The University of Manitoba

GENERALIZATION OF HABITUATION IN NONAMBULATORY PROFOUNDLY MENTALLY RETARDED CHILDREN

By

William Kelman

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MASTER OF ARTS

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ABSTRACT

The present study had three objectives: first, to demonstrate habituation of a visual fixation response in the nonambulatory profoundly mentally retarded (NPMR); second, to demonstrate generalization of habituation along a stimulus continuum; third, to examine systematic changes in latencies to first fixation as a function of repeated stimulus exposure.

Twelve NPMR children were given 12 habituation trials with one of four simple geometric stimuli on each of four testing days. Following the habituation trials, the subjects received eight test trials consisting of two presentations of each of four stimuli. The test stimuli consisted of the habituation stimulus and three stimuli which differed from the habituation stimulus along the form dimension. Visual fixations were measured by means of a corneal reflection technique.

The data were examined on both a group and single-

subject basis. The group data demonstrated habituation of the visual fixation response combined with response reinstatement to all stimuli during test trials. However, there was no evidence of an ability to discriminate one test stimulus from another in the group data. Two of the subjects demonstrated habituation and an ordering of test stimuli means along the form continuum consistent with a generalization hypothesis. Latencies to first fixation were short and showed almost no variability in the group data. One subject demonstrated decreased latencies over habituation trials which is consistent with a conditioning effect. The results of this study suggest that the NPMR are deficient in the ability to make discriminations among an ordered set of visual stimuli.

The subjects displayed a great deal of interindividual response variability. Many of the subjects exhibited ideosyncratic behaviors, involuntary movements, and motor control disorders which made testing difficult. Methodological variations aimed at reducing these problems were discussed.

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Introduction

The American Association on Mental Deficiency (AAMD) classification system (Grossman, 1973) categorizes those individuals who fall more than 5 standard deviations below the mean on a standardized intelligence test as profoundly mentally retarded. Although this criterion is stated in terms of a standardized test score, these individuals are difficult to test and such classifications are generally made on the basis of other behavioral and medical criteria. These individuals display deficits in terms of central nervous system integrity, physical growth and development, and behavioral repertoires. The category of profound mental retardation does not delineate a homogeneous group, as individuals who are so classified have a wide variety of medical disorders and display highly ideosyncratic responding.

The nonambulatory profoundly mentally retarded (NPMR) form a distinct subcategory of the profoundly mentally retarded. Landesman-Dwyer and Sackett (1978) define the NPMR as follows: (a) they are incapable of moving through space, (b) they are totally lacking in adaptive behavior skills, and (c) they are extremely small for their chronological age, generally below the third percentile for height, weight, and head circumference. Finding adequate methods for studying the behavior of NPMR subjects has been a difficult problem for researchers. Landesman-

Dwyer and Sackett (1978) indicate that NPMR subjects are not amenable to most conventional methods of psychological research due to their extremely low level of behavioral responsivity, their numerous neurological and physical handicaps, and their high degree of interindividual response variability.

Visual attention paradigms have been a major tool for the study of discrimination and generalization in human infants (Cohen, 1976; Cohen & Salapatek, 1975; Werner & Perlmutter, 1979). Recently, such procedures have also been used in research on the discriminative abilities of profoundly mentally retarded children (Shepherd & Fagan, 1981). These methods may be generally categorized into two major classifications: (a) the familiarization-novelty paradigm, and (b) the habituation-dishabituation paradigm. The former involves simultaneous presentations of two exemplars of the same stimulus during familiarization trials followed by presentations of the familiar stimulus paired with a novel stimulus during test trials. Significantly longer looking times to the novel stimulus are taken to indicate discrimination between the novel and familiar stimuli. The habituation-dishabituation procedure involves repeated presentations of one stimulus followed by the individual presentation of the novel stimulus. A decrement in looking times over

trials of the familiarization series is described as habituation, and a subsequent increase in responding to the novel stimulus is called dishabituation. The ability to discriminate between novel and familiar stimuli is inferred from dishabituation.

Clifton and Nelson (1976) describe habituation as a simple type of learning which is useful for the study of learning processes in individuals incapable of more sophisticated types of learning. These authors were referring to human neonates, but the same logic is also applicable to profoundly retarded individuals and more specifically to the nonambulatory profoundly mentally retarded. However, it should be noted that there has been some debate as to whether or not habituation can properly be considered a form of learning (Jeffrey & Cohen, 1971). Learning is generally defined as a relatively permanent or stable change in behavior due to experience and excluding such transitory changes as might, for example, result from fatigue or sensory adaptation. Response decrement due to habituation does not appear to display the same durability over time as do responses established by either classical or operant conditioning procedures. Kimmel (1973) has suggested that retention of habituation is relatively more permanent than had been thought but not nearly so permanent as classical conditioning. While he differentiates

habituation from conditioning both in terms of durability and procedural aspects, he indicates that there are enough similarities to give credence to the notion that habituation may be a related but more primitive form of conditioning or learning. In the same edited volume of review papers, Petrinovich (1973) reaches the same conclusion following similar logic. Whether or not habituation is ascribed the status of learning, it is clear that it is an example of behavioral plasticity having many characteristics in common with learning.

One of these characteristics is stimulus generalization. In conditioning paradigms, stimulus generalization refers to the empirical finding that a response which has been conditioned to a specific stimulus will occur to novel stimuli which are similar along some qualitative or quantitive continiuum, even though the subject has not been conditioned to respond to the novel stimuli. Response strength varies as a function of the degree of similarity between the conditioned and novel stimuli. Brown (1965) suggests that the term stimulus generalization is actually used to mean two things: "either (1) a simple, concrete empirical phenomenon or (2) some rather abstract process that underlies, mediates, and allegedly explains the empirical phenomenon" (p. 7). The present research will treat generalization as an empirical phenomenon.

Response decrement due to habituation will generalize

to other stimuli. The degree of generalization is greater to stimuli relatively more similar to the habituating stimulus as compared to stimuli which are relatively more discrepant (Graham, 1973). Cohen, Gelber, and Lazar (1971) have studied the generalization of habituation in infants using visual attention as a response. The present study proposed to use a similar methodology to examine generalization in the nonambulatory profoundly mentally retarded.

Visual Fixation Research with the Nonambulatory Profoundly Mentally Retarded

There have been a few experiments on visual fixation carried out using the NPMR as subjects. These studies have concentrated on showing that NPMR subjects fixate visual stimuli, that habituation of visual fixation occurs, and that following familiarization, NPMR subjects can discriminate novel from familiar stimuli. Table 1 presents a summary of the methodologies of the NPMR research.

Berkson (1966) reported two experiments which demonstrated that some members of a sample of NPMR children (CA = 3 years, 5 months; developmental level less than 1 year) could discriminate between moving and non-moving stimuli when differential looking times were used as a measure. Visual fixations were scored by an observer who recorded the reflection of light from the stimuli (which were illuminated

by two 3-W bulbs) on the pupils of the subject. Observations were made through a small aperture in the experimental chamber directly in front of the subject's eyes. The stimuli were small discs covered with multi-colored random shapes. The discs were either motionless or rotated at 60 rpm. In the first experiment, the disc was presented for 60 s during which time: (a) it was rotated continually, (b) it was stationary throughout, (c) it was rotated for 30 s and stationary for 30 s, or (d) it was stationary for 30 s and rotated for 30 s. Each subject received three trials of each condition on each of four testing days. Response to onset of movement was greater than response to offset. When the stimulus presentation time was partitioned into 5-s intervals, the group data showed some tendency for subjects to decrease their fixation times over successive intervals, and to increase their fixation times momentarily in response to a change in stimulus movement. There was a preference for the rotating as compared to the stationary disc. Because a wide variety of individual differences in responding tended to obscure the effects of the experimental conditions, Berkson presented several examples of individual subject data. Some subjects failed to demonstrate habituation, and others failed to fixate the stimulus at all. He also indicated that several subjects failed to discriminate between the

Table 1

Summary of NPMR Visual Fixation Research

Author(s)	Mental Age	Chronological Age	N	Stimuli
Berkson (1966)				
Expt. 1	Under 1 year	*Mdn* = 3 years, 5 months	15	Multicolored disc presented rotating or stationary
Expt. 2	Under 1 year	*Mdn* = 3 years, 5 months	10	Multicolored disc presented rotating or stationary
Goshgarian (1968)	No detailed information available			Pictures of people and places
Lederman (1969)	No detailed information available			Pictures of people, places
Butcher (1977)	*M* = 5.3 months	*M* = 6.1 years	16	Red square, green square, red diamond, green diamond, male & female faces
Shepherd & Fagan (1981)	*M* = 4 months	Approx. 7 years	17	High & low contrast achromatic patterns
Switzky, Woolsey-Hill, & Quoss (1979)	*M* = 6 months	*M* = 10.3 years	12 (6 male, 6 female)	4-or 144-square checkerboard pattern

Table 1 (Cont'd)

Summary of NPMR Visual Fixation Research

		Familiarization Trials	
Author(s)	Paradigm	Number of Trials	Trial Duration
Berkson (1966)			
Expt. 1	Habituation	3 trials of each condition	60 s
Expt. 2	Habituation	One trial of each of three durations on each of 4 sessions	8 min, 3 min, 30 s
Goshgarian (1968)	No detailed information available		
Lederman (1969)	No detailed information available		
Butcher (1977)	Familiarization-novelty	1	2 min
Shepherd & Fagan (1981)	Familiarization-novelty	2	15 s
Switzky, Woolsey-Hill, & Quoss (1979)	Habituation	Habituation criterion but a minimum of 8 trials	Subject controlled offset

Table 1 (Cont'd)

Summary of NPMR Visual Fixation Research

	Familiarization Trials		Test Trials
Author(s)	ITI[a]	ISI[b]	Number of Trials
Berkson (1966)			
Expt. 1	Not applicable	Not applicable	No test series as such
Expt. 2	Not applicable	Nil	Disc presented stationary for 30 s
Goshgarian (1968)	No detailed information available		
Lederman (1969)	No detailed information available		
Butcher (1977)	Not applicable	10, 40 or 180 s	2
Shepherd & Fagan (1980)	No detailed information available	--	2
Switzky, Woolsey-Hill & Quoss (1979)	2 s	10 s	6 (3 novel, 3 familiar)

Table 1 (Cont'd)

Summary of NPMR Visual Fixation Research

Aurhor(s)	Test Trials: Trial Duration	Test Trials: ITI[a]	Dependent Variable
Berkson (1966)			
Expt. 1	No test series as such	No test series as such	Percent time fixating per 5-s interval
Expt. 2	Disc presented stationary for 30 s	Not applicable	Percent time fixating per trial Number of fixations Duration of fixations Interval between fixations
Goshgarian (1968)	No detailed information available		
Lederman (1969)	No detailed information available		
Butcher (1977)	5 s	10 s	Percent fixation to novel stimulus
Shepherd & Fagan (1981)	5 s	No detailed information available	Percent fixation time to novel stimulus
Switzky, Woolsey-Hill & Quoss (1979)	Subject controlled offset	2 s	Total fixation time per trial

[a]Intertrial Interval

[b]Interseries Interval

rotating and stationary stimulus conditions. However, it would appear that he is referring to a lack of preference between the two rather than a lack of discrimination. He plotted fixation curves for the moving and stationary stimuli for each individual for both the 60-s rotating and 60-s stationary conditions; if the curve for the moving stimulus was not higher than the curve for the non-moving stimulus for a given individual, Berkson concluded that this indicated a lack of discrimination between the two stimuli. This is not the same as assessing discriminability on the basis of a change in fixation times at the point of stimulus switchover.

Procedurally, the second experiment reported by Berkson (1966) is similar to the first. Seven of the initial group of subjects and three naive subjects were run for four additional sessions. Each session consisted of randomized presentations of three stimulus conditions. The rotating disc was presented for 8 min, 3 min, or 30 s, following which the stationary disc was presented for 30 s. In the 8-min exposure condition, it was found that the initial visual fixation was followed by a series of fixations which declined in number and duration with the greatest decrement occurring during the first 2 min.

Goshgarian (1968) used a visual paired-comparison procedure in a study of social preference by eight NPMR

children. When two slides were presented, subjects looked significantly longer at people than at places, at familiar than at unfamiliar persons, and at caretakers than at peers. Lederman (1969) attempted to replicate these findings using a visual fixation procedure to which she had also added several behavioral and physiological measures of attention (stereotyped behavior, total activity, vocalizations, and heart rate). None of her subjects showed social preferences. Four subjects showed a preference for pictures as compared to blank stimuli when looking time was the measure of preference. However, there was no correlation between looking time and the other measures of attention.

Butcher (1977) studied memory for colors and faces in a group of 16 NPMR children with developmental ages ranging from 2.0 to 11.0 months as measured on the Bayley Scales of Infant Development (mean CA = 6.1 years). The stimuli were photographs of two male and two female faces, one red and one green square, and two diamond shaped patterns composed of either 24 small red diamonds or 24 small green diamonds. The stimuli were approximately the same size. Each child was given a 2-min familiarization period during which the to-be-familiarized target appeared for 1 min on either the right or left side of the stimulus display, and then for 1 min on the other side. Immediately

thereafter, the familiarized stimulus was paired for two 5-s periods with a specific test stimulus. The sides on which the stimuli appeared were reversed from the first to the second 5-s test. The green square was always used as a test stimulus following familiarization with the red square, as was the green diamond following familiarization with the red diamond. Subjects were always familiarized to one of the male faces, with one of the female faces serving as a test stimulus. The same female face always appeared with a given male face. After familiarization and testing with stimuli from either the color or face category, the procedure was repeated with a stimulus from the non-tested category (e.g., if one of the color pairings had been presented first, one of the face pairings would be presented second). As a test of delayed recognition, the four test pairings were then presented again in the same order in which they had been presented in the immediate testing. The delay was approximately 180 s for the first problem presented and about 40 s for the second problem. On the second day, the children were tested with the color pairing and the face pairing that had not been used in the first session.

An analysis of fixation times during familiarization indicated that the children looked at all four stimulus pairings presented to them for approximately equal amounts

of time, and that they exhibited about half the absolute level of fixation that would be expected of normal infants. As in the Lederman study, no preference was found for faces as compared to the colored geometric stimuli. Reliable novelty preferences, measured in terms of percentage fixation to the novel stimulus during testing, were found for all the pairings other than the red and green diamonds on immediate testing. The only significant novelty preference in delayed testing was to the red and green square pairing. Butcher suggests that the failure to find novelty preferences for any of the other stimulus pairings during delayed testing may be due either solely to the delay or to a combination of delay and interference effects.

Shepherd and Fagan (1980) used a procedure similar to Butcher's to determine whether profoundly retarded children could discriminate a novel from a previously seen stimulus within a series of stimulus presentations. Seventeen profoundly mentally retarded children (CA approximately 7 years; mean Bayley Developmental Age of 4 months) served as subjects. The stimuli were nine high contrast and four lower contrast achromatic patterns. In each of the three sessions, the children were presented with four memory problems consisting of a 15-s familiarization with one stimulus followed by two 5-s test trials in which the

familiar stimulus was paired with a novel stimulus. As a group, the children showed a significant preference for novelty (as measured by the percentage of time spent fixating the novel stimulus) over the first three problems but not the fourth. Recognizing that the profoundly mentally retarded are a heterogeneous group, Shepherd and Fagan analyzed each subject's data and found reliable individual differences; only 41% of the children demonstrated significant differences.

