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# Perception of Figure Orientation and Delayed Recognition Memory in Nonambulatory, Profoundly Mentally Retarded Children

by

Marlene J. Krenn

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## Abstract

The assessment of sensory capabilities in nonambulatory, profoundly mentally retarded children is problematic due to their extreme degrees of physical and mental handicap. Recently, the methodologies used to examine infant visual recognition memory have been applied to this population. For normal infants, both immediate and delayed recognition memory have been demonstrated (Martin, 1975). The perception of changes in stimulus orientation, particularly changes which involve oblique orientations, presents a more difficult recognition task (Bornstein, Gross, & Wolf, 1978). Nonambulatory, profoundly mentally retarded children have also shown the capacity for immediate recognition memory. Examples of this capacity have been demonstrated for faces and colors (Butcher, 1977); patterns (Switzky, Woolsey-Hill, & Quoss, 1979); and both high and low contrast abstract stimuli (Shepherd & Fagan, 1980). There is little evidence concerning their delayed recognition memory.

In the present study, the subjects were 16 nonambulatory, profoundly mentally retarded children. On each of three consecutive days, subjects were given 16 habituation trials with a patterned stimulus consisting of four black circles on a white background. These circles were arranged in a horizontal or

vertical line. Following habituation trials, 8 test trials were given with alternating presentations of the familiarized stimulus and a novel stimulus. Novel stimuli were a 45° rotation of the habituation phase stimulus, a 90° rotation of the habituation stimulus, or the four circles arranged in a square pattern. A different novel stimulus was presented on each of the test days. Visual fixations were measured by videotaping corneal reflections.

The results showed that significant response decrements occurred over the habituation trials. Response recovery to the novel stimuli was observed in the test phase, indicating that the subjects perceived changes in orientation of the habituation stimulus. Since there were no significant differences in the rate of response decrement during the habituation phase across days, delayed recognition memory was not demonstrated.

The results were discussed in terms of the infant literature on visual recognition memory and perception of figure orientation. The findings of this study indicate that the perception of changes in figure orientation can be demonstrated in nonambulatory, profoundly mentally retarded children with the habituation-dishabituation procedure.

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Nonambulatory, profoundly mentally retarded chidren exhibit extreme degrees of both physical and mental handicap (cf. Berkson & Landesman-Dwyer, 1977). Landesman-Dwyer and Sackett (1978) describe nonambulatory, profoundly mentally retarded individuals as: (a) being incapable of moving through space, (b) totally lacking in adaptive behavior skills, and (c) typically extremely small for their chronological age, particularly in head circumference. Although they are classified as individuals who fall more than five standard deviations below the mean on standardized intelligence tests (Grossman, 1973), many are untestable by any standard means, due to the difficulty or impossibility of test administration (Berkson & Landesman-Dwyer, 1977). These individuals often have severe forms of cerebral palsy, resulting in scoliosis, muscular atrophy, and joint stiffness. Problematically, the use of experimental techniques to assess perceptual and sensory capabilities is also limited due to the various motoric and multisensory deficits which characterize this population. Recently however, habituation paradigms have been used to investigate perceptual and cognitive functioning with these individuals (e.g., Shepherd & Fagan, 1981).

In the developmental research literature, the term habituation has been used to refer to decrements in measurable responses, such as the amount of time spent looking at a stimulus, which result from repeated exposure to a stimulus (e.g., Clifton & Nelson, 1976). One critical feature which distinguishes habituation from other response decrement phenomena is that the habituated response can be elicited by stimuli that are discrepant from the habituating stimulus (Jeffrey & Cohen, 1971). Moreover, habituation has been demonstrated to occur more rapidly under certain conditions; such as with less intense stimuli, with longer stimulus durations, and with shorter intertrial intervals.

The habituation phenomenon is useful for studies of development and behavior. It is an example of behavioral plasticity which in some species is the only demonstrable evidence of behavior modifiability. Although a matter of some dispute, habituation may represent a simple form of learning (Clifton & Nelson, 1976; Jeffrey & Cohen, 1971). The habituation paradigm is widely applicable and has been successfully employed in the study of a variety of stimuli and responses (Clifton & Nelson, 1976; Jeffrey & Cohen, 1971). In particular, the habituation paradigm has provided a commonly used method for the evaluation of sensory capabilities, such as vision, in the human infant.

According to Cohen (1976), habituation, as it is applied to research on infant visual attention and memory, is defined as a reduction in fixation time in response to the repeated presentation of a visual stimulus. Empirically, there are two components to this definition; it must be demonstrated that (a) an infant's fixation time decreases over trials, and (b) the response decrement is specific to the target stimulus. The latter component is needed to show that the observed decrease in responding is not due to factors such as fatigue. It is assumed that if the infant's visual fixation time decreases over the habituation trials, but increases upon presentation of a novel stimulus of equal intensity, then the initial decrease in responding was specific to the habituated stimulus.

Visual fixations are measured by observing the amount of time a subject is looking at the target stimulus. This is accomplished via the corneal reflection technique, which is a method of determining where a subject is looking (Maurer, 1975). Corneal light reflection refers to the pinpoint of light seen reflected on the cornea of a subject who is gazing directly at a light source (Utley, Duncan, Strain, & Scanlon, 1983). It is possible for an observer who is situated near the light source to see a reflection of that light on the subject's cornea. The reflection will appear to be over the pupil when the subject is fixating the light source (Maurer, 1975; Slater & Findlay, 1975). This method of measurement has been preferred for the study of infant visual attention because it is easy to implement and it can tolerate some degree of head movement (Maurer, 1975).

Two methods of testing using the corneal reflection technique have been developed which employ the assumptions of habituation to examine the visual fixation of infants. One of these methods of testing, called the visual preference test (cf. Shepherd & Fagan, 1981), employs a paired presentation procedure. In this paradigm, the underlying assumption is that if an infant looks at one target more than another, then the infant must be able to discriminate between them. The infant is shown a pair of identical target stimuli. After repeated presentations of the pair, a new set, which consists of one of the previously seen stimuli paired with a novel stimulus, is shown to the infant. Differential visual fixation to the stimuli in the new set is interpreted as an ability to discriminate between the stimuli.

The second method of testing involves the repeated presentation of one stimulus followed by the presentation of a novel stimulus. The infant is repeatedly exposed to one stimulus. Subsequently, the infant is given a series of test trials which involve the presentation of a novel stimulus alternating with presentations of the familiarized stimulus. A decrement in fixation time over trials to the repeatedly presented stimulus is referred to as habituation, and a subsequent increase in responding to the novel stimulus is referred to as dishabituation. The extent of this recovery from habituation is used as an index of the infant's ability to perceive a difference between the previously seen and the novel stimulus. The magnitude of response recovery is interpreted as corresponding to the infant's perception of the actual differences between the test figure and the habituating figure (Schwartz & Day, 1979).

Of these two methods, the one most commonly employed in the infant literature for tests of immediate and delayed recognition memory involving simple discrimination tasks has been the visual interest test. Both methods have been found to be equally feasible, however, and the results obtained have tended to concur (cf. Shepherd & Fagan, 1981). However, the paired presentation procedure has been shown to be inadequate for the specific assessment of orientation discrimination. In studies which have directly compared the differences in findings between methodologies, the paired presentation procedure has been found to be a less sensitive measure for visual discrimination tasks involving the perception of changes in figure orientation (McGurk, 1970; McKenzie & Day, 1971).

The following sections present the results of selected studies which have employed either of these methodologies to examine immediate and delayed recognition memory in nonhandicapped infants. Results from similar research with nonambulatory, profoundly mentally retarded children are compared with the infant findings. A review of the findings of orientation discrimination research in infants is also presented. Discrimination of figure orientation has not been studied in nonambulatory, profoundly retarded children.

## Recognition Memory Research with Infants

From the first few days of life, infants are capable of encoding and retaining some information about their visual world (Werner & Perlmutter, 1979). This retention capacity is referred to as visual recognition, and consists of perceiving an object as something which has been experienced in the past. As such, recognition memory is measured by higher responsiveness to novel as compared to familiar stimuli. It is assumed that decreased fixation time to a familiarized stimulus is the result of matching between the perceptual representation of the stimulus and its internal, memory representation.

The experimental procedures for investigating visual recognition memory in infants consist of a familiarization phase, and a novelty test phase. When the novelty test phase immediately follows the familiarization phase, the task is referred to as one of immediate recognition memory. When a time interval follows the familiarization phase prior to the test phase, the task is referred to as delayed recognition (Werner & Perlmutter, 1979). Delayed recognition memory has also been examined by presenting infants with the familiarization/novelty test phases over consecutive days, and examining responses on successive familiarization trials (e.g., Martin, 1975).

For normal infants, recognition memory for visual stimuli may be demonstrated at any age depending on the discriminability of the stimuli, and provided that adequate familiarization time is given (Fagan, 1973, 1974; Shepherd & Fagan, 1981; Werner & Perlmutter, 1979). In general, as age increases, the ability to discriminate between more complex stimuli increases. Also, with increasing age, the amount of familiarization time necessary to demonstrate immediate recognition memory decreases. For example, Fagan (1974) found that as little as 3 to 4 seconds of study time were required for 5-month-old infants to exhibit a novelty preference on a recognition task when the targets were highly variable. Stimuli which differed in pattern only, required approximately 17 seconds of study time, and faces required 20 to 30 seconds of familiarization. Cornell (1979) found similar study times for comparable types of stimuli with infants 5 to 6 months of age.

The demonstration of recognition memory is dependent upon the discriminability of the stimuli utilized in the task. Marked visual preferences have been observed using patterns that differ along several dimensions. As an example of this type of investigation, Fantz, Fagan, and Miranda (1975) used the visual interest test to examine variations in several stimulus features. Infants ranging in age from 5 to 19 weeks were presented with pairs of patterns that differed in size, orientation, number of elements, degree of curvature, concentricity, or figure-ground relationship. In addition, each pair consisted of a contrast between one curved stimulus and one straight stimulus. Infants were tested over four sessions for visual acuity and preference for variations of stimulus forms. The results indicated a reliable curvature preference. Further, the preference for curved elements varies with age. For example, newborns and infants aged 4 to 6 weeks attend more to stimuli where the outermost contour is curved, whereas older infants aged 8 to 10 weeks prefer to fixate on inner curved elements of stimuli (Fantz, Fagan, & Miranda, 1975; Haith, 1983). Overall, the results of various studies suggest that the demonstration of immediate recognition memory in normal infants may be facilitated by choosing stimuli that have been demonstrated to elicit reliable preferences in studies of infant attention.

Generally, recognition decreases as retention intervals increase. Even after long delays, however, recognition memory in normal infants may be demonstrated (Werner & Perlmutter, 1979). A representative study in the area of infants' delayed recognition memory is that of Fagan (1973). In a series of five experiments, Fagan (1973) investigated immediate and delayed recognition memory in infants aged 21 to 25 weeks for abstract black and white targets of varying degrees of similarity, and for face masks and face photos. The visual preference test was used throughout. Experiment 1 examined immediate (10 s) and delayed (24 and 48 hr) recognition memory for abstract stimuli varying either multidimensionally or only in patterning. For both the multidimensional and patterning problems, the infants fixated longer to novel targets in all three tests of retention, indicating both immediate and delayed recognition memory for a period of up to 48 hours. In Experiment 2, photographs of faces were examined in tests of immediate and delayed (3 hr, 24 hr, 48 hr, 1 week, and 2 weeks) recognition memory in 98 infants. Each infant received an immediate test and one of the delayed tests. The results indicated reliable recognition memory for faces at all retention intervals. Experiment 3 examined recognition of three-dimensional face masks, and found a decline in recognition memory over a delay of 3 hours. Experiments 4 and 5 examined interference effects for the recognition of face photos, and found that delayed recognition could be hindered by presenting the infant with perceptually similar stimuli immediately following the familiarization phase.

