) suggest that the traditional visual fixation preference methods are severely limited in their usefulness for investigating the discrimination abilities of infants. Furthermore, the theory was designed to predict the preference behavior of individuals, but despite this has seldom been applied to the behavior of individual infants. Individual results may be more variable than the group results cited, and thus introduce an even greater unpredictability into the suggested outcomes.

The methodological problem of the difference between preference for stimuli and discrimination of stimuli has been discussed at length in the theoretical papers of Irwin (1958), and in discussion of taste perception in the rat by Young (1966, 1968). Although conceptually these writers distinguish preference and discrimination in slightly different ways, both agree that the most effective way to test for discrimination by individual subjects is by means of an operant conditioning technique. Young supports this con-

tention by indicating that the lowest thresholds for taste perception in the rat are obtained by operant conditioning procedures rather than by spontaneous preference, or motivated preference procedures.

Since operant conditioning procedures are considered more sensitive than any other procedures, including spontaneous preference procedures, the purpose of this study was to develop an operant conditioning procedure and to evaluate it relative to the traditional visual fixation preference procedure. The evaluation would involve comparing discrimination evidenced when infants were tested on a certain set of stimuli with traditional visual fixation procedures, as opposed to when tested on the same set of stimuli with an operant conditioning procedure.

The set of stimuli and age of infant used in the present study were chosen in light of predictions and findings relative to the Dember and Earl theory of stimulus selection. The findings of Brennan, Ames, and Moore (1966) support the theory, indicating that, as a group, infants eight weeks old preferred an 8x8 checkerboard stimulus to a 24x24 checkerboard, while at fourteen weeks, infants preferred the 24x24 checkerboard. These results explained in terms of the theory, suggest that at twelve weeks the pacer, and preferred stimulus, should lie between the 8x8 and 24x24 checkerboard patterns. In addition, it would be expected that preference for other stimuli would vary directly with their difference from the pacer stimulus. Thus, infants were tested at twelve weeks of age with checkerboard patterns varying in number of squares.

Infants tested according to visual fixation preference pro-

cedures were presented with nine checkerboard stimuli varying from 4x4 to 24x24 squares. Because it would be impossible to pair each stimulus with every other stimulus during the limited time within which infants remain testable, each checkerboard pattern was paired with the 24x24 pattern in order to provide a common basis for comparison.

Operant Conditioning Procedure

Following Lipsitt's chapter in Advances in Child Development and Behavior (1963), which indicated that operant conditioning was feasible with young infants, a large number of research papers have been published which support his findings. With newborns, operant conditioning procedures have been successful in establishing headturning (Siqueland & Lipsitt, 1966), and non-nutritive sucking (Stern & Jeffrey, 1965). With infants between two and one-half to four and one-half months, operant conditioning has been established with respect to sucking by Siqueland (1964, 1967) and Bower (1967), headturning by Bower (1965, 1966) and Caron (1967), smiling by Brackbill (1958), vocalizations by Rheingold, Gewirtz & Ross (1959), and Weisberg (1963), and visual fixation by Watson, (1965, 1966). A more extensive summary including research with older infants can be found in Horowitz (1968).

While the number of studies demonstrating modification of behavior through operant conditioning has been large, few have been concerned with using the conditioning method to investigate discrimination abilities. Only two of those studies cited above could

be considered to fall into the latter category: Bower (1965, 1966) trained infants to make a headturning response in the presence of a cube but not in the absence of it; and Bower (1967) also reports differential conditioning of a high magnitude sucking response in the presence versus the absence of a stimulus.

In addition to these two studies, Watson (1966) attempted to condition the visual fixation response. He reported that he was able to increase the number of fixations to a left or right position by providing auditory or visual stimulation contingent upon looking in the appropriate direction. The operant conditioning method used in the present research was based on increasing fixation time to one of two stimuli irrespective of position.

Since visual stimulation has been used successfully as a reinforcer for young infants (Heid, 1966; Caron, 1967; Siqueland, 1967; Bower, 1967), in the present study visual stimulation in the form of a film was made contingent upon looking at a given stimulus. The filmed events were selected on the basis of movement, colour, variety, shininess, and figure-ground contrast.

The stimuli presented in the operant conditioning procedure were the same as those presented in the visual fixation preference procedure, except that only checkerboards varying from 10x10 to 24x24 patterns were used. Again each stimulus was paired with the 24x24 stimulus. The whole range of stimuli was not presented in the operant conditioning procedure because of practical limitations resulting from the training procedure. In addition, results of a pilot study using the preference method strongly suggested that pairs of stimuli more similar than the 10x10 and 24x24 were not differentiated by twelve-week-old infants. Thus, the power of

the conditioning procedure could best be assessed by testing infants with stimuli that were more similar to one another than those discriminated when infants were tested by a preference procedure.

Ss were trained first with the 10x10 and 24x24 stimulus pair. Subsequent to meeting a criterion of discrimination[1] in favor of the 10x10 pattern, Ss were presented with the 12x12 and 24x24 pair, then the 14x14 and 24x24 pair, and so on. The order was selected such that the most different, and hence, most discriminable stimulus pair was presented first, while the less discriminable pairs were presented subsequently in order of increasing similarity. Spiker (1959) suggests presenting distinctive stimuli first facilitates orientation to the relevant features of the stimuli and thus facilitates subsequent performance with more similar stimuli. Further, it may be assumed that response strength established to the 10x10 pattern would generalize to similar stimuli and in this way facilitate discrimination of subsequent stimulus pairs.

In order to better assess the effect of the operant conditioning procedure, two additional groups were necessary. The purpose of the first, the control group, was to determine the likelihood that infants might meet the criterion of fixation merely as a result of continually viewing the stimuli. This likelihood was investigated by treating control infants exactly as experimental infants except that reinforcement was never presented. The groups were compared with respect to number of infants meeting the criterion of fixation.

The second group, called the criterion preference group, was

[1]This criterion is specified on page 18 in the experimental procedure section.

essentially a modified visual fixation preference group in which infants were presented with same stimulus pairs until they met a criterion of fixation: then succeeding pairs were presented in the same order as for the experimental group. The purpose of this group was to determine whether the general stimulus presentation procedure involving repeated presentation of the same stimuli, a serial ordering of the stimuli, and the criterion procedure, resulted in as great an indication of discrimination as did the experimental procedure. A second purpose was to determine whether the criterion preference procedure facilitated discrimination relative to the usual visual fixation preference procedure. Thus, the criterion preference group was compared with both the experimental and the visual fixation preference groups with respect to the number of Ss showing differential responding on each pair of stimuli.

Method

Visual Fixation Preference Method

Subjects

Subjects (Ss) were 27 normal, full-term infants within four days of twelve weeks of age. Four others were tested but did not complete the procedure.

Apparatus

The infant lay supine in a three sided "baby box" (Brennan, 1965) covered with navy blue felt and lit by two 60 watt lamps directed at the ceiling from either side of the infant's cradle below his line of vision. The ceiling of this box, 14 in. above the infant, was covered by a blind, also navy blue, which when released displayed a pair of stimuli held in slots 7½ in. apart on the left and right of the midline. The ceiling was hinged to allow stimulus cards to be changed between trials. Release of the blind also started a timer that buzzed to indicate the end of a trial. E watched the infant through a peephole .13 in. in diameter, 3½ in. to the right of the midline on the top of the box. An identical peephole 3½ in. to the left of the midline allowed another observer to watch simultaneously. Fixation of Left and right stimuli, as determined by reflection of the stimulus directly over the pupil of the eyes, was recorded by pressing left or right buttons which activated two pens on a Rustrak Model 921 event recorder moving at a speed of .05 in. per second. A second pair of buttons connected to the two remaining pens on the recorder permitted simultaneous recording by two observers.

Stimuli

The stimuli were 4¼ in. square, black and white checkerboard patterns composed of different number of squares: 4x4, 6x6, 8x8, 10x10, 12x12, 14x14, 16x16, 20x20, and 24x24.

Procedure

Three procedural variations were used in an attempt to develop the most sensitive method for establishing differentiation of stimuli. They varied with respect to number of sessions and stimulus presentation procedure. In every case, Ss were presented with the 24x24 stimulus paired with each of the 4x4, 6x6, 8x8, 10x10, 12x12, 14x14, 16x16 and 20x20 stimuli. Since the 24x24 stimulus was always present, the stimulus pairs are referred to in terms of the other member of the pair, for example, the 4x4 stimulus pair.

Study A. Eleven infants were presented with the eight stimulus pairs in two sessions on successive days. The 4x4, 8x8, 12x12 and 16x16 stimulus pairs were each presented for four 30-sec. trials on the first day, and similarly the 6x6, 10x10, 14x14, and 20x20 stimulus pairs on the second day. The two sets of stimuli were chosen to maximize the differences between the stimuli presented on a particular day.

Stimulus pairs were presented in ascending (e.g. 4x4, 8x8, 12x12, 16x16) or descending (e.g. 16x16, 12x12, 8x8, 4x4) order on successive trials. Over all trials in one session the sequence of stimulus presentation was either ascending, descending, ascending, descending; or the reverse. The same number of Ss were assigned each order on each day.

On successive trials the 24x24 stimulus was alternated from left

to right, thus determining the position of the stimulus with which it was paired. Each stimulus was presented equally often in left and right positions.

Study B. In an effort to increase the likelihood of obtaining significant preferences between pairs of stimuli, for both individual Ss and the group as a whole, the number of presentations of each stimulus pair was increased from four to twelve. Ten Ss were presented with all 8 stimulus pairs, four times per day, on each of three successive days. On the basis of a finding in Study A that the behavior observed in the first 15 seconds of a trial was the same as that in the total 30-sec. trial, 15-sec. trials were used. Thus total testing time per day was the same as for Study A although there were twice as many trials.

The procedure of alternating the 24x24 stimulus on successive trials was the same as in Study A, and each stimulus was presented equally often in left and right positions. In each session, S was assigned at random one of four sequences of stimulus presentations: ascending, descending, ascending, descending; descending, ascending, descending, ascending; ascending, descending, descending, ascending; or descending, ascending, ascending, descending.

Seven Ss completed the testing. Three others were omitted on the basis of either extreme fussiness or inability to return for all 3 days of testing.

Study C. Because the results of Study B suggested that presentation of eight stimulus pairs in one session might have created a confusing situation, Study C was designed to reduce the possibility of confusion while at the same time maximizing the number of stimulus

presentations. Ten infants were presented with the same stimuli over a four day period such that only two pairs were presented each day.

Each stimulus pair was presented for sixteen 15-sec. trials. As in the previous studies, the 24x24 stimulus was alternated from left to right, and stimuli were presented equally often on both sides. Each stimulus pair was presented twice within four trials in ABBA or BAAB sequence. The choice of sequence was determined from a table of random numbers with the condition that each sequence should occur equally often (four times) within the 32 trials.

The two pairs of stimuli presented on any single day formed a set such that the difference between the pairs was maximized. The four sets presented to all Ss were: the 4x4 and 12x12 stimulus pairs; the 6x6 and 14x14 stimulus pairs; the 8x8 and 16x16 stimulus pairs; and the 10x10 and 20x20 stimulus pairs. The order in which these four sets were presented over the four test days was determined by random selection from the 24 possible orders with the restriction that each set was presented an equal number of times on Day 1.

Interobserver Reliability. Two observers simultaneously recorded the fixations of 10 Ss randomly selected from Studies A, B, and C. Interobserver reliability was calculated by counting the number of seconds in a 15-sec. trial during which the observers agreed that S was fixating or not fixating a particular stimulus.

These agreement scores were totalled over all trials for each S and expressed as a percentage of the total possible looking time.

Interobserver reliability ranged from 82.2% to 98.57% with an average of 92.9%.

Operant Conditioning Method

Subjects

The Ss were 45 normal full term infants within four days of twelve weeks of age. Nine other Ss who were tested were omitted from the study on the basis of extreme fussiness, difficulty in scheduling tests, or procedural errors.

Apparatus

During testing S was placed on a table in a specially built reclining infant chair which was a deeper and wider, plywood version of the commercial infant seat, built to prevent the possibility of the infant lurching forward or rocking the seat. It reclined at an angle of approximately 45 degrees, and had sandbags under the padding in the head region to restrict head movements to the midline area. The chair was 28 in. from a 10 in. x 30 in. screen mounted at a right angle to the infant's eyes. A black plywood panel extending below the screen to the table occluded extraneous visual stimulation in front of S. Removable panels to the right and left of the S completed the enclosure.

Two Pradovit slide projectors, with a single polarizing filter over each lens, were mounted on a stand behind the infant and simultaneously projected stimuli to the left and right sides of the screen. The projected images were 8½ in. square and 10 in. apart. The visual angle of 8½ in. patterns 28 in. from S's eyes equalled that of the stimuli presented in the visual fixation preference studies described earlier.

The light of each projector was connected to a rheostat with

which E manually controlled the brightness of the light and hence the brightness of the projected stimuli. The stimuli were square black and white checkerboard patterns composed of different numbers of squares: 10x10, 12x12, 14x14, 16x16, 18x18, 20x20, and 24x24.

A Technicolor 500 8 mm film loop projector, also situated on the stand behind the infant, was oriented toward the screen such that it superimposed a brightly coloured moving picture directly over either the left or right stimulus on the screen. The pictures included a marionette, a toy ferris wheel, burning candles, a stuffed tiger, a pin wheel, and Christmas tinsel. They were contained on a three-minute film loop such that each object occupied about 30 seconds of film time. The projector motor ran continuously but the pictures were projected only for as long as E pressed a button activating the light source.

E stood facing the infant, behind the screen and front panel. The following mechanisms were mounted on the panel in front of E: a Lafayette Universal timer which indicated the end of a trial; remote control switches for changing slides; a button for activating the film loop projector; and buttons for recording fixations. S was observed through a ½ inch opening between the panel and the screen.

Fixations of left and right stimuli, as determined by a combination of head orientation and reflection of the stimulus over a pupil of the eye, were recorded by pressing left or right buttons which activated two pens on a 4 channel Rustrak Model 921 event recorder, and two Hunter Model 120A electronic Klockounters. The latter permitted E to monitor fixation time on each trial. Again, there

were two sets of recording buttons so that observers could simultaneously record fixations in order to obtain a measure of interobserver reliability.

Procedure

The testing was conducted in a darkened room with the only light coming from the projected stimuli and a 10 watt light focused on E's control mechanisms.

The 24x24 checkerboard was paired first with the 10x10 checkerboard and, if S met the differential fixation criterion at each stage, was paired subsequently with 12x12, 14x14, 16x16, 18x18, and 20x20 checkerboards in that order. The number of stimulus pairs presented to each S varied according to the number of pairs on which he met criterion.

Fifteen Ss were randomly assigned to each of three groups.

Experimental group. The 10x10 and 24x24 checkerboards were presented initially for two 15-sec. trials to determine S's initial preference. Training and test trials followed these initial preference trials.

Training trials were 20-sec. trials in which fixations to the two stimuli were differentially reinforced. The 24x24 stimulus was always the non-reinforced, or negative, stimulus. The stimulus with which it was paired, initially the 10x10 checkerboard, was always the reinforced, or positive, stimulus. When S fixated the positive stimulus, E activated the film loop projector and a brightly coloured moving object was superimposed on it. Then, the positive stimulus was gradually dimmed by means of a rheostat control until it was completely eliminated and the movie was fully visible.

Gradually the stimulus was returned to full brightness at which time the movie was turned off. This whole procedure, which took approximately 3 seconds, was defined as the reinforcement.

At the end of a reinforcement, the subject was required to fixate the positive stimulus for one additional second before the reinforcement was re-presented. This period was increased to 2 seconds if the S met the one-second criterion three times in a row. It was then increased to 3 seconds if S met the 2-second criterion three times in a row, and so on up to 5 seconds. Training trials were extended beyond 20 seconds only if extra time was needed to complete presentation of the reinforcement.