Switzky, Woolsey-Hill, and Quoss (1979) habituated a group of 12 NPMR children (mean CA 10.3 years; mean developmental age 6 months as measured on the Denver Developmental Screening Test) to a black and white checkerboard pattern with either four squares or 144 squares. After the children reached an habituation criterion, they were presented with six test trials on which the habituated pattern was alternated with the other pattern. The habituation pattern was presented on the first, third, and fifth trials, whereas, the novel pattern was presented on the second, fourth, and sixth trials. There was a 10-s delay between the habituation and test series. The subjects demonstrated habituation to the repeated stimulus, and dishabituation (response recovery) to the novel stimulus. There was also some recovery of response to the interspersed presentations of the habituated stimulus during the test trials. Approximately two weeks later, the children were

involved in what the authors' referred to as a control-habituation condition. In this condition, the children were again habituated to the same checkerboard pattern but during the test series only the habituated stimulus was presented. When the novel stimulus was not presented, there was no evidence of response recovery.

In summary, it would appear that many NPMR children are capable of visual fixation, habituation of visual fixation, and discrimination between a novel and familiar stimulus. In particular they are able to discriminate the colors red and green, geometric shapes, rotation, faces, and pattern stimuli. However, the NPMR are a heterogeneous group, and even studies which report consistent responding in terms of group data do not necessarily show that even a majority of the group responded consistently.

One important topic which has not been explored using the visual fixation paradigm is stimulus generalization. There is no data pertaining to the generalization of visual habituation (or familiarization) in NPMR children. Since there are similarities in mental age and level of dependency between these handicapped individuals and normal infants, infant research on generalization of habituation would seem to be a reasonable starting point for research on generalization with NPMR children.

Generalization of Visual Fixation Habituation in Infants

A summary of the subjects and procedures employed in infant research on generalization of habituation to visual stimuli is presented in Table 2. In an often cited experiment, Cohen, Gelber, and Lazar (1971) demonstrated generalization of habituation in infants. They showed that the amount of response recovery was proportional to the number of novel dimensions in the test stimuli. Their sample consisted of 32 male and 32 female, 4-month-old infants who were presented with 15-s exposures to a simple geometric pattern on 12 trials. The stimuli were a red circle, a green circle, a red triangle, and a green triangle. Following habituation to one of these four stimuli, eight test trials were given with each of the four stimuli being presented twice. Order of presentation of the four stimuli on the test trials was counterbalanced across groups of subjects. Visual fixations were scored by observing the subjects' head and eye orientations on a television monitor. The television camera was located directly below the stimulus projection screen.

Subjects showed less recovery to a change in form or color than to a change in both. The authors described this as generalization of habituation. Further analysis of the data showed no effect due to order of presentation during the test phase. They did, however, find significant

Table 2

Summary of Infant Generalization Research

Author(s)	Chronological Age	N	Stimuli
Cohen, Gelber, & Lazar (1971)	*M* = 17.8 weeks	64 (32 male, 32 female)	Red circle, green circle, red triangle, green triangle
Cohen (1973)	16 weeks	Not reported	Red circle, green triangle, green circle, red triangle, blue square, yellow dumbbell
Welch (1974)	*M* = 18.5 weeks	72 (36 male, 36 female)	Various arrangements of red & green circles & squares
Bornstein (1976)	*M* = 17.8 weeks	50 (25 male, 25 female)	Munsell colors varying from green to yellow
Bornstein, Kessen, & Weiskopf (1976)	*M* = 17.7 weeks	30	Munsell colors varying from blue to green
Bornstein (1979)	*M* = 16 weeks	16	Checkerboard, female face; Munsell colors - blue, green, yellow, red, and mixtures of these
Schwartz & Day (1979)	Expt. 1, *M* = 11 weeks, 1 day Expt. 2, *M* = 11 weeks, 4 days	12 (6 male, 6 female)	Square & Rhomboid, rectangle & square
Dirks & Gibson (1977)	*M* = 22 weeks	12 (8 male, 4 female)	Live faces & photographs of faces
Caron, Caron, Caldwell, & Weiss (1973)	*Mdn* = 17 weeks	238 (119 males, 119 females)	Schematic facial representations

Table 2 (Cont'd)

Summary of Infant Generalization Research

		Familiarization Trials		
Author(s)	Paradigm	Number of Trials	Trial Duration	ITI[a]
Cohen, Gelber, & Lazar (1971)	Habituation	12	15 s	.9 s
Cohen (1973)	Habituation	16	Not reported	Not reported
Welch (1974)	Familiarization-novelty	1	60 s	Not applicable
Bornstein (1976)	Habituation	15	10 or 15 s	5 or 7.5 s
Bornstein, Kessen, & Weiskopf (1976)	Habituation	24	15 s	7.5 s
Bornstein (1979)	Habituation	Habituation series run until 50% decrement in successive trials	Duration of first unrestricted looks	Not reported
Schwartz & Day (1979)	Habituation	8	20 s	5 s
Dirks & Gibson (1977)	Habituation	6 or 7	20 s	10 s
Caron, Caron, Caldwell, & Weiss (1973)	Habituation	6-8 (not including warm-up slides)	30 s beginning with first fixation	Not reported

Table 2 (Cont'd)

Summary of Infant Generalization Research

	Familiarization Trials	Test Trials		
Author(s)	ISI[b]	Number of Trials	Trial Duration	ITI[a]
Cohen, Gelber, & Lazar (1971)	.9 s	8	15 s	.9 s
Cohen (1973)	Not reported	4	Not reported	Not reported
Welch (1974)	10-15 s	3	10 s	10-15 s
Bornstein (1976)	Not reported	9	10 or 15 s	5 or 7.5 s
Bornstein, Kessen, & Weiskopf (1976)	No test series	No test series	No test series	No test series
Bornstein (1979)	Not reported	2	Not reported	Not reported
Schwartz & Day (1979)	Not reported	4	20 s	5 s
Dirks & Gibson (1977)	10 s	1	20 s	Not applicable
Caron, Caron, Caldwell, & Weiss (1973)	Not reported	2 (not including warm-up slides)	30 s	Not reported

Table 2 (cont'd)

Summary of Infant Generalization Research

Author(s)	Dependent variable
Cohen, Gelber, & Lazar (1971)	Total fixation time per trial
Cohen (1973)	Total fixation time
Welch (1974)	Percent fixation time to novel stimulus per trial
Bornstein (1976)	Percent fixation time per trial
Bornstein, Kessen, & Weiskopf (1976)	Fixation time per trial
Bornstein (1979)	Duration of first look
Schwartz & Day (1979)	Total fixation time per trial
Dirks & Gibson (1977)	Length of first look, total looking time
Caron, Caron, Caldwell, & Weiss (1973)	Total fixation time per trial

[a]Intertrial Interval

[b]Interseries Interval

sex differences, with males showing greater response decrement over the habituation trials. Males also showed less absolute recovery (shorter fixation times) but greater proportional recovery (difference between fixation times to novel vs. familiar stimuli) during the test trials.

In a further experiment Cohen (1973) demonstrated generalization effects within the habituation series. Four-month-old infants were given 16 habituation trials with alternate presentations of two colored geometric stimuli: a red circle alternated with a green triangle. During the test phase, which consisted of four trials, the subjects were divided into three groups. The first group received alternating trials of the same red circle and green triangle; the second group received alternating trials of a green circle and red triangle; the third group received alternating presentations of a blue square and a yellow dumbbell. The mean fixation times for the first and second groups were not statistically different. However, the mean fixation times of the third group were significantly different from the fixation times of each of the other two. These findings suggest that exposure to the values on the color and form dimension of the test series stimuli during habituation resulted in generalization of habituation to a novel combination of these values.

Using a familiarity-novelty procedure Welch (1974) found a linear relationship between percentage of fixation time to the novel stimulus and the degree of discrepancy between the familiarized and novel stimulus. Discrepancy was defined in terms of a change in color, element shape, and element arrangement. For example, one of the stimulus series consisted of small squares arranged in concentric circles, the same squares arranged in a checkerboard pattern, circles of approximately the same area as the squares arranged in the same concentric circle pattern, and the small circles arranged in a square such that the positioning of the circles matched the positioning of the squares in the previous checkerboard pattern. There was a red version and a green version of each of these patterns. The subjects consisted of 36 male and 36 female infants with a mean postnatal age of 18.5 weeks. During familiarization infants were shown two copies of one stimulus for 60 s. They were then given three 10-s test trials during which a novel stimulus was paired with a familiar stimulus. Sides on which the familiar and novel stimuli appeared were reversed half-way through each test trial. During the test phase each infant was given one trial on which one characteristic was changed, one trial on which two characteristics were changed, and one trial on which all three characteristics were changed. Although the procedure in this experiment is different

than that used by Cohen et al. (1971), the findings are essentially similar in that following familiarization to one stimulus the percentage of time spent in fixating the novel stimulus was shown to be a direct linear function of the number of stimulus dimensions changed.

The infant research reviewed so far has concentrated on changes in response recovery related to changes in one or more physical characteristics of the familiarization stimulus rather than on the amount of change along a single physical continuum.

Schwartz and Day (1979) habituated infants (mean chronological age 11 weeks, 1 day) to the outline of a square, and then presented a test series consisting of the habituation stimulus, the same square rotated 45^{o}, and a rhomboid which was constructed by rotating the vertical edges of the square 15^{o}. Neither the rhomboid nor the rotated square produced complete response recovery expressed in terms of mean fixation time per trial. However, the rhomboid was fixated significantly longer than the rotated square. Similar results were found when a second group of infants of approximately the same age were habituated to a rectangle, and then presented with a test series which consisted of the habituation stimulus, the same rectangle rotated 90^{o}, and a square. Response to the rotated rectangle did not differ from the response to the habituation stimulus during the test phase. There was

complete response recovery to the square.

The stimuli in both of the Schwartz and Day (1979) experiments were outlines of geometric forms which appeared red against a dark grey background. The habituation series consisted of eight trials of 20-s duration and the test phase consisted of one presentation of each of the stimuli for 20 s. Presentation orders for different groups during the test series were arranged so that each test stimulus appeared only once in each serial position. The subjects were observed by the experimenter through a small aperture in the stimulus presentation screen. A fixation was scored when at least 75% of the pattern was reflected by the cornea over the pupil of the infant's left eye.

Generalization of visual habituation has been demonstrated within a hue category (Bornstein, 1976; Bornstein, Kessen, & Weiskopf, 1976) in research on infant color perception. Bornstein et al. (1976) also demonstrated generalization effects during the habituation series. They presented one group of infants with 24 consecutive trials of one wavelength of light, and a second group with 12 trials of the same wavelength interspersed with 12 trials with a wavelength from the same hue category. There were no differences in habituation rate between the two groups. In contrast, a third group which was given 12 trials of the same wavelength common to the first two

groups, interspersed with 12 trials of a wavelength from a different hue category habituated at a slower rate. Bornstein (1979) has further shown that infants who see a variety of different hues during habituation trials generalize habituation to a novel hue.

Dirks and Gibson (1977) habituated five-month-old infants to presentations of a live face following which they were shown either a photograph of the face they had seen or a photograph of a face judged to be highly similar. The infants did not show differential total fixation time of the novel as compared to the previously seen face despite the fact that a comparable group of infants had been able to discriminate a familiar from a dissimiliar novel face in a previous experiment reported in the same article. While generalization of habituation appears to be a viable explanation of these findings, it is difficult, in this instance, to delineate in what ways the stimuli are similar or dissimiliar. Facial stimuli can only be described as grossly and subjectively the same. In previous research using schematic faces which could be varied more precisely, Caron, Caron, Caldwell, and Weiss (1973) had demonstrated that habituation generalizes to novel facial configurations as a function of the degree of similarity between the habituated and novel facial stimuli.

Caron et al. (1973) habituated infants (chronological age range 17 weeks to 19 weeks) to a distorted face stimulus. Each subject was given at least six 30-s presentations of a particular distorted face. The 30-s time period began with the initial fixation of the stimulus rather than stimulus onset. If the total fixation time per trial had not decreased by at least 25% from the first to the sixth presentation, then a maximum of two further trials were given. If the infant had not reached the habituation criterion of a 25% reduction in total looking time by the eight trial, it was discarded from the sample. The stimuli consisted of a series of schematic representations of the human face, each of which had been distorted to a lesser or greater extent. In general, the distortions may be categorized by the following classifications: (a) eye distortions, (b) nose-mouth distortions, (c) inner-face distortions, (d) head distortions, and (e) head and face distortions. All subjects were given two post-habituation trials with an undistorted face composed of the same elements which occurred in the distorted faces. The post-habituation trials were interspersed with trials of different multicolored stimuli which were unrelated to the facial stimuli and intended solely as a measure of general attentiveness. The data showed that response decrement due to habituation generalized to the undistorted

face as a function of the degree of similarity between it and the distorted face used as an habituation stimulus.

General Methodological Considerations

Habituation criterion. In a review of infant visual fixation research Werner and Perlmutter (1979) discussed the advantages of an habituation criterion. Such a criterion might, for example, be stated in terms of a percentage decrement in looking time as compared to the first trial. The stimulus would be repeatedly presented until the subject attained the performance criterion. Although there are advantages to the use of an habituation criterion, one major disadvantage is the fact that subjects receive an unequal number of habituation trials. Clifton and Nelson (1976) also indicate that it must be ensured that subjects experience enough stimulus presentations or stimulus exposure to habituate. They suggest that this may be ensured by the selection of an habituation criterion or the provision of a large number of trials.

Fixed-and infant-controlled procedures. Werner and Perlumtter (1979) compared fixed and infant-controlled familiarization procedures. In the fixed trial procedure, the onset and duration of each stimulus presentation is determined a priori by the experimenter. Onset or duration in

infant-controlled procedures are determined by the infant's behavior during the trial. A trial may, for example, begin with the infant's first fixation and terminate when the infant looks away from the stimulus for a specified period to time (e.g., 2 s). Werner and Perlmutter (1979) suggest that infant-controlled procedures provide not only a more sensitive measure of experimental effects but also decrease subject attrition. However, a direct experimental comparison of fixed-trial and infant-controlled procedures (Haaf, Smith, & Smitley, 1983) showed no specific advantage for the infant-controlled procedure in terms of either sensitivity to experimental effects or subject attrition. As well, the use of an infant-controlled offset procedure might result in artificially short and unequal exposure times. For example, subjects whose looking behavior consists of numerous short regards of the stimulus would receive less exposure than those subjects who attend to the stimulus for longer durations on each look. The total looking time per trial might be equivalent for both types of subjects using the fixed-trial but the infant-controlled offset procedure would show that the latter type of subject had shorter total looking times per trial. Converseley an infant-controlled onset procedure would not artificially reduce the stimulus exposure times of those subjects who were not oriented to the stimulus presentation screen at the time of stimulus onset as would a standard fixed-trial procedure.