Fagan's (1973) conclusion that 5-month-old infants demonstrate long-term retention of information has been supported by several other investigators (e.g., Caron & Caron, 1968; Cornell, 1979). However, few studies have compared long-term recognition memory among different age groups of normal infants. One such study was done by Martin (1975) who compared infants of three different ages on immediate and delayed recognition tasks involving stimuli of varying complexity. Infants of 2, 3.5, and 5 months of age were given habituation training for a fixed number of trials (totalling 4.5 min of familiarization time) and then tested for response to novelty. For each infant, the procedure was repeated on the next day. Results indicated that fixation of the familiar stimulus was significantly lower on Day 2 than on Day 1. Further, the older infants showed a more rapid response decrement during familiarization on Day 2 than did the younger infants. For all ages, the decreased responsiveness during Day 2 was demonstrated only to the previously familiarized stimulus. The novel stimulus resulted in response recovery. Jeffrey and Cohen (1971) state that one of the critical characteristics of habituation is that if repeated series of habituation trials are given, habituation becomes more rapid. This result was noted in Martin's (1975) subjects on Day 2, and was interpreted as an indication that the infants recognized some aspects of the previously familiarized stimuli. Thus, Martin's results indicate recognition memory for up to 24 hours in infants as young as two months.

In summary, normal infants are capable of recognizing previously seen stimuli after relatively long retention intervals. With increasing age, the infant (a) recognizes more complex stimuli, (b) requires less study time for later recognition, and (c) retains visual information for longer periods of time.

Recognition Memory Research with Nonambulatory, Profoundly Mentally Retarded Children

The methodologies used to study infant recognition memory have been applied to nonambulatory, profoundly mentally retarded children. Butcher (1977) examined recognition memory for face photos and colors under both immediate and short-term delay conditions. Subjects were 16 profoundly mentally retarded children (mean CA = 6.1 years; mean MA = 5.3 months on the Bayley Scales of Infant Development). The two classes of stimuli were black and white face photographs (2 male, 2 female) and colored patterns (red square, green square, red diamond, green diamond). Using the visual preference test, subjects were given two immediate and two delayed recognition problems on each of two days. On Day 1, subjects were first given a 20 s warm-up which consisted of a paired presentation of a baby's photo and a red/green checkerboard for the first 10 s and the same stimuli with positions reversed for the second 10 s. Following warm-up, each child was shown one stimulus from either the color or face class for a 2-min familiarization period, reversing positions after the first minute. Then, an immediate recognition test was given by pairing the familiarized stimulus with its corresponding target (e.g., red square with green square) for two 5-s periods, reversing positions from one period to the next. This familiarization-test procedure was repeated with the stimuli from the second class. Delayed recognition was tested by repeating the four 5-s test pairings in the same order that they had been originally presented. The elapsed time between immediate and delayed testing was about 180 s for the first problem and about 40 s for the second problem. The average time taken by the experimenter to change or reverse the stimuli was 10 s. On Day 2, the familiarization-test procedure was repeated using the remaining stimuli. The order of presentation of class of problem, sex of face photo, and color of pattern used for the familiarization period remained constant for each child across days, but was counterbalanced over subjects.

The results indicated no differences between type of problem in the amount of fixation elicited during the 2-min familiarization period. Moreover, there was no evidence of differential responsiveness to patterned over plain targets. On the immediate recognition test, all subjects fixated for significantly longer times to all novel targets with the exception of the colored diamond pattern. On delayed testing, only the novel colored square was fixated for a significantly greater amount of time than its paired familiar target. The results indicate that profoundly mentally retarded children can demonstrate immediate recognition memory for faces and simple patterns, and that simple colored patterns may be remembered for periods of up to 180 s.

Switzky, Woolsey-Hill, and Quoss (1979) used the habituation-dishabituation procedure to examine recognition memory in 12 nonambulatory, profoundly mentally retarded children (mean CA = 10.3 years; mean level of mental functioning ranged from 2.9 to 8.6 months on the Denver Developmental Screening Test). The stimuli were 2 x 2 and 12 x 12 black and white checkerboard patterns. Each subject was given an experimental and a control habituation series. In the experimental series, subjects were repeatedly exposed to one of the checkerboard patterns until a response decrement criterion was met. Then, following a 10-s delay, six test trials were given which consisted of presentations of the repeated pattern on odd numbered trials, alternating with presentations of the novel pattern on even numbered trials. Two weeks later each subject was given the control series, which was identical to the first series except that only the originally habituated stimulus was presented on all trials. Stimulus exposure duration was subject-controlled throughout; stimulus offset occurred if the subject did not fixate for 2 s. Intertrial interval was 2 s for all phases of the experiment. The results indicated a habituation-dishabituation effect in the experimental condition. There was no evidence of delayed recognition over the 2-week interval between the habituation and the control series.

Shepherd and Fagan (1980) attempted to confirm the findings of Butcher (1977) and Switzky et al. (1979) that visual recognition memory occurs in the profoundly mentally retarded for various patterned targets. A second purpose of the study was to find out whether or not this population could demonstrate immediate recognition memory for each familiarized stimulus within a series of tasks presented during an experimental session. Subjects were 17 nonambulatory, profoundly mentally retarded children (mean CA = 7 yrs; mean MA = 4 months, Bayley Scales of Infant Development), who had been previously tested for visual acuity. The stimuli were made up of patterns presumed to be readily visible to the subjects. Subjects were given four memory tasks per session, each involving a distinction between two abstract patterns. The target pattern was presented for two 15-s study periods, then two 5-s test trials were given. On the test trials, the target stimulus was paired with a novel stimulus, reversing right-left positions on each trial. All subjects were given three sessions, yielding a total of 12 immediate recognition tests. For the first two sessions, only black and white stimuli were used; whereas for the final session, the stimuli were lower in color-contrast, and consisted of grey and white patterns. A mean percentage of fixation to novel stimuli score was obtained for each serial position, collapsed across the three sessions. Results indicated significant preferences for the novel stimuli for the first three of four tasks administered during a test session. However, as a group, the children did not demonstrate recognition memory for problems which were presented in the fourth serial position. Individual subject data analyses revealed individual differences in immediate recognition memory, with seven of the 17 subjects showing statistically significant preferences for novelty.

The results of Butcher (1977), Switzky et al. (1979), and Shepherd and Fagan (1980) support the notion that the capacity for immediate recognition memory is present in profoundly mentally retarded children, and holds for faces, colors, patterns, and level of contrast of stimuli. These studies provide little evidence of delayed recognition.

It is possible that the response to the novel stimuli on both immediate and delayed recognition tasks is dependent upon the degree of similarity between the habituating stimulus and the novel stimulus. That is, dishabituation may be more likely to be demonstrated when the novel stimulus is highly discrepant from the habituating stimulus. Conversely, novel stimuli that are similar along several dimensions to the habituating stimulus may not be perceived as being different (cf. Haith, 1980), resulting in less recovery of visual fixation times during the test trials (e.g., Cohen, Gelber, & Lazar, 1971).

Kelman and Whiteley (1986) investigated such generalization of habituation along a form dimension in 12 nonambulatory, profoundly mentally retarded children (mean CA = 7.83 years; median MA = 3.50 months on the Mental Scale of the Bayley Scales of Infant Development). Over four sessions, subjects were habituated to either a circle or an ellipse for 12 trials, then they were given an 8-trial test phase during which the habituating stimulus was interspersed among presentations of three novel (i.e., generalization) stimuli. The generalization stimuli represented three levels of shape discrepancy from the habituating stimulus. For example, when the habituating stimulus was the circle, a wide ellipse was the small change, a narrow ellipse was the medium change, and a triangle was the large change stimulus.

The subjects demonstrated visual fixation response decrements across the habituation trials, and some recovery of response to the generalization stimuli. As a group, a generalization gradient was not found. Only two of the subjects showed increasing amounts of response recovery as a function of the discrepancy of the generalization stimulus. Since all of the stimuli used were equated for color, approximate area covered, and number of elements (i.e., one), it is possible that the amount of discrepancy between the generalization stimuli was not enough to be responded to differentially, even though all three were perceived by the subjects as being different from the habituating stimulus. Finally, the results suggested that differences in response to novelty may be associated with either chronological age or IQ (calculated as MA/CA X 100) supporting the notion that the profoundly mentally retarded are a heterogeneous population (cf. Haskett & Bell, 1978), and that reliable individual differences exist in their capacity to demonstrate immediate recognition memory (Fagan & Singer, 1983; Shepherd & Fagan, 1980).

## Perception of Figure Orientation in Infants

Investigations of perception of figure orientation in normal infants have reported variable results based on methodological differences between studies. For example, McKenzie and Day (1971) compared a method which measured spontaneous visual fixations with the operant training of head turns as techniques to assess orientation discrimination in infants aged 7 to 12 weeks. Stimuli were a series of vertically and horizontally striped patterns, which were assessed for both discriminability and generalization. With the spontaneous fixation method, horizontal patterns were fixated more than vertical patterns. However, there was no evidence for discrimination based on orientation when the measures used were total duration of fixation, or duration of first fixation. With subsequent operant training of head turning to either a horizontal or a vertical pattern, all subjects showed pattern orientation discrimination as well as some generalization to the other striped patterns. McKenzie and Day (1971) concluded that demonstration of the ability to discriminate between orientations was highly dependent upon the type of task required of the infant. Moreover, the indices of discrimination based on spontaneous visual preference seem to be less sensitive than those based on operant conditioning.

Although the indices of discrimination remain the same across visual fixation methods, the actual procedures employed differ in relative sensitivity. In a series of three experiments, McGurk (1970) provided additional evidence that a failure to demonstrate orientation discrimination may be more a function of the test of discrimination than an inability on the part of the infant. In his experiments, the role of object orientation for the perception of simple abstract shapes (faces and funnels) in infants between 6 and 26 weeks of age was examined. Experiment 1 utilized the paired presentation procedure of the visual preference test. Experiments 2 and 3 both employed a habituation-dishabituation paradigm in which successive presentations of familiar then novel stimuli were given. In Experiment 2, familiarization consisted of discrete trial presentations of the target stimulus; whereas, in Experiment 3, familiarization consisted of a continuous exposure to the target stimulus. During the familiarization phase of all three experiments, subjects were habituated to a stimulus in a constant orientation, either up or down, then tested with the same stimulus rotated 180°. In Experiment 1, the infants demonstrated no consistent preference for one orientation over the other for either the face or the funnel. The results of Experiment 2 and 3 are in direct opposition to the finding of no difference in Experiment 1. In Experiments 2 and 3, the infants demonstrated habituation to the constant stimulus and significant recovery of response to the rotated stimulus. The results suggest that normal infants can perceive a 180° change in orientation of an object that has previously been encountered in a constant orientation.

The divergence between the results of the three experiments emphasize the caution necessary when interpreting data from tests of visual preference, particularly when figure orientation is being examined. Specifically, a conclusion that the subject does not demonstrate a preference for one of two stimuli does not necessarily mean that the subject cannot perceive differences between them (McGurk, 1970). Taken together, the results of McKenzie and Day (1971) and McGurk (1970) indicate that when visual fixation is used as the measure of orientation discrimination ability, the paired presentation procedure is not sensitive enough to detect perceived differences between stimuli. Furthermore, McGurk (1970) concluded that the more sensitive procedure to assess infants' capacity to discriminate perceptually between stimuli is one based on the habituation-dishabituation paradigm.

Despite its relative lack of sensitivity, the paired presentation procedure has been used in a major portion of infant perception studies which have demonstrated significant differences in responding to line orientations. For example, Slater and Sykes (1977) examined newborn infants' visual responses to black and white square wave gratings in horizontal or vertical orientations, and to checkerboard patterns aligned along an oblique axis. The set of four experiments was designed to investigate salient determinants of infant visual attention. Using the visual preference procedure, infants up to 8 days of age were shown combinations of pairs of the three stimuli. In the first two experiments, six stimulus pairs were shown for 30 s each to groups of 15 and 14 infants, respectively. In Experiments 3 and 4, 12 stimulus pairings were presented for 15 s each ($N$=15 and $N$=8, respectively). Experiment 1 examined the ordering of pattern preferences when the stimuli were equated for amount of contour. Experiments 2 to 4 investigated the interaction between horizontal and vertical pattern preferences and size of elements in the figures.