Test trials were 15-sec. periods in which the positive and negative stimuli were presented together without reinforcement. At the end of this 15-sec. period, Ss were reinforced for fixation of the positive stimulus in order to retard possible extinction. In the case S was not fixating the positive stimulus, the movie was flicked on and off over that stimulus, and, if this S fixated the pattern, reinforcement was administered. Four consecutive test trials on which S fixated the positive stimulus approximately two-thirds of the time, and at least 4 seconds longer than the negative stimulus, constituted evidence of a discrimination between a pair of stimuli and was referred to as the differential-fixation criterion.

When the differential-fixation criterion was met, the next pair of stimuli in the series was presented for two initial test trials followed by training and further test trials. If S did not meet the differential-fixation criterion within 20 test trials, training was terminated for that stimulus pair, and one further

stimulus pair was tested.

A given stimulus pair was presented in a second session if 20 test trials with that pair were not completed in the first session, or if the infant was fussy and would not look at the stimuli in the first session. A given session was terminated if after at least three efforts to placate or interest the infant, he continued to cry or refused to look at the stimuli. The infant was retested the following day, but if he continued to be inattentive, no further testing was attempted. All Ss in the experiment were terminated in accord with these conditions.

Most Ss could be scheduled for testing on three consecutive days, the sessions lasting about 20 minutes on each day. Few could be scheduled for more, thus, in practice, Ss received for the most part, only as many stimulus pairs as they could discriminate in three sessions of testing.

The left-right position of the stimuli and the placing of test trials was determined prior to testing according to the following rules. The stimuli of each pair were presented an equal number of times in left and right positions within every block of eight trials, and no stimulus was presented for more than two successive trials in one position. On the two initial preference trials and the first two training trials the stimuli were presented in alternate left and right positions. Over all Ss each stimulus was presented equally often in left and right positions on the first trial. Within these restrictions, the order of presentation was determined randomly for each S.

There was a test trial, on the average, once every three trials, beginning after the fourth or fifth training trial, the exact trial

depending on the following rule. On test trials, the stimuli were always presented in positions opposite to those of the preceding training trial, and opposite to those of the previous test trial.

Between trials, the parent, who acted as assistant, covered the projector lens while the slides were changed and redirected the film loop projector to the side where the positive stimulus would next be presented. The inter-trial-interval varied from 5 to 10 seconds.

Control Group. Subjects in the control group were tested according to the same procedure as Ss in the experimental group except that no reinforcement was ever administered. The 10x10 and 24x24 stimuli were presented initially for two 15-sec. preference trials, followed by 20-sec. "training" trials, in which control Ss had the same opportunity to view the stimuli as the experimental Ss, but without receiving reinforcement. "Test" trials, equivalent to those administered to the experimental Ss, were 15 seconds in length. The position of stimuli and placing of "test" trials followed the same rules as for the experimental group. Similarly, an infant was required to meet the same differential fixation criterion within a maximum of 20 "test" trials. Fixations were recorded on all trials, although only fixations on "test" trials were considered for purposes of comparison with experimental Ss.

If S met the differential-fixation criterion on "test" trials, he was tested on the next pair of stimuli in the series in the same manner as the experimental Ss. If he did not meet the criterion within 20 "test" trials, he nevertheless was tested on one

further pair of stimuli. It was expected that, compared to the experimental Ss, relatively fewer control Ss would meet the differential-fixation criterion and therefore fewer would be eligible for testing with subsequent pairs of stimuli. Thus, in an effort to keep the number of Ss tested with each pair of stimuli the same between the two groups, as many Ss as possible were also tested on subsequent stimuli.

Most control Ss, like experimental Ss could only be scheduled for 3 days of testing. Since few Ss met the differential-fixation criterion, most stimulus pairs had to be presented the maximum number of times. This limited the number of different pairs which could be presented and as a result, it was not always possible to match perfectly the control and experimental groups with respect to the number of different stimulus pairs presented.

Criterion preference group. Subjects were tested in the experimental situation according to a visual fixation preference method modified by the criterion procedure used in the experimental condition. The stimulus presentation technique varied from the usual visual fixation preference procedure in that the same stimulus pair was presented repeatedly for a series of trials, and subsequent stimulus pairs were presented in a serial order.

The 10x10 and 24x24 stimulus pair was projected for two initial 15-sec. preference trials followed by a series of up to twenty 15-sec. trials similar to experimental "test" trials. Positions of the stimuli were alternated on each successive trial. This procedure was equivalent to presenting a series of experimental test trials in consecutive order. Omission of "training" trials differentiated this from the control procedure.

As in the case of the experimental group, when S met the differential-fixation criterion, the next pair of stimuli in the series was presented. Since neither stimulus was "positive" for these Ss, the differential-fixation criterion could be achieved by looking consistently longer at either of the two stimuli. If for any pair of stimuli, S did not meet this criterion within 20 trials, testing was terminated for that pair and the next pair was presented.

Although testing on only one further pair was sufficient for comparisons with the experimental group, Ss were tested on all stimulus pairs whenever possible in order to broaden the basis for comparing this procedure with those of the visual fixation preference studies. Since these Ss received no training-equivalent trials, the maximum number of stimulus presentations on each stimulus pair was 20. Hence, it was possible to present most Ss with at least four different stimulus pairs during the three days on which testing could be scheduled.

State of the Infant

Many of the infants in the control and criterion preference groups became restless during the testing period and whimpered, played with their hands, or ceased to watch the stimuli. If, however, the movie was projected in the centre of the screen for a few seconds during an inter-trial-interval, the infant would cease his restless activity and fixate the screen. Adoption of this procedure whenever an infant became fussy established a quieter state which continued during the stimulus presentation trials and allowed longer testing sessions than would otherwise have been possible. This procedure was followed for 12/15 control Ss and 6/15 criterion

preference Ss. In addition, Ss in any of the groups were pacified with a soother, and picked up between trials to be cuddled, changed, or fed if this was considered necessary to maintain the infant in a state conducive to testing.

Inter-observer reliability.

Two observers simultaneously recorded the fixations of ten infants randomly selected from the experimental, control, and criterion preference groups. Inter-observer reliability, calculated in the previously described manner, ranged from 93.1% to 98.5% with an average of 95.32%.

Data Preparation

In accordance with the aims of the study, the major analyses are concerned with the effectiveness of each procedure in producing evidence of discrimination by individual Ss on stimulus pairs varying in degree of similarity. Two different indices of discrimination were investigated; the differential-fixation criterion and a t-test criterion.

Discrimination as Indicated by the Differential-Fixation Criterion.

Discrimination for the experimental, criterion preference, and control Ss was defined in terms of the differential-fixation criterion. In each of these groups, it was determined for each S whether he met the differential-fixation criterion on each pair of stimuli. Ss in the experimental group could only meet the differential-fixation criterion by showing consistent fixation of the positive stimulus. For all other groups, consistent fixation of either

stimulus constituted meeting the differential-fixation criterion.

Ss who failed to meet criterion, and who could not be scheduled for the maximum 20 trials on the last stimulus pair presented, were included as not meeting criterion on this pair. Since scheduling difficulties effected evenly all groups and stimulus pairs, this procedure provided a conservative estimate of discrimination, and at the same time permitted utilization of the results from all Ss tested on a given stimulus pair.

Two sets of data were collected from each control S: performance on "test" trials, subsequently referred to as control (test) results, and performance during the first 20 consecutive trials, subsequently referred to as control (20) results. The first 20 trials in the control condition included both 20 second "training" and 15 second "test" trials. Performance was considered only for the first 15 seconds of each trial.

Results for individual Ss with respect to meeting the differential-fixation criterion, together with the number of trials received on each stimulus pair are presented in Appendix A, Table 1, for experimental Ss, Table 2 for criterion preference Ss, and Tables 3 and 4 for control (test) and (20) results respectively. Performance relative to meeting the differential-fixation criterion on each pair of stimuli is also presented in Appendix A, Table 5 for each S in Groups A, B, and C. In these and all subsequent tables the lack of a cell entry indicates S was not tested.

Discrimination as Indicated by a t-test Criterion.

As noted earlier, results of visual fixation preference studies are usually presented in terms of significant preferences as

indicated by a t-test applied to group results, and preferences of individual Ss are rarely reported. In order to provide a criterion of discrimination for individual Ss which was more similar to that normally used in visual fixation preference studies than was the differential fixation criterion, a t-test was applied to the results for each S. A significant preference of either stimulus ($p<.05$, two-tailed) was taken as an index of discrimination, and Ss were designated as meeting the t-test criterion.

Performance on each pair of stimuli presented to Ss in Studies A, B, and C was analysed to determine whether S met the t-test criterion with respect to measures of fixation time, span (average length of each look), and number of looks. The measure, or measures, with respect to which each S met the t-test criterion on each stimulus pair are presented in Appendix B, Table 1 for Ss in Studies A and B, and in Table 2 for Ss in Study C.

Since the criterion preference and control procedures were essentially modified visual fixation preference procedures, it was also determined for each of these Ss on each stimulus pair whether or not he met the t-test criterion with respect to the three preference measures. This was determined for control Ss on the first 20 trials as well as on the total number of trials. The latter results are referred to as the control (all) results. The measure, or measures, with respect to which each S met the t-test criterion on each stimulus pair are presented in Appendix B, Tables 3, 4 and 5 for the criterion preference, control(20), and control (all) groups respectively.

Results

The results of this research are evaluated first in terms of individual Ss evidencing discrimination, and then in terms of group preferences and discriminations. First, individual results are compared among the visual fixation preference procedures. Following this, results for experimental Ss are compared with results for Ss in other groups: first, with respect to the number of Ss discriminating each stimulus pair, and second, with respect to number of stimulus pairs discriminated by each S. Group analyses of each preference study follows.

I. Evaluation of the Three Visual Fixation Preference Procedures in Terms of Individual Results

Visual fixation preference procedures were varied in Studies A, B, and C in an attempt to determine the most successful method for eliciting differential responding by individual Ss. The three procedures were evaluated in terms of the number of Ss responding differentially in each study.

Considering each of the eight stimulus pairs (4x4 to 20x20) separately, Groups A, B, and C were first compared with respect to number of Ss meeting the t-test criterion on measures of fixation time, span, number of looks, or any one of the three measures. Ninety-four percent (90/96) of these scores ranged from 0/11 to 2/8 Ss in a group meeting criterion, while the other 6% fell

between 3/10 and 4/8. These results are presented in Appendix C, Table 1. Fisher exact tests were applied to the four largest differences between groups on any stimulus pair, or measure. Since none of these differences were significant, no further tests were applied.

The studies were also compared with respect to the number of Ss in a group meeting the differential-fixation criterion on each of the eight stimulus pairs. These 24 scores, ranging from 0/11 to 2/6 Ss meeting the differential-fixation criterion, are presented in Appendix C, Table 2. Again, since the largest difference between groups, was not significant according to a Fisher exact test, no further tests were applied.

Since there were no significant differences among Groups A, B, and C with respect to the number of Ss meeting the t-test or differential-fixation criterion on a given stimulus pair, the groups were combined for all further analyses of discrimination on single pairs of stimuli.

Using a less stringent basis for comparison, the three studies were further evaluated in terms of the number of Ss meeting the t-test criterion with respect to each preference measure on at least one of the eight stimulus pairs. These results are reported in Table I. Chi-square analyses of the results obtained with the various preference measures indicated a significant difference among groups when the number-of-Looks measure was considered ($\chi^2 = 18.65$, df-2, $p < .001$) and when S could meet criterion on anyone of three measures ($\chi^2 = 9.69$, df-2, $p < .01$). No significant differences were obtained, how-

Table I

Number of Ss in Studies A, B, & C meeting t-test criterion with respect to each preference measure on at least one stimulus pair

Preference Measure	Group A	Group B	Group C
Fixation time	3/11	0/7	2/10
Span	1/11	1/7	5/10
No. of looks	4/11	0/7	9/10
Any preference measure	6/11	1/7	9/10

ever, with respect to the fixation time measure ($\chi^2 = 2.21$, df = 2) or span measure ($\chi^2 = 4.6$, df = 2).

Fisher exact tests applied to the results obtained with the number-of-looks measure indicated that significantly more Ss in Study C met the t-test criterion on at least one of the eight stimulus pairs than did Ss in Study A ($p < .05$), or Study B ($p < .01$). The difference between Studies A and B was not significant. When meeting criterion on any one of the three measures was considered, Fisher exact tests again indicated that significantly more Ss in Study C met criterion than did Ss in Study B ($p < .01$). The differences between Studies C and A, and B and A, were not significant.

The three studies were also evaluated in terms of the number of Ss meeting the differential-fixation criterion on at least one of the eight stimulus pairs. In Study A 1/11 Ss, in Study B 2/6 Ss, and in Study C 4/10 Ss met this criterion. A chi-square analysis of these results indicated that there were no significant differences among the groups ($\chi^2 = 2.79$, df = 2).

In summary, these results show there were no significant differences between Groups A, B, and C with respect to the number of Ss meeting either the t-test or differential-fixation criterion on a given stimulus pair. However, when the number of Ss meeting the t-test criterion on at least one stimulus pair was compared between groups, there was a slight indication that the Study C procedure was more effective in providing evidence of preference by individual Ss.

II Evaluation of the Experimental Procedure Relative to Each Other Procedure in Terms of Number of Ss Discriminating each Stimulus Pair

In order to determine whether the experimental, control, and criterion preference groups differed in initial preference for the 10x10 and 24x24 stimuli, the groups were compared with respect to differences in fixation time to the two stimuli on the two initial baseline trials. An analysis of variance revealed that there was initially no significant difference among the groups ($F = .79$, $df = 2/42$. For all groups the total fixation time to the 10x10 stimulus was longer than to the 24x24 stimulus.

The effectiveness of the experimental procedure relative to each of the others for assessing the discrimination abilities of individual Ss was determined by comparing the number of Ss in each group meeting the differential-fixation and t-test criteria. The differences between the groups were evaluated by means of a chi-square analysis using Yates's correction and a two-tailed test of significance. Where the number of Ss for the groups compared was fewer than 25, a Fisher exact test was applied. The results of all analyses are reported in the text as significant when $p < .05$. The exact probabilities, the chi-square values, and the differences tested can be found in the relevant tables. If the number of Ss tested was fewer than six in any group, no statistical analyses were conducted.

A. Evaluation in Terms of the Differential-Fixation Criterion.

The effectiveness of the experimental procedure was first evaluated by comparing the experimental group with each of the other groups with respect to the number of Ss meeting the differential-fixation criterion on each pair of stimuli. In general, the groups were compared regarding performance on the 10x10, 12x12, 14x14, and 16x16 stimulus pairs. The number of Ss in each group meeting the differential-fixation criterion on each stimulus pair is presented in Figure 2 as a proportion of the total number of Ss presented with the stimuli. In this, and all subsequent figures and tables, the abbreviation Exp refers to the experimental group, Cont to the control group, Crit Pref to the criterion preference group, and Vis Pref to combined results of Groups A, B, and C.

1. Evaluation relative to the control procedure. In order to determine the effectiveness of the reinforcement procedure, the number of experimental Ss meeting criterion was compared with the number of control Ss meeting criterion on "test" trials. Only on the 10x10, 12x12, and 14x14 stimulus pairs was there a sufficient number of control Ss for statistical analyses. The results of these analyses, presented in Table II, indicate that significantly more experimental than control Ss met the differential-fixation criterion on each of these stimulus pairs. This indicates that on test trials the reinforcement procedure produced greater evidence of discrimination than would be expected if Ss merely viewed the stimuli without reinforcement.