A combination of the two procedures with a trial beginning at the subject's first fixation and terminating after a specific time period would appear to be most appropriate.

Dependent measures. Werner and Perlmutter (1979) also briefly reviewed dependent measures used in infant visual fixation research. They suggest that total length of visual fixation per trial is the most commonly used measure. However, other measures include first fixation duration, mean fixation duration, number of fixations, and latency to first fixation.

Cohen (1976) has suggested that total fixation time per trial is a measure of the attention holding properties of a stimulus while latency to first fixation is a measure of the stimulus' attention getting properties. He equated decreases in latency over trials with a conditioning effect. That is, although the stimulus is not presented by the experimenter contingent upon head turning, the effect of the subject bringing the stimulus into view is essentially con contingent presentation. The stimulus in this instance is conceptualized as a reinforcer and head turning as an operant response. Several studies by Cohen and his co-workers (Cohen, Deloache, & Rissman, 1975; Deloache, Whetherford, & Cohen, 1972; McDonough & Cohen, 1982) have demonstrated that non-handicapped infants show a pattern of decreased latencies over habituation trials and that latency level is a function of the experimenter judged attractiveness of the stimulus.

Latencies are shorter to more complex or attractive stimuli. The latency curves published by Cohen display a decrease in latencies early in the habituation series followed by an increase in later trials, suggesting a decrease in the attractiveness of the stimulus concomitant with a decrement in its novelty due to habituation.

Corneal reflection. Visual fixation is frequently measured by corneal reflection techniques. The eye acts as a mirror and light striking it is reflected back toward the source. Maurer (1975) reviewed general methodological considerations in the use of the corneal reflection technique. She indicates that "in most studies of infants' visual preferences, an observer simply notes whether the reflection of the stimulus falls over the center of the pupil" (p. 51). One of the sources of measurement error that she discusses, parallax, would appear to be important in research on infant visual habituation. Parallax refers to the fact that any displacement of the observer from the source of light striking the cornea results in an apparent shifting of the image on the cornea. As the determination of fixation in visual habituation research is comparatively crude it would seem that the observer should be placed as close as possible to the light source, but unless there is an extreme discrepancy between the positioning of the light

source and observer a correction for parallax is not necessary.

While the foregoing discussion of the corneal reflection technique has used the term observer, it should be noted that this need not always refer to a live observer present during the experimental session. Video or film recording of the subject's face and eyes has often been used (e.g., Cohen, Gelber, & Lazar, 1971; Bornstein, 1979).

The Present Study

In normal subjects the discriminative and reinforcing properties of environmental stimuli play a major role in the development of adaptive behavior. Landesman-Dwyer and Sackett (1978) outline the difficulties in establishing and generalizing operant responses in the NPMR and suggest that deficiencies in the responsivity of these subjects to external stimuli may be a factor. They also suggest that many NPMR subjects are "highly selective in responding preferentially to certain reinforcers within a common class" (p. 60) and do not necessarily generalize within this class. The present research proposed, therefore, to study stimulus discrimination and generalization in a number of NPMR subjects by way of habituation of visual fixation responses. Such responses are within the limited

behavior repertoires of many NPMR subjects (Shepherd & Fagan, 1981). The methodology was similar to that used by Cohen et al. (1971) in their study of normal infants, but the experimental design was altered in order to allow for the analysis of single-subject data. It was expected from previous habituation research (Kelman & Whiteley, 1983) that the subjects would display a great deal of interindividual variability in responding. For this reason individual-subject data were analyzed for evidence of habituation and generalization in addition to the analysis of the group data.

The statistical analysis of single-subject data presents unique difficulties to the psychological researcher, the solutions of which have been the subject of debate at various times during the last decade (Gentile, Roden, & Klein, 1972; Hartmann, 1974; Keselman & Leventhal, 1974; Kratochwill, Alden, Demuth, Dawson, Panicucci, Arnston, McMurray, Hempstead, & Levin, 1974). The focus of the debate has been the necessarily high degree of error correlation in single-organism data and the effect of this correlation on the assumptions of parametric statistical tests, the violation of which may inflate Type I error rates by an indeterminable amount. Several authors (Levin, Marascuilo, & Hubert, 1978; Hersen & Barlow, 1976; Edington, 1975) have described statistical tests based on nonparametric randomization techniques which are applicable

specifically to N = 1 reversal designs and have suggested the application of these techniques to single-subject data in general. Their rationale is that tests based on randomization procedures do not require an assumption of uncorrelated errors and that, although these tests have less power than analagous parametric tests (Bradley, 1968), decreased sensitivity is preferable to Type I error rates that exceed tabled values by an unknown amount. Nonparametric randomization techniques were adopted as the basis of the major statistical analyses of single-subject data in the present research.

Subjects consisted of 12 NPMR children selected from the residential population of the St. Amant Centre in Winnipeg. On each of four testing days, the subjects were given 12 presentations of one of four habituation stimuli: a clear circle, a yellow circle, a clear ellipse, or a yellow ellipse. Following habituation to one of these stimuli, the subjects received eight test trials, consisting of two presentations of each of four stimuli. The test stimuli consisted of the habituation stimulus and three stimuli which differed from the habituation stimulus along the form dimension but were the same color as the habituation stimulus. Visual fixations were measured by means of a corneal reflection technique.

Method

Subjects

The subjects were 12 NPMR children (7 girls and 5 boys) selected from the residential population of the St. Amant Centre. Their chronological ages ranged from 2 years, 3 months to 14 years, 3 months (mean 7 years, 10 months; SD 3 years,8 months). Selection was based on the following criteria: (a) incapable of moving through space; (b) totally lacking in adaptive behavior skills; (c) extremely small for their chronological age; (d) ability to visually fixate as indicated by passing three of the test items requiring visual fixation from the Bayley Scales of Infant Development (Bayley, 1969; see Appendix A). Ward observation and information from the institutional staff were used to further evaluate possible visual impairment. Of the 26 children originally selected in this manner, 14 were dropped after an initial testing session due to behaviors which were incompatible with the testing procedure, such as crying, extreme self-stimulatory behavior, or an inability to keep their heads upright for any significant period of time. Many of the children in the final sample exhibited a great deal of self-stimulatory behavior and involuntary body movements but not to the extent that they were untestable. Table 3 describes the final sample on an individual basis in terms of sex, chronological age, major medical classification and

etiology, cranial anomalies, seizure and motor control disorders, sensory impairments, medication intake, and functional level. The subjects are identified by their initials. The information was obtained from the subjects' medical files. The estimates of functional level when available were generally made on the basis of a subjective judgement by the institutional staff. Some children were assessed on standardized developmental instruments but these were not always identified.

Apparatus and Stimuli

The study was conducted in a research room in the psychology department of the St. Amant Centre which had an adjoining control room. Testing took place in a three-sided enclosure, the top of which was covered by a piece of cardboard. The front of the enclosure consisted of a table on which was placed a box and framework containing the stimulus presentation projector and a rear projection screen. The top of the box was hinged to allow access to the projector. A fluorescent light was attached to the top of the frame above the screen. This light served as a reference point to facilitate the scoring of visual fixations as well as providing adequate lighting for the operation of a video recording system. The framework could be adjusted to a variety of heights by the use of

Table 3

Summary of Subjects' Medical Reports

NAME	SEX	AGE[a]	DIAGNOSIS	MOTOR	SENSORY	MEDICATIONS	PSYCHOLOGICAL
DF	M	14:03	Microcephaly of Unknown Prenatal Origin	Spastic Quadriplegic Scoliosis Hip Dislocation	Can See and Hear Well	Valium Phenobarb	Functional Level 12 to 15 Months
CT	F	9:01	Encephalopathy of Uncertain Etiology, Seizure Disorder Beginning at 4 Months	Spastic Quadriplegic	Can See And Hear Well	Valium Depakene Dilantin Folic Acid Colace	
JS	M	4:09	Microcephaly Seizure Disorder	Spastic Quadriplegic	Can See And Hear Well	Valium Depakene	
RA	M	11:08	Seizure Disorder Born Premature, Anoxia Congestive Heart Failure as Neonate	Spastic Quadriplegic Scoliosis Hip Dislocation	Ground Glass Opacification of Left Eye Lens Possible Cortical Blindness	Valium Depakene Dilantin	
CS	F	6:04	Microcephalic Delayed Development of Unknown Etiology	Choreoathetoid Movements Scoliosis Hip Dislocation	Some Hearing Loss in Right Ear		

Table 3 (Cont'd)

Summary of Subjects' Medical Reports

NAME	SEX	AGE[a]	DIAGNOSIS	MOTOR	SENSORY	MEDICATIONS	PSYCHOLOGICAL
DK	F	6:07	Seizure Disorder Born Premature Hyaline Membrane Disease	Spastic Quadriplegic Hip Dislocation	Strabismus Eye Movements Jerky	Depakene	
AT	F	2:03	Cerebral Atrophy Fetal Distress and Perinatal Asphyxia	Spastic Quadriplegic Increased Muscle Tone	Has Glasses	Valium Depakene Colace	Yale Dev. Sched. 2 months
BP	F	13:11	Seizure Disorder Intracranial Hemorrhage as Neonate	Spastic Quadriplegic Hip and Foot Deformities	Can See and Hear Well	Dilantin Mysoline	
JH	F	3:00	Microcephaly Seizure Disorder Cerebral Atrophy	Spastic Quadriplegic Movements Dominated by Very Active Neonatal Reflexes Severe Head Drop	Eyes Not Well Coordinated		
CD	M	7:01	Hydrocephalic, Athetoid Cerebral Palsy, Head Completely Flat at Back, Emergency Caesarian Due to Fetal Distress	Spastic Quadriplegic Choreathetoid Movements	Can See and Hear Well	Colace Agarol Pitressin Tannate	Socially Responsive

Table 3 (Cont'd)

Summary of Subjects' Medical Reports

NAME	SEX	AGE[a]	DIAGNOSIS	MOTOR	SENSORY	MEDICATIONS	PSYCHOLOGICAL
SB	F	7:04	Severe Brain Damage Due to Encephalitis at 1 year Seizure Disorder	Double Paraplegia Spasticity of Hands Kyphosis	Can See And Hear Well	Phenobarb Folic Acid	Functional Level 6-7 Months
JF	M	7:05	Seizure Disorder Born Premature by Caesarian	Involuntary Athetoid Movements of Head, Regurgitation of Undigested Food	Can See And Hear Well	Depakene Phenobarb Maxeran Folic Acid Noctec	

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

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wooden blocks which could be placed underneath it. A shorter table was used to lower the screen for small subjects. The screen was adjusted so that the stimulus was approximately at the subject's eye level.

The two 150-cm x 60-cm side-panels were detachable and fastened to the framework by C-clamps. This allowed the enclosure to be quickly dismantled in order to adjust the screen height as well as allowing the placement of subject wheelchairs. The side-panels and projection screen mount were painted with a white matte finish paint. The removable top was also white.

The stimuli consisted of a circle (9 cm in diameter), a moderate ellipse (minor axis = 10 cm; major axis = 13 cm), a stretched ellipse (minor axis = 9.5 cm; major axis = 16.5 cm), and an equilateral triangle (10 cm on a side). There were two versions of each stimulus, one clear and one yellow in color (Edmund Scientific Co. No. 809). Figure 1 illustrates the geometric forms used as stimuli.

The stimuli were projected by a Kodak carousel projector onto a rear projection screen mounted in the frame at the front of the enclosure. The projector was controlled and timed by relay equipment located in the control room. A pushbutton in the testing room was used to initiate the operation of the relay system at the

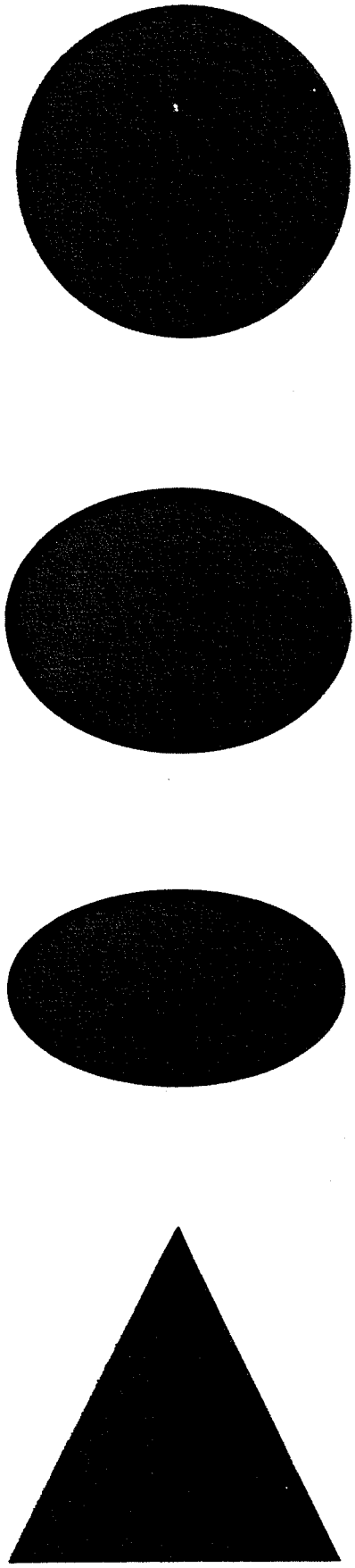


Figure 1. Stimuli Shapes; in order from top to bottom, circle, moderate ellipse, stretched ellipse, triangle.

beginning of a testing session and a reset switch could be pressed to interrupt the timing cycle in the event of any problems during the session. A foot switch was depressed when the first fixation was observed; this switch began the operation of a timer in the control circuitry which controlled the duration of the stimulus presentation following the first fixation. A clock, which was placed beside the camera, timed the interval from stimulus presentation to operation of the foot switch; that is, the latency of the first fixation.

The child's face was videotaped using a Panasonic video cassette recorder, providing a permanent tape record of each session. The camera was mounted on a tripod behind the projection screen framework (approximately 25 cm above the stimulus) and aimed through a 12-cm by 24-cm rectangular opening directly above the screen. The distance between the child's face and the stimulus projection screen ranged from 70 cm to 85 cm depending on the size of the wheelchair. A black cloth with a circular hole to accommodate the camera lens extended from the camera to the back of the screen framework enclosing the projection screen and shielding the camera from the child's view. This arrangement allowed the camera to be moved in any direction to track the child's face. As all of the light sources in the room (i.e., the light bar and the projection screen) were in front of the

cloth, it was opaque from the child's side but enabled the experimenter to view the child. The video camera was equipped with a zoom lens (f 11.5-70 mm Macro close-up) which gave a close-up view of the child's face. A television monitor attached to the camera was used to detect the first stimulus fixation during a trial and also enabled the experimenter to keep the camera lens centered on the child's face. A microphone attached to the video camera recorded the click when the projector advanced. This provided an auditory marker at the beginning and end of trials which facilitated the later scoring of the tapes. The experimenter was also able to record the latency to first fixation by reading the times aloud into the microphone during intertrial intervals. The constant noise of the projector fan masked the experimenter's voice from the subject.