Taken together, the results of the four experiments indicated that, according to the amount of fixation time per stimulus, infants preferred to look at horizontal patterns, checkerboard patterns, and vertical patterns, in that order. Secondly, the infants demonstrated a strong preference for horizontal over vertical line gratings over a range of element sizes from ¼ inch to 2 inch lines. Finally, there was a size effect such that when stimulus orientation was controlled for, the preferred stripe width was between 1 and 1½ inches. The results suggest that normal infants may exhibit natural preferences for stimuli oriented along a horizontal axis, and that the amount of fixation time devoted to stimuli may be the result of an interaction between figure orientation and size of elements.

Slater, Earle, Morison, and Rose (1985, Experiment 3) examined the interaction between the newborn's preference for horizontality and habituation-induced novelty preferences. Based on the results of Slater and Sykes (1977), three pairs of black and white line gratings were constructed such that each pair consisted of one horizontal and one vertical pattern. The first pair combined stripe widths which would maximize the likelihood of a horizontal preference being demonstrated. The second pair equated stripe width and contrasted orientation. Pair 3 consisted of stimuli which were highly discriminable (i.e., a ¼-inch horizontal, and a 2-inch vertical pattern) yet which had been demonstrated to be equally non-preferred. The subjects were 3 groups of 8 infants each (age range = 7 hours to 7 days, 12 hours; _mdn_ = 2 days, 20 hours). In each group, half of the subjects were habituated to one member of the stimulus pair, and half to the other. The non-habituated stimulus in each pair served as the novel stimulus in the test trials. All infants were habituated to a previously determined criteria using infant-controlled procedures.

The results showed the strongest novelty preferences for the third pair of stimuli where the stimuli were equated for natural non-preference. A weak novelty preference was demonstrated for the pair of stimuli equated for stripe width but differing in orientation (Pair 2). However, for Pair 1, a very strong preference was found for the horizontal stimulus in the test trials regardless of whether the infant had been habituated to the preferred horizontal or the non-preferred vertical pattern. Moreover, the magnitude of the preference was virtually identical for the vertical-habituated and the horizontal-habituated condition (88% and 89% horizontal preference, respectively). The results suggest that in very young infants, the preference for horizontally aligned stimuli may outweight the effects of habituation in tests for novelty. However, when no prior preference exists, and when stimuli are easily discriminable to the infant, then differences in fixation time to novel versus familiar stimuli can be demonstrated using a habituation-dishabituation procedure.

In a series of nine experiments using a habituation paradigm, Schwartz and Day (1979) investigated the ability of normal infants between 8 and 17 weeks of age to perceive outline shapes. Three of these experiments are directly relevant to the perception of changes in orientation. Experiment 4 compared responses to a square, a diamond formed by rotating the square 45° from the horizontal axis, and a rhomboid formed by rotating the vertical edges of the square 15°. Theories of shape discrimination that involve coding based on the orientation of edges would predict higher discriminability between the square and the diamond than between the square and the rhomboid. However, in the first three experiments within this series, infants responded to angular relationships between contours. As such, to perceive the diamond as more similar to the square would mean that angular relationships between the contours are salient for the infant. In fact, the infants fixated more to both the diamond and the rhomboid than to the square. The rhomboid was perceived to be more different from the square than the diamond, suggesting that a change in angular relationship is more salient for the infant than a change in the orientation of edges.

In Experiment 5, Schwartz and Day (1979) examined the discriminability of rectangles and squares, thus holding angular relationships constant while varying length of edges and internal size. The stimuli were a vertical rectangle (the habituating stimulus), an equal sized but horizontally oriented rectangle, and a square equated at the base line with the vertical rectangle. In the test phase, the infants responded similarly to both the vertical and horizontal rectangle. Upon presentation of the square, there was a significant increase in fixation time. The authors suggested that the infants may have been responding to the relationship between the length of the contours of the figures. In any case, a rectangle rotated 90° from its original vertical position was not responded to as a discriminative cue, even though Experiment 4 indicated response differences to a 45° change in the orientation of a square.

Experiment 7 (Schwartz & Day, 1979) further examined the role of oblique contours by habituating infants to a vertical rectangle and testing them with the same rectangle, a 90° rotation of the rectangle, a 45° rotation of the rectangle, and a square equated at the base line with the vertical rectangle. The results showed that responding to a rectangle in any of the three orientations was virtually identical during the test phase. Again, infants spent a significantly longer time fixating the square. From the results of Experiments 4, 5 and 7, it would appear that a square rotated 45° from the vertical results in a significant change in perception, whereas a rectangle rotated either 45° or 90° from the vertical does not.

Rock (1973) suggested that the recognition of a figure which has changed in orientation might fail because the description of the figure in its new form would be entirely different. Further, differences in orientation of a figure in a frontal plane (for example, by a 45° rotation) would be the most difficult to recognize. This may explain Schwartz and Day's (1979) finding that a diamond is perceived differently than a square, but fails to account for the lack of discrimination between rectangles oriented in vertical, horizontal, or 45° oblique positions.

According to Appelle (1972), performance on perceptual tasks is generally superior when the visual stimuli are oriented either horizontally or vertically, as opposed to stimuli in oblique orientations. As an example of this "oblique effect" (Appelle, 1972), Bornstein (1978, Experiment 2) provided evidence that normal 16-week-old infants prefer to look at vertically or horizontally oriented stimuli as compared to oblique stimuli, when given a preferential looking task.

In a series of five experiments, Bornstein, Gross, and Wolf (1978) used an habituation-dishabituation procedure to examine the perception of mirror images in normal 3- to 4-month old infants. The stimuli used were faces (Experiment 1), line segments (Experiments 2 and 3) and geometric shapes (Experiments 4 and 5). In Experiment 1 subjects were habituated to a right-side profile of a man, then tested with the original profile, a left-side profile of the same man and a right-side profile of a different man. During the test phase, infants looked significantly longer at the profile of the different man, but showed no increase in looking time to either the habituated profile or its mirror image. Experiments 2 through 5 examined the effects of varying the degree of orientation between the habituated and novel stimuli. In each experiment, a group of infants was habituated to a stimulus in a constant orientation. A test phase followed in which randomized presentations of the stimulus were given in the original and in different orientations. The infants demonstrated habituation and recovery of response to differences in stimulus orientation that did not involve mirror images. Specifically, infants responded differentially to a vertical versus a 45° line, and a 20° versus a 70° oblique, but did not discriminate between a 45° oblique and its mirror image, a 135° oblique. Stimuli that differed in orientation by 90° along a vertical or horizontal axis, however, were discriminated.

Bomba (1984) used the paired presentation procedure in three experiments to study visual recognition of vertical and oblique stimuli in 2-, 3-, and 4-month-old infants. The results of the experiments revealed that infants familiarized with a stimulus in one orientation (either vertical or 45°) showed significant novelty preferences when the familiar stimulus was paired with the unfamiliar orientation of the same stimulus (i.e, either the 45° oblique or the vertical, respectively). Further, age differences were found, such that younger infants habituated more slowly during the familiarization phase; and whereas the tendency to generalize within obliques increases with age, the ability to discriminate between obliques also increases.

The somewhat discrepant results reported by studies of orientation perception in infants may be due to differences in procedure, stimuli used, or interpretation of results obtained. From the results of McGurk (1970), McKenzie and Day (1971), Slater and Sykes (1977), Slater et al. (1985), Schwartz and Day (1979), Bornstein et al. (1978), and Bomba (1984), it would appear that the ability to discriminate between figure orientations increases with age and that differences along the horizontal or vertical axis may be easier to detect than differences between obliques.

### The Present Study

Studies of perception of orientation have not been conducted with nonambulatory, profoundly mentally retarded children. The present study investigated their perception of orientation and their immediate and delayed recognition memory for visual stimuli. The habituation-dishabituation paradigm was chosen to investigate perception of orientation because it is a more sensitive measure than other procedures using visual fixation (McGurk, 1970; McKenzie & Day, 1971). Subjects were habituated to a constant orientation of a target stimulus (in either a vertical or a horizontal line configuration). Immediately following the habituation trials, a series of test trials was given which consisted of alternating presentations of the habituated stimulus and a novel stimulus. This series of habituation and test trials was presented to each subject over three consecutive days, with a different novel stimulus presented on each day. Novel stimuli consisted of a 45° rotation of the habituating stimulus, a 90° rotation of the stimulus, and a 2 x 2 block pattern.

It was predicted that the magnitude of response recovery in the test phases would be a function of the amount of discrepancy between the habituation stimulus and the novel stimulus. That is, magnitude of response recovery should be greatest for the block pattern, less for a 90° rotation along the horizontal-vertical axes, and least for a 45° rotation from the habituated stimulus.

Delayed recognition was to be inferred from increases in rate of response decrement within the habituation phases across sessions. It was expected that if delayed recognition of the habituated stimulus occurred, then habituation would be achieved more rapidly across sessions (Jeffrey & Cohen, 1971).

Total visual fixation time per trial was the main dependent variable. Fixations were judged to occur when the stimulus pattern was reflected on the cornea over the pupil of either of the subject's eyes.

## Method

### Subjects

The final sample consisted of 16 children (12 girls and 4 boys) selected from the residential population of the St. Amant Centre. Eight of the children (5 girls and 3 boys) had been participants in a previous visual fixation study (Kelman & Whiteley, 1986). The children's chronological ages ranged from 4 years, 4 months, to 15 years, 4 months (mean = 10 years, 2 months; SD 3 years, 1 month). Prior to the beginning of the study, all participants had been assessed with the Mental Scales of the Bayley Scales of Infant Development (Whiteley & Krenn, 1986). The resulting mental ages ranged from less than 2 months to 8 months (median = 5.0 months). Medical records obtained for each of the participants showed that a variety of diagnoses were represented (see Table 1). All participants demonstrated an

Table 1

Description of Subjects

| Name | Sex | Chronological Age[a] | BSID[b] Raw Score | Diagnosis/Medical History | Motor | Sensory |
|---|---|---|---|---|---|---|
| DF | M | 15:04 | 82 | Microcephaly of unknown prenatal origin<br>Seizure disorder | Spastic<br>Quadriplegia<br>Scoliosis | Can see and hear well |
| GM | F | 16:00 | 44 | Cerebral hypogenesis<br>Perinatal anoxia | Spastic<br>Quadriplegia | Can see and hear well |
| CT | F | 10:03 | 39 | Encephalopathy of uncertain etiology<br>Seizure disorder from 4 months of age | Spastic<br>Quadriplegia | Can see and hear well |
| SH | F | 12:11 | 33 | Acute Western Equine Encephalitis at 7 months<br>Cerebral palsy<br>Seizure disorder | Severe athetoid<br>Spastic<br>Quadriplegia<br>Osteoporotic bones | Can see and hear well |
| RL | F | 11:01 | 60 | Encephalopathy with microcephaly<br>Perinatal asphyxia<br>Cerebral palsy<br>Seizure disorder | Spastic<br>Paraplegia<br>Some athetoid movements of head, neck, arms | Can eye-point on request |
| KN | F | 9:05 | 43 | Leigh's disease (questionable)<br>Possible degenerative CNS disease<br>Seizure disorder | Crude palmar grasp | No gross impairment of of vision or hearing |

| Name | Sex | Chronological Age[a] | BSID[b] Raw Score | Diagnosis/Medical History | Motor | Sensory |
|---|---|---|---|---|---|---|
| CS | F | 7:04 | 49 | Microcephaly<br>Delayed development of unknown etiology | Choreoathetoid movements<br>Scoliosis | Some hearing loss in right ear<br>Sees well |
| DK | F | 7:08 | 43 | Hyaline membrane disease<br>Seizure disorder | Spastic Quadriplegia | Strabismus<br>Eye movements jerky |
| DM | M | 13:05 | 37 | Microcephaly<br>Seizure disorder | Spastic Quadriplegia | Can see and hear well |
| JH | F | 4:05 | 23 | Microcephaly<br>Cerebral atrophy | Spastic Quadriplegia<br>Movements dominated by very active neonatal reflexes | Eyes not well coordinated |
| MC | F | 12:07 | 45 | Cerebral palsy following cerebral anoxia due to prolonged febrile convulsions<br>Seizure disorder | Very athetoid<br>Slight spasticity<br>Minimal scoliosis | Can see and hear well |
| SB | F | 8:09 | 57 | Severe brain damage due to encephalitis at 1 year<br>Seizure disorder | Quadriplegia<br>Spasticity of hands | Can see and hear well |
| JM | F | 10:09 | 11 | Microcephaly due to unknown origin | Spastic Quadriplegia<br>Choreoathetoid hand movements | No gross impairment of vision or hearing |

| Name | Sex | Chronological Age[a] | BSID[b] Raw Score | Diagnosis/Medical History | Motor | Sensory |
|---|---|---|---|---|---|---|
| TK | F | 9:06 | 28 | Born with a Tetralogy of Fallot<br>Two episodes of cerebral vascular accidents with whooping cough led to double hemiplegia<br>Myoclonic epilepsy<br>Bulbar palsy | Spastic Quadriplegia<br>Scoliosis of thoracic spine | Vision and hearing clinically intact |
| JS | M | 5:02 | 56 | Microcephaly<br>Seizure Disorder | Spastic Quadriplegia | Can see and hear well |
| RA | M | 12:10 | 8 | Born premature<br>Anoxia<br>Congestive heart faiulre as neonate | Spastic Quadriplegia<br>Scoliosis | Ground glass opacification of left eye lens<br>Possible cortical blindness<br>Right eye normal |

[a]Age at the beginning of the experiment in years:months.