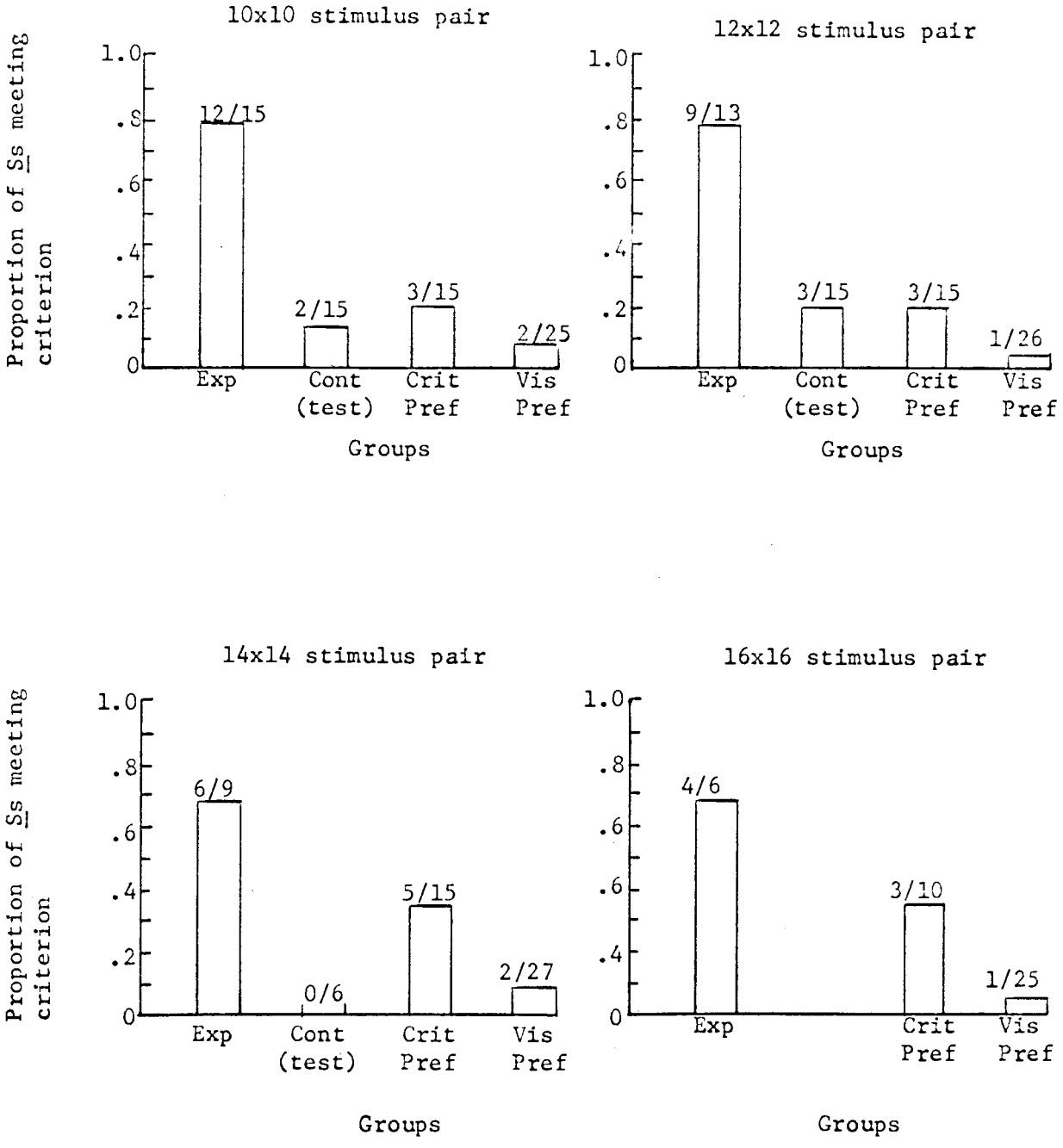

Fig. 1. Proportion of Ss in each group meeting differential-fixation criterion on each stimulus pair.

Table II

Chi-square analyses of number of Ss meeting differential-fixation criterion on each stimulus pair: experimental group versus each other group

Stimulus Pair		Group			
		Exp.	Cont. (test)	Crit. Pref.	Vis. Pref.
10x10	N	12/15	2/15	3/15	2/25
	χ^2		11.57	8.53	18.32
	p		<.001	<.01	<.001
12x12	N	9/13	3/15	3/15	1/26
	χ^2		5.03	5.03	16.15
	p		<.05	<.05	<.001
14x14	N	6/9	0/6	5/15	2/27
	χ^2				10.5
	p		< .05	NS	< .01
16x16	N	4/6	1/2	3/10	1/25
	χ^2		-		9.81
	p			NS	<.01

For the experimental Ss the average number of test trials to criterion, including the criterion trials, was 6 (SD = 6.5, N = 15) on the 10x10 stimulus pair, 8.1 (SD = 2.9, N = 13) on the 12x12 pair, 6.3 (SD = 14, N = 9) on the 14x14 pair, and 4.5 (SD = 6.9, N = 6) on the 16x16 pair. The average time to criterion, based on time elapsed between onset of the first trial and offset of the fourth criterion trial, was 8.4 minutes for the 10x10 stimulus pair, 7.5 minutes for the 12x12 pair, 4.6 minutes for the 14x14 pair, and 5.3 minutes for the 16x16 pair.

The following comparisons with the criterion preference and visual fixation preference groups indicates the effectiveness of the experimental procedure relative to other types of non-reinforced, stimulus presentation procedures.

2. Evaluation relative to the criterion preference procedure.

The stimulus presentation technique of the criterion preference procedure was designed to maximize the opportunity for Ss to differentiate spontaneously between stimuli. Comparison with the experimental procedure revealed that significantly more experimental than criterion preference Ss met the differential-fixation criterion for the 10x10 and 12x12 stimulus pairs, but there was no significant difference between the groups on the 14x14 and 16x16 pairs where the number of experimental Ss tested was smaller. These results are also presented in Table II.

3. Evaluation relative to the visual fixation preference procedures. The different stimulus presentation techniques of the three visual fixation preference groups are a small but representative sample of the various presentation techniques normally used. As there were no significant differences between

the three groups, the combined results were compared with the experimental results. Significantly more experimental Ss met the differential-fixation criterion on each of the 10x10, 12x12, 14x14, and 16x16 stimulus pairs. These results are presented in Table II also.

In summary, these results indicate that the experimental procedure is more effective than any of the control (test), criterion preference, or visual fixation preference procedures in producing Ss who meet the differential-fixation criterion of discrimination on individual stimulus pairs.

B. Evaluation Relative to Procedures Assessed by the t-test Criterion.

Since results of preference procedures are most usually assessed by a t-test criterion, the effectiveness of the experimental procedure relative to preference procedures was determined by comparing the number of experimental Ss meeting the differential-fixation criterion with the number of Ss in each preference group meeting the t-test criterion. The t-test criterion was applied separately to measures of fixation time, span, and number of looks. In addition, the number of Ss meeting the t-test criterion on any one of the three measures was also considered. The t-test criterion was not applied to experimental results because the experimental procedure was designed expressly to facilitate differential looking time that was consistent on only four consecutive test trials. Certainly a t-test applied to these trials would be significant, and thus provide identical information as the differential fixation criterion. On the

other hand, inclusion of the remaining non-criterion test trials, which varied considerably in number from S to S, might or might not result in a significant t value. Either way it would be irrelevant to an evaluation of the experimental procedure if, in fact, Ss had met the differential-fixation criterion.

The experimental results were compared with results for each of the visual fixation preference, criterion preference, and control groups. Figure 2 shows the proportion of experimental Ss meeting the differential-fixation criterion on each stimulus pair relative to the proportion of Ss in the other groups meeting the t-test criterion for fixation time. Figure 3 presents these proportions for span, Figure 4, for number of looks, and Figure 5, for the proportion meeting criterion on any one of the three measures.

1. Evaluation relative to the visual fixation preference procedure. Considering the most liberal index of discrimination for the visual fixation preference Ss, that is, the number of Ss meeting the t-test criterion with respect to any one of the preference measures, significantly more experimental than preference Ss met criterion on each stimulus pair from 10x10 to 16x16. These results are presented in Table III. No additional analyses of individual preference measures were conducted since these results indicate that the experimental procedure was more effective than the visual fixation preference procedure even when Ss could meet the t-test criterion on any, rather than just one, of the three measures.

2. Evaluation relative to the criterion preference and control procedures. The criterion preference and control procedures are essentially visual fixation preference procedures,

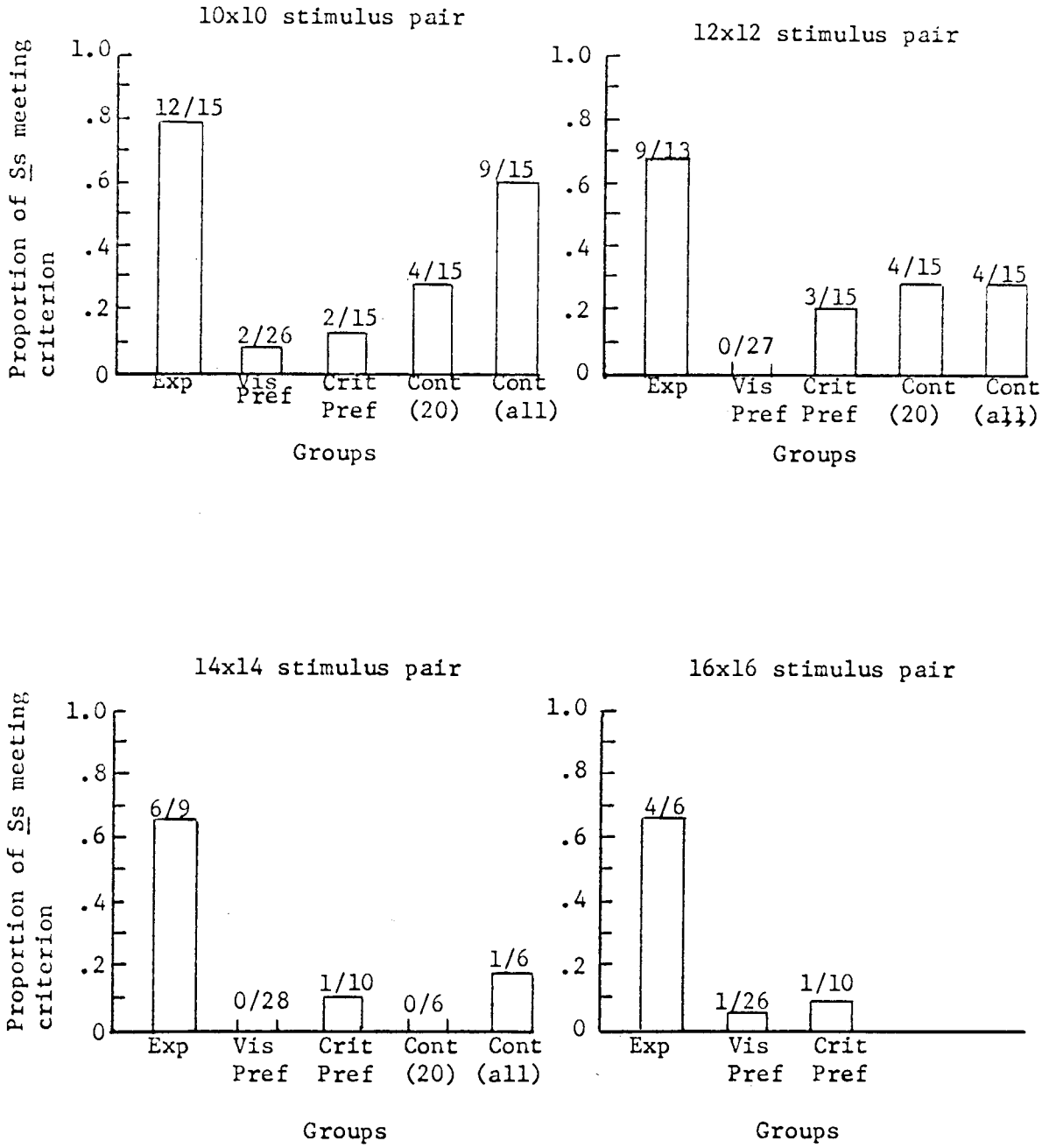

Fig. 2. Proportion of experimental Ss meeting differential-fixation criterion relative to proportion of Ss in other groups meeting t-test criterion of fixation time.

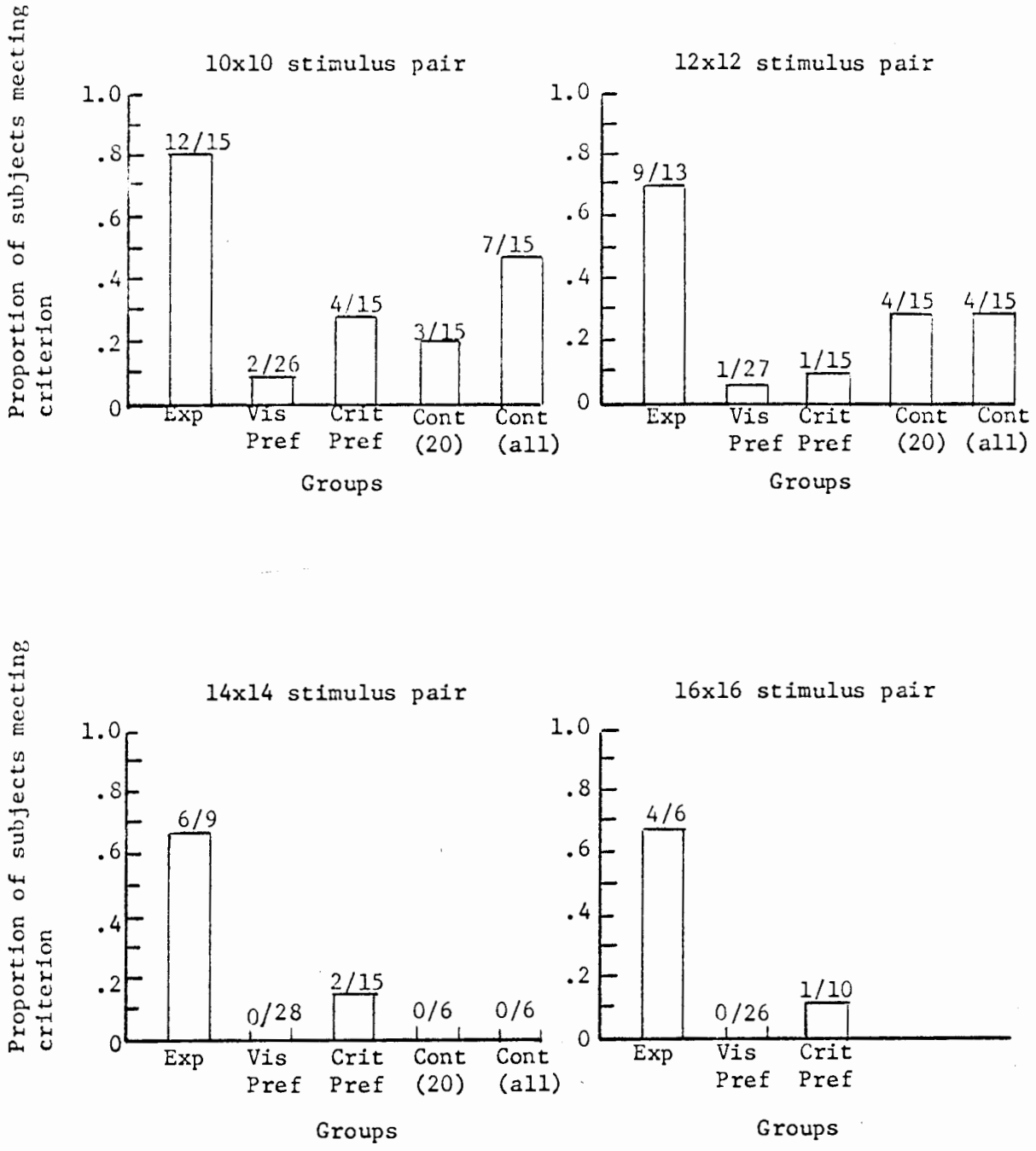

Fig. 3. Proportion of experimental Ss meeting differential-fixation criterion relative to proportion of Ss in other groups meeting t-test criterion of span.