Procedure

Subjects were transported to the testing room by the experimenter in the wheelchairs which they normally used on their ward. Upon entering the testing room they were moved into the enclosure, one side of which had previously been removed to facilitate the movement of the wheelchair. The wheelchair was positioned directly in front of the screen and pushed forward until the footrests touched the front

of the enclosure. The side panel was then put back in place and fastened with a C-clamp, following which the cardboard top of the enclosure was put in place.

As the subjects were of different sizes and were not capable of responding to verbal instructions, they were individually positioned in order to ensure that their faces occupied most of the video camera's monitor screen, and the camera was focused so that the eyes were clearly visible. This requirement necessitated some movement of the wheelchair, either forward or back, to find a position that allowed the image of the face to be enlarged without being blurred. The fluorescent light above the screen and the projector were then turned on; an opaque slide in the projector prevented the screen from being illuminated. The overhead light in the room was then turned off and, after ensuring that the subject was not startled by the change in lighting, the experimenter stepped behind the camera and projection screen framework out of the subject's sight.

Any necessary adjustments to the camera focus were made to ensure that the reflected image of the fluorescent light on the cornea was clear. The locking mechanisms on the tripod were released so that the camera could be moved both horizontally and vertically within the range allowed by the black cloth which enclosed the screen and

camera aperture. During this time the subject was monitored and when the face was oriented towards the screen, the experimenter operated the record button on the video camera and initiated the stimulus presentation sequence by pushing the start button. Following a 5-s delay, which provided time to adjust the camera position if the subject had moved, the first stimulus of the habituation series was presented. On each of the habituation and test trials,the stimulus was projected on the screen at the beginning of the trial and the subject was monitored through the video camera until the experimenter observed the first fixation of the stimulus at which time the foot switch which operated the presentation interval timer was depressed. If no fixation had occurred within 10 s the presentation timer was operated regardless of the subject's looking behavior. At the end of 15 s, a solid blank slide was presented during the 5-s intertrial interval.

The habituation stimulus was one of two geometric forms (circle or ellipse) either clear or yellow in color. The stimulus was presented for 12 trials of 15-s duration. The 15-s stimulus presentation was timed from the subject's first fixation. On each of four successive testing days each subject was shown one of the four habituation stimuli. The orders of presentation of the four stimuli across testing days was determined by the latin-square design

illustrated in Table 4. In this particular latin-square each stimulus follows each of the other stimuli only once, and appears in each serial position only once. Each column corresponds to the order of habituation stimuli for one quarter (N = 3) of the subjects. Subjects were assigned to presentation orders 1 to 4 in a cyclic fashion as they were selected for testing.

The eight-trial test phase began on the trial following the 12th habituation trial, intertrial interval and stimulus presentation procedures were the same as during habituation trials. Each of the four stimuli used during the test phase was presented twice. Order of presentation of the four stimuli during the test phases of the four sessions was determined by one of a series of randomized latin-squares (Edwards, 1960, p. 258) designed so that the habituation stimulus (circle or stretched ellipse), small change (moderate ellipse), medium change (stretched ellipse or circle), and large change (triangle) appeared only once in each serial position. An example of one of the latin-squares is presented in Table 5. Subjects were randomly assigned to one of the latin squares shown in Appendix B. The order of presentation for the first four test trials was repeated for the second four test trials. This method of assigning subjects to different presentation orders provided a control for order effects while avoiding confounds due to incomplete counterbalancing of the serial

Table 4

Stimulus Presentation Order During Habituation Phase

	Subjects			
Sessions	1	2	3	4
1	YCi	CCi	CEs	YEs
2	CCi	CEs	YEs	YCi
3	YEs	YCi	CCi	CEs
4	CEs	YEs	YCi	CCi

Note. Y = yellow, C = clear, Ci = circle, Es = stretched ellipse.

Table 5

Sample Stimulus Presentation Order During Test Phase

	Test Trials			
Sessions	1 & 5	2 & 6	3 & 7	4 & 8
1	H	MC	SC	T
2	MC	H	T	SC
3	T	SC	H	MC
4	SC	T	MC	H

Note. H = habituation stimulus, SC = small change (moderate ellipse), MC = medium change (alternate habituation stimulus), T = triangle (large change).

position of the habituation stimulus and the three generalization stimuli in the test series.

Visual fixations were coded from the video tapes separately by two observers who viewed the tapes and recorded each fixation by pressing a pushbutton for the duration of the fixation. The button provided input to a clock (Rockwell MCS 6522 VIA) in an Apple IIe computer. A program (see Appendix C) recorded the fixations in 1/100ths s, and calculated the total fixation time for each trial.

A fixation was scored when the reflection of the stimulus appeared over the pupil. However, since the clear and colored stimuli were of different intensities and the background color of the children's eyes varied, the reflection was not always clearly visible. Therefore, additional scoring criteria were developed using the reflection of the fluorescent cue light as a reference point. The image of the cue light appeared on the eye as a bar. Measurement of tapes on which the stimulus was visible, and live observation of several children in the testing room, indicated that the stimulus reflection occurred at a point approximately half the diameter of the pupil below the image of the cue light on a line which bisected that image. No matter which way the child's head moved the cue light always appeared as a line parallel

to the floor, providing a stable reference point. A momentary eyeblink was not considered the termination of a fixation. If the stimulus reflection was visible it was always used in preference to the cue light. If neither the stimulus nor the cue light were visible on the cornea no fixation was scored.

Results

Interobserver reliability was estimated for the total fixation time measure separately for each subject by correlating the scores obtained by the two observers over the 20 trials. The mean Pearson product-moment correlation coefficient was .83 (SD = .17). Total fixation times per trial and latency to first fixation were analyzed separately on both a group and single-subject basis.

Total Fixation Time

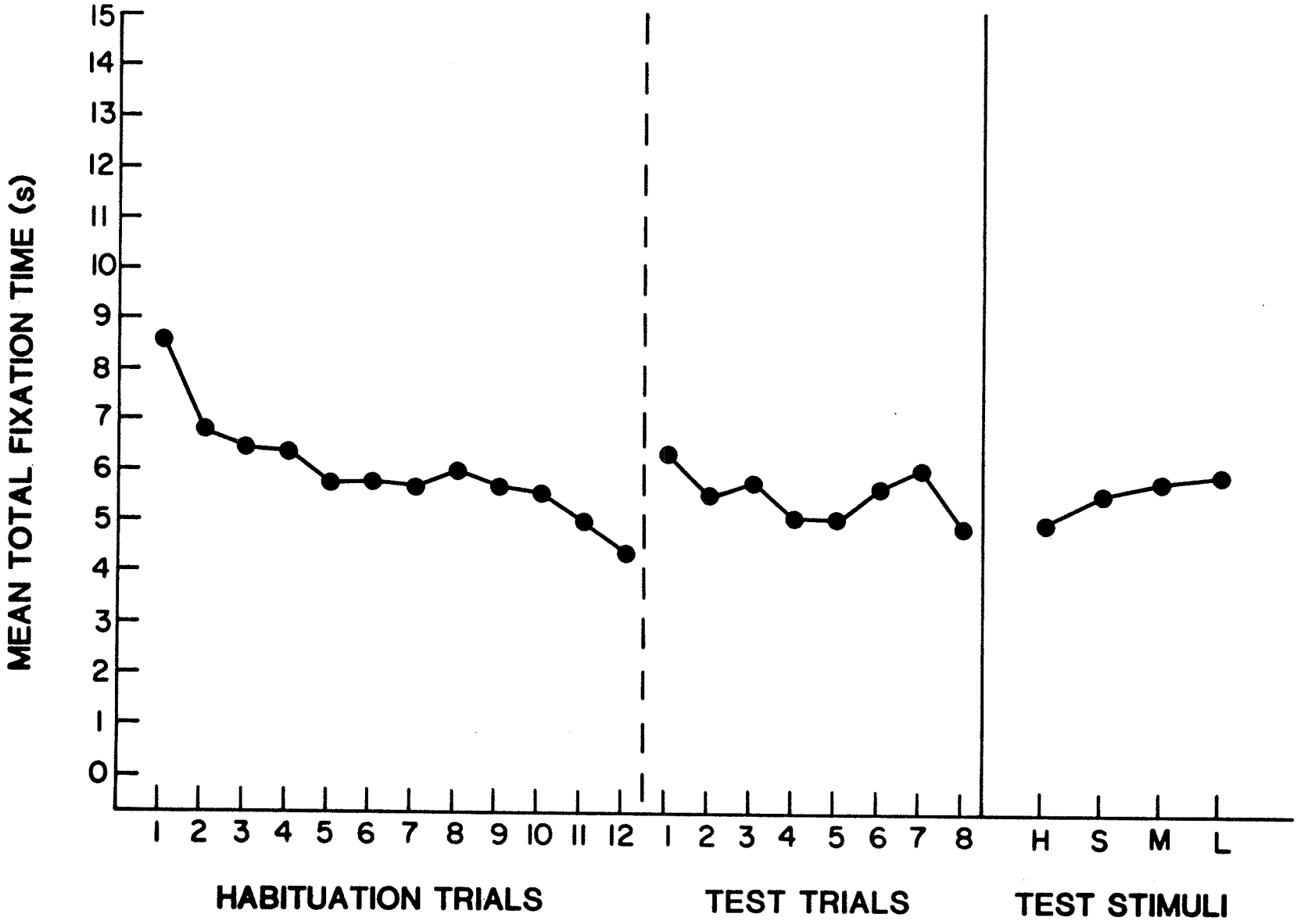
Analysis of group data. Changes in total fixation times during habituation trials were examined using a 4 x 12 repeated measures analysis of variance. Factors in the design were habituation stimulus and trials. A summary of the analysis is presented on Table 6, and indicates that the only significant effect was for trials, F (11, 121) = 5.15, p = .01. The mean total fixation time on each trial is shown in Figure 2. Visual inspection indicates that the trials effect took the form of a monotonic decrease in looking times over trials. Average total looking times decreased from 8.51 s on the first habituation trial to 4.28 s by the 12th trial. Pairwise comparisons among the set of trial means were computed using the Tukey HSD test (Kirk, 1968). The results

Table 6

Summary of ANOVA of Group Habituation Series Data

Source	SS	df	MS	F	P
Stimulus	178.55	3	59.52	2.10	.119
Error	934.27	33	28.31		
Trials	576.22	11	52.28	5.15	.01
Error	1230.56	121	10.17		
Stimulus x Trials	251.07	33	7.61	1.24	.179
Error	2233.41	363	6.15		

Figure 2. Mean total fixation time per trial during habituation and test series, and mean total fixation time to test stimuli arranged according to degree of change from the habituation stimulus for the group (H = habituation stimulus, S = small change stimulus, M = medium change stimulus, L = large change stimulus).


MEAN TOTAL FIXATION TIME (s)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
1 2 3 4 5 6 7 8 9 10 11 12
1 2 3 4 5 6 7 8
H S M L
HABITUATION TRIALS
TEST TRIALS
TEST STIMULI

indicate that, at the .05 level of significance (HSD = 2.13 s),the mean of Trial 1 differed from the means of Trials 3 through 12, and the mean of Trial 2 differed from the mean of Trial 12.

Changes in fixation times during the test series were examined by a 4 x 8 (sessions x trials) analysis of variance. There was no significant effect due either to testing sessions or test trials (Table 7).

The test series data were also arranged according to the degree of difference of the test stimuli as compared to the habituation stimulus (no difference, small change, medium change, and large change). The main question of interest was whether or not there were significant differences in looking times that were a function of this degree of difference. The mean fixation times for each degree of difference are shown in Figure 2; fixation times to the habituation stimulus appear to be shorter than to the other test stimuli. Other questions concerned whether there was an effect due to the type of habituation stimulus, and whether fixations of the first and second presentation of the test stimuli differed. The 4 x 2 x 4 (habituation stimulus x first vs. second presentation x degree of difference) repeated measures analysis of variance, summarized in Table 8, found no significant effects.

Visual inspection of the fixation times shown in

Table 7

Summary of ANOVA of Group Test Series Data Arranged According to Trial Number

Source	SS	df	MS	F	P
Session	255.77	3	85.26	1.30	.292
Error	2171.11	33	65.79		
Trial	210.03	7	30.00	1.14	.348
Error	2027.79	77	26.33		
Session x Trial	774.66	21	36.89	1.44	.103
Error	5932.31	231	25.68		

Table 8

Summary of ANOVA of Group Test Series Data Arranged According to Degree of Difference

Source	SS	df	MS	F	P
Stimulus	206.85	3	68.95	1.94	.14
Error	1175.26	33	35.61		
Presentation[a]	6.31	1	6.31	1.58	.23
Error	43.85	11	3.99		
Stimulus x Presentation	59.29	3	19.76	1.42	.26
Error	460.09	33	13.94		
DDif[b]	346.69	33	10.51		
Stimulux x DDif	41.84	9	4.65	0.50	.68
Error	916.71	99	9.26		
Presentation x DDif	11.88	3	3.96	0.56	.64
Error	231.32	33	7.01		
Stimulus x Presentation x DDif	30.20	9	3.36	0.48	.88
Error	690.27	99	6.97		

[a]First vs. second presentation of test stimuli

[b]Degree of difference

Figure 2 suggests that these times increased during the test trials as compared with the last habituation trials. To investigate the reliability of this change,the fixation times on the 12 habituation trials and eight test trials averaged over sessions were conceptualized as an interrupted time-series with intervention occurring at the onset of the test series. As the number of trials was not adequate for statistical identification of an appropriate stochastic model for the time-series process and as there was no literature available which would suggest a model, a two-step model identification procedure was adopted which provided an adequate description of the underlying process (Gottman & Glass, 1978) while providing maximum protection from spurious Type I error estimates known to result from misclassifications (Padia, 1977). In the first step, the undifferenced, 1-, 2-, 3-, and 4- differenced lag k autocorrelations and partial autocorrelations (Bower, Padia, & Glass, 1974) were examined for the group data and the data of three individual subjects who had demonstrated response decrement across the habituation trials. The behavior of the autocorrelations and partial autocorrelations in each case was consistent with an Auto-Regressive Integrated Moving Averages (ARIMA) (1,0,0) model (Glass, Wilson,& Gottman, 1975). In the second step, the data referred to above were graphically analyzed (Gottman &

Leiblum, 1974); the results of this analysis also provided support for an ARIMA (1,0,0) model. The interrupted times series analysis of fixation times using this model indicated a significant increase in level of the series contiguous with the onset of the test series, t (18) = 2.40 $p < .025$., showing a consistent increase in fixation times during test trials.