[b]Bayley Scales of Infant Development (Mental Scale) raw scores.

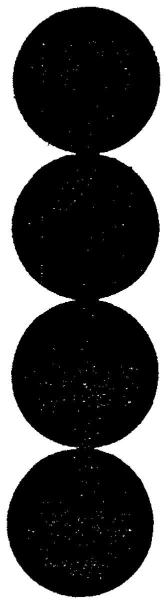
ability to visually fixate as indicated by their performance on the Bayley Scale items which require visual fixation (see Appendix A), and by the ward staff's evaluation of each child's visual capabilities. Of the 24 children originally selected to participate, 8 were excluded due to illness (N = 4), excessive head movement (N = 3), and fatigue (N = 1).

Apparatus and Stimuli

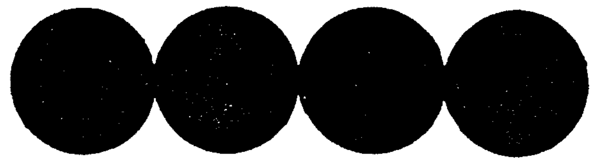
The stimuli are shown in Figure 1. Each stimulus was a pattern consisting of four black circles with 4-cm diameters on a white background. The first three stimuli formed lines which were vertical, horizontal, and oblique, respectively. The fourth stimulus was arranged in a 2 x 2 block configuration. Stimuli were thus equated for color, curvature, contrast, and number and size of individual elements. Slides with a solid black background were interposed between each of the stimuli.

The stimuli were presented on a 22.5- x 22.5-cm rear projection screen by a Kodak Carousel 800 projector. The height of the screen was adjustable so that the stimuli were presented at approximately the subject's eye level. The screen was surrounded by a flat white frame with outer dimensions of 48-cm x 57-cm. A 15-W fluorescent light, 24-cm long, situated on top of this frame in a horizontal position 25-cm above the screen, provided adequate lighting for the operation of the video camera. This light also served as a reference point to facilitate scoring of visual fixations. A video camera equipped with a zoom lens (f1l.5-70mm

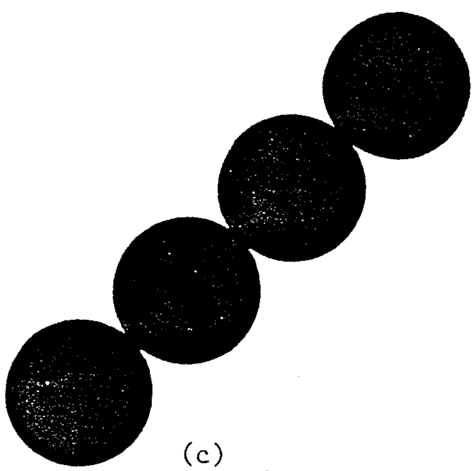
Figure 1. The stimuli used in this study: Panel (a) is the vertical line configuration; panel (b) is the horizontal line configuration; panel (c) is the 45° oblique line configuration; and panel (d) is the 2 x 2 square pattern.



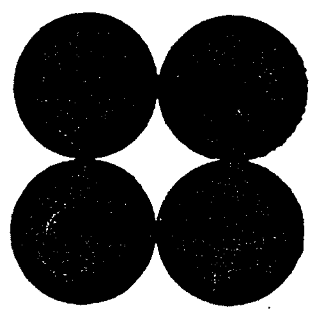
(a)



(b)



(c)



(d)

Macro) was mounted above the projection screen, approximately 25-cm above the projected stimulus. A black cloth with a circular hole to accommodate the camera lens extended from the camera to an opening in the frame above the screen, thus shielding the camera from the subject's view. This arrangement allowed the camera to be adjusted during the sessions to track the subject's face. The white frame was attached to flat white side-panels, 0.6-m wide and 1.5-m high, forming a three sided enclosure. When placed in this enclosure in a wheelchair, the subject's face was 70 to 85 cm from the screen, depending on the height of the wheelchair. Onset and offset of stimuli and intertrial intervals were controlled by electromechanical equipment located in a room adjacent to the testing room.

Procedure

Testing was conducted in a research room in the Psychology department at the St. Amant Centre. Subjects were tested in the wheelchairs that they normally used on their ward. They were placed within the enclosure and positioned as close to the screen as their wheelchairs would allow. The experimenter then moved behind the projection screen out of the subject's view and adjusted the camera so that the child's face occupied most of the camera's monitor. When the subject's face was oriented toward the screen and his or her eyes were open, the experimenter began the session by pressing a hand held button which started the timer controlling the presentation of the stimuli. A blank slide was shown during a 2-s delay between the initiation of the session and the presentation of the first stimulus. Throughout the session, the experimenter observed the child's face through the camera monitor and made the necessary adjustments to the camera to keep the child's eyes clearly in view.

Each subject participated in three experimental sessions over consecutive days. Each session consisted of 24 trials; a 16-trial habituation phase and an 8-trial test phase. A trial consisted of a 20-s stimulus presentation; intertrial intervals were 2 s in duration. The habituation phase involved the presentation of a single stimulus for 16 trials. Subjects were habituated to either the vertical or horizontal line configuration. The habituation stimulus remained constant for each subject across sessions.

The test phase immediately followed the habituation phase, and consisted of a total of eight trials during which the habituating stimulus alternated with a novel stimulus (HN HN HN HN). A different novel stimulus was presented on each of the three test days. The order of presentation of novel stimuli was counterbalanced across groups as shown in Table 2. In this design, each stimulus appeared in each serial position only once. This order of presentation ensured that each subject received as novel stimuli a square figure, a line which differed by 45° from the habituated line, and a line which differed by 90° from the habituated line configuration. Subjects were assigned to each pattern group in a cyclic fashion as they were selected for testing.

Table 2

Novel Stimulus Presentation Order During the Test Phase

| | Sessions | | |
|---|---|---|---|
| Subject Groups | 1 | 2 | 3 |
| 1 | A | B | C |
| 2 | B | C | A |
| 3 | C | A | B |

*Note*. A = a 45° rotation of the habituation phase stimulus; B = a 90° rotation of the habituation phase stimulus; C = square pattern.

Visual fixations were judged to occur when the stimulus pattern was observed to be reflected on the cornea over the pupil of either of the subject's eyes. When the reflection of the stimulus light was not visible on the cornea, the reflection of the fluorescent light was used to estimate the location of the image of the stimulus. To facilitate the scoring of visual fixations a time base accurate to 1/30th of a second was superimposed onto each video tape. Visual fixations were coded from the videotapes directly onto an Apple IIe computer. A computer program calculated the fixation time per trial.

## Results

The results of the current experiment were organized and analyzed in the following sequence. First, an analysis of visual fixation times during the 16 habituation trials was conducted to assess the occurrence of response decrement within sessions, and delayed recognition memory between sessions. Second, visual fixation to the familiar and novel stimuli during test trials was analyzed to ascertain the occurrence of dishabituation. And third, the response patterns of individual subjects were examined.

### Habituation Phase

Table 3 presents the results of a 2 (Habituating Stimulus) X 3 (Session Days) X 16 (Trials) analysis of variance on the habituation phase data. In this analysis, habituating stimulus refers to the type of stimulus, either horizontal or vertical, that was presented to the subjects over the three consecutive days during the 16 trial habituation phase. Table 3 confirms the

Table 3

Summary of Analysis of Variance of Habituation Phase Data

| Source | Sum of Squares | df | Mean Square | F | *p* | Greenhouse Geisser *p* |
|---|---|---|---|---|---|---|
| Habituation | | | | | | |
| Stimulus (H) | 0.61 | 1 | 0.61 | 0.00 | 0.977 | |
| Error | 10351.63 | 14 | 739.40 | | | |
| Days (D) | 271.44 | 2 | 135.72 | 0.95 | 0.398 | 0.385 |
| D x H | 127.10 | 2 | 63.55 | 0.45 | 0.645 | 0.609 |
| Error | 3989.52 | 28 | 142.48 | | | |
| Trials (T) | 557.51 | 15 | 37.17 | 2.68 | 0.001 | 0.020 |
| T x H | 188.70 | 15 | 12.58 | 0.91 | 0.558 | 0.495 |
| Error | 2914.61 | 210 | 13.88 | | | |
| D x T | 333.62 | 30 | 11.12 | 0.99 | 0.477 | 0.445 |
| D x T x H | 499.88 | 30 | 16.66 | 1.49 | 0.049 | 0.167 |
| Error | 4694.42 | 420 | 11.18 | | | |

presence of a reliable response decrement by revealing a significant trials effect, $F(15,210) = 2.68$, $p = .001$, which contained a marginally significant linear component, $F(1,14) = 4.35$, $p = .056$, and a significant quadratic component $F(1,14) = 11.61$, $p = .004$. It should be noted that this main effect is significant using the Greenhouse-Geisser correction. Figure 2 presents the mean visual fixation times on habituation trials collapsed across type of habituation stimulus and days. As indicated in the figure, visual fixation times decreased across the habituation phase.

Although there were no significant main effects for type of habituation stimulus, or for the rate of response decrement over the three consecutive days, Table 3 indicates the presence of a significant Days X Trials X Habituating Stimulus interaction, $F(30,420) = 1.49$, $p = .049$. It should be noted that this interaction is not significant using the Greenhouse-Geisser correction. In order to probe this interaction further, separate 3 (Days) X 16 (Trials) analyses of variance were conducted for subjects receiving the Vertical stimulus ($N = 9$), and for subjects receiving the Horizontal stimulus ($N = 7$). The results for the horizontal-habituated group are presented in Table 4 and revealed a significant main effect for Trials, $F(15,90) = 2.44$, $p = .005$. Figure 3 illustrates this trials' effect, and shows a response decrement over trials for the horizontal-habituated group.

For the vertical-habituated group, the Days X Trials interaction approached significance, as shown in Table 5. Figure 4 presents the mean fixation times across the 16 trials for each

Figure 2. Mean total fixation time per trial during the habituation phase collapsed across sessions.