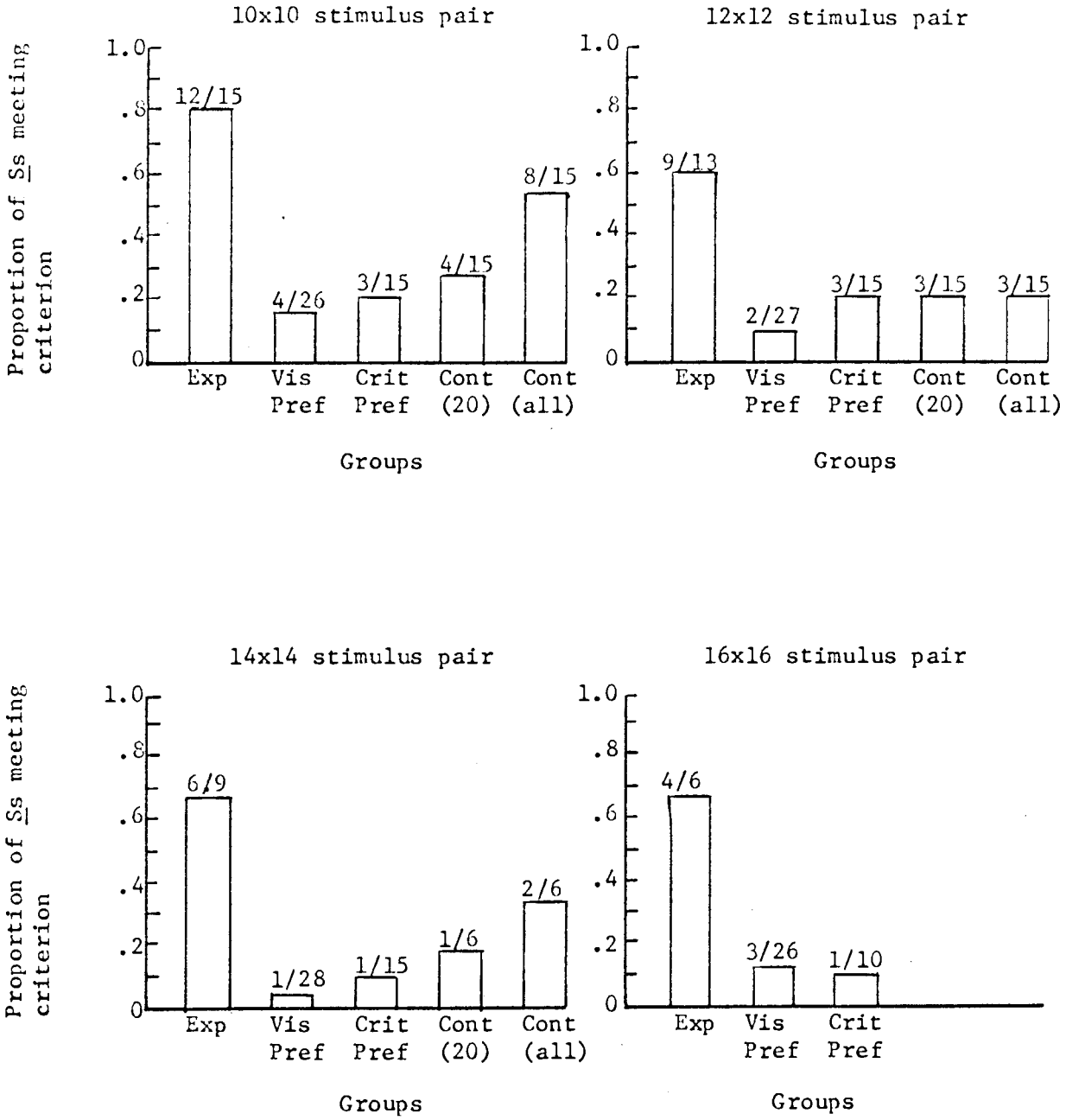

Fig. 4. Proportion of experimental Ss meeting differential-fixation criterion relative to proportion of Ss in other groups meeting the t-test criterion of number of looks.

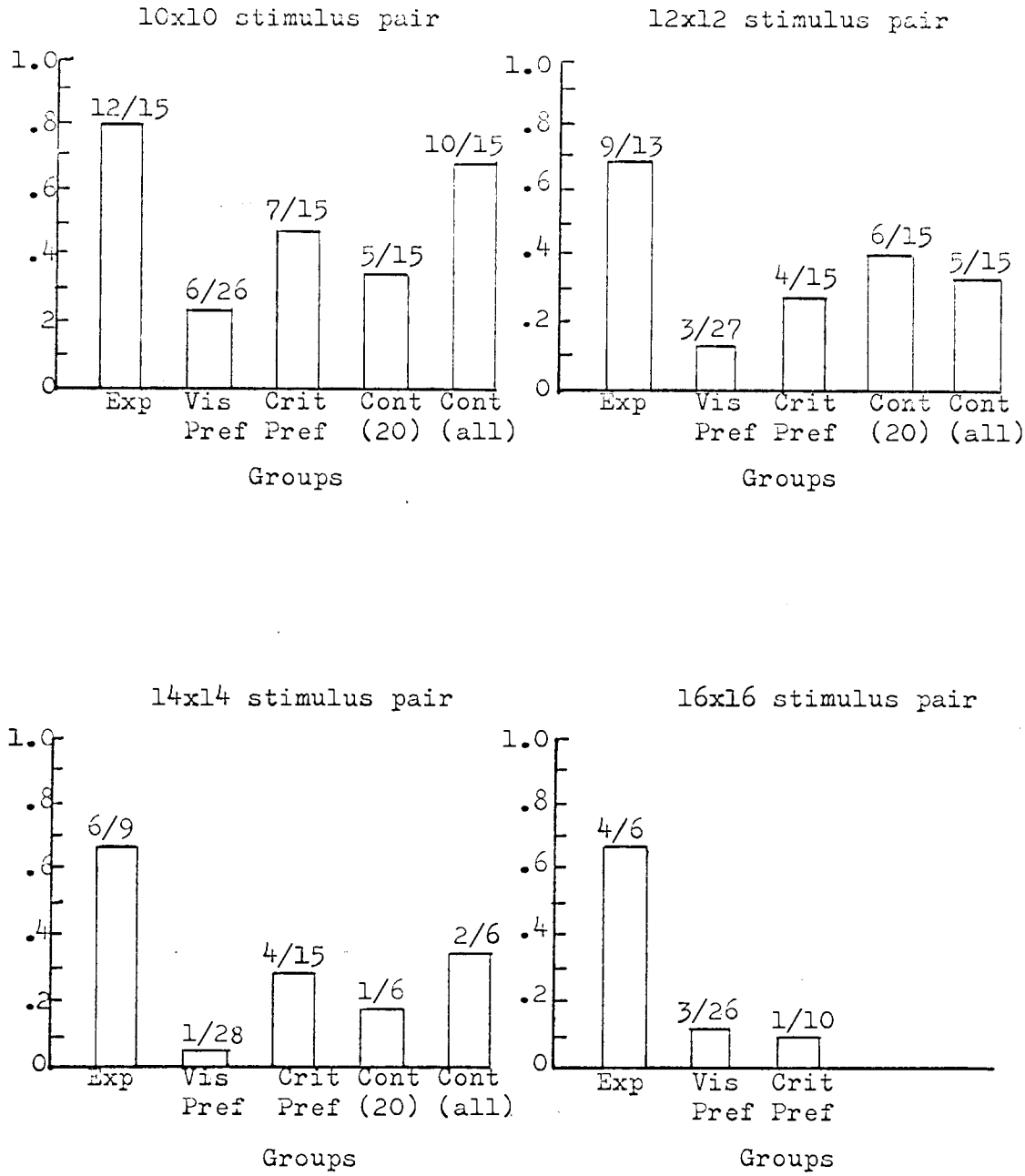

Fig. 5. The proportion of experimental Ss meeting differential-fixation criterion relative to proportion of Ss in other groups meeting t-test criterion on any preference measure.

Table III

Chi-square analyses of number of experimental Ss meeting differential-fixation criterion on each stimulus pair versus number in each other group meeting t-test criterion with respect to any preference measure.

Stimulus Pair		Group				
		Exp.	Vis. Pref.	Crit. Pref.	Cont (20)	Cont. (all)
10x10	N	12/15	6/26	7/15	5/15	10/15
	χ^2		6.63	2.30	4.89	.17
	p		<.02	NS	<.05	NS
12x12	N	9/13	3/27	4/15	6/15	5/15
	χ^2		11.49	3.51	1.36	2.30
	p		<.001	<.06	NS	NS
14x14	N	6/9	1/28	4/15	1/6	2/6
	χ^2		13.8			
	p		<.001	NS	NS	NS
16x16	N	4/6	3/26	1/10	1/2	1/2
	χ^2		5.74		-	-
	p		<.02	<.1		

modified in that, rather than presenting different pairs of stimuli in random order, the same stimulus pair is presented repeatedly for a series of trials, and subsequent stimulus pairs are presented in a serial order. In order to assess the effectiveness of this type of procedure relative to the experimental procedure, the number of the criterion preference and control Ss meeting the t-test criterion on each pair of stimuli was compared with the number of experimental Ss meeting the differential-fixation criterion. Control results were based on $\leq$ 20 trials, since 20 was the maximum number administered to criterion preference and experimental Ss. All criterion preference Ss were included in this analysis since, of the small number who met the differential-fixation criterion, most met the t-test criterion as well.

a. Criterion Preference Group. The number of experimental Ss meeting the differential-fixation criterion on each stimulus pair was in every case more than the number of criterion preference Ss meeting the t-test criterion with respect to each of the preference measures. Considering first the fixation time measure, significantly more experimental than criterion preference Ss met criterion on the 10x10 and 12x12 stimulus pairs, and a similar difference, while not significant, approached significance on the 14x14 and 16x16 stimulus pairs ($p < .1$ in both cases). These results are presented in Table IV.

Turning next to measures of span and number of looks, with respect to each, significantly more experimental Ss met criterion on the 10x10, 12x12, and 14x14 stimulus pairs, and a similar difference, while not significant, approached significance on the 16x16 pair ($p < .1$). The results for span are presented in Table V and those

Table IV

Chi-square analyses of number of experimental Ss meeting differential-fixation criterion on each stimulus pair versus number in each other group meeting t-test criterion with respect to fixation time.

Stimulus Pair		Group			
		Exp.	Crit. Pref.	Cont. (20)	Cont. (all)
10x10	N	12/15	2/15	4/15	9/15
	χ^2		11.57	6.56	.63
	p		<.001	<.02	NS
12x12	N	9/13	3/15	4/15	4/15
	χ^2		5.03	3.51	3.51
	p		<.05	<.06	<.06
14x14	N	6/9	3/15	0/6	1/6
	χ^2				
	p		<.1	<.05	NS
16x16	N	4/6	1/10	1/2	1/2
	χ^2			-	-
	p		<.1		

for number of looks in Table VI.

When the number of Ss who met criterion on any one of the three preference measures was considered, there were no significant differences between the experimental and criterion preference groups, although more experimental Ss met criterion on each pair. The difference, while not significant, approached significance for the 12x12 and 16x16 stimulus pairs ($p<.06$, $p<.1$). These results are presented in Table III.

b. Control group. The control and experimental groups were compared only on the 10x10, 12x12, and 14x14 stimulus pairs, in that the number of control Ss tested on the 16x16 pair was less than 6. Again, on each stimulus pair there were more experimental Ss who met the differential-fixation criterion than there were control (20) Ss who met the t-test criterion with respect to each preference measure.

With respect both to fixation time and span measures, significantly more experimental, than control Ss, met criterion on the 10x10 and 14x14 stimulus pairs, and a similar, while not significant difference, approached significance on the 12x12 pair ($p<.06$). The results for fixation time are presented in Table IV, and for span, in Table V.

Considering next the number-of-looks measure, significantly more experimental than control Ss met criterion on the 10x10 and 12x12 stimulus pairs, but the difference was not significant on the 14x14 pair. These results are presented in Table VI.

When the t-test criterion was considered in terms of the number of Ss who met criterion on any one of the three measures, signifi-

Table V

Chi-square analyses of number of experimental Ss meeting differential-fixation criterion on each stimulus pair versus number in each other group meeting t-test criterion with respect to span.

Stimulus Pair		Group			
		Exp.	Crit. Pref.	Cont. (20)	Cont. (all)
10x10	N	12/15	4/15	3/15	7/15
	χ^2		6.56	8.53	2.30
	p		<.02	<.01	NS
12x12	N	9/13	1/15	4/15	4/15
	χ^2		7.66	3.51	3.51
	p		<.01	<.06	<.06
14x14	N	6/9	2/15	0/6	0/6
	χ^2				
	p		<.05	<.05	<.05
16x16	N	4/6	1/10	1/2	1/2
	χ^2			-	-
	p		<.1		

cantly more experimental than control Ss met criterion on the 10x10 stimulus pair only. Differences with respect to other stimulus pairs were not significant. These results are presented in Table III.

3. Evaluation relative to the control (all trials) Procedure. Since it is possible that the likelihood of differentiating two stimuli increases with the opportunity to view them, the number of experimental Ss meeting the differential-fixation criterion was compared with the number of control Ss meeting the t-test criterion when all control trials were considered. The 10x10 stimulus pairs was presented to control Ss for an average of 46.6 trials, the 12x12 stimulus pair for an average of 27.3 trials, and the 14x14 stimulus pair for an average of 30.8 trials. The 16x16 stimulus pair was not considered because only 2 subjects were presented with this pair.

Again, the number of experimental Ss meeting the differential-fixation criterion was greater than the number of control (all) Ss meeting the t-test criterion with respect to each preference measure on each stimulus pair. However, the differences between the experimental and control groups were not significant on the 10x10 stimulus pair with respect to any of the preference measures. When the number-of-looks measure was considered on the 12x12 stimulus pair, significantly more experimental than control Ss met criterion. A similar difference, while not significant, approached significance with respect to measures of fixation time and span ($p<.06$ in each case). The difference between the groups was not significant with respect to the number of Ss meeting criterion on any one of the

Table VI

Chi-square analyses of number of experimental Ss meeting differential-fixation criterion on each stimulus pair versus number in each other group meeting t-test criterion with respect to number of looks.

Stimulus Pair		Group			
		Exp.	Crit. Pref.	Cont. (20)	Cont. (all)
10x10	N	12/15	3/15	4/15	8/15
	χ^2		8.53	6.56	1.35
	p		<.01	<.02	NS
12x12	N	9/13	3/15	3/15	3/15
	χ^2		5.03	5.03	5.03
	p		<.05	<.05	<.05
14x14	N	6/9	1/15	1/6	2/6
	χ^2				
	p		<.01	NS	NS
16x16	N	4/6	1/10	0/2	0/2
	χ^2			-	-
	p		<.1		

three measures. For the 14x14 stimulus pair, significantly more experimental than control Ss met criterion when span was considered. However, when the t-test criterion was considered with respect to fixation time, number of looks, and any one of the measures, there were no significant differences between the groups. The results regarding the number of Ss meeting criterion with respect to any one of the preference measures are presented in Table III, fixation time in Table IV, span in Table V, number of looks in Table VI.

In summary, these results indicate that the experimental procedure is significantly more effective in producing Ss who meet the differential-fixation criterion of discrimination than is the traditional visual fixation preference procedure in producing Ss who meet the t-test criterion. Similarly, relative to the control and criterion preference procedures, which are modifications of the visual fixation preference procedure, the experimental procedure was more effective overall, although only with respect to some response measures on some stimulus pairs were the differences significant.

III. Comparison of Criterion Preference and Visual Fixation Preference Procedures in terms of Number of Ss Discriminating each Stimulus Pair.

In order to evaluate the effectiveness of the two types of stimulus presentation procedures the criterion preference and visual fixation preference procedures, the number of criterion

preference Ss meeting the t-test criterion with respect to each preference measure on each stimulus pair was compared to the number of visual fixation preference Ss meeting the same criterion. The results indicated no significant difference between groups with respect to any preference measure on any stimulus pair. These results are presented in Appendix D, Table 1.

When the groups were compared with respect to number of Ss meeting the differential-fixation criterion on each stimulus pair, significantly more criterion preference Ss met criterion on the 14x14 pair, but all other differences were not significant. These results are presented in Appendix D, Table 2.