Analyses of single-subject data. The single-subject data were examined for a response decrement over the habituation series, response diminution over the test series trials, and differences in fixation times to the test stimuli. Spearman rank-order correlations were computed between total fixation time per trial averaged across sessions and trial number during the habituation series. A significant negative correlation indicates a decrease in looking times associated with an increase in trial number across the habituation series. Applying the same logic to the test series data, the Spearman correlation was computed between total fixation time per test trial and the test trial number. The Friedman two-way analysis of variance by ranks was computed on the fixation times to the test stimuli arranged according to the degree of difference from the habituation stimulus. The means for those subjects who demonstrated significant results on the Friedman test were probed using the Wilcoxon rank sum test.

Table 9 summarizes the results of the Spearman tests and Friedman two-way analysis of variance for each subject. The mean interobserver reliability score for each subject is also given in Table 9. As can be seen from this table analysis of the data for six of the subjects (DF, CT, JS, RA, DK, JH) yielded no significant results. These subjects demonstrated neither statistically significant response decrement over the habituation and test series, nor differential responding to the test stimuli. None of the other subjects showed a significant correlation between fixation times and test trial number.

Analysis of AT, SB, and JF's data yielded significant negative correlations between looking times and trial number during the habituation phase as well as a significant effect for degrees of difference among the test stimuli. Mean fixation times of the habituation, small, medium, and large change stimuli for AT were 4.54 s, 5.35 s, 6.33 s, and 9.33 s respectively (see Figure 3). The post-hoc Wilcoxon rank sum test showed that the looking time to the large degree of change stimulus was significantly different from the other three. The means for SB in ascending order of change were 4.57 s, 4.58 s, 5.73 s, and 7.96 s (see Figure 4). The Wilcoxon test indicated that the significant differences were between the large degree of difference condition and the habituation and small change condition. Mean fixation times of the ordered set of test stimuli for

Table 9

Summary of Single Subject Total Fixation Time Data Analyses

SUBJECT	SPEARMAN r_s(H)[a]	SPEARMAN r_s(T)[b]	FRIEDMAN χ_r^2	p[c]	IOR[d]
DF	-.20	-.33	1.50	.68	.92
CT	.27	-.43	.75	.86	.88
JS	-.37	-.52	3.45	.33	.89
RA	-.14	.19	1.65	.65	.62
DK	-.36	-.45	1.69	.64	.90
JH	-.28	-.02	4.99	.17	.88
AT	-.64*	-.48	9.04	.03	.89
SB	-.73**	.14	8.80	.03	.90
JF	-.71**	-.52	10.27	.02	.95
CS	-.66*	.33	5.10	.16	.93
BP	-.72**	-.29	1.95	.58	.56
CD	-.69*	.02	1.05	.79	.77

[a] Spearman r_s for habituation trials.

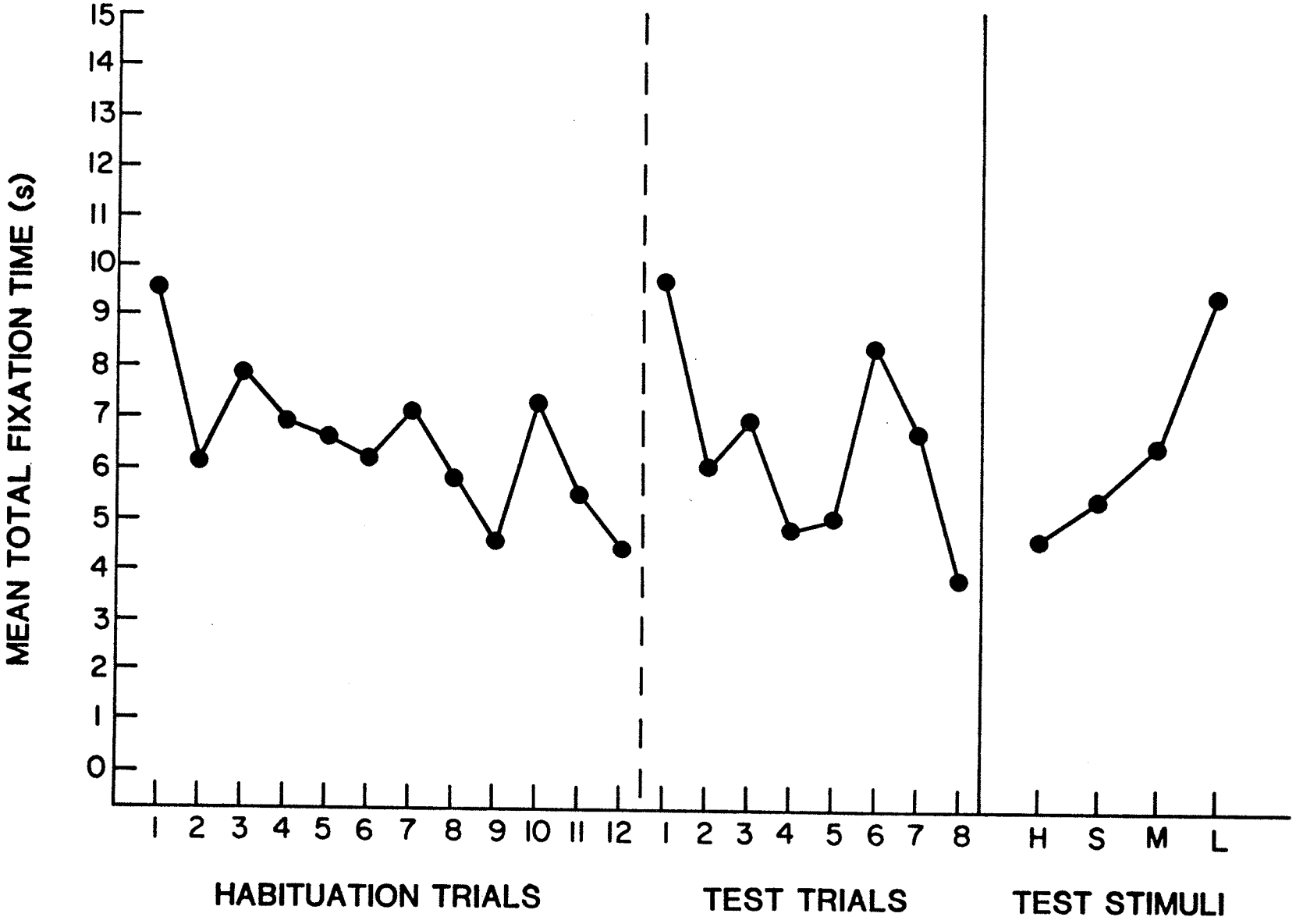
[b] Spearman r_s for test trials.

[c] Exact probabilities associated with χ_r^2.

[d] Average interobserver reliability estimate ($\overline{ro_1 \cdot o_2}$).

* $p < .05$, ** $p < .01$.

Figure 3. Mean total fixation time per trial during habituation and test series, and mean total fixation time to test stimuli arranged according to degree of change from the habituation stimulus for AT (H = habituation stimulus, S = small change stimulus, M = medium change stimulus, L = large change stimulus).


MEAN TOTAL FIXATION TIME (s)
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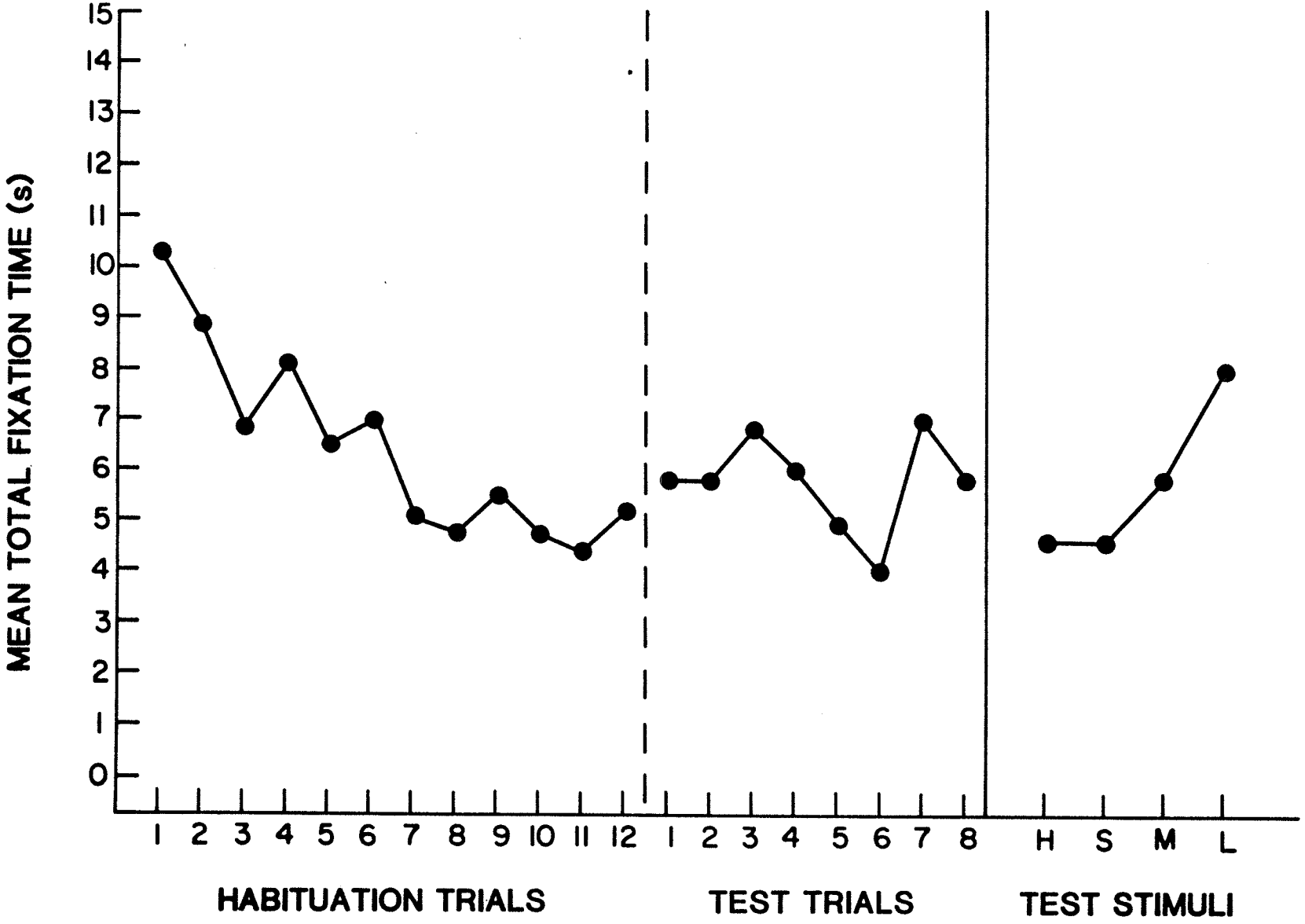
1 2 3 4 5 6 7 8 9 10 11 12
1 2 3 4 5 6 7 8
H S M L
HABITUATION TRIALS
TEST TRIALS
TEST STIMULI

Figure 4. Mean total fixation time per trial during habituation and test series, and mean total fixation time to test stimuli arranged according to degree of change from the habituation stimulus for SB (H = habituation stimulus, S = small change stimulus, M = medium change stimulus, L = large change stimulus).


MEAN TOTAL FIXATION TIME (s)
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1 2 3 4 5 6 7 8
H S M L
HABITUATION TRIALS
TEST TRIALS
TEST STIMULI

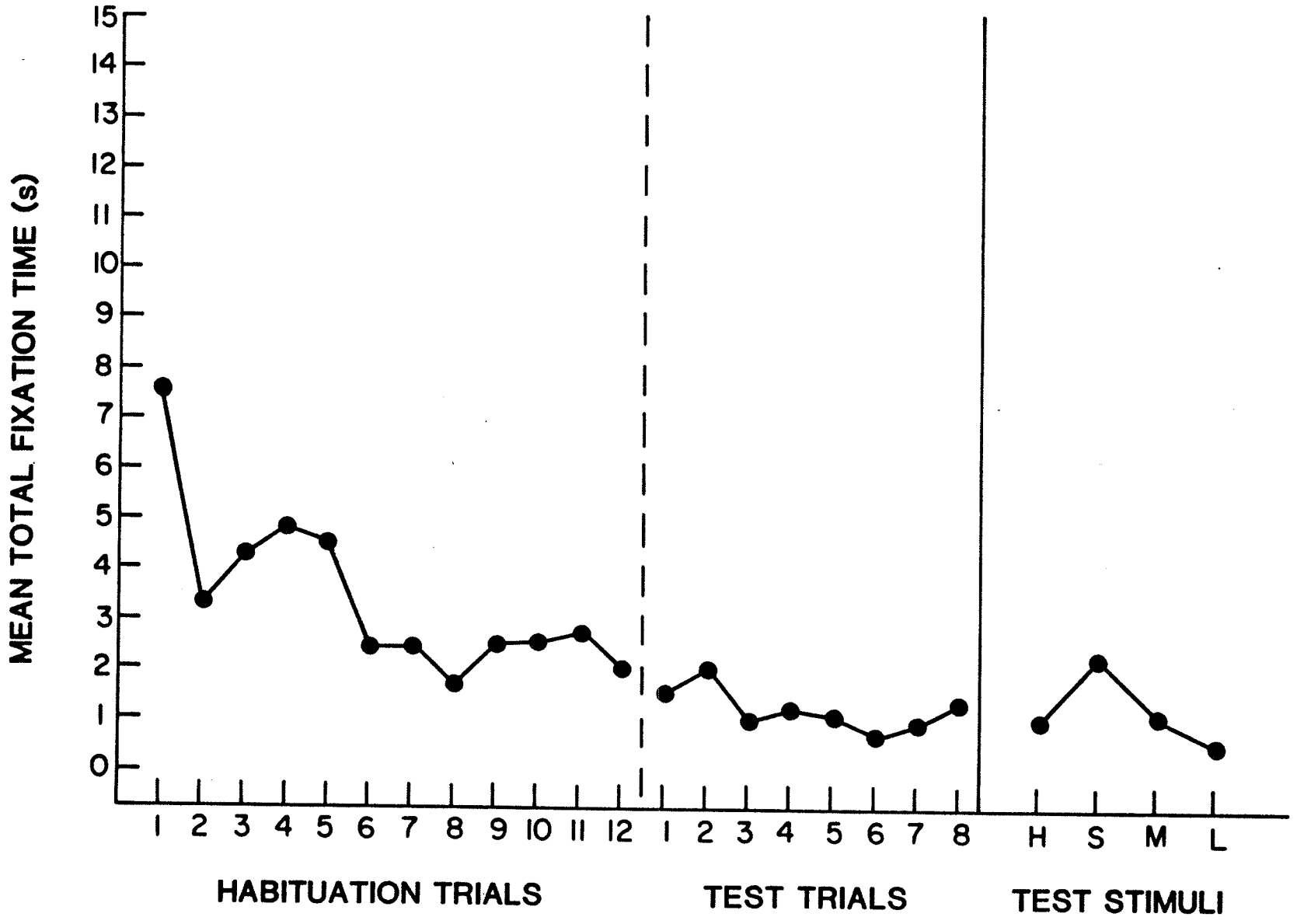
JF were .97 s, 2.16 s, 1.08 s, and .43 s (see Figure 5). The Wilcoxon test revealed (a) significant differences between the habituation and small change stimuli, and (b) significant differences between the large change and the small and medium change stimuli.