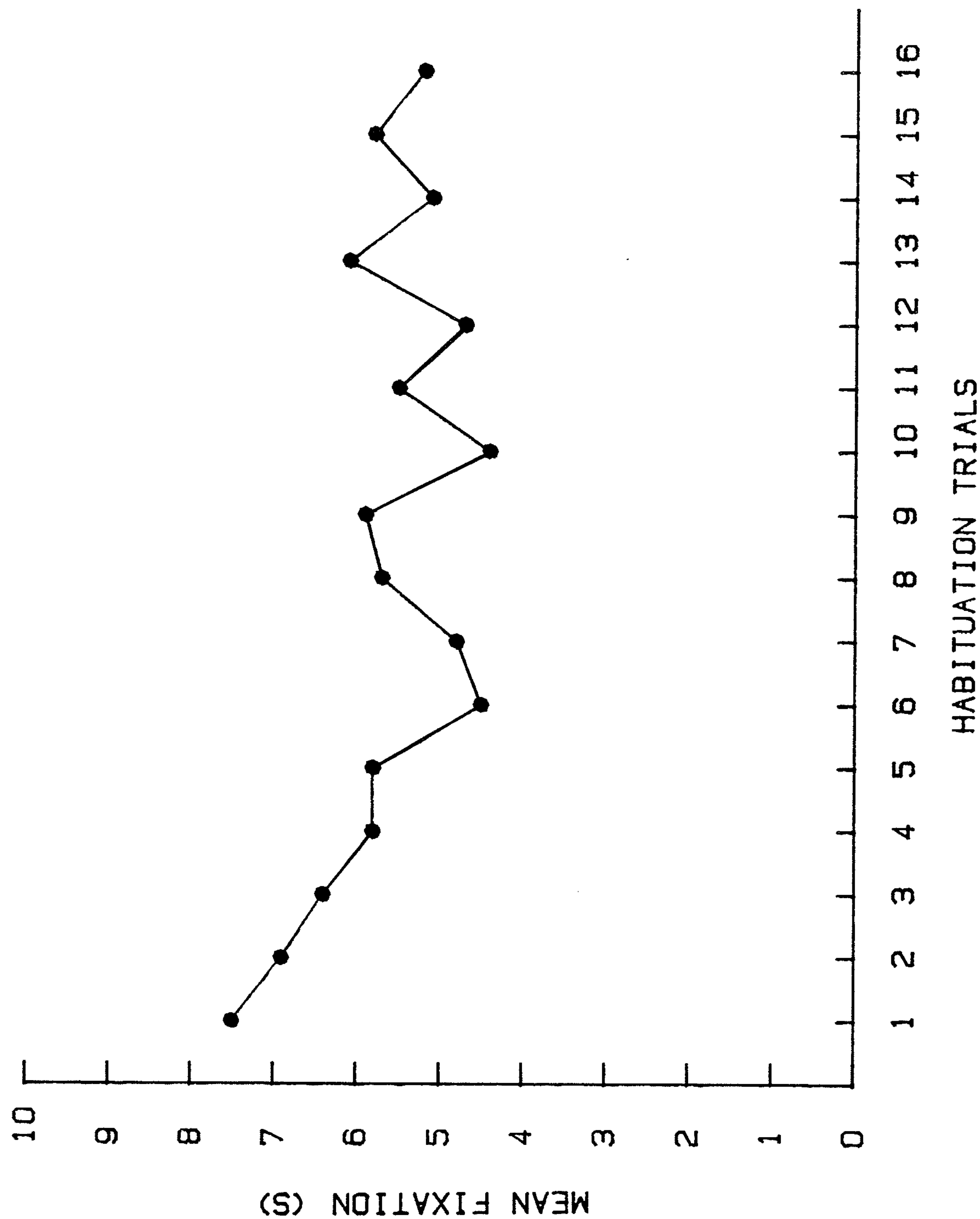

MEAN FIXATION (S)
0 1 2 3 4 5 6 7 8 9 10
HABITUATION TRIALS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

Table 4

Summary of Analysis of Variance for Subjects Receiving the Horizontal Stimulus During the Habituation Phase

| Source | Sums of Squares | df | Mean Square | *F* | *p* | Greenhouse Geisser *p* |
|---|---|---|---|---|---|---|
| Days (D) | 110.82 | 2 | 55.41 | 0.84 | 0.455 | 0.433 |
| Error | 789.56 | 12 | 65.80 | | | |
| Trials (T) | 473.08 | 15 | 31.54 | 2.44 | 0.005 | 0.081 |
| Error | 1164.79 | 90 | 12.94 | | | |
| D x T | 388.31 | 30 | 12.94 | 1.11 | 0.331 | 0.376 |
| Error | 2102.29 | 180 | 11.68 | | | |

Figure 3. Mean total fixation time per trial during the habituation phase for subjects receiving the horizontal stimulus.

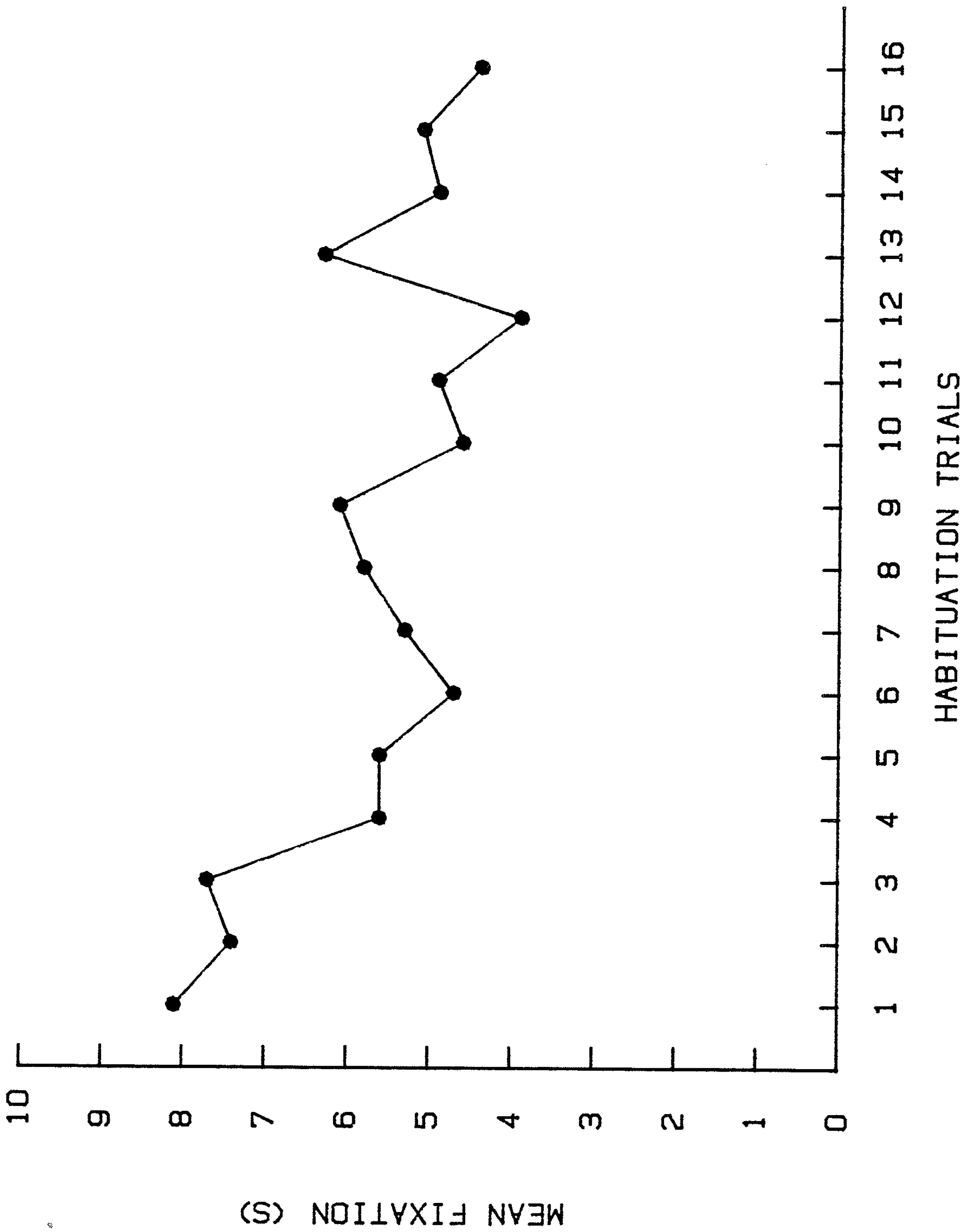
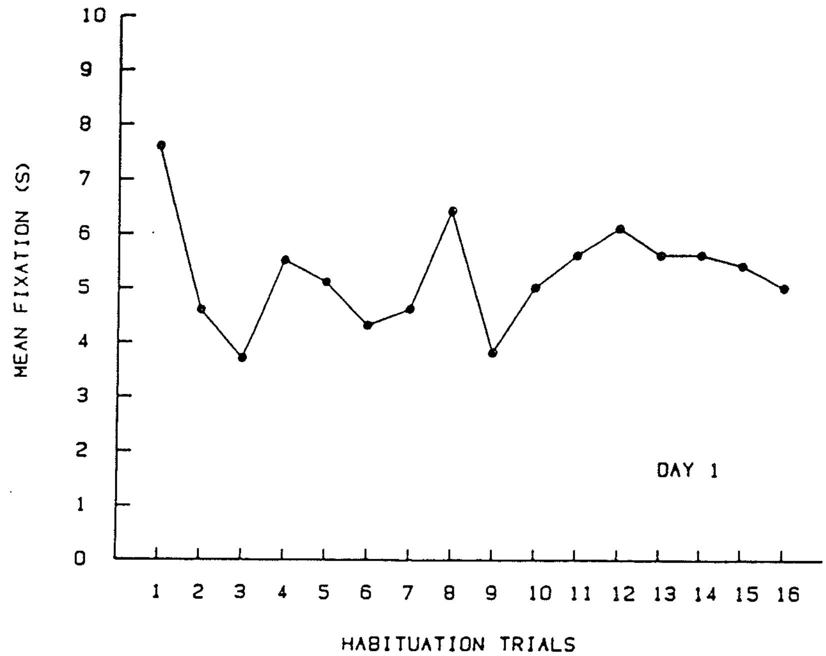

MEAN FIXATION (S)
0 1 2 3 4 5 6 7 8 9 10
HABITUATION TRIALS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

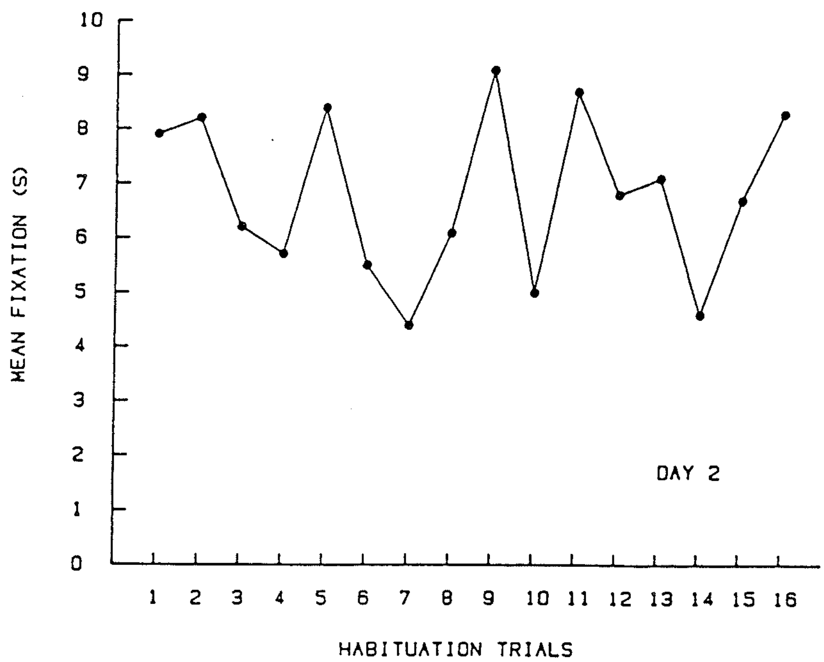
Table 5

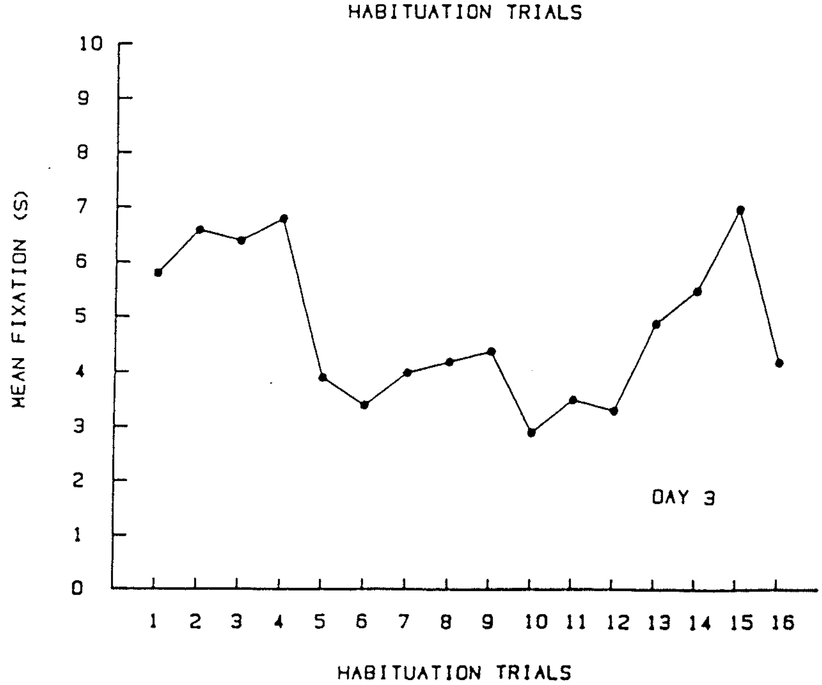
Summary of Analysis of Variance for Subjects Receiving the Vertical Stimulus During the Habituation Phase