IV. Evaluation of the Experimental Procedure Relative to Each Other Procedure in terms of Number of Stimulus Pairs Discriminated per S

A. Discrimination of Successive Stimulus Pairs

The purpose of this study was to develop a procedure with which to determine the discrimination ability of individual Ss . There are two aspects to consider in assessing the success of the various procedures in achieving this aim. The first, discussed in the previous section, concerned the success of the different procedures for indicating discrimination by individual Ss on each pair of stimuli. The second, discussed below, concerns the success of each procedure in indicating a regular pattern of discrimination in which Ss meet criterion on a series of progressively more

similar pairs of stimuli. The stimulus pairs ranging from a 10x10 and 24x24 pair, to a 20x20 and 24x24 pair, form such a series.

In order to assess the success with which each procedure produced a regular pattern of discrimination, the experimental procedure was compared to each other procedure in terms of the number of Ss in each group who discriminated two, three and four successive stimulus pairs in the series. The number who met criterion on each of two, three, and four successive stimulus pairs was expressed as a proportion of the number to whom these stimuli were presented.

All comparisons with the visual fixation preference group are based on the combined results of Studies A, B, and C, since a Fisher exact test was not significant when applied in the only instance where the numbers of Ss discriminating any of two, three, or four successive stimuli was not zero. These results are presented for each group in Appendix E.

1. Evaluation in terms of the differential-fixation criterion. The proportion of Ss in each group meeting the differential-fixation criterion on two, three and four successive stimulus pairs is presented in Figure 6. The results of the comparison of the experimental group with each of the criterion preference, control, and visual fixation preference groups are presented in Table VII.

The number of Ss meeting criterion on at least two successive stimulus pairs is the least stringent index of success in producing a regular pattern of discrimination for individual Ss. Even on this index, significantly more Ss in the experimental group met the differential-fixation criterion than did Ss in other groups,

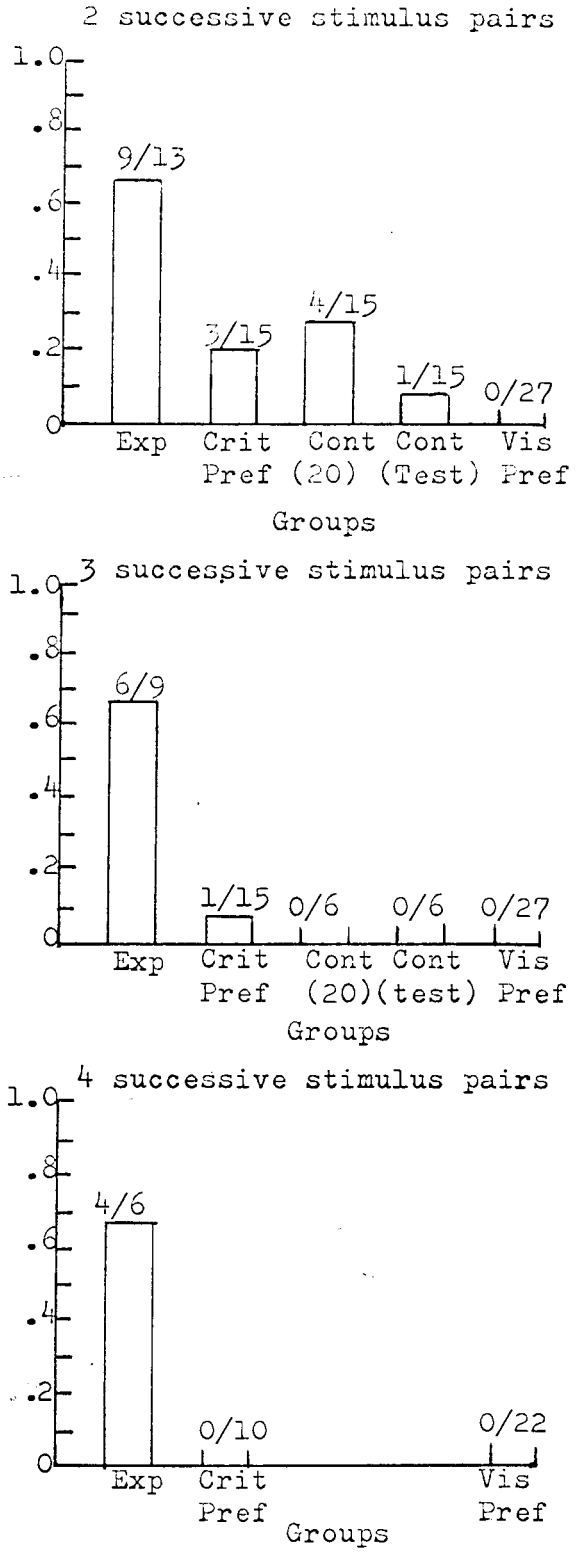

Fig. 6. Proportion of Ss in each group meeting differential-fixation criterion on 2, 3 and 4 successive stimulus pairs.

Table VII

Chi-square analyses of number of Ss meeting differential-fixation criterion on successive stimulus pairs: experimental group versus each other group.

Number of successive stimulus pairs		Group			
		Exp.	Crit. Pref.	Cont. (20)	Vis. Pref.
Two	N	9/13	3/15	4/15	0/27
	χ^2		5.03	3.51	20.3
	p		<.05	<.06	<.001
Three	N	6/9	1/15	0/6	0/27
	χ^2				17.07
	p		<.01	<.05	<.001
Four	N	4/6	0/10	0/2	0/22
	χ^2			-	12.1
	p		<.02	-	<.001

with the exception of the control (20) group where the difference, while not significant, approached significance ($p<.06$). Similarly, significantly more experimental Ss met criterion on three and four successive stimulus pairs than did Ss in any other group.

2. Evaluation relative to procedures assessed by the t-test criterion. Figure 7 presents the number of Ss in each of the visual fixation preference, criterion preference, and control (20) groups who met the t-test criterion with respect to any one of the three preference measures, and the number of experimental Ss who met the differential-fixation criterion. The results of the comparisons between the experimental group and each of the other groups are presented in Table VIII.

Significantly more experimental Ss met criterion on two, three, and four successive stimulus pairs than did Ss in any other group. This indicates that the experimental procedure was more effective than any other procedure, even when Ss in other conditions could meet the t-test criterion on any, rather than just one, of the three measures. Consequently, analyses with individual preference measures were not conducted.

B. Discrimination of Multiple Stimulus Pairs in any Order

The effectiveness with which each procedure provided evidence of multiple discriminations for individual Ss was evaluated in terms of the number of Ss meeting criterion on two, three and four stimulus pairs regardless of order. The number of Ss meeting criterion on each of two, three and four stimulus pairs was expressed as a proportion of the number presented with these stimuli. Again,

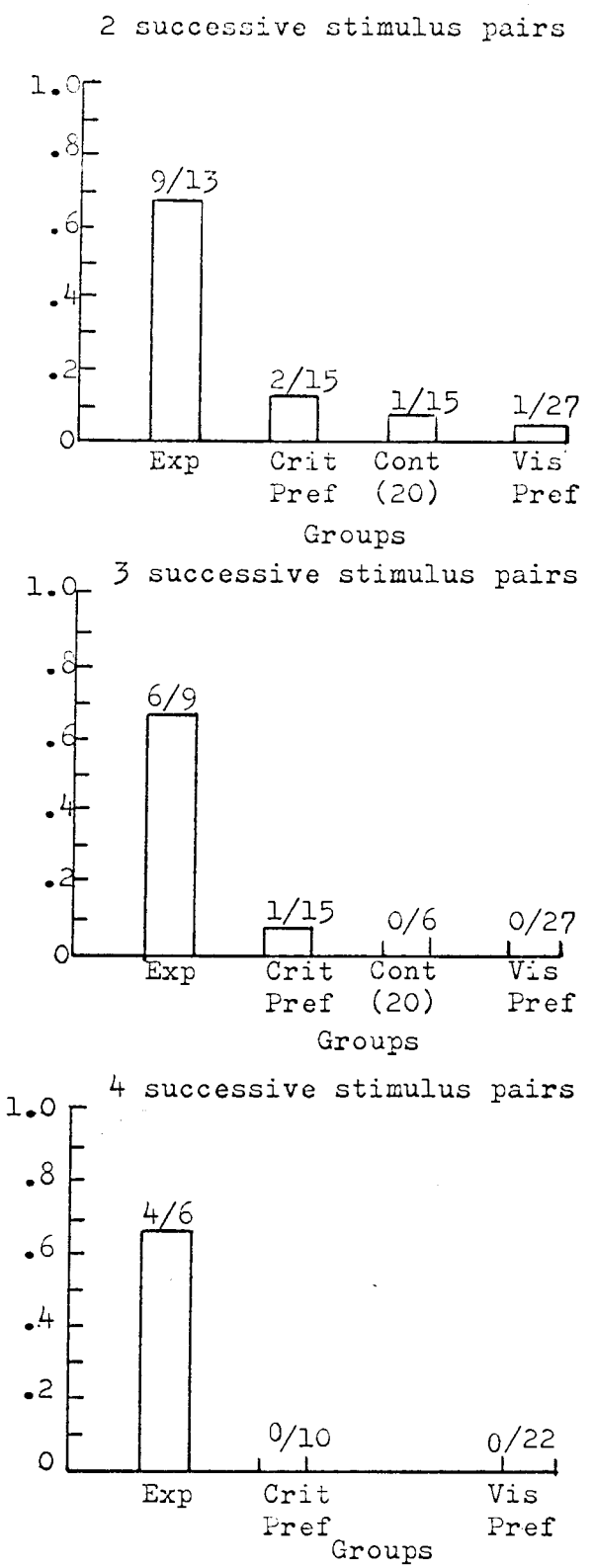

Fig. 7. Proportion of experimental Ss meeting the differential-fixation criterion on 2, 3 and 4 successive stimulus pairs relative to proportion in other groups meeting t-test criterion on any preference measure.

Table VIII

Chi-square analyses of number of experimental Ss meeting differential-fixation criterion on successive stimulus pairs versus number in each other group meeting t-test criterion with respect to any preference measure.

Number of successive stimulus pairs		Group			
		Exp.	Crit. Pref.	Cont. (20)	Vis. Pref.
Two	N	9/13	2/15	1/15	1/27
	χ^2		6.93	7.66	16.75
	p		<.01	<.01	<.001
Three	N	6/9	1/15	0/6	0/27
	χ^2				17.07
	p		<.01	<.05	<.001
Four	N	4/6	0/10	0/2	0/22
	χ^2			-	12.1
	p		<.02		<.001

stimulus pairs from 10x10 to 20x20 were considered in computing these results.

In all comparisons the results of the three visual fixation preference studies were combined, since a Fisher exact test of the largest difference between the three groups was not significant. The number of visual fixation preference Ss in each group discriminating two, three and four stimuli irrespective of order is presented in Appendix E.

1. Evaluation in terms of the differential-fixation criterion. The proportion of Ss in each group meeting the differential-fixation criterion on two, three and four stimulus pairs is presented in Figure 8. It should be noted that the number of experimental Ss discriminating stimuli in any order is the same as the number discriminating successive pairs of stimuli. The number of criterion preference Ss discriminating multiple stimulus pairs irrespective of order, however, is higher than the number discriminating successive stimulus pairs.

The results of the comparisons of the experimental group with each of the criterion preference, control, and visual fixation preference groups are presented in Table IX. Again, with respect to discrimination of two stimulus pairs, the least stringent index of success, significantly more experimental than visual fixation preference Ss met criterion. A similar difference, while not significant, approached significance with respect to the criterion preference and control (20) groups ($p<.06$ in both cases). As compared with each of the other groups, significantly more experimental Ss met criterion on three as well as four stimulus pairs.

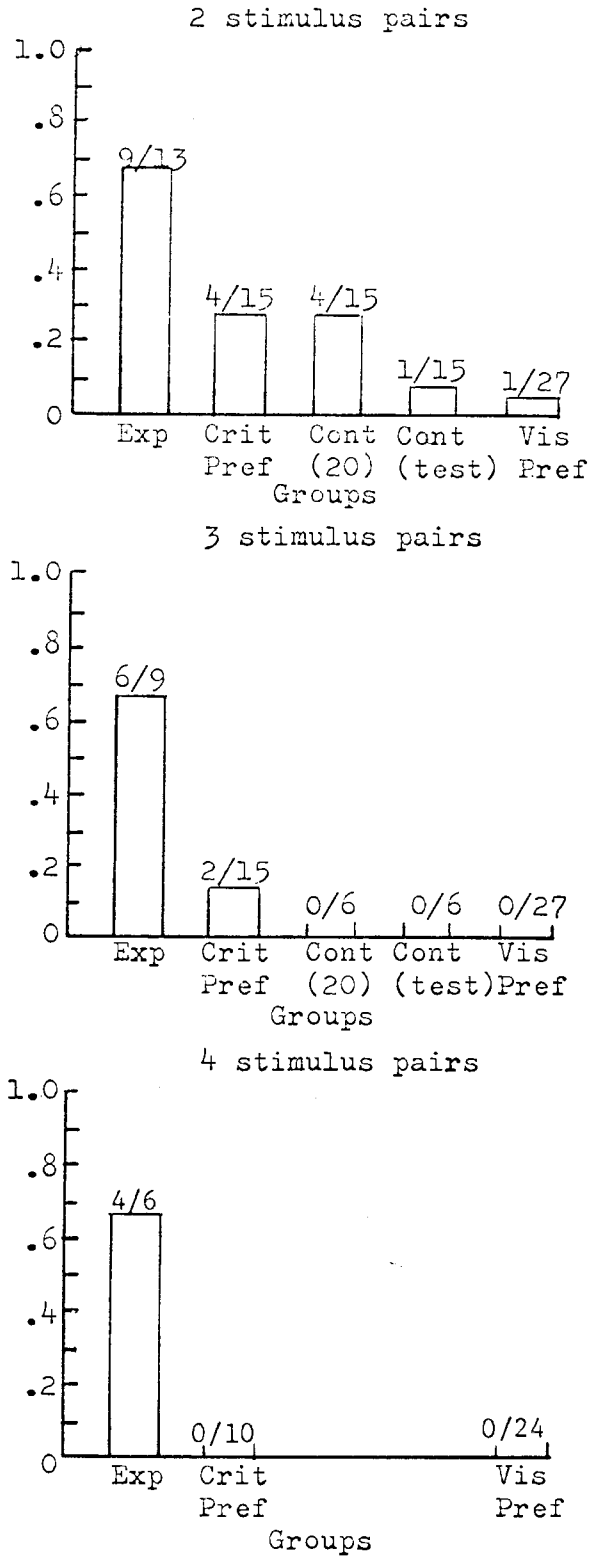

Fig. 8. Proportion of Ss in each group meeting differential-fixation criterion on multiple stimulus pairs irrespective of order.

Table IX

Chi-square analyses of number of Ss meeting differential-fixation criterion on multiple stimulus pairs: experimental group versus each other group.

Number of stimulus pairs		Group			
		Exp.	Crit. Pref.	Cont. (20)	Vis. Pref.
Two	N	9/13	4/15	4/15	1/27
	χ^2		3.51	3.51	16.75
	p		< .06	< .06	< .001
Three	N	6/9	2/15	0/6	0/27
	χ^2				17.07
	p		< .05	< .05	< .001
Four	N	4/6	0/10	0/2	0/24
	χ^2				13.14
	p		< .02	-	< .001

2. Evaluation relative to procedures assessed by the t-test criterion. Figure 9 presents the proportion of experimental Ss meeting the differential-fixation criterion on each of two, three, and four stimulus pairs and the proportion of Ss in the visual fixation preference, criterion preference, and control (20) groups meeting the t-test criterion with respect to any one of the preference measures. The results of comparisons between the experimental group and each of the others are presented in Table X.

Significantly more experimental Ss met criterion for two stimulus pairs than did Ss in either the control (20) or visual fixation preference groups. This difference was not significant, however, with respect to the criterion preference group. Compared to each of the other groups, significantly more experimental Ss met criterion on both three and four stimulus pairs.