The analysis of the data for the remaining three subjects, CS, BP, CD yielded a significant negative correlation between looking times and trial number during the habituation phase; however, these subjects did not demonstrate statistically reliable differential responding to the test stimuli. The mean fixation times for CS, BP, and CD are shown in Figures 6, 7, and 8, respectively.

Latency to First Fixation

Changes in latency to first fixation during habituation trials, collapsed across sessions, were examined using a one-way analysis of variance with trials as the factor. There was not a significant effect for trials (Table 10). Mean latency over habituation trials was 2.5 s. An analysis of variance with trials as the factor examined changes in latency during test trials and also yielded no significant trial effect (Table 11). Similarily, the 4 x 2 x 4 (habituation stimulus x first vs. second presentation x degree of difference) repeated measures analysis of variance on the test series data yielded no significant results (Table 12).

Figure 5. Mean total fixation time per trial during habituation and test series, and mean total fixation time to test stimuli arranged according to degree of change from the habituation stimulus for JF (H = habituation stimulus, S = small change stimulus, M = medium change stimulus, L = large change stimulus).


MEAN TOTAL FIXATION TIME (s)
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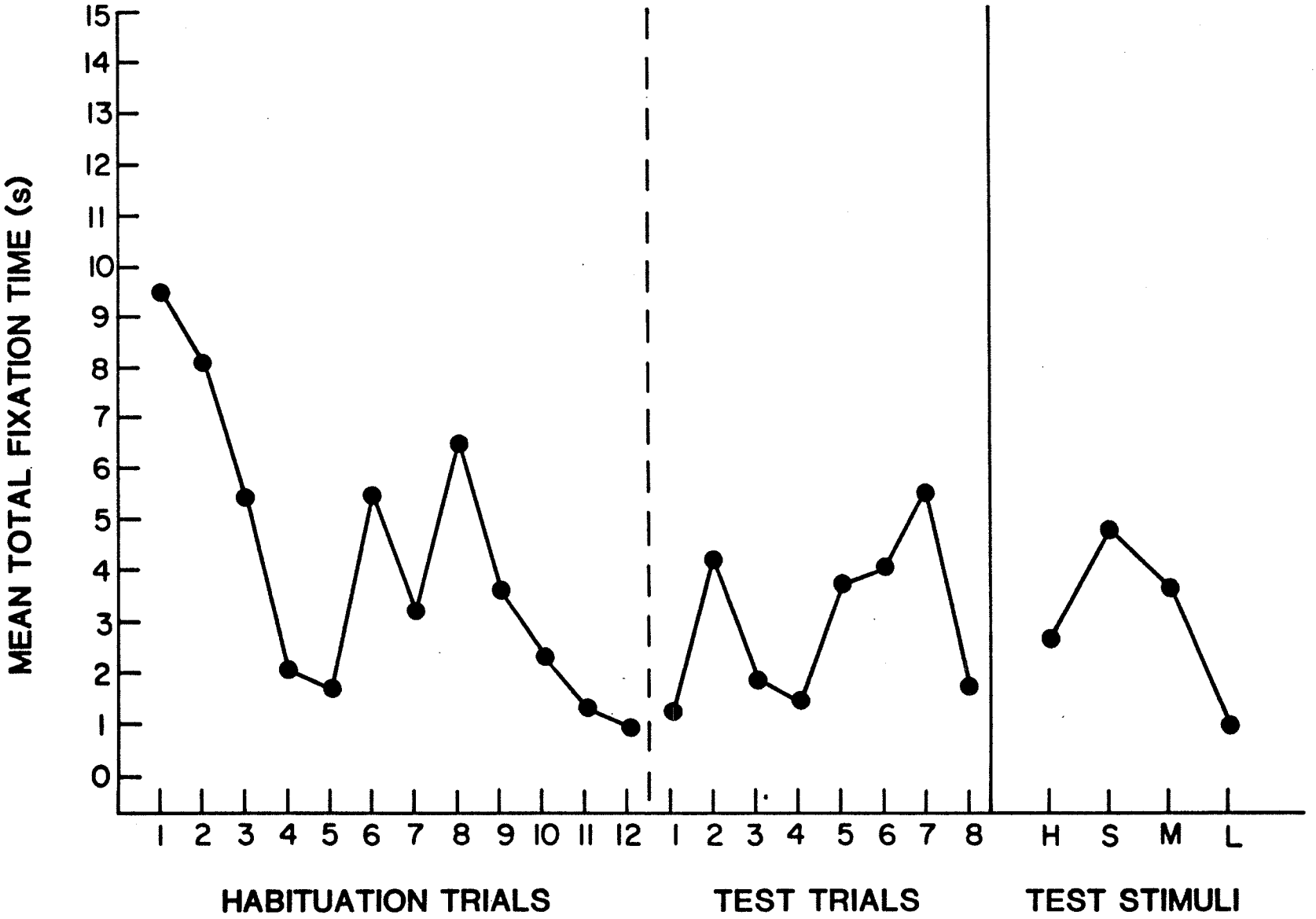
HABITUATION TRIALS
1 2 3 4 5 6 7 8
TEST TRIALS
H S M L
TEST STIMULI

Figure 6. Mean total fixation time per trial during habituation and test series, and mean total fixation time to test stimuli arranged according to degree of change from the habituation stimulus for CS (H = habituation stimulus, S = small change stimulus, M = medium change stimulus, L = large change stimulus).


MEAN TOTAL FIXATION TIME (s)
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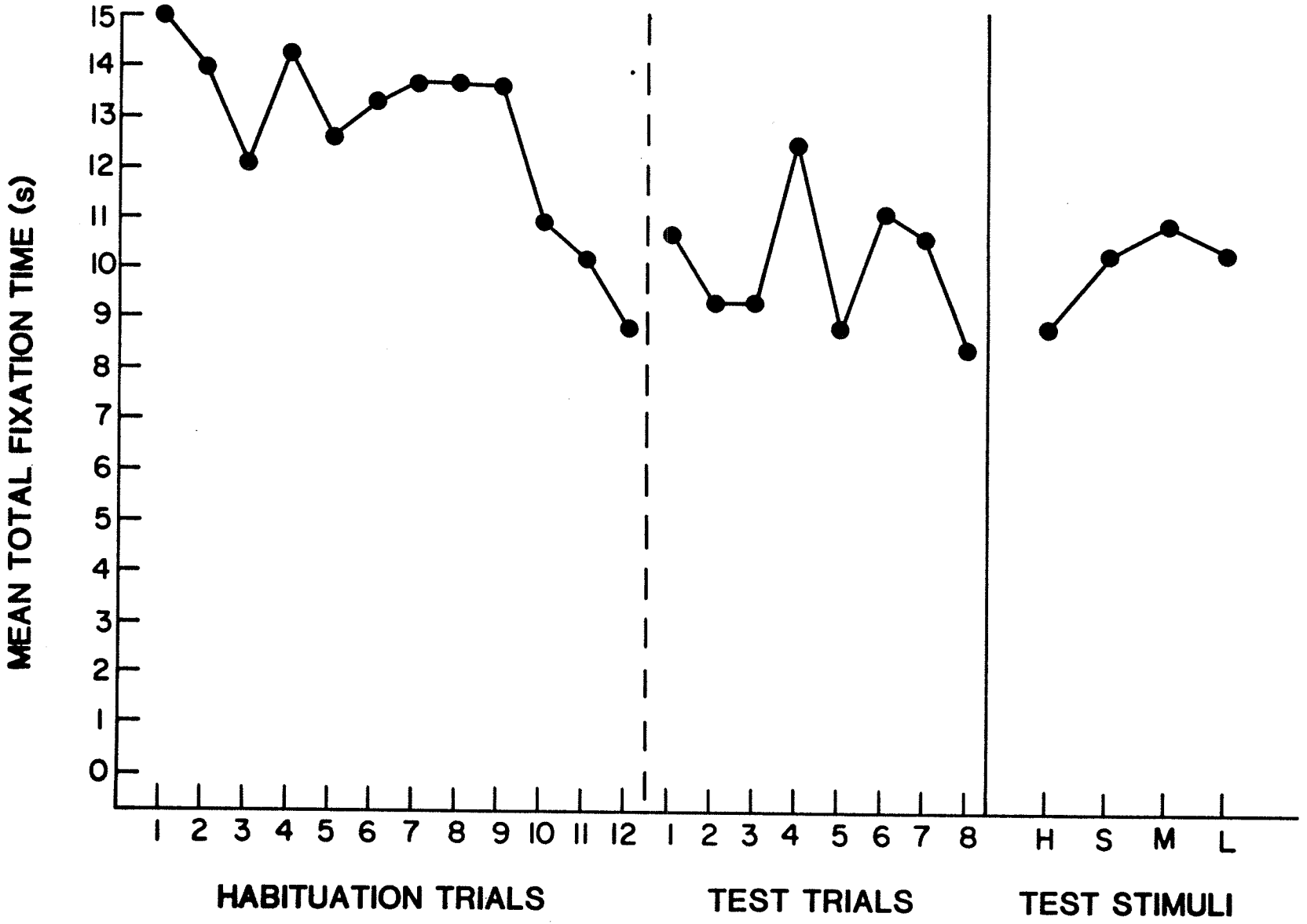
1 2 3 4 5 6 7 8
H S M L
HABITUATION TRIALS
TEST TRIALS
TEST STIMULI

Figure 7. Mean total fixation time per trial during habituation and test series, and mean total fixation time to test stimuli arranged according to degree of change from the habituation stimulus for BP (H = habituation stimulus, S = small change stimulus, M = medium change stimulus, L = large change stimulus).


MEAN TOTAL FIXATION TIME (s)
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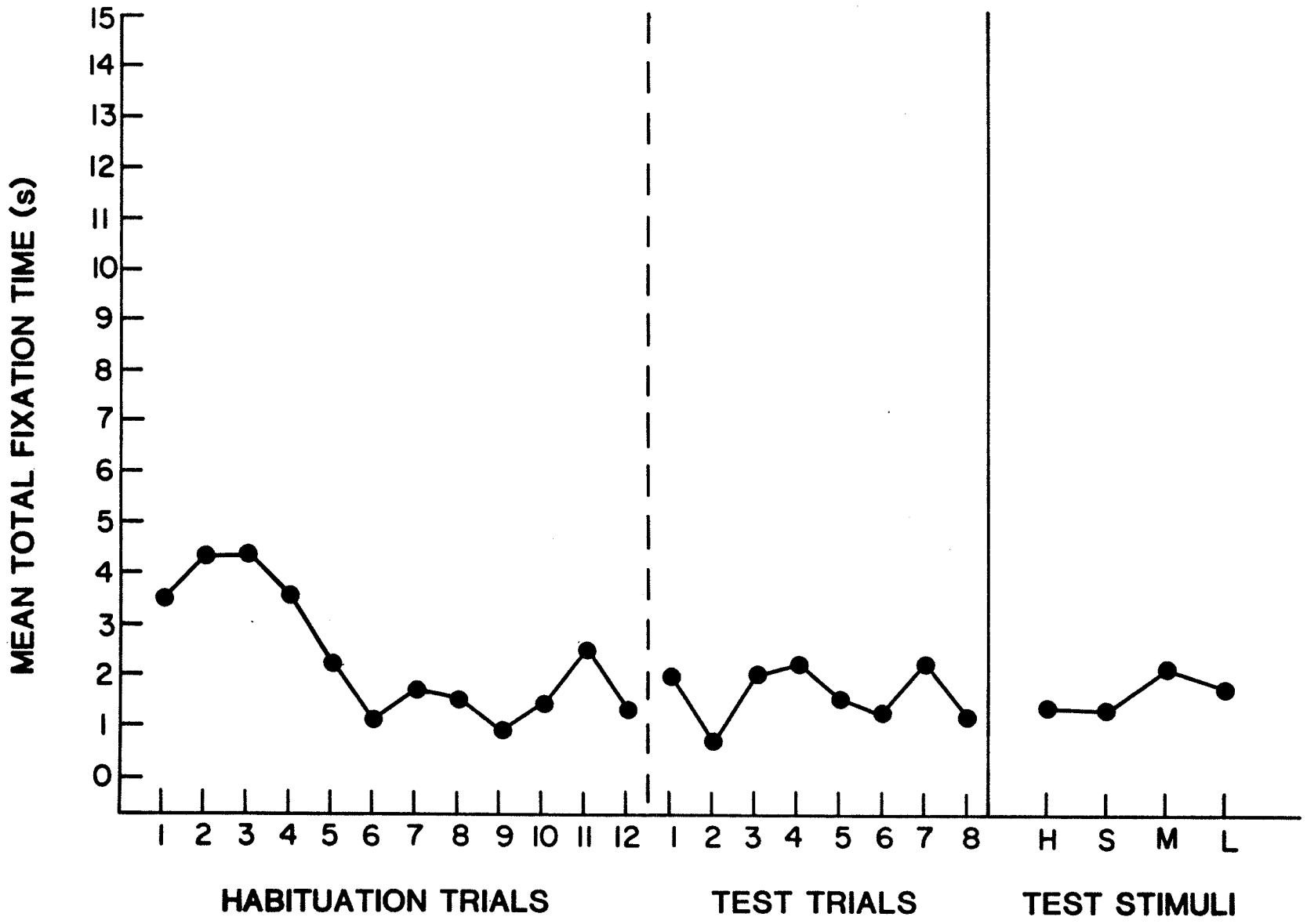
1 2 3 4 5 6 7 8
H S M L
HABITUATION TRIALS
TEST TRIALS
TEST STIMULI

Figure 8. Mean total fixation time per trial during habituation and test series, and mean total fixation time to test stimuli arranged according to degree of change from the habituation stimulus for CD (H = habituation stimulus, S = small change stimulus, M = medium change stimulus, L = large change stimulus).


MEAN TOTAL FIXATION TIME (s)
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1 2 3 4 5 6 7 8
H S M L
HABITUATION TRIALS
TEST TRIALS
TEST STIMULI

Table 10

Summary of ANOVA of Group Habituation Series Latency Data

Source	SS	df	MS	F	r
Trials	13.449	11	1.223	.97	.4778
Error	152.592	121	1.261		

Table 11

Summary of ANOVA of Group Test Series Latency Data Arranged According to Trial

Source	SS	df	MS	F	r
Trials	6.673	7	0.952	.78	.6036
Error	93.764	77	1.218		

Table 12

Summary of ANOVA of First Fixation Latencies to Test Stimuli Arranged According to Degree of Difference

Source	SS	df	MS	F	p
Stimulus	12.61	3	4.20	.81	.50
Error	172.21	33	5.22		
Presentation[a]	1.31	1	1.31	.36	.56
Error	39.99	11	3.64		
Stimulus x Presentation	23.37	3	7.79	1.08	.37
Error	238.39	33	7.22		
DDif[b]	23.22	3	7.74	2.04	.13
Error	125.19	33	3.79		
Stimulus x DDif	40.05	9	4.45	1.04	.41
Error	423.95	99	4.28		
Presentation x DDif	4.96	3	1.66	.48	.70
Error	113.84	33	3.45		
Stimulus x Presentation x DDif	37.47	9	4.16	1.33	.23
Error	309.79	99	3.13		

[a]First vs. second presentation of test stimuli.