| Source | Sums of Squares | df | Mean Square | *F* | *p* | Greenhouse Geisser *p* |
|---|---|---|---|---|---|---|
| Days (D) | 312.99 | 2 | 156.50 | 0.78 | 0.474 | 0.437 |
| Error | 3199.96 | 16 | 200.00 | | | |
| Trials (T) | 244.57 | 15 | 16.30 | 1.12 | 0.348 | 0.366 |
| Error | 1749.82 | 120 | 14.58 | | | |
| D x T | 453.32 | 30 | 15.11 | 1.40 | 0.089 | 0.240 |
| Error | 2592.13 | 240 | 10.80 | | | |

Figure 4. Mean total fixation time per trial on each day of the habituation phase for subjects receiving the vertical stimulus.


MEAN FIXATION (S)
10
9
8
7
6
5
4
3
2
1
0
DAY 1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
HABITUATION TRIALS


MEAN FIXATION (S)
10
9
8
7
6
5
4
3
2
1
0
DAY 2
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
HABITUATION TRIALS


MEAN FIXATION (S)
10
9
8
7
6
5
4
3
2
1
0
DAY 3
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
HABITUATION TRIALS

of the three days, and suggests a decrement across trials for Day 1 which was similar in pattern to the overall response decrement of the horizontal-habituated group. Figure 4 shows that this response decrement was not present on Days 2 or 3. However, when the data from each day were analyzed separately no significant trial effects were found.

Test Phase

Table 6 presents the results of a 3 (Discrepancy) X 4 (Familiar/Novel Pairings) X 2 (Contrast) analysis of variance. Since the novel stimuli represented three levels of discrepancy from the habituation phase stimulus, the discrepancy variable refers to the type of novel stimulus presented in the test trial phase on each of the three days. Within each session there were four pairs of familiar-novel presentations, which entered the analysis as Familiar/Novel Pairings. Contrast refers to the comparison between the familiar and the novel stimuli within each of the pairs.

The analysis (see Table 6) revealed a significant main effect for contrast, $F(1,45) = 4.71$, $p = .035$. Trials in which the novel stimuli were presented resulted in greater mean fixation times (mean = 5.5 s) as compared to trials in which the familiar stimulus was presented (mean = 4.7 s). The other main effects and interactions were nonsignificant.

Individual Subject Analyses

The individual subject data were examined for evidence of a response decrement over the habituation phase, and a difference in

Table 6

Summary of Analysis of Variance of the Test Phase Data

| Source | Sum of Squares | df | Mean Square | *F* | *p* | Greenhouse Geisser *p* |
|---|---|---|---|---|---|---|
| Discrepancy (G) | 43.86 | 2 | 21.93 | 0.15 | 0.863 | |
| Error | 6662.41 | 45 | 148.05 | | | |
| Familiar/Novel Pairs (F) | 33.70 | 3 | 11.23 | 0.78 | 0.509 | 0.485 |
| F x G | 77.74 | 6 | 12.96 | 0.90 | 0.500 | 0.484 |
| Error | 1953.07 | 135 | 14.47 | | | |
| Contrast (C) | 74.49 | 1 | 74.49 | 4.71 | 0.035 | |
| C x G | 2.61 | 2 | 1.30 | 0.08 | 0.921 | |
| Error | 711.02 | 45 | 15.80 | | | |
| F x C | 17.37 | 3 | 5.79 | 0.43 | 0.729 | 0.703 |
| F x C x G | 82.16 | 6 | 13.69 | 1.03 | 0.412 | 0.408 |
| Error | 1803.53 | 135 | 13.36 | | | |

fixation times to the novel, as compared to the familiar stimuli, during the test phase. For the habituation phase, Spearman rank-order correlations were computed between the mean fixation time collapsed across sessions and trial number. A significant negative correlation indicates that a decrease in fixation time across trials is associated with an increase in trial number. Table 7 presents the individual subjects' results for both the habituation and the test phases. As Table 7 shows, four of the subjects (GM, CT, RL, CS) demonstrated a significant response decrement over the habituation trials. One subject (RA) demonstrated a significant increase in fixation time during the habituation phase.

For the test trial series, Table 7 presents the ratio of mean Novel to Familiar fixation times for each of the different novel stimuli presented. Table 7 also presents the results of the Wilcoxon Matched-Pairs Signed-Ranks test (Z) for each subject, collapsed across type of novel stimulus. According to the results of the Wilcoxon test, only one subject (SB), showed a significant overall novelty preference during the test phase.

As a final aspect of the individual subject analyses, Spearman Rank-order correlations were computed between novel versus familiar difference scores and chronological age, Bayley Scale raw scores, and mental age equivalents, and IQ. IQ was calculated as (MA/CA) X 100. A significant negative correlation was found between the novel versus familiar contrast, and chronological age ($\underline{r}_s = -.526$, p = .035). Intercorrelations were

Table 7

Individual Subjects' Results for Habituation and Test Phases

| Subject | Habituation Phase: Rho[a] | Habituation Phase: p[b] | 45° Novel[c] | 90° Novel[c] | Test Phase: Square Novel[c] | z[d] | p[e] |
|---|---|---|---|---|---|---|---|
| DF | -.191 | .484 | 1.02 | 2.70 | 0.46 | -0.23 | .682 |
| GM | -.526 | .035 | 1.18 | 0.00 | 3.12 | 0.73 | .472 |
| CT | -.779 | .001 | 1.05 | 2.40 | 0.56 | -0.77 | .448 |
| SH | +.247 | .359 | 0.43 | 0.75 | 1.58 | -0.15 | .633 |
| RL | -.782 | .001 | 5.00 | 2.20 | 4.95 | 1.73 | .080 |
| KN | +.091 | .683 | 0.68 | 1.44 | 3.76 | 0.53 | .595 |
| CS | -.785 | .001 | 0.99 | 0.95 | 2.71 | 0.86 | .393 |
| DK | -.058 | .675 | 1.48 | 0.90 | 0.47 | -0.45 | .637 |
| DM | -.046 | .648 | 1.12 | 0.79 | 0.68 | -0.41 | .657 |
| JH | -.347 | .186 | 1.75 | 4.51 | 0.57 | 0.03 | .452 |
| MC | -.252 | .347 | 1.73 | 0.99 | 2.16 | 1.41 | .155 |
| SB | +.138 | .607 | 1.15 | 2.20 | 1.53 | 2.51 | .012 |
| JM | -.238 | .377 | 1.10 | 1.34 | 2.36 | 1.33 | .179 |
| TK | +.164 | .547 | 1.35 | 0.93 | 1.34 | 1.25 | .207 |
| JS | +.377 | .147 | 2.08 | 1.00 | 1.08 | 0.62 | .537 |
| RA | +.547 | .027 | 1.47 | 0.41 | 1.41 | -1.01 | .309 |

[a] Spearman's Rho calculated between fixation time and trial number during the Habituation phase.

[b] Exact probabilities associated with Spearman's Rho.

[c] The ratio of mean novel to mean familiar fixation times during the test trials.

[d] The Wilcoxon Matched-Pairs Signed-Ranks test (z) for novel vs. familiar contrast during the test trials.

[e] Exact probabilities associated with the Wilcoxon Matched-Pairs Signed-Rank test statistic (z).

also calculated between chronological age, mental age equivalents, and IQ score. It was found that IQ was positively correlated with MA ($r$ = .581, $p < .02$), and negatively correlated with CA ($r$ = -.615, $p < .02$).

## Discussion

The present study investigated recognition memory and the perception of figure orientation in a group of 16 nonambulatory, profoundly mentally retarded children. In order to infer that recognition memory occurred, the habituation-dishabituation procedure requires that a response decrement to repeated presentations of one stimulus be demonstrated, and a recovery of the response be elicited upon presentation of a novel stimulus (Cohen, 1976). This habituation-dishabituation effect was found in the present study. Looking times decreased over the habituation trials to the repeatedly presented stimulus, and recovered to the novel stimulus during the test trial phase. This result agrees with previous studies demonstrating the capacity for immediate recognition memory in nonambulatory, profoundly mentally retarded children (Butcher, 1977; Kelman & Whiteley, 1986; Shepherd & Fagan, 1980; Switzky et al., 1979).

Previous research has obtained little evidence of delayed recognition memory in nonambulatory, profoundly mentally retarded children even though recognition memory for intervals of 2 weeks have been demonstrated in samples of normal infants (Fagan, 1973). In comparison to Fagan's (1973) findings with 5-month-olds, Switzky et al. (1979) found no evidence of 2-week delayed recognition memory for black and white checkerboard patterns in their sample of nonambulatory, profoundly mentally retarded children. Butcher (1977) found delayed recognition memory in a similar sample for much briefer intervals of time (i.e., 40 s and 180 s) when the stimuli used were single squares varying only in color. However, when the stimuli were pictures of faces or colored diamond shapes, delayed recognition memory was not found.

The studies of Butcher (1977) and Switzky et al. (1979) examined the retention interval over which the familiar versus novel contrast in looking time during the test trials could be demonstrated. The present study, however, followed Martin's (1975) approach with nonhandicapped infants by examining the differences in the rate of habituation to the familiar stimulus over successive sessions. Martin (1975) found that for infants between 2 and 5 months of age, total fixation time to the familiar stimulus during the habituation phase was significantly shorter on the second day of presentation as compared to the first. The novel stimulus resulted in response recovery on both days.

In keeping with Martin's (1975) findings, it was predicted that over the three consecutive series of habituation trials, habituation to the familiar stimulus would become more rapid. Such differences in the rate of response decrement over days would have indicated that the habituation stimulus was remembered across the 24-hr intervals. However, in the analysis of the habituation phase, no effect of days was found. Hence, delayed recognition memory has not been demonstrated in the present study. This result supports the previous findings of Butcher (1977), and Switzky et al. (1979) that recognition memory beyond a few seconds duration was not evidenced in profoundly mentally retarded children.

The perception of differences between the novel and familiar stimuli were examined in the test phase. It was hypothesized that if 45° or 90° changes in the orientation of the habituation phase stimulus were perceived, then dishabituation would occur. A significant main effect for the contrast between the novel and familiar stimulus was found. This result indicates that the subjects did perceive the change in orientation. Such a finding is consistent with the evidence obtained in the infant literature. Bornstein et al. (1978) found that 90° differences along the horizontal and vertical axes could be discriminated. Similarly, Bomba (1984) showed that infants could perceive differences between stimuli oriented in a vertical as compared to a 45° oblique orientation.