Further analyses were conducted with respect to the one instance in which the experimental procedure was not significantly more effective, that is, as compared to the number of criterion preference Ss meeting criterion on two stimulus pairs. The number of experimental Ss meeting the differential-fixation criterion was compared with the number of criterion preference Ss meeting the t-test criterion with respect to each of the separate preference measures. Fisher exact tests indicated that in all cases significantly more experimental Ss met criterion ($p<.01$ in each case).

In summary, the experimental procedure was more effective than any other procedure in producing discrimination of two, three and four successive stimulus pairs, even when Ss tested under other

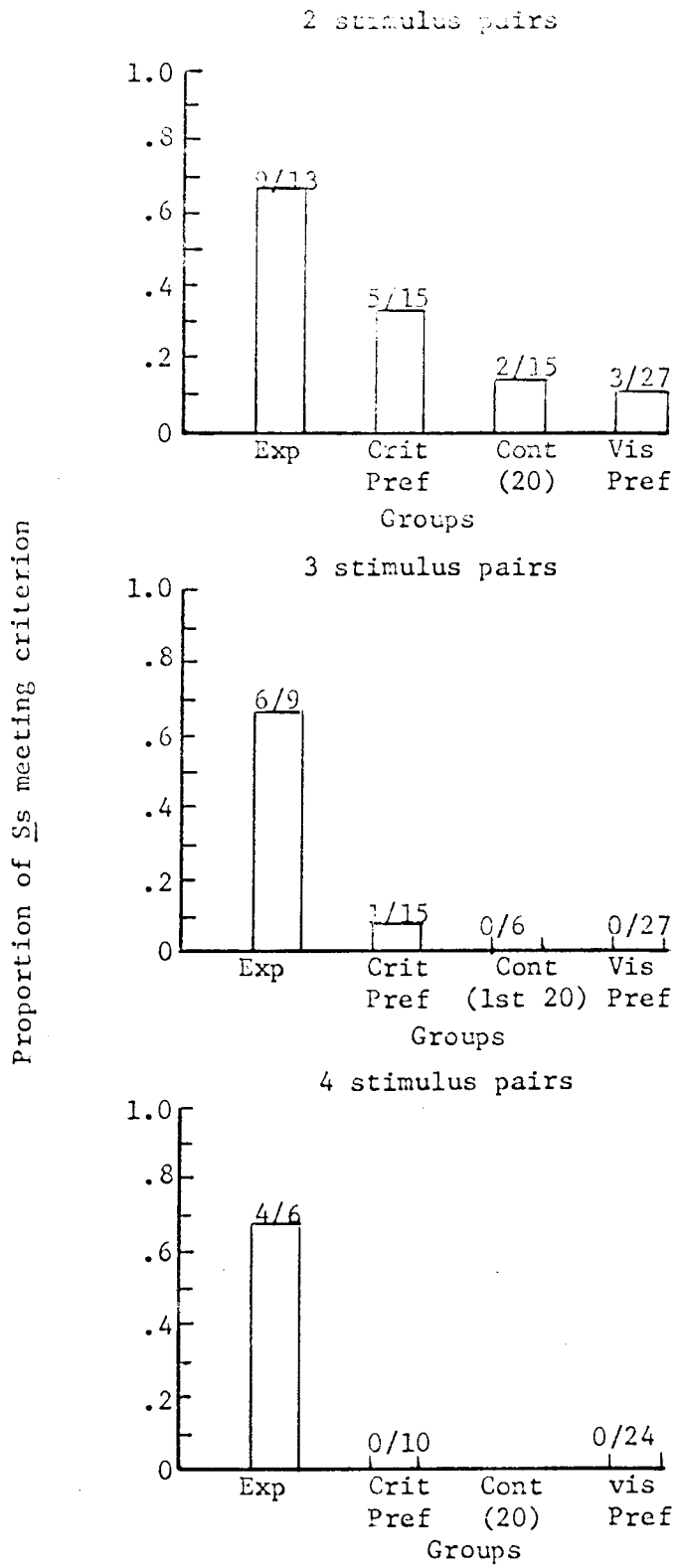

Fig. 9. Proportion of experimental Ss meeting differential-fixation criterion on multiple stimulus pairs relative to proportion of Ss in other groups meeting t-test criterion on any preference measure.

Table X

Chi-square analyses of number of experimental Ss meeting differential-fixation criterion on multiple stimulus pairs versus number in each other group meeting t-test criterion with respect to any preference measure.

Number of stimulus pairs		Group			
		Exp.	Crit. Pref.	Cont. (20)	Vis. Pref.
Two	N	9/13	5/15	2/15	3/27
	χ^2		2.30	6.93	11.48
	p		NS	<.01	< .001
Three	N	6/9	1/15	0/6	0/27
	χ^2				17.07
	p		<.01	<.05	<.001
Four	N	4/6	0/10	0/2	0/24
	χ^2				13.14
	p		<.02	-	<.001

procedures could show evidence of discrimination by meeting criterion on any of three preference measures. Similarly, the experimental group was more effective in producing discrimination of two, three and four stimulus pairs irrespective of order.

V. Analysis of Preference over Groups of Ss

As noted earlier, the results of visual fixation preference studies are usually analysed in terms of the preferences shown by groups of Ss, rather than by individual Ss. In order to relate the present findings more closely to those of other preference studies using checkerboard stimuli, particularly to the Brennan et al (1966) study, the results were also analyzed in terms of the group preferences shown by the visual fixation preference, criterion preference, and control (20) groups. Results were considered in terms of the preferences shown by each group for each pair of stimuli. As is typically the case with group analyses of visual fixation preference results, matched-group t-tests were computed with respect to differences in the fixation time to each stimulus in a pair. Differences in span and number of looks were also analyzed. Results of these analyses, presented in Table XI, indicate for each group the stimulus pairs and response measures contributing to a significant t-test ($p<.05$, two-tailed). The t values for these analyses are presented in Appendix F. In the subsequent discussion of results, meeting the t-test criterion with respect to any one of the three preference measures constitutes a

Table XI

Significant measures of group preference, fixation time (FT) span (S), or number of looks (NL) on each stimulus pair.

Stimulus pair	Group A	B	C	Crit. Pref.	Cont. 20
4x4	FT, S	-	S		
6x6	NL	-	S, NL		
8x8	-	-	S		
10x10	FT, NL	-	FT, NL	FT, S, NL	FT, S, NL
12x12	-	-	-	FT, S, NL	NL
14x14	-	-	-	FT	NL
16x16	-	-	-	S, NL	
20x20	-	-	-	-	

Note.- Underlining indicates preference for 24x24 stimulus.

significant preference, and thus discrimination of the pair.

None of the three visual fixation preference groups evidenced discrimination of the 12x12, 14x14, 16x16, or 20x20 stimulus pairs. Both groups A and C, however, discriminated the 4x4, 6x6, and 10x10 stimulus pairs, and Group C discriminated the 8x8 pair as well. Group B did not discriminate any stimulus pair.

The criterion preference and control (20) groups discriminated the 10x10, 12x12 and 14x14 stimulus. In addition, the criterion preference group discriminated the 16x16 pair, but failed to discriminate the 20x20 pair, which was presented only to that groups. Neither the criterion preference, nor the control (20) Ss were presented with the 4x4, 6x6, or 8x8 stimulus pairs.

Thus, in summary, discrimination was evidenced for the 10x10 pair by all groups, excluding Group B, which discriminated no stimulus pairs at all. Only the criterion preference and control (20) groups, however, discriminated the 12x12, 14x14 or 16x16 stimulus pairs.

Considering the direction of preference where preferences were significant, both Groups A and C preferred the 24x24 stimulus relative to the 4x4. In comparison with the 6x6 stimulus, the 24x24 was again preferred by Group A, however, Group C indicated preference for the 24x24 stimulus with respect to one measure but not with respect to another. Group C preferred the 8x8 stimulus relative to the 24x24, and all groups preferred the 10x10 stimulus relative to the 24x24. Both the criterion preference and control (20) groups preferred the 12x12, and 14x14 stimuli, while the criterion preference group also preferred the 16x16 stimulus.

In general, then, the 4x4 stimulus was less preferred relative to the 24x24; the 6x6 versus 24x24 comparison was ambiguous; and the 8x8, 10x10, 12x12, 14x14 and 16x16 stimuli, if differentiated from the 24x24 stimulus, were preferred to it.

These findings may be illustrated graphically in terms of relative fixation time to the variable stimulus in each pair. The curves are presented in terms of fixation time since it is the most commonly used preference measure. The percentage of time fixating the variable stimulus of the pair, relative to the total time fixating both, is presented in Figure 10 for Study A, which is representative also of Study C results, and in Figure 11 for the criterion preference group, representative also of the control (20) results. Significant differences in fixation time are indicated by circles around the appropriate point.

The discriminations shown by criterion preference and control groups, of stimulus pairs are more similar than those discriminated by visual fixation preference groups, cannot be attributed to a difference in the opportunity to view the stimuli since the groups differed very little in this respect. Each stimulus pair was presented to Group C for 16 trials, while they were presented to the control group for an average of 17 trials, and to the criterion preference group for an average of 17 and 15 and 13 trials for the 12x12, 14x14 and 16x16 stimulus pairs respectively.

The possibility that discrimination of smaller differences evidenced by the criterion preference and control groups might be due to a differential habituation effect was also investigated, since the order in which the stimulus pairs were presented was not randomized for these Ss as it was for the visual fixation prefer-

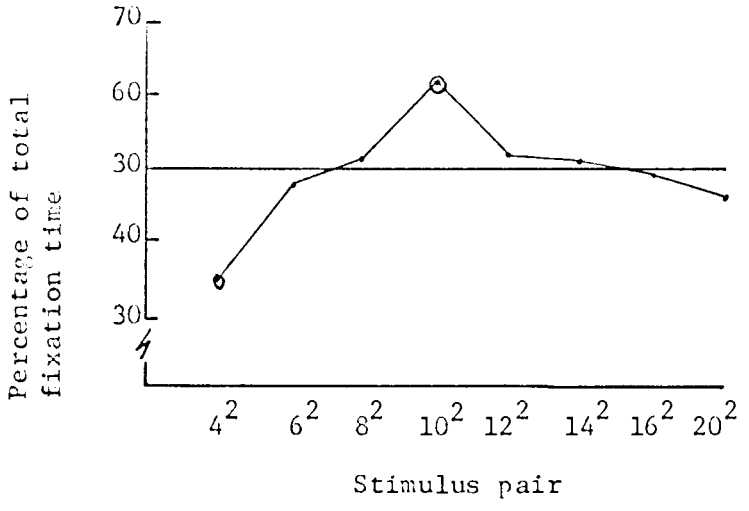

Fig. 10. Percentage of time fixating each stimulus relative to total time fixating both stimuli of each pair for group A.

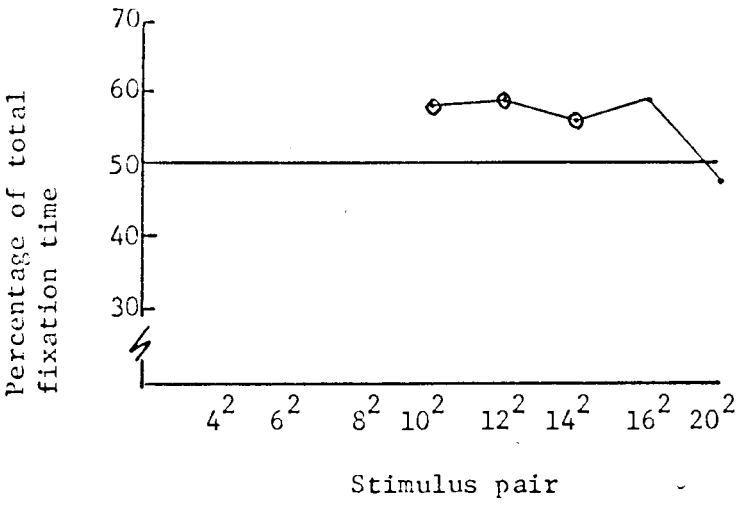

Fig. 11. Percentage of time fixating each stimulus relative to total time fixating both stimuli of each pair for criterion preference group.

Note.- Circled points indicate a significant difference in fixation of the stimulus pair.

ence Ss. Inspection of the relative fixation times to each stimulus of the pair over successive blocks of trials reveals little evidence of differential habituation. The fixation times to each stimulus of the pair parallel each other, and fixation time to the repeated stimulus, the 24x24 pattern, does not appear to decrease, as would be expected if habituation were occurring. Figure 12 presents the fixation time to each stimulus over blocks of ten trials for the control group, and Figure 13 presents the same information over blocks of five trials for the criterion preference group. The curves for the control group represent all control trials rather than just the first 20, since habituation effects would be more likely to appear with greater numbers of trials.

VI. Comparison of the Three Preference Measures

In order to determine whether any one preference measure provided a more sensitive index of differential responding for infants of this age, the number of Ss meeting the t-test criterion with respect to fixation time, span, and number of looks was compared within each of the visual fixation preference, the criterion preference, and the control (20) groups. Inspection of the results for each group revealed that on any single stimulus pair, the number of Ss meeting criterion with respect to a given preference measure was very small and varied little among the measures.

When performance on all stimulus pairs was considered for each group, the number of Ss meeting criterion on at least one stimulus pair varied only slightly among the measures. Only for Study C

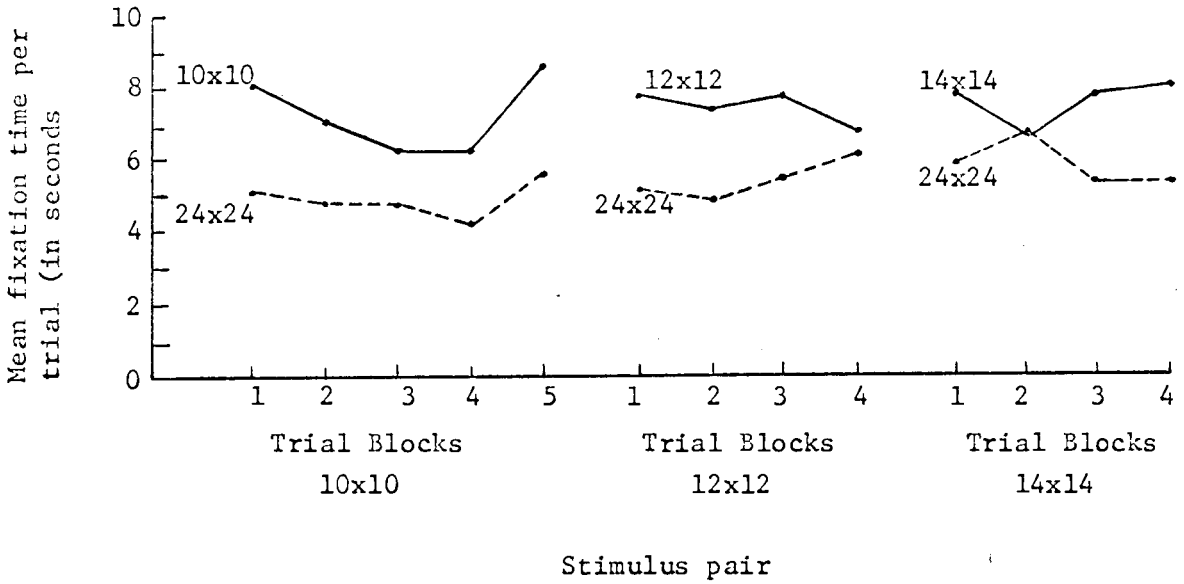

Fig. 12. Mean fixation time of the contral group averaged in blocks of 10 trials to each stimulus of each pair.