[b]Degree of difference.

Table 13 summarizes the results of the Spearman tests and Friedman analysis of variance for each subject as well as the Pearson product-moment correlation coefficient between total fixation time per trial and latency to first fixation on each trial for individual subjects. Only the results for BP demonstrated a significant negative correlation between latencies and test trial number. DF demonstrated a significant effect for degrees of difference among the test stimuli, $\chi_r^2 = 11.29$, $p = .01$. Mean latencies to the stimuli in ascending order of difference from the habituation stimulus were 1.61 s, 1.75 s, 1.54 s, and 2.37 s. A post-hoc Wilcoxon rank sum test showed that the only significant differences were between the large degree of change condition and the other stimuli. There was a significant negative correlation between total fixation time and latency to first fixation for CT, RA, DK, JF, and CD. BP showed a significant positive correlation.

Table 13

Summary of Single Subject Latency Data Analyses

SUBJECT	SPEARMAN r_s(H)[a]	SPEARMAN r_s(T)[b]	FRIEDMAN χ_r^2	p[c]	ro_1o_2[d]
DF	-.09	.14	11.29	.01	.11
CT	-.26	.55	4.39	.22	-.31*
JS	-.19	.44	1.69	.64	-.07
RA	-.20	-.62	1.41	.70	-.21*
DK	.48	-.56	2.89	.40	-.39*
JH	.47	-.45	2.15	.54	-.18
AT	-.19	.29	2.45	.49	.01
SB	-.12	.41	0.19	.98	.07
JF	.20	.42	2.36	.50	-.34*
CS	0.0	.22	2.40	.49	-.12
BP	-.60*	-.28	3.34	.34	.27*
CD	.16	-.41	0.80	.85	-.35*

[a] Spearman r_s for habituation trials.

[b] Spearman r_s for test trials.

[c] Exact probabilities associated with χ_r^2.

[d] Pearson product-moment correlation between the two dependent variables.

*$p < .05$.

Discussion

The present research was undertaken to study stimulus discrimination and generalization in nonambulatory profoundly mentally retarded children by way of habituation of visual fixation responses. The study first sought to demonstrate habituation of visual fixation, a phenomenom found in previous studies (Berkson, 1966; Switzky, Woolsey-Hill, & Quoss, 1979), and then to demonstrate generalization of habituation to stimuli that differed from the habituation stimulus along a form dimension. Generalization of habituation along a stimulus continuum is a robust phenomenon among nonhandicapped infants (Bornstein, 1976; Caron, Caron, Caldwell, & Weiss, 1973; Dirks & Gibson, 1977; Schwartz & Day, 1979) but has not been reported in studies of the profoundly handicapped. A third intent of the present research was to examine systematic changes in latencies to first fixation as a function of repeated stimulus exposure, a measure which has been suggested by Cohen (1976) as an index of the attention eliciting properties of a stimulus. The data were examined on both a group and single-subject basis as it was hypothesized that there would be a high degree of interindividual response variability.

The group curve displayed a negative exponential decrease over habituation trials, suggesting an ongoing, albeit decelerating, process rather than an abrupt, all-or-

nothing phenomenon. Leaton and Tighe (1976) indicate that this is a common finding in the developmental literature on habituation. It is also consistent with the data from profoundly handicapped subjects presented by Berkson (1966).

Although repeated presentation of the stimulus produced a decrement in looking times, this finding cannot be unambiguously described as habituation without evidence of response reinstatement during the test series. Response reinstatement is necessary to demonstrate that the observed decrease was not the result of sensory or effector fatigue. The time-series analysis indicated an abrupt increase in level of fixations contiguous with the onset of the test series. Furthermore, the analysis of variance comparing the test series means showed no significant differences among these means. This small but constant increase in responding during the test trials can be attributed to the properties of the test stimuli and eliminates fatigue as an explanation of the observed response decrement during the habituation phase.

Inspection of the mean looking times to the test stimuli, ordered according to their degree of difference from the habituation stimulus, did not reveal the linear relationship that has been consistently found in research with normal infants (Cohen, Gelber,& Lazar, 1971; Welch,

1974). In fact, there was no evidence of differential looking to the four test stimuli.

Six of the subjects demonstrated a statistically reliable response decrement over habituation trials. Of these six only three showed differential responding to the test series stimuli. AT and SB demonstrated response decrement with response dishabituation to the triangular stimulus and generalization of habituation to two of the other three stimuli. Overall these two subjects showed the expected generalization gradient. The habituation curves for both of these subjects were similar in form to the group habituation curve. JF, who also had response decrement combined with differential fixation of the test stimuli, fixated the triangle least and the small change ellipse most during the test series. These differences between test stimuli are not consistent with a generalization gradient explanation.

In summary, only two of the subjects displayed habituation and the expected generalization gradient. Although there was evidence of stimulus control, in the group data, that is an increase in fixation times during test trials, there was no evidence that fixation times were a function of the degree of stimulus change - - no generalization gradient was obtained. It is difficult to

make any clear interpretation of a flat generalization gradient. Mackintosh (1977) points out that a generalization gradient is not necessarily a sensitive measure of the potential degree of control acquired by the stimuli. In interpreting the present research, one is left with the dilemma of determining whether the subjects were unable to display the expected linear generalization gradient due to perceptual deficiencies and neurological pathology, or whether the experimental procedures themselves prevented the demonstration of such a gradient. Mackintosh, for example, suggests that low rates of responding might result in a flat gradient due to floor effects. The low level of responding by several subjects at the end of the habituation series may, therefore, be a factor which contributed to a flattening of the gradient. Another factor may have been unplanned respondent contingencies in the experimental setting which masked the effect of the test stimuli. Some of the subjects exhibited a tendency to orient towards the blank screen following the projector click accompanying stimulus offset, which suggests that orienting to the screen might have been under the control of this unconditioned stimulus. Tomie (1981) indicates that the control exerted by such contextual stimuli may have the effect of flattening the generalization gradient.

Cohen (1976) equated decreases in latency to first fixation with a conditioning effect. Turning towards the stimulus screen was conceived of as an operant reinforced by the visual stimulus. The absence of a significant decrease in latencies to first fixation in the present study may indicate that the simple geometric stimuli were not sufficiently reinforcing to condition fixating the stimuli. On the other hand, latencies found in this experiment were short compared to the latencies reported for normal infants (Cohen, Deloache, & Rissman, 1975; Deloache, Whetherford, & Cohen, 1972), suggesting that a floor effect may have prevented demonstrating a further decrease. The click from the projector when the slide changed may have acted as an auditory prompt serving to orient the subjects towards the screen. By contrast, the Cohen studies used a blinking light to orient the infants' eyes to a portion of the screen slightly away from the stimulus presentation area prior to onset of the stimuli. These procedural differences may account for the shorter latencies to first fixation in the present study.

The analysis of latency to first fixation data for single subjects yielded only two significant results. BP demonstrated faster fixations across the habituation trials. This trend would be consistent with an operant conditioning effect. During the test series, DF had

slower orienting times to the triangle than to the other three stimuli. There is no readily apparent explanation for this finding.

For several subjects there was a negative correlation between total fixation time and latency to first fixation. There are two possible explanations for these correlations. First, those subjects who engaged in self-stimulatory behaviors at the beginning of a trial took longer to make an initial fixation and generally spent a large portion of the remainder of the trial engaging in these competing behaviors thereby decreasing the amount of time spent fixating the stimulus. Second, even if a subject had not fixated the stimulus by the end of 10 s, the 15-s stimulus presentation period was commenced. Thus, the amount of time available to the subject to view the stimulus following the first fixation was less when the latency to first fixation was more than 10 s as compared to the time available when the latency was shorter than 10 s.

As predicted, the subjects exhibited a great deal of interindividual response variability (Landesman-Dwyer & Sackett, 1978; Shepherd & Fagan, 1981). Many of the subjects in the final sample exhibited ideosyncratic behaviors and motoric disorders, such as an inability to control head movements, which contributed to a high degree of intersubject variability. Fourteen subjects

were eliminated after one testing session due to behaviors that were totally incompatible with the testing procedure. Methodological improvements aimed at reducing these difficulties would allow a greater proportion of the NPMR population to be tested. Prosthetic devices attached to the wheelchair, which provide head support and a degree of restraint, could reduce movements due to motor control disorders and decrease some classes of self-stimulatory behavior, such as head rocking. There is evidence that the presentation of appropriate stimuli acts to suppress self-stimulatory behavior in NPMR subjects (Meyerson, Kerr, & Michael, 1967; Murphy, Nunes, & Hutchings-Ruprecht, 1977). A set of stimuli that has higher interest value than those used in this experiment might reduce self-stimulatory behavior. Since the amount of self-stimulatory behavior for many of the subjects was directly related to the amount of time spent in the experimental setting, a shorter habituation series might be advisable.

Further research using a similar design but varying stimulus exposure times and incorporating stimuli of high interest value would help to determine optimum exposure parameters and methodology for the investigation of generalization of habituation in the NPMR. The present research suggests that as little as 45 s of stimulus presentation might be sufficient to demonstrate habituation.

Such research would also allow the investigation of possible changes in the slope of the generalization gradient as a function of the amount of stimulus exposure time. Graham (1973) has suggested that the slope of the generalization gradient is directly proportional to exposure time. That is, the longer the habituation series the steeper the slope of the generalization gradient.

The present research demonstrated habituation of a visual fixation response in a group of NPMR subjects combined with response reinstatement during test trials. There was no evidence of ability to discriminate one test stimulus from another in the group data. Two of the subjects demonstrated habituation and generalization.

The NPMR are a unique population. It would be an understatement to say that the development of adaptive behavior-change programs for these individuals has been extremely difficult. They are not amenable to most conventional methods of psychological research and their learning processes are not well understood. An important factor contributing to the difficulty in the development of a practical behavioral technology for training these individuals is their low level of responsivity to external stimuli. Habituation research is of value in determining the extent to which manipulations of external stimuli exert behavioral control among the NPMR.

There are numerous problems in demonstrating habituation and a generalization gradient in the NPMR using visual fixation responses. The most obvious difficulties in the present research resulted from impairment of motor functioning, involuntary movements, and self-stimulatory behaviors. Despite these difficulties research of this nature appears useful for the study of sensory processes and behavioral plasticity in this population.

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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. (8) Horizontal eye coordination: red ring
5. (9) Horizontal eye coordination: light
6. (10) Eyes follow moving person
7. (12) Vertical eye coordination: light
8. (14) Vertical eye coordination: red ring
9. (15) Circular eye coordination: light
10. (16) Circular eye coordination: red ring
11. (19) Turns eyes to red ring
12. (20) Turns eyes to light
13. (24) Blinks at shadow of hand
14. (34) Glances from one object to another
15. (37) Reaches for dangling ring
16. (40) Head follows dangling ring
17. (45) Inspects own hands
18. (46) Closes on dangling ring

[a]Numbers in parantheses indicate item numbers from Bayley Scale

APPENDIX B

Habituation Stimuli Presentation Orders and Test Series Latin Squares

On the following pages Sess = session, H = habituation stimulus, Y = yellow, C = clear, Ci = circle, E_S = stretched ellipse, E_M = moderate ellipse, T = triangle. The test stimuli are the same color as the habituation stimulus on each session. The test series latin-squares show the stimuli representing the appropriate degree of difference from the habituation stimulus.

Subject DF

Sess	H	Test Order			
1	YCi	T	E_M	Ci	E_S
2	CCi	E_M	T	E_S	Ci
3	YE_S	E_S	Ci	E_M	T
4	CE_S	Ci	E_S	T	E_M

Subject CT

Sess	H	Test Order			
1	CCi	E_S	Ci	T	E_M
2	CE_S	T	E_M	E_S	Ci
3	YCi	E_M	T	E_S	Ci
4	YE_S	E_S	Ci	E_M	T

Subject JS

Sess	H	Test Order			
1	CE_S	E_S	E_M	T	Ci
2	YE_S	E_M	Ci	E_S	T
3	CCi	T	Ci	E_S	E_M
4	YCi	E_S	T	E_M	Ci

Subject RA

Sess	H	Test Order			
1	YE_S	E_S	E_M	T	Ci
2	YCi	T	E_S	Ci	E_M
3	CE_S	E_M	T	Ci	E_S
4	CCi	E_S	Ci	E_M	T

Subject CS

Sess	H	Test Order			
1	YCi	E_S	T	E_M	Ci
2	CCi	Ci	E_S	T	E_M
3	YE_S	E_M	E_S	Ci	T
4	CE_S	T	E_M	E_S	Ci

Subject DK

Sess	H	Test Order			
1	CCi	E_M	T	Ci	E_S
2	CE_S	E_S	E_M	Ci	T
3	YCi	E_S	Ci	T	E_M
4	YE_S	T	Ci	E_M	E_S

Subject AT

Sess	H	Test Order			
1	CE_S	E_S	Ci	E_M	T
2	YE_S	Ci	E_S	T	E_M
3	CCi	T	E_M	Ci	E_S
4	YCi	E_M	T	E_S	Ci

Subject BP

Sess	H	Test Order			
1	YE_S	E_S	E_M	Ci	T
2	YCi	E_M	Ci	T	E_S
3	CE_S	Ci	T	E_M	E_S
4	CCi	T	E_S	Ci	E_M

Subject JH

Sess	H	Test Order			
1	YCi	T	E_M	Ci	E_S
2	CCi	E_M	E_S	T	Ci
3	YE_S	E_S	T	Ci	E_M
4	CE_S	Ci	E_S	E_M	T

Subject CD

Sess	H	Test Order			
1	CCi	E_M	Ci	T	E_S
2	CE_S	T	Ci	E_M	E_S
3	YCi	Ci	E_M	E_S	T
4	YE_S	Ci	T	E_S	E_M

Subject SB

Sess	H	Test Order			
1	CE_S	E_M	T	Ci	E_S
2	YE_S	Ci	E_M	E_S	T
3	CC	Ci	E_S	T	E_M
4	YC	T	Ci	E_M	E_S

Subject JF

Sess	H	Test Order			
1	YE_S	E_M	T	Ci	E_S
2	YC	T	E_S	Ci	E_M
3	CE_S	Ci	E_S	E_M	T
4	CC	Ci	E_M	T	E_S