The magnitude of response recovery during the test phase was expected to be a function of the amount of discrepancy between the habituation stimulus and the novel stimulus. That is, magnitude of response recovery should have been greatest for the square pattern, and least for the 45° rotation. However, no main effect for discrepancy was found. This result indicates that in the test trials there was no relation between amount of dishabituation and the type of novel stimulus presented. The lack of sensitivity to different amounts of stimulus change was also noted by Kelman and

Whiteley (1986). In their study, the form of the stimuli was varied during test trials but response recovery was not affected by the amount of change in form.

During the habituation phase, subjects were familiarized to either a horizontal or a vertical stimulus. In research with normal infants, Slater and Sykes (1977) and Slater et al. (1985) found strong preferences for horizontally oriented stimuli during the test trials regardless of whether the infants were habituated to a horizontal or a vertical stimulus. In the present study however, no significant differences were found in responding to the type of stimulus that was used during the habituation phase. This outcome would suggest that, unlike the findings for nonhandicapped infants, this group of nonambulatory, profoundly mentally retarded children does not demonstrate a preference for stimuli which have a horizontal orientation. Further evidence for this conclusion may be found in the test series. If a strong preference for horizontality had been demonstrated, a significantly greater novel versus familiar contrast should have been found within the vertically habituated group as compared with the horizontally habituated group; however, there was no difference between the two groups.

Since the children who participated in the present study are a heterogeneous population in terms of chronological age, mental age, and medical diagnoses, individual data were examined. Four of the subjects (GM, CT, RL, and CS) demonstrated statistically significant response decrements over the habituation trials. Of the four, one subject (RL) showed an overall novelty preference during the test phase that approached significance. A significant response increment over the habituation trials was demonstrated by RA. And finally, although one subject (SB) did not show response decrements over the habituation trials, the results of the Wilcoxon test indicated that fixation times to the novel stimuli as compared to the familiar were significantly greater during the test phase.

These divergent results are consistent with previous research with nonambulatory, profoundly mentally retarded children, which have indicated that individual differences exist in their patterns of responding to visual stimuli (Kelman & Whiteley, 1986), and in their capacity to demonstrate recognition memory (Fagan & Singer, 1983; Shepherd & Fagan, 1980).

The significant negative correlations of chronological age with both IQ and the amount of response recovery during the test phase were consistent with the results of Kelman and Whiteley (1986). In the present study, however, no correlation was found between response recovery and IQ. These results suggest that declines in response recovery to novel stimuli may be associated more with increasing chronological age than with decreasing IQ for this population of profoundly mentally retarded children.

In research with nonretarded infants, habituation of visual attending is used to assess the rate of encoding of visual stimuli (Bornstein, 1985; Bornstein & Benasich, 1986). It is generally presumed that faster habituation indicates quicker encoding of a stimulus. For children who have no other measurable response, and who are not amenable to testing with conventional methods, habituation may provide a method by which the processing of visual information can be examined.

Further research using a design similar to the one in the present study could examine whether nonambulatory, profoundly mentally retarded children can perceive changes along the horizontal or vertical axes more readily than changes between obliques. Similar research with infants (e.g., Bornstein et al., 1978) has shown that 90° differences along horizontal and vertical axes can be discriminated; whereas 90° differences along oblique axes are not. There is evidence that in nonhandicapped infants the ability to discriminate between obliques increases with age (Bomba, 1984). As such, individual differences in perception of changes in orientation may be helpful for the examination of visual capabilities and the development of visual information processing abilities in nonambulatory, profoundly mentally retarded children.

In summary, the present research demonstrated response decrements to repeatedly presented visual stimuli, and subsequent recovery of the visual fixation response to novel stimuli. There was no evidence of delayed recognition memory across days. The results indicate that the capacity for perception of changes in orientation may be demonstrated in profoundly mentally retarded children with the use of a habituation-dishabituation procedure.

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# APPENDIX A

## Selected Bayley Infant Development Scale Visual Fixation Items

1. (5)[a] Momentary regard of red ring
2. (6) Regards person momentarily
3. (7) Prolonged regard of red ring
4. (19) Turns eyes to red ring
5. (20) Turns eyes to light
6. (34) Glances from one object to another
7. (37) Reaches for dangling ring
8. (45) Inspects own hands
9. (46) Closes on dangling ring

[a]Numbers in parentheses indicate Bayley Scale test item numbers.