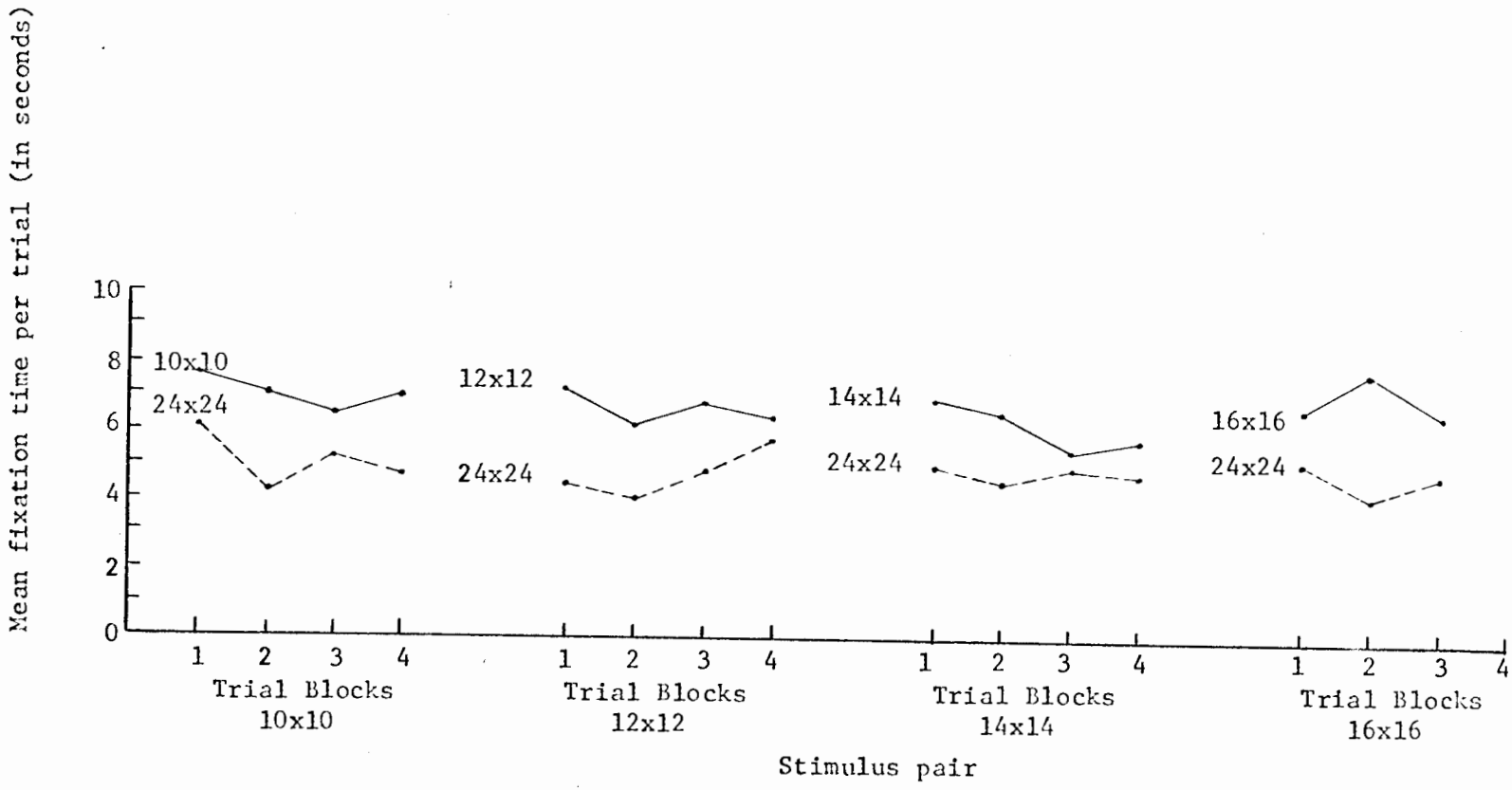

Fig. 13. Mean fixation times of criterion preference group averaged in blocks of 5 trials to each stimulus of the pair.

was there a marked difference between the measures: many more Ss met criterion with respect to the number of looks measure, than with respect to span or fixation time. These results are presented in Appendix G.

In addition, the measures contributing to the significant preferences evidenced by groups of Ss were also considered. Inspection of Table XI shows that of the 14 stimulus pairs that were significantly differentiated, in 10 cases the number-of-looks measure was significant, in 8, the span measure, and in 7, the fixation time measure. Again, these differences are small, although they slightly favour the number-of-looks measure, as was the case for individual Ss in Study C.

Discussion

The major aim of this research was to develop an operant conditioning procedure with which to assess visual discrimination ability in infants, and to compare results obtained by this operant conditioning procedure with those obtained by the traditional visual preference methods. The operant conditioning procedure which was developed involved increasing fixation time to one of two stimuli by making a brightly coloured moving picture contingent upon looking at the stimulus.

Evaluation of Conditioning Procedure

Initial evaluation of the conditioning procedure, assessed by comparing the experimental with the control group on test trials, showed that the experimental procedure was significantly more effective in eliciting differential fixation from individual Ss on each pair of stimuli. That this occurred in spite of the fact that the control group had extensive opportunity to view the stimuli, indicates that the fixation response is modifiable by conditioning procedures in which the visual stimulation is used as a reinforcer. The latter is in line with the findings of other investigators that response rate increases when visual stimulation is contingent on making the response (Heid, 1966; Caron, 1967; Siqueland, 1967; Bower, 1967).

This conditioning procedure, in which fixation time serves as the response measure, has several advantages. For one thing, the response may be easily recorded without elaborate apparatus. A more important advantage, however, is that the infant has only two responses available, looking at one or the other stimulus. Since these responses are incompatible, strengthening one necessarily weakens the other, and thus it is not necessary to undertake extensive inhibition training in order to demonstrate discrimination learning. This is particularly interesting in that conditioning of headturning and sucking, the other responses used for discrimination training, is usually rapid, but the inhibition training necessary for successful discrimination training takes many additional sessions (Bower, 1966, 1967). Similarly, differential fixation is also conditioned rapidly, usually within ten minutes, but when this is accomplished, discrimination training is complete without further inhibition training.

Evaluation of the usefulness of the operant conditioning method relative to spontaneous preference methods indicated that, generally, the operant conditioning procedure was more effective in providing evidence of discrimination by individual Ss. This applied both to number of Ss discriminating any one stimulus pair, and the number discriminating several stimulus pairs.

Relative to Traditional Visual Fixation Preference Procedures

Relative to the visual fixation preference procedures, significantly more experimental Ss evidenced discrimination on every stimulus pair from the 10x10 to the 16x16 pair, when Ss in both groups were assessed by the differential-fixation criterion. This

was also true even when the visual fixation preference Ss were given the opportunity to meet a t-test criterion on any one of three preference measures. With respect to these same two criteria, more experimental than visual fixation preference Ss also discriminated two, three, and four stimulus pairs in successive order, as well as in any order. These results clearly indicate that the experimental procedure is more effective than traditional visual fixation preference procedures in providing evidence of discrimination by individual Ss.

Relative to the Criterion Preference Procedure

In addition to the traditional visual fixation preference procedure, a modification of this method, called the criterion preference procedure, was also studied. This procedure involved repeated presentation of each stimulus pair, presentation of different pairs in order of increasing similarity, and use of a criterion procedure such as was employed in the experimental procedure. It was postulated that this modified preference procedure might facilitate differential responding. If this were so, it would provide an alternative to the discrimination training procedure as well as a refinement of visual fixation preference procedures.

Considering the differential-fixation criterion, more experimental than criterion preference Ss met criterion on all pairs. These differences were not significant, however, on the 14x14 and 16x16 stimulus pairs, which may be accounted for, in part, by the smaller number of experimental Ss tested on these pairs. These results suggest that with respect to the differential-fixation criterion of discrimination, the experimental procedure was gener-

ally more effective than the criterion preference procedure.

Compared with criterion preference results assessed by the t-test criterion, more experimental Ss discriminated each pair than did criterion preference Ss when each of the preference measures, fixation time, span, or number of looks was considered separately. In all of these comparisons a difference favoring the experimental group was significant or, while not significant, approached significance. Only if the number of Ss meeting criterion with respect to any one of the three measures was considered, was the difference between experimental and criterion groups reduced. A difference favouring the experimental procedure, while not significant, approached significance on the 12x12 and 16x16 stimulus pairs, and although in the same direction, was not significant for the 10x10 or 14x14 stimulus pairs. In other words, only if an infant was allowed to meet criterion in any one of a number of ways, did the criterion preference procedure approach the effectiveness of the experimental procedure in providing evidence of discrimination on any single stimulus pair.

In addition, the two procedures were compared with respect to number of Ss discriminating more than one stimulus pair. As assessed by the differential-fixation criterion, significantly more experimental than criterion preference Ss discriminated two, three, and four successive, as well as multiple, stimulus pairs. Even when the performance of criterion preference Ss was considered in terms of meeting the t-test criterion with respect to any one of the three preference measures, significantly more experimental Ss discriminated two, three, and four successive stimulus pairs, as well as three and four pairs in any order. The criterion preference and

experimental procedures did not differ significantly in number of Ss discriminating two stimulus pairs irrespective of order. However, when the performance of criterion preference Ss on two pairs was evaluated in terms of the individual preference measures, differences in favor of the experimental group were significant.

Thus, these results indicate that when the discrimination criteria are applied to individual response measures, the experimental procedure is more effective than the criterion preference procedure in providing evidence of discrimination by individual Ss. Only when discrimination may be evidenced by meeting criterion with respect to any one of three measures, does the criterion preference procedure approach the experimental procedure in terms of the number of Ss indicating discrimination. However, even with such a liberal index of discrimination, the criterion preference procedure is clearly inferior to the experimental procedure in providing evidence of discrimination for an individual S on successive, or multiple, stimulus pairs. Very few criterion preference Ss discriminated more than one stimulus pair while the opposite was true for the majority of experimental Ss. Almost identical findings were obtained for the control (20) group, which was similar to the criterion preference group with respect to method of stimulus presentation.

The experimental group was also compared with the control (all) group to determine the effectiveness of the experimental procedure relative to a modified preference procedure in which Ss were presented with an unusually large number of trials. In general, the results were similar to those of the criterion preference group,

although there were fewer significant differences between the groups when the number of Ss discriminating single stimulus pairs was considered. This suggests that a large number of trials (the average was 34 per stimulus pair) may somewhat facilitate differential responding, although the experimental procedure was still more effective.

In evaluating these various methods, the number of stimuli that S discriminates is probably the most relevant index of the effectiveness of the procedures in providing information about the discrimination abilities of individual Ss. It is in regard to precisely this index that the experimental procedure is strikingly superior to other procedures. Even allowing the spontaneous preference procedures the most liberal measure of multiple discriminations, that is, meeting criterion with respect to any one of three measures, experimental Ss nevertheless discriminate more stimuli than Ss in any other group.

Evaluation of Preference Procedures

The criterion preference and visual fixation preference groups were compared to determine whether the criterion preference procedure was in any way superior to traditional preference procedures. The results of comparing the two groups in terms of both differential-fixation and t-test criteria, indicate that there were no significant differences between them on any stimulus pair. These results suggest that the criterion preference procedure is no more effective than the traditional preference procedure.

On the other hand, comparisons with the experimental procedure indicated that although the experimental procedure was always more effective than the visual fixation preference procedure, this was not necessarily true with respect to the criterion preference procedure. These findings suggest, therefore, that the criterion preference procedure may be slightly more effective than the traditional preference procedure.

Consideration of the different preference measures, fixation time, span, and number of looks, indicated that each provided evidence of discrimination about the same number of times, both for group and individual analyses. This suggests that twelve-week-old infants are intermediate between making a few long looks, which is characteristic of young infants, and many short ones, characteristic of older infants (Ames, 1966), and hence no one measure is more sensitive than any other. Being able to meet a discrimination criterion on any one of the three measures, however, provides a broader indication of discrimination. Since infants do seem to vary in their mode of responding, both between infants and within a given infant, it would seem that serious consideration whould be given to including each of these measures in any statement about preferences.

Evaluation of Preferences for Groups of Ss

When evidence of discrimination by groups of Ss was investigated, the results for the criterion preference and control (20) groups indicated that twelve-week-old infants prefer, and thus discriminate,

10x10, 12x12, 14x14, and 16x16 stimuli relative to the 24x24 stimulus. Of these pairs, only the 10x10 stimulus was preferred by the visual fixation preference groups. This suggests that a stimulus presentation method in which stimuli are presented for a series of trials, as in the criterion preference procedure, provides evidence of finer discrimination than one in which stimuli are randomized over trials, as in traditional preference procedures. The smallest differences discriminated using the traditional preference procedures was a 10x10 versus a 24x24 checkerboard pattern, while the smallest difference discriminated using the criterion preference procedure was a 16x16 versus a 24x24 pattern.

The possibility that these differences in discrimination could be attributed to a differential habituation effect was investigated for both the criterion preference, and control (all) groups since the procedure of presenting the same stimulus pair repeatedly might have been expected to facilitate habituation. Curves of the fixation time to each stimulus of a pair provided no evidence of habituation to either the 24x24 stimulus, the one presented most often, or the variable stimulus. This was true for both groups, even though the control (all) group received many more trials than the criterion preference group. Thus, these results indicate that the superiority of the criterion preference procedure is more likely attributable to the stimulus presentation technique, than to a differential habituation effect.

In addition, the smallest difference discriminated by the criterion preference Ss as a group, the 16x16 versus the 24x24 stimulus, was also discriminated by the majority of individual experimental

Ss. That these results are so similar strongly supports the conclusion that twelve-week old infants are able to discriminate a 16x16 checkerboard from a 24x24 checkerboard. In addition, these results indicate that the criterion preference procedure provides the same indication of discrimination ability for groups of Ss as does the experimental procedure for individual Ss.

Relative to the Dember and Earl Theory

The results obtained for the visual fixation preference groups to some extent support predictions derived from the Dember and Earl theory, and extend the finding reported by Brennan et al, (1966). In line with the latter findings that eight-week-olds preferred the 8x8 stimulus, and fourteen-week-olds preferred the 24x24 stimulus, the twelve-week-olds in this study preferred a stimulus intermediate to these two, the 10x10 checkerboard stimulus. If age can be equated with experience, as suggested by Ames (1966), these results would be predicted by the Dember and Earl theory which states that with experience, the pacer, or preferred stimulus, changes in the direction of greater complexity.

The finding illustrated in Figure 10, that stimuli with fewer or greater numbers of squares were fixated less than the 10x10 stimulus would also be predicted by the theory. That the shape of this preference curve is similar to one reported by Brennan et al, (1966) suggests the consistency of the phenomenon for groups of Ss. The pattern of preferences for individual Ss, however, was highly variable and seldom approximated the group curves.

The preference curves for the criterion preference and control

(20) groups, as illustrated in Figure 11, are not so clearly in line with the theory. Not only is the 10x10 stimulus preferred, but also, the 12x12, 14x14, and 16x16 stimuli. Again, this may result from the stimulus presentation procedure employed. The practice of presenting one stimulus pair for a series of trials and of presenting successive stimulus pairs in order of similarity, may have facilitated the generalization of preference from the 10x10 to the 12x12 stimulus, et cetera. Since the difference between successive stimuli was slight even to the adult eye, it is possible that the infant did not actually differentiate any two successive stimuli. Thus with a constant, ordered stimulus presentation procedure such as this, generalization from a preferred stimulus to similar stimuli could have occurred.

In general, the 10x10 checkerboard stimulus does appear to be the preferred pattern for infants twelve weeks of age. This is evidenced by the fact that all groups showed a preference for this stimulus (except for one group which showed no preferences at all), and also that more individual Ss preferred this pattern to any other. Since a fairly consistent preference is indicated for the 10x10 pattern, and since that stimulus is intermediate between the 8x8 and 24x24 stimuli, as would be predicted from the Brennan et al. (1966) study, the results support the idea that infants do have a preferred stimulus which changes with age along the dimension represented by the varying checkerboard patterns. If the Dember and Earl theory is applied, the preferred stimulus could be conceptualized as a pacer stimulus, and the checkerboard dimension as a complexity dimension.

Considering the overall results of this research, the major implication is that the visual discrimination abilities of infants can be better investigated by means of an operant conditioning procedure than by means of visual fixation preference procedure. The particular stimulus presentation technique used in the present conditioning procedure was designed to maximize the possibility of Ss evidencing discrimination. To determine which of the various aspects of the procedure were important in this regard, further investigation is necessary.