APPENDIX C

Data Reduction Computer Program

```
10 D$ =  CHR$ (4)
20  PRINT D$;"BLOAD C3000H"
24  DIM F(20),Z(200)
30  POKE 49339,224
40  POKE 49332,243
50  POKE 49333,39
60  POKE 49336,196
70  POKE 49337,9
80 D$ =  CHR$ (4)
100 I = 0:T = 0:F1 = 0:B = 0:H = 0:PR = 0
200  HOME :S$ = "S"
210  INPUT " TYPE SUBJECT NUMBER ? ";A$
220 S$ = S$ + A$
230  PRINT : PRINT :C$ = " SESSION NUMBER# "
240  INPUT " TYPE SESSION NUMBER ? ";A$
250 C$ = C$ + A$
260  PRINT : PRINT :O$ = "NUMBER OF OBSERVERS= "
270  INPUT " TYPE NUMBER OF OBSERVERS ? ";A$
280 O$ = O$ + A$
290  PRINT : PRINT :T1$ = "NUMBER OF TRIALS= "
300  INPUT " TYPE NUMBER OF TRIALS ? ";L
310  HOME : PRINT : PRINT
320  PRINT "    TRIAL NUMBER 1"
330  PRINT "    ***************"
340  IF A$ = "2" THEN 2000
350  PRINT : PRINT
360  INPUT "  PRESS RETURN TO BEGIN TRIAL";R$
370  POKE 49337,9: REM  RESET CLOCK2
380  CALL 12288: REM   GO TO CLK ROUTINE 3000H
390  REM  STORE DATA AFTER EACH TRIAL.
400 T = T + 1
500 F(T) =  PEEK (8): REM  FIXATION COUNTER
502  IF F(T) <  > 0 THEN 505
503 I = I + 1:F1 = F1 + 1:Z(I) = 0
504  GOTO 590
505 F1 = F1 + F(T)
510  REM  PROCESS RESPONSE TIME
515 D = 1:D1 = 2
520 I = I + 1
525  REM  JOIN LO/HI BYTE CLOCK TIME
530 Y =  PEEK (8191 + D) +  PEEK (8191 + D1) * 256
540 D = D + 2:D1 = D + 1
550 X =  PEEK (8191 + D) +  PEEK (8191 + D1) * 256
553 D = D + 2:D1 = D + 1
555  IF Y >  = X THEN 560
557 Y = Y + 2500
560 Z(I) = Y - X: REM  STORE RESPONSE TIME Y=ON,X=OFF
580  IF I <  > F1 THEN 520
590  IF T = L THEN 620
```

```
600  PRINT : PRINT
610  PRINT "    TRIAL NUMBER ";T + 1
615  GOTO 350
620  HOME : PRINT : PRINT
630  PRINT "    SESSION IS OVER....."
640  PRINT : PRINT
650  PRINT "DATA IS NOW BEING STORED ON DISK."
660  PRINT D$;"OPEN";S$: PRINT D$;"DELETE";S$
670  PRINT D$;"OPEN";S$
680  PRINT D$;"WRITE";S$
690  PRINT S$: PRINT C$
700  PRINT O$: PRINT T1$;L
710  PRINT L
800  FOR J = 1 TO T
805  PRINT F(J): REM    FIXATION COUNT
807  IF F(J) <  > 0 THEN 810
808 H = H + 1: GOTO 820
810 H = H + F(J)
820 B = B + 1
830  PRINT Z(B): REM  RESPONSE TIME.
840  IF B < H THEN 820
860  NEXT J
870  PRINT D$;"CLOSE";S$
880  PRINT : PRINT
890  PRINT "DATA IS NOW STORED UNDER FILE ";S$
900  PRINT : PRINT
910  INPUT "DO YOU WISH TO BEGIN ANOTHER SESSION?";R$
915  PRINT : PRINT
920  IF R$ = "YES" THEN 100
930  IF R$ = "NO" THEN 950
940  GOTO 900
950  PRINT "IF YOU WISH TO DISPLAY DATA TYPE'RUN 1000'"
960  PRINT "   ************"
970  PRINT "   **   END  **"
980  PRINT "   ************"
990  END
1000  REM  THIS ROUTINE READS A FILE AND DISPLAYS DATA.
1005  DIM F1(20),Z(200)
1007 D$ =  CHR$ (4)
1010  HOME :K = 0
1020  INPUT "  TYPE FILE NAME TO BE READ ";F$
1030  PRINT D$;"OPEN";F$
1040  PRINT D$"READ";F$
1050  INPUT S$,C$,O$,T1$,L
1060  FOR I = 1 TO L
1070  INPUT F1(I)
1072  IF F1(I) <  > 0 THEN 1080
1074 K = K + 1: INPUT Z(K)
1076  GOTO 1110
```

```
1080  FOR J = 1 TO F1(I)
1085 K = K + 1
1090  INPUT Z(K)
1100  NEXT J
1110  NEXT I
1112  PRINT D$;"CLOSE";F$
1115 K = 0:S = 0:CT = 0:X = 0
1120  HOME
1124  PRINT "WANT TO PRINT DATA?"
1126  INPUT "TYPE YES OR NO.";A$
1130  IF A$ = "NO" THEN 1135
1132  PRINT D$;"PR#1"
1133 PR = 1
1135  FOR I = 1 TO L
1140  PRINT "TRIAL = ";I;" FIXATION = ";F1(I)
1141  IF F1(I) <  > 0 THEN 1143
1142 S = S + 1: GOTO 1145
1143 S = S + F1(I)
1145 K = K + 1
1160  PRINT Z(K)
1165 X = X + Z(K)
1170  IF K < S THEN 1145
1174  PRINT "TOTAL = ";X
1176 X = 0
1180  PRINT
1185  IF PR = 1 THEN 1198
1190 CT = CT + 1
1192  IF CT <  > 5 THEN 1200
1194 CT = 0: PRINT
1196  INPUT " TYPE RETURN TO CONTINUE.....";A$
1198  PRINT
1200  NEXT I
1205  IF PR <  > 1 THEN 1210
1207  PRINT D$;"PR#0"
1210  INPUT "WANT TO PRINT?";A$
1212  IF A$ = "YES" THEN 1132
1220  PRINT "*****************"
1230  PRINT "**     END    **"
1240  PRINT "*****************"
1250  END
2000  REM  ROUTINE TO SOLVE FOR 2 RESPONSES
2010  END
```

APPENDIX D

Total Fixation Time Raw Data Files

Total Fixation Time Per Habituation Trial Raw Data

The following page presents a listing of the total fixation time per habituation trial for all subjects. Each line shows the fixation times on 12 trials for a given subject on one testing session; each set of four successive lines refers to four successive testing sessions for a given subject (ie. lines 1-4 are the four testing sessions for the first subject, lines 5-8 the four testing sessions for the second subject and so on). The data is in 1/100ths s and is presented in four digit, right-justified format.

Line Numbers	Subject
1 - 4	DF
5 - 8	CT
9 - 12	JS
13 - 16	RA
17 - 20	CS
21 - 24	DK
25 - 28	AT
29 - 32	BP
33 - 36	JH
37 - 40	CD
41 - 44	SB
45 - 48	JF

1. 0587092606250717031702820262105310630118092202812. 0803044601510491022606341282010503280238011404453. 0413026501040919068405830716009208320868055002494. 0351046902820581033200840480025707460450001900315. 0923102413551204142213971109152614241621116015086. 1570094315881559135315231552148513631305089615087. 1565051806610797062906011497149409741389084213908. 1542136815481518148115281496143710421433153815359. 0563019303630139012605130110030305100165045102841 0. 1107087901740601023510650534069601860198076203661 1. 0999085400570629014004790467052805870205126404301 2. 0808077810440803106512740367072708080579083005511 3. 1346000012450151010601910192016103880555050100181 4. 1306035305050601141903931034074807841268063505931 5. 0071053605720600019202040575045201310748021403431 6. 1119097015280304030205820298099709370654090006191 7. 0803083807750069003205170537101905700461020700001 8. 0528052202100131033607460483065700000072002900161 9. 1192095109490245007102680131024605170028025702992 0. 1270092902050322021106510070065103200341000000332 1. 1267066901500241042900000000026901420000030103452 2. 0402036401720114054700000296081601220100000000002 3. 0655115601530136020004150105067003921055021501282 4. 0796059103240575043500550392034504550650015501152 5. 1061059006650415038101650603061706421106102507972 6. 1023055108540762082810170889030901530476042304762 7. 1029067107340536061607140754018304570521049204652 8. 0650059208561025081105730588121105440796025500003 9. 1391140014831439142414431523145314711048150314203 0. 1642145212891518126914151501128011601347145707613 1. 1481121006021260092409450953131512410404000000004 2. 1504151714001486140614911472143115551526111113133 3. 0302029104370048033902080109012500260182018600954 4. 0000010604590791055707160574022006210247022602785 5. 0058010401330710064800640128016702550017000000346 7. 0197036706610156018601100159000004560804001904357 8. 0197035301820211002200000118001300000018015500678 9. 0354023000980000000000310000000000350151038400389 0. 0659098506220827050802930367053302690357038403701 1. 0181012208190397034901070191001500390020005800442 2. 1153068903460860037202760641030204700567039703843 3. 0838117410700552079406730633038003290300026102984 4. 0972068007130760034407430191063707020327039006975 5. 1144098105911030105911000522055606880661069306956 6. 0693012800460128040005910076005100500217005500247 7. 0756044409090895034100520590033804920442033502738 8. 0415018504570162002600990079024402290135019202629 9. 1164053503050722099502180224001602040174048002060

Total Fixation Time Per Test Trial Raw Data

The following page presents a listing of the total fixation time per test trial for all subjects. Each line shows the fixation times on eight trials for a given subject on one testing session; each set of four successive lines refers to four successive testing sessions for a given subject (ie. lines 1-4 are the four testing sessions for the first subject, lines 5-8 the four testing sessions for the second subject and so on). The data is in 1/100ths s and is presented in four digit, right-justified format.

Line Numbers	Subject
1 - 4	DF
5 - 8	CT
9 - 12	JS
13 - 16	RA
17 - 20	CS
21 - 24	DK
25 - 28	AT
29 - 32	BP
33 - 36	JH
37 - 40	CD
41 - 44	SB
45 - 48	JF

1. 11760628114906371013030408650844
2. 10191236036200750504083004620661
3. 12930689072606350713055602540645
4. 05310364008305010938010706080839
5. 15131242138307541534159315061538
6. 15641543138506650725146214681005
7. 14321352147307731563143714981374
8. 14441250127711461023007110191242
9. 03970549059503170827041607290332
10. 12850756047904330262091402600608
11. 02870166067104610301020104210242
12. 03010474020901850227044300420285
13. 09651166093506750232140904910222
14. 01960334049101790334060202790284
15. 01840148075715040845071613771311
16. 08210267039305950368061906530316
17. 01740264005500000362000010240135
18. 00390081006300000084070801140334
19. 02650695013500000794019006550024
20. 00000611045705460213067304050165
21. 04260687086614400449067705990408
22. 03160263005603340382000001020065
23. 02860000047203680795084807540233
24. 13100076053000000000007505970000
25. 00000000021002780625064506560843
26. 14710922116605060561027707840162
27. 11880147053506920382092303890042
28. 12141309088004220461151408180464
29. 11770742069010330284068813170666
30. 13701298142415071217130913761107
31. 15051487156315871551160715171331
32. 01930159000008890421081400000246
33. 01170677001800000183084004200850
34. 08658936121105920597065303260040
35. 00570260063600600000027508500167
36. 00000089000002260155016000390694
37. 01100097043808100446030803820149
38. 01790022019100000069005100000027
39. 03670142007300000000006303060218
40. 01180000007900430065002401690016
41. 07091068070105920426060807110460
42. 06830487048008460347024102720411
43. 01930327128806030868036011410312
44. 06970426024003250313036306451132
45. 02870034016402780314027102970126
46. 00000223001901200000000000000344
47. 00440081019700250084000000360015
48. 02690429000000540000000000000000

Total Fixation Time Per Test Stimulus Arranged According to Degree of Difference from Habituation Stimulus

The following two pages present a listing of the total fixation time per test stimulus arranged according to degree of difference from the habituation stimulus. Each line presents in order the fixation times to the habituation, small change, medium change and large change stimuli. Each successive set of two lines represents the first and second presentations of the test stimuli on a given session for a subject; each successive set of eight lines represents the two test stimuli presentation sets for a subject on four successive days. The data is in 1/100ths s and is presented in four digit, right-justified format.

Line Numbers	Subject
1 - 8	DF
9 - 16	CT
17 - 24	JS
25 - 32	RA
33 - 40	CS
41 - 48	DK
49 - 56	AT
57 - 64	BP
65 - 72	JH

Line Numbers	Subject
73 - 80	CD
81 - 88	SB
89 - 96	JF

1. 11490628063711 76
2. 08650304084410 13
3. 00751019036212 36
4. 06610504046208 30
5. 12930726068906 35
6. 07130254055606 45
7. 03640501053100 83
8. 01070839093806 08
9. 12420754151313 83
10. 15931538153415 06
11. 13851543066515 64
12. 14681462100507 25
13. 07731432147313 52
14. 13741563149814 37
15. 14441277125011 46
16. 10231019007112 42
17. 03970549031705 95
18. 08270416033207 29
19. 04791285075604 33
20. 02600262092406 08
21. 01660461067102 87
22. 02010242042103 01
23. 01850209030104 74
24. 02850042022704 43
25. 09651166067509 35
26. 02321409022204 91
27. 04910179033401 96
28. 02790284060203 34
29. 15040184075701 48
30. 13110845137707 16
31. 02670393082105 95
32. 06190653036803 16
33. 00000055017402 64
34. 01351024036200 00
35. 00390000008100 63
36. 00840334070801 14
37. 06950265013500 00
38. 01900794065500 24
39. 04570611054600 00
40. 04050673016502 13
41. 08660426144006 87
42. 05990449040806 77
43. 03160263005603 34
44. 03820000010200 65
45. 00000368028604 72
46. 08480233079507 54
47. 00000530007613 10
48. 00000597007500 00
49. 00000210000002 78
50. 06250656064508 43
51. 09220506147111 66
52. 02770162051607 84
53. 05350147069211 88
54. 03890923004203 82
55. 04221214088013 09
56. 04640461081815 14
57. 11770742069010 33
58. 02840688131706 66
59. 12981370150714 24
60. 13091217110713 76
61. 15871563150514 87
62. 13311517155116 07
63. 00000889015901 93
64. 00000246081404 21

65. 0018067700000117
66. 0420084008500183
67. 0592086509361211
68. 0040059706530326
69. 0057006006360260
70. 0000016708500275
71. 0089000000000226
72. 0160003901550694
73. 0097011008100438
74. 0308044601490382
75. 0000019100220179
76. 0027000000510069
77. 0367014200730000
78. 0000006303060218
79. 0118004300790000
80. 0065001601690024
81. 0592070907011068
82. 0460042607110608
83. 0480048706830846
84. 0272024103470411
85. 0193060303271288
86. 0868031203601141
87. 0426024003250697
88. 0363064511320313
89. 0278028701640034
90. 0126031402970271
91. 0019012002230000
92. 0000034400000000
93. 0081019700440025
94. 0000003600840015
95. 0269042900540000
96. 0000000000000000