# APPENDIX B

## Raw Data

The data files were arranged in the following manner for each subject. Line 1: subject number; habituating stimulus (1 = horizontal; 2 = vertical); age in years, months; novel sequence identifiers. Lines 2 to 7: total mean fixation times (s) per trial coded consecutively as 16 habituation trials, followed by a discrepancy score (1 = 45° novel stimulus; 2 = 90° novel stimulus; 3 = square novel stimulus), followed by the 8 test trials.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | 1 | 1 | 82 | 15.33 | 1 | 1 1 | | | | | | |
| 2. | 7.07 | 3.03 | 8.67 | 8.87 | 3.40 | 0.63 | 0.87 | 0.00 | 2.73 | 7.80 | 2.07 | 0.37 |
| 3. | 3.90 | 0.00 | 3.33 | 0.701 | 0.50 | 9.47 | 9.57 | 0.00 | 1.87 | 5.47 | 4.07 | 1.33 |
| 4. | 0.00 | 10.17 | 10.50 | 0.00 | 0.40 | 2.87 | 0.33 | 0.00 | 0.00 | 0.00 | 0.53 | 4.97 |
| 5. | 6.70 | 1.70 | 2.53 | 6.372 | 0.00 | 5.70 | 3.90 | 1.93 | 0.00 | 3.63 | 1.63 | 3.60 |
| 6. | 1.90 | 8.17 | 12.03 | 5.83 | 10.53 | 0.00 | 2.23 | 1.60 | 13.83 | 1.37 | 5.20 | 0.00 |
| 7. | 13.43 | 11.70 | 0.57 | 2.533 | 3.27 | 5.53 | 12.50 | 2.40 | 3.53 | 3.50 | 13.97 | 3.80 |
| 8. | 2 | 2 | 44 | 15.00 | 2 | 1 2 | | | | | | |
| 9. | 2.97 | 10.40 | 5.00 | 0.00 | 3.93 | 0.63 | 1.07 | 0.00 | 6.97 | 0.43 | 0.00 | 0.00 |
| 10. | 0.00 | 0.00 | 0.00 | 8.972 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 11. | 3.17 | 1.53 | 1.77 | 0.00 | 0.00 | 0.00 | 3.27 | 0.83 | 3.67 | 1.57 | 0.00 | 0.00 |
| 12. | 0.00 | 0.00 | 0.83 | 0.003 | 0.00 | 0.00 | 0.00 | 1.37 | 1.73 | 4.00 | 0.00 | 0.00 |
| 13. | 5.67 | 2.33 | 4.37 | 0.67 | 3.47 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 14. | 0.00 | 0.00 | 0.00 | 0.001 | 0.00 | 4.40 | 0.00 | 0.00 | 3.70 | 0.00 | 0.00 | 0.00 |
| 15. | 11 | 2 | 39 | 10.25 | 5 | 1 3 | | | | | | |
| 16. | 16.67 | 16.87 | 16.53 | 17.63 | 15.50 | 19.13 | 17.37 | 20.73 | 19.77 | 20.97 | 17.47 | 19.13 |
| 17. | 18.50 | 11.53 | 12.67 | 20.473 | 17.40 | 13.47 | 9.47 | 6.20 | 10.57 | 0.00 | 5.83 | 4.63 |
| 18. | 15.60 | 20.63 | 20.83 | 20.77 | 20.17 | 20.70 | 20.77 | 20.77 | 10.53 | 10.47 | 20.30 | 20.67 |
| 19. | 20.67 | 18.67 | 9.67 | 7.911 | 11.56 | 6.87 | 10.37 | 18.10 | 18.70 | 18.13 | 18.57 | 19.03 |
| 20. | 14.40 | 20.70 | 20.70 | 20.77 | 13.43 | 2.00 | 7.63 | 13.03 | 15.30 | 4.40 | 12.20 | 0.00 |
| 21. | 6.03 | 0.00 | 8.40 | 3.002 | 0.00 | 0.00 | 0.00 | 9.70 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22. | 21 | 2 | 33 | 12.08 | 2 | 1 2 | | | | | | |
| 23. | 10.90 | 4.57 | 10.97 | 7.03 | 0.93 | 3.63 | 0.00 | 5.57 | 9.70 | 7.33 | 1.10 | 0.00 |
| 24. | 3.30 | 4.87 | 12.53 | 0.002 | 1.67 | 3.53 | 3.37 | 0.00 | 0.00 | 0.00 | 2.70 | 2.27 |
| 25. | 1.50 | 0.00 | 0.00 | 0.00 | 1.80 | 8.67 | 9.17 | 7.70 | 5.40 | 0.00 | 0.00 | 0.00 |
| 26. | 3.70 | 10.40 | 0.00 | 0.003 | 4.70 | 8.43 | 5.47 | 4.87 | 12.10 | 2.20 | 0.00 | 19.63 |
| 27. | 0.00 | 0.00 | 4.20 | 5.60 | 2.17 | 0.00 | 0.00 | 4.07 | 5.77 | 4.57 | 12.50 | 3.40 |
| 28. | 7.70 | 2.60 | 11.73 | 5.331 | 5.13 | 0.00 | 1.23 | 0.00 | 0.00 | 0.00 | 0.00 | 2.77 |
| 29. | 9 | 2 | 60 | 11.08 | 2 | 1 2 | | | | | | |
| 30. | 12.90 | 0.93 | 2.27 | 4.47 | 2.17 | 0.87 | 3.27 | 0.47 | 0.67 | 1.17 | 3.13 | 0.30 |
| 31. | 0.00 | 0.00 | 0.00 | 0.002 | 0.00 | 5.10 | 4.33 | 0.43 | 0.23 | 1.33 | 0.20 | 3.60 |
| 32. | 3.83 | 2.30 | 2.00 | 0.00 | 0.50 | 0.00 | 0.83 | 0.00 | 0.17 | 0.00 | 0.00 | 0.23 |
| 33. | 2.70 | 0.00 | 0.33 | 0.533 | 0.00 | 3.43 | 0.63 | 0.47 | 1.03 | 3.70 | 0.00 | 0.73 |
| 34. | 2.70 | 0.00 | 0.00 | 0.00 | 0.87 | 0.00 | 0.00 | 1.20 | 2.27 | 1.80 | 0.40 | 1.40 |
| 35. | 0.00 | 0.13 | 0.00 | 0.001 | 0.00 | 2.90 | 0.70 | 0.00 | 0.00 | 0.00 | 0.00 | 0.70 |
| 36. | 23 | 2 | 43 | 10.00 | 3 | 2 1 | | | | | | |
| 37. | 5.43 | 0.00 | 1.97 | 4.93 | 0.00 | 1.37 | 1.63 | 5.63 | 5.70 | 5.07 | 5.90 | 6.17 |
| 38. | 2.60 | 5.77 | 4.17 | 6.201 | 4.50 | 3.20 | 6.67 | 4.07 | 5.87 | 6.50 | 6.20 | 2.00 |
| 39. | 3.47 | 2.90 | 1.33 | 0.27 | 11.97 | 2.50 | 4.67 | 7.53 | 13.10 | 1.50 | 13.70 | 0.00 |
| 40. | 1.27 | 0.27 | 8.90 | 0.002 | 11.60 | 16.40 | 2.20 | 0.17 | 0.00 | 3.33 | 0.00 | 0.00 |
| 41. | 1.83 | 4.17 | 6.43 | 11.93 | 0.00 | 3.60 | 1.03 | 3.83 | 1.60 | 0.00 | 0.00 | 2.27 |
| 42. | 0.63 | 1.97 | 5.37 | 4.773 | 0.00 | 3.23 | 1.00 | 3.40 | 0.40 | 1.23 | 0.77 | 0.27 |
| 43. | 3 | 2 | 49 | 7.33 | 3 | 2 1 | | | | | | |
| 44. | 10.00 | 3.97 | 2.43 | 13.60 | 9.33 | 7.80 | 12.00 | 2.50 | 6.97 | 7.40 | 1.80 | 9.60 |
| 45. | 9.30 | 5.47 | 0.00 | 1.101 | 5.97 | 0.00 | 2.50 | 0.97 | 8.37 | 9.27 | 1.77 | 8.17 |
| 46. | 11.47 | 16.87 | 8.37 | 9.67 | 12.67 | 7.50 | 1.40 | 7.43 | 10.97 | 6.30 | 7.37 | 9.77 |
| 47. | 6.10 | 2.07 | 2.77 | 2.102 | 2.77 | 2.30 | 4.03 | 0.77 | 1.63 | 3.40 | 2.60 | 3.97 |
| 48. | 5.43 | 10.80 | 15.50 | 7.37 | 1.37 | 1.63 | 0.00 | 1.20 | 2.40 | 2.40 | 4.80 | 4.57 |
| 49. | 1.33 | 5.83 | 2.17 | 1.073 | 2.33 | 6.00 | 2.83 | 15.67 | 5.97 | 1.13 | 0.00 | 7.27 |
| 50. | 4 | 2 | 43 | 7.67 | 4 | 2 2 | | | | | | |
| 51. | 8.47 | 7.53 | 3.03 | 4.07 | 0.93 | 2.03 | 0.00 | 3.93 | 2.67 | 0.43 | 2.73 | 2.07 |
| 52. | 1.73 | 3.53 | 5.17 | 0.832 | 5.48 | 4.17 | 2.33 | 1.23 | 1.87 | 3.27 | 0.00 | 0.00 |
| 53. | 5.03 | 1.40 | 2.10 | 0.00 | 2.33 | 0.50 | 0.00 | 0.00 | 2.87 | 0.83 | 4.70 | 1.60 |
| 54. | 1.63 | 0.37 | 0.00 | 8.503 | 2.73 | 0.00 | 0.47 | 3.17 | 1.40 | 0.00 | 2.10 | 0.00 |
| 55. | 2.77 | 7.03 | 0.00 | 3.60 | 0.00 | 0.00 | 2.00 | 0.97 | 0.00 | 0.00 | 0.47 | 2.67 |
| 56. | 1.33 | 2.30 | 0.63 | 5.831 | 0.00 | 0.00 | 0.00 | 6.17 | 2.83 | 3.93 | 4.50 | 0.73 |
| 57. | 10 | 1 | 37 | 13.42 | 4 | 2 2 | | | | | | |
| 58. | 6.00 | 5.60 | 1.57 | 2.70 | 0.00 | 2.07 | 0.00 | 2.73 | 0.00 | 8.17 | 7.10 | 2.60 |
| 59. | 7.77 | 2.33 | 6.37 | 0.002 | 0.00 | 0.00 | 0.00 | 4.60 | 1.73 | 0.00 | 5.23 | 0.93 |
| 60. | 4.30 | 1.63 | 8.17 | 0.00 | 1.93 | 0.63 | 1.50 | 0.00 | 3.20 | 0.00 | 0.00 | 0.00 |
| 61. | 5.17 | 0.00 | 0.00 | 2.533 | 2.97 | 0.00 | 3.47 | 0.00 | 0.00 | 7.40 | 4.40 | 0.00 |
| 62. | 0.00 | 0.80 | 0.00 | 0.00 | 2.77 | 1.70 | 6.00 | 0.57 | 0.77 | 2.67 | 0.90 | 0.00 |
| 63. | 7.30 | 5.70 | 4.20 | 0.001 | 0.00 | 0.00 | 0.00 | 0.00 | 0.43 | 1.47 | 0.93 | 0.00 |
| 64. | 18 | 2 | 23 | 4.33 | 3 | 2 1 | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 65. | 9.07 | 4.70 | 2.00 | 3.33 | 3.63 | 0.63 | 0.00 | 2.77 | 1.67 | 10.30 | 9.07 | 2.73 |
| 66. | 3.53 | 0.00 | 1.10 | 3.731 | 0.70 | 13.97 | 5.27 | 1.00 | 2.83 | 0.00 | 0.00 | 0.47 |
| 67. | 15.20 | 6.23 | 0.53 | 3.73 | 7.93 | 5.07 | 3.93 | 8.13 | 11.00 | 4.37 | 2.27 | 0.00 |
| 68. | 10.93 | 1.33 | 2.57 | 0.002 | 0.00 | 4.27 | 1.80 | 3.93 | 0.80 | 2.40 | 0.00 | 1.13 |
| 69. | 5.60 | 0.90 | 1.93 | 6.13 | 1.87 | 1.17 | 0.00 | 3.00 | 0.17 | 0.00 | 0.00 | 0.00 |
| 70. | 2.17 | 0.17 | 1.60 | 1.473 | 0.83 | 0.00 | 4.50 | 1.30 | 9.70 | 7.43 | 0.37 | 0.00 |
| 71. | 19 | 2 | 45 | 7.58 | 1 | 1 1 | | | | | | |
| 72. | 5.00 | 1.97 | 1.97 | 2.10 | 2.53 | 4.20 | 1.80 | 3.97 | 4.20 | 2.97 | 1.13 | 2.93 |
| 73. | 2.63 | 1.13 | 6.50 | 3.101 | 1.77 | 3.50 | 3.10 | 0.40 | 0.00 | 2.30 | 1.37 | 1.47 |
| 74. | 16.73 | 10.37 | 3.60 | 5.17 | 6.27 | 9.47 | 8.73 | 7.30 | 1.90 | 7.60 | 1.47 | 3.97 |
| 75. | 9.50 | 4.70 | 5.90 | 6.602 | 10.40 | 12.90 | 9.70 | 4.73 | 2.40 | 4.27 | 6.47 | 6.90 |
| 76. | 6.97 | 4.97 | 3.23 | 1.20 | 4.07 | 6.37 | 1.40 | 3.13 | 4.70 | 0.30 | 2.97 | 4.50 |
| 77. | 0.00 | 3.87 | 3.37 | 1.333 | 1.90 | 4.53 | 0.87 | 1.10 | 2.30 | 5.03 | 3.43 | 7.77 |
| 78. | 16 | 2 | 57 | 8.75 | 6 | 2 3 | | | | | | |
| 79. | 13.70 | 10.00 | 11.06 | 10.40 | 16.30 | 16.67 | 11.33 | 18.10 | 12.83 | 3.43 | 10.07 | 13.53 |
| 80. | 7.20 | 11.57 | 20.17 | 20.333 | 14.37 | 16.50 | 13.07 | 19.17 | 7.57 | 9.73 | 8.10 | 20.77 |
| 81. | 6.60 | 6.40 | 1.57 | 10.17 | 8.70 | 9.20 | 8.03 | 3.23 | 9.77 | 7.90 | 16.73 | 13.30 |
| 82. | 8.63 | 4.40 | 6.10 | 18.901 | 16.77 | 16.87 | 4.90 | 10.10 | 13.17 | 17.37 | 14.67 | 12.80 |
| 83. | 12.40 | 11.50 | 5.87 | 14.17 | 9.73 | 5.20 | 4.60 | 2.47 | 11.83 | 3.90 | 6.13 | 6.93 |
| 84. | 6.17 | 0.60 | 16.47 | 2.602 | 2.97 | 18.60 | 12.20 | 10.00 | 3.10 | 17.60 | 11.53 | 19.27 |
| 85. | 12 | 2 | 11 | 10.67 | 1 | 1 1 | | | | | | |
| 86. | 12.80 | 15.30 | 16.97 | 5.83 | 12.37 | 2.87 | 13.63 | 10.33 | 9.60 | 7.57 | 5.33 | 6.10 |
| 87. | 15.93 | 13.70 | 4.47 | 11.231 | 10.40 | 6.03 | 6.17 | 11.07 | 12.23 | 6.73 | 9.43 | 18.10 |
| 88. | 14.63 | 11.13 | 11.93 | 3.70 | 9.50 | 6.90 | 4.93 | 11.33 | 2.40 | 8.40 | 4.70 | 9.13 |
| 89. | 11.90 | 6.03 | 13.60 | 5.972 | 3.70 | 12.13 | 1.10 | 8.97 | 6.57 | 4.33 | 13.53 | 8.03 |
| 90. | 15.47 | 9.53 | 4.73 | 7.00 | 4.50 | 8.87 | 14.00 | 9.73 | 8.77 | 7.27 | 11.87 | 5.37 |
| 91. | 6.73 | 12.00 | 11.63 | 7.503 | 4.53 | 5.40 | 1.17 | 4.93 | 8.30 | 12.13 | 0.00 | 10.57 |
| 92. | 26 | 2 | 28 | 10.08 | 6 | 2 3 | | | | | | |
| 93. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.17 | 0.00 | 0.00 | 0.00 | 0.00 |
| 94. | 0.00 | 0.00 | 0.00 | 4.273 | 5.07 | 5.97 | 0.17 | 9.27 | 7.47 | 3.47 | 4.33 | 4.03 |
| 95. | 13.57 | 14.67 | 13.10 | 14.30 | 18.47 | 14.43 | 17.20 | 17.73 | 14.10 | 19.20 | 16.47 | 18.67 |
| 96. | 12.37 | 18.10 | 17.37 | 19.301 | 17.03 | 17.70 | 17.50 | 19.90 | 5.27 | 19.37 | 8.77 | 8.50 |
| 97. | 16.60 | 18.40 | 14.27 | 11.43 | 17.13 | 15.73 | 19.00 | 14.73 | 7.13 | 12.63 | 14.57 | 9.80 |
| 98. | 19.73 | 13.17 | 11.53 | 16.872 | 14.17 | 0.00 | 3.27 | 9.07 | 16.77 | 19.80 | 17.57 | 19.20 |
| 99. | 20 | 1 | 56 | 6.17 | 4 | 2 2 | | | | | | |
| 100. | 12.27 | 5.77 | 5.40 | 6.53 | 4.17 | 6.03 | 2.77 | 11.07 | 2.50 | 1.60 | 7.90 | 9.30 |
| 101. | 6.70 | 9.27 | 7.37 | 5.032 | 15.00 | 10.23 | 5.87 | 4.17 | 6.87 | 9.77 | 6.07 | 9.80 |
| 102. | 7.37 | 11.87 | 7.83 | 5.97 | 2.57 | 6.43 | 1.00 | 7.00 | 9.87 | 2.07 | 7.40 | 8.30 |
| 103. | 4.13 | 3.17 | 9.63 | 3.573 | 5.83 | 12.00 | 14.90 | 7.73 | 12.73 | 11.70 | 6.60 | 11.93 |
| 104. | 7.67 | 5.67 | 12.70 | 6.47 | 2.57 | 1.27 | 3.03 | 11.37 | 15.23 | 4.50 | 4.20 | 2.97 |
| 105. | 5.57 | 19.43 | 19.10 | 5.101 | 0.00 | 18.47 | 7.97 | 2.87 | 1.70 | 14.07 | 10.03 | 5.63 |
| 106. | 8 | 1 | 8 | 12.83 | 3 | 2 1 | | | | | | |
| 107. | 3.40 | 3.37 | 5.37 | 3.80 | 11.10 | 1.93 | 13.97 | 5.83 | 1.60 | 8.40 | 5.40 | 8.83 |
| 108. | 11.97 | 11.97 | 4.07 | 3.771 | 3.97 | 11.40 | 1.50 | 7.80 | 5.33 | 4.37 | 6.43 | 1.73 |
| 109. | 4.17 | 11.47 | 12.37 | 7.50 | 9.33 | 2.90 | 1.70 | 3.43 | 6.77 | 2.90 | 9.37 | 9.30 |
| 110. | 13.2 | 11.37 | 12.50 | 19.672 | 19.53 | 7.13 | 9.67 | 4.50 | 13.40 | 4.68 | 15.00 | 7.30 |
| 111. | 0.00 | 0.00 | 0.53 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 112. | 0.00 | 0.00 | 2.13 | 0.003 | 0.00 | 0.77 | 8.57 | 6.83 | 0.33 | 0.00 | 1.70 | 7.33 |