For one thing the positive stimulus in this conditioning procedure was particularly chosen because it was somewhat preferred relative to the negative stimulus. Whether or not it would be possible to use the least preferred stimulus as the positive stimulus and the most preferred, as the negative stimulus, remains to be investigated. Further, the technique of conditioning differential responding first to the most different stimuli and subsequently to more similar stimuli, may or may not be necessary for obtaining evidence of discrimination similar to that reported in this research. This could be investigated by varying the order in which the stimuli are presented.

The second implication of this research, considered in conjunction with the Brennan et al. (1966) results, is that preferences for stimuli, at least on the dimension used here, do appear to vary with age in an orderly fashion. These findings suggest possible changes in perceptual-cognitive functioning (Fantz, 1966) occur with age which can only be investigated with a preference method. In order to ascertain whether the developmental changes in preference found for groups of Ss in these cross-sectional

studies also held for individual Ss, longitudinal studies of preference are needed.

A general summary of results indicates that the operant conditioning procedure developed in this research is an effective tool for determining the discrimination abilities of infants. Compared with any preference procedure, the experimental procedure is more effective for producing evidence of discrimination for individual Ss. Additional analyses of the preference procedures indicated that the results for groups of Ss were consistent with other findings using checkerboard stimuli. These results provided support for the Dember and Earl theory that preferences changed in a predicted direction with experience (age). Group results for the criterion preference procedure, and individual findings for the majority of experimental Ss, indicated that twelve-week-old infants can discriminate between patterns at least as similar as 16x16 versus 24x24 squares.

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APPENDIX A

Table 1

Differential-fixation criterion: number of test trials to criterion or maximum number of test trials for each experimental S on each pair of stimuli.

	Stimulus pair					
S	10x10	12x12	14x14	16x16	18x18	20x20
1	4	4	4	4	(8)	
2	4	6	4	(6)		
3	4	4	12	6	4	8
4	4	12	4	4		
5	14	5	10	4		(10)
6	10	7	4	(20)		
7	4	4	(12)			
8	4	16	(5)			
9	4	17	(6)			
10	12					
11	4	(12)				
12	4	(20)				
13	(7)					
14	(16)	(4)				
15	(20)	(3)				

Note.- Parentheses indicate maximum number of trials presented when S failed to meet criterion.

Table 2

Differential-fixation criterion: number of trials to criterion or maximum number of trials for each criterion preference S on each pair of stimului.

S	Stimulus pair 10x10	12x12	14x14	16x16	20x20
1	4	(20)	6	11	(13)
2	9	(20)	14	(20)	
3	9	(20)	(20)	(20)	(4)
4	(20)	5	19	8	(20)
5	(20)	11	(20)	(19)	
6	(20)	4	(20)	(14)	
7	(20)	(20)	13	6	(19)
8	(20)	(18)	4		
9	(20)	(20)	(20)	(6)	
10	(20)	(20)	(20)	(7)	
11	(20)	(20)	(20)	(20)	
12	(20)	(20)	(15)		
13	(20)	(20)	(15)		
14	(20)	(20)	(10)		
15	(20)	(20)	(9)		

Note.- Parentheses indicate maximum number of trials presented when S failed to meet criterion; underlining indicates preference for the 24x24 stimulus.

Table 3

Differential-fixation criterion: number of test trials to criterion or maximum number of trials for each control (test) S on each pair of stimuli.

S	Stimulus pair 10x10	12x12	14x14	16x16
1	20	5	(20)	
2	8	(18)		
3	(20)	9	(16)	
4	(20)	5	(20)	(12)
5	(20)	(20)	(10)	10
6	(20)	(20)	(4)	
7	(20)	(20)	(10)	
8	(20)	(14)		
9	(20)	(9)		
10	(20)	(18)		
11	(20)	(10)		
12	(20)	(4)		
13	(20)	(4)		
14	(20)	(16)		
15	(20)	(20)		

Note.- Parentheses indicate maximum number of trials presented when S failed to meet criterion.

Table 4

Differential-fixation criterion: number of trials to criterion or maximum number of trials for each control (20) S on each pair of stimuli.

S	Stimulus pair 10x10	12x12	14x14	16x16
1	(20)	8	(20)	
2	4	4		
3	14	4	(20)	
4	9	14	(20)	(20)
5	(20)	(20)	20	19
6	(20)	(20)	(6)	
7	(20)	(20)	(20)	
8	(20)	(20)		
9	5	(20)		
10	4	(18)		
11	17	(19)		
12	(20)	(7)		
13	13	(7)		
14	(20)	(20)		
15	(20)	(20)		

Note.- Parentheses indicate maximum number of trials presented when S failed to meet criterion; underlining indicates preference for 24x24 stimulus.

Table 5

Differential-fixation criterion: number of trials to criterion on each stimulus pair for those Ss in Study A, B, and C meeting criterion.

Study		Stimulus pair 4x4	6x6	8x8	10x10	12x12	14x14	16x16	20x20
A (N=11)	S 1	-	-	-	4	-	-	-	-
B (N=6)[a]	S 1	4	8	-	-	-	-	8	-
	S 2	4	-	-	-	-	4	-	-
C (N=10)	S 1	14	-	-	-	-	-	-	13
	S 2	4	-		-	14	-		4
	S 3	-	15		-	-	4		-
	S 4	-	-	-	10	-	-	-	-

Note.- Underlining indicates preference for 24x24 stimulus.

[a]One S was omitted from this group due to stimulus presentation difficulties which made application of the differential-fixation criterion inappropriate.

APPENDIX B

Table 1

The t-test criterion: Ss in Study A and B meeting criterion on each stimulus pair with respect to fixation time (FT), span (S) or number of looks (NL).

Study		Stimulus pair 4x4	6x6	8x8	10x10	12x12	14x14	16x16	20x20
A (N=11)	S 1	-	-	-	FT	-	-	-	-
	S 2	NL	-	-	-	-	-	-	FT
	S 3	-	NL	-	-	-	-	-	-
	S 4	-	-	NL	-	NL	-	-	-
	S 5	-	-	FT, S	-	-	-	-	-
	S 6	-	-	-	NL	-	-	-	-
B (N=7)	S 1	-	S	-	-	-	-	-	-

Note.- Underlining indicates preference for 24x24 stimulus.

Table 2

The t-test criterion: Ss in Study C (N=10) meeting criterion on each stimulus pair with respect to fixation time (FT), span (S), or number of looks (NL).

Ss	Stimulus pair 4x4	6x6	8x8	10x10	12x12	14x14	16x16	20x20
1	S	-	-	-	-	-	-	NL
2	-	-		FT,S,NL	NL	-		-
3	-	NL		S	-	-		S
4	S	-	NL	-	-	-	-	-
5		-	-	-		-	NL	-
6	-	-	FT,NL	NL	-	-	FT,NL	-
7	-	NL	-	NL	-	-	-	-
8	-	NL	-		S	-	NL	
9	-	-	-		-	NL	-	

Note.- Underlining indicates preference for 24x24 stimulus.

Table 3

The t-test criterion: criterion preference Ss meeting criterion on each stimulus pair with respect to fixation time (FT), span (S) or number of looks (NL), computed over indicated number of trials.

	Stimulus pair									
	10x10		12x12		14x14		16x16		20x20	
S	Criterion Measure(s)	Trials	Criterion Measure(s)	Trials	Criterion Measure(s)	Trials	Criterion Measure(s)	Trials	Criterion Measure(s)	Trials
1	FT, S	4	FT, NL	20	-	6	-	11	-	13
2	-	9	-	20	-	14	-	20		
3	FT, S	9	-	20	-	20	-	20	FT	4
4	-	20	FT, NL	5	FT,S	19	FT, S, NL	8	-	20
5	-	20	NL	11	-	20	-	19		
6	-	20	FT, S	4	-	20	-	14		
7	-	20	-	20	-	13	-	6	-	9
8	-	20	-	18	FT	4				
9	NL	20	-	20	-	20	-	6		
10	NL	20	-	20	FT, NL	20	-	7		
11	-	20	-	20	-	20	-	20		
12	NL	20	-	20	-	15				
13	S	20	-	20	-	15				
14	S	20	-	20	S	10				
15	-	20	-	20	-	9				

Note.- Underlining indicates preference for 24x24 stimulus.

Table 4

The t-test criterion: control (20) Ss meeting criterion on each stimulus pair with respect to fixation time (FT), span (S), or number of looks (NL), computed over indicated number of trials.

	Stimulus pair							
	10x10		12x12		14x14		16x16	
S	Criterion Measure(s)	Trial	Criterion Measure(s)	Trial	Criterion Measure(s)	Trial	Criterion Measure(s)	Trial
1	FT, S	20	-	10	NL	20		
2	FT, S, NL	20	FT, S, NL	20				
3	-	20	FT, S, NL	20	-	20		
4		20	-	16	-	20		
5	-	20	-	20	-	20	FT, S	20
6	FT, S, NL	20	-	20	-	6		
7	NL	20	-	20	-	20		
8	-	20	FT, S	20				
9	-	20	-	20				
10	FT, NL	20	-	18				
11	-	20	NL	19				
12	-	20	FT	7				
13	-	20	S	7				
14	-	20	-	20				
15	-	20	-	20				

Table 5

The t-test criterion: control (all) Ss meeting criterion on each stimulus pair with respect to fixation time (FT), span (S), or number of looks (NL), computed over indicated number of trials.

	Stimulus pair							
	10x10		12x12		14x14		16x16	
S	Criterion Measure(s)	Trials	Criterion Measure(s)	Trials	Criterion Measure(s)	Trials	Criterion Measure(s)	Trials
1	FT, S, NL	50	-	10	FT, NL	40		
2	FT, S, NL	23	FT, S	42				
3	-	51	FT, S, NL	20	-	35		
4	FT, S, NL	48	-	16	NL	38		
5	-	48	-	48	-	45	FT, S,	20
6	FT, S	49	-	42	-	6		
7	FT, NL	46	-	46	-	21		
8	FT, S, NL	44	FT, S, NL	36				
9	FT, S	49	-	20				
10	FT, S, NL	46	-	18				
11	-	49	NL	19				
12	-	48	-	7				
13	NL	50	FT, S	7				
14	FT, NL	47	-	33				
15	-	51	-	46				

Note.- Underlining indicates preference for 24x24 stimulus.

APPENDIX C

Table 1

Number of visual fixation preference Ss meeting the t-test criterion on each pair of stimulus with respect to each preference measure .

Stimulus Pair	Preference Measure: Fixation Time Group			Span Group			No. of looks Group			All three measures Group		
	A	B	C	A	B	C	A	B	C	A	B	C
4x4	0/11	0/7	0/9	0/11	0/7	2/9	1/11	0/7	0/9	1/11	0/7	2/9
6x6	0/11	0/7	0/10	0/11	1/7	0/10	1/11	0/7	3/10	1/11	1/7	3/10
8x8	1/11	0/7	1/8	1/11	0/7	0/8	1/11	0/7	2/8	2/11	0/7	2/8
10x10	1/11	0/7	1/8	0/11	0/7	2/8	1/11	0/7	3/8	2/11	0/7	4/8
12x12	0/11	0/7	0/9	0/11	0/7	1/9	1/11	0/7	1/9	1/11	0/7	2/9
14x14	0/11	0/7	0/10	0/11	0/7	0/10	0/11	0/7	1/10	0/11	0/7	1/10
16x16	0/11	0/7	1/8	0/11	0/7	0/8	0/11	0/7	3/8	0/11	0/7	3/8
20x20	1/11	0/7	0/8	0/11	0/7	1/8	0/11	0/7	1/8	1/11	0/7	2/8

Table 2

Number of visual fixation preference Ss meeting the differential-fixation criterion on each of pair of stimuli.

Stimulus pair	Group A	Group B	Group C
4x4	0/11	2/6	2/9
6x6	0/11	1/6	1/10
8x8	0/11	0/6	0/8
10x10	1/11	0/6	1/8
12x12	0/11	0/6	1/9
14x14	0/11	1/6	1/10
16x16	0/11	1/6	0/8
20x20	0/11	0/6	2/8

APPENDIX D

Table 1

Chi-square analyses of number of criterion preference versus number of visual-fixation preference Ss meeting t-test criterion with respect to each preference measure or each stimulus pair.

		Preference Measure							
		Fixation time		Span		No. of looks		Any pref. measure	
		Group		Group		Group		Group	
Stimulus pair		Crit. Pref.	Vis. Pref	Crit. Pref.	Vis. Pref.	Crit. Pref.	Vis. Pref.	Crit. Pref.	Vis. Pref.
	N	2/15	2/26	4/15	2/26	3/15	4/26	7/15	6/26
10x10	χ^2		.002		1.43		.003		1.48
	p		NS		NS		NS		NS
	N	3/15	0/27	1/15	1/27	3/15	2/27	4/15	3/27
12x12	χ^2		3.19		.11		.50		.75
	p		<.08		NS		NS		NS
	N	3/15	0/28	2/15	0/28	1/15	1/28	4/15	1/28
14x14	χ^2		3.33		1.48		.09		3.07
	p		<.07		NS		NS		<.08
	N	1/10	1/26	1/10	0/26	1/10	3/26	1/10	3/26
16x16	χ^2		.008		.25		.52		.52
	p		NS		NS		NS		NS

Table 2

Chi-square analyses of number of criterion preference versus number of visual fixation preference Ss meeting differential-fixation criterion on each stimulus pair.

Stimulus pair		Group: Crit. Pref.	Group: Vis. Pref.
10x10	N	3/15	2/15
	χ^2		.38
	p		NS
12x12	N	3/15	1/26
	χ^2		1.28
	p		NS
14x14	N	5/15	2/27
	χ^2		2.99
	p		<.01
16x16	N	3/10	1/25
	χ^2		2.55
	p		NS

Appendix E

Number of Ss in Study A, B, and C meeting differential-fixation and t-test criteria on successive and multiple stimulus pairs.

Number of stimulus pairs	Criterion: Differential-fixation, Group A	Differential-fixation, Group B	Differential-fixation, Group C	t-test, Group A	t-test, Group B	t-test, Group C
	Successive Stimulus Pairs					
Two	0/11	0/6	0/10	0/11	0/7	1/10
Three	0/11	0/6	0/10	0/11	0/7	0/10
Four	0/11	0/6	0/5	0/11	0/7	0/5
	Multiple Stimulus Pairs					
Two	0/11	0/6	1/10	0/11	0/7	3/10
Three	0/11	0/6	0/10	0/11	0/7	0/10
Four	0/11	0/6	0/7	0/11	0/7	0/7

Appendix F

Significant t-tests ($p<.05$ two tailed) of group preferences on each stimulus pair with respect to fixation time (FT), span (S) or number of looks (NL).

Stimulus pair		Group A t	A df	B t	B df	C t	C df	Crit.Pref. t	Crit.Pref. df	Cont.20 t	Cont.20 df
4x4	FT	2.46	10								
	S	2.39	10			2.68	8				
	NL										
6x6	FT										
	S					4.68	9				
	NL	3.42	10			3.13	9				
8x8	FT										
	S					2.87	7				
	NL										
10x10	FT	2.96	10			2.94	7	2.96	14	3.92	14
	S							2.21	14	4.69	14
	NL	3.52	10			3.47	7	4.27	14	3.86	14
12x12	FT							3.47	14		
	S							2.52	14		
	NL							5.63	14	2.39	11
14x14	FT							2.55	14		
	S										
	NL							3.85	5	3.85	5
16x16	FT							2.39	9		
	S							2.43	9		
	NL										

Appendix G

Number of Ss in each preference group meeting t-test criterion with respect to each measure on at least one stimulus pair.

	Preference Measure		
Group	Fixation	Span	No. of looks
A	3/11	1/11	4/11
B	0/7	1/7	0/7
C	2/10	5/10	9/10
Crit. Pref.	6/15	6/15	6/15
Cont. (20)	8/15	7/15	7/15