DISCRIMINATION OF FACIAL EXPRESSIONS BY NONAMBULATORY PROFOUNDLY MENTALLY RETARDED CHILDREN

by

Mohammad Mahmudur Rahman

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A thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF ARTS

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ABSTRACT

Profoundly mentally retarded persons who are nonambulatory because of severe motor disabilities have been especially difficult to assess. Recently, methods devised for studying infant perceptual and memorial abilities, such as the habituation-dishabituation paradigm, have enabled researchers to obtain information about the cognitive functioning of this population (e.g., Berkson, 1966; Kelman & Whiteley, 1986; Switzky, Woolsey-Hill, & Quoss, 1979). Researchers have found that nonambulatory profoundly mentally retarded subjects can discriminate between male and female faces (Butcher, 1977), as well as between facial and non-facial stimuli (Shepherd, Kleiner, & McMurrer, 1984). Research with nonhandicapped infants has demonstrated that infants can discriminate between emotional expressions as early as 3 months of age (Barrera & Maurer, 1981). But no study has been conducted to find out whether nonambulatory profoundly mentally retarded individuals can discriminate among the fundamental facial expressions. The purpose of the present study was to investigate whether nonambulatory profoundly mentally retarded children and adolescents can discriminate between facial expressions of happiness and surprise posed by a female adult. It was hypothesized that subjects who are habituated to one facial expression will

show dishabituation when a second facial expression is presented.

Fourteen nonambulatory profoundly mentally retarded subjects (mean CA = 10.3 years, mean MA = 4.1 months) participated in the study. The method involved a fixed-trial habituation-dishabituation paradigm. The stimuli were colored slides of facial expressions of happiness and surprise posed by a female model. Each subject participated in four sessions. An interval of at least 24 hours was maintained between sessions. Each session consisted of four phases: 1 pretest trial, a series of 12 or 14 habituation trials, 4 test trials, and 1 posttest trial. Subjects in the Happy-Surprise (HSHS) group received the happy expression as the habituating stimulus in Session 1, the surprise expression as the habituating stimulus in Session 2, happy in Session 3, and surprise in Session 4. The Surprise-Happy (SHSH) group received the reversed order of stimulus presentation.

The total fixation time on each trial was the dependent measure in this study. There was a significant increase in total fixation time from habituation phase to test phase (p =0.004). It was also found that fixation times of the profoundly mentally retarded individuals in this study declined significantly from Trial Block 1 to Trial Block 6 (p = 0.001) during habituation. A significant cubic trend was found. Fixation times declined over the first three habituation trial blocks, then increased on the fourth trial block, and declined again over the fifth and sixth trial blocks. Subjects' total fixation times were stable over the four sessions; the mean intersession correlation was .89.

The increase in fixation times from habituation to test phase indicates that nonambulatory profoundly mentally retarded children discriminate between happy and surprised facial expressions. Whereas previous studies found that profoundly mentally retarded individuals can discriminate between different faces, between male and female faces, and between facial and nonfacial stimuli, the present study demonstrates that they can also discrminate between happy and surprised facial expressions. Kelman and Whiteley (1986) and Krenn (1986) have found evidence of habituation using simple geometric patterns. This study also demonstrates that habituation occurs to complex stimuli, such as facial expressions. It was suggested that the complexity of the stimulus with respect to subject's cognitive ability was responsible for producing the increase in fixation times on Block 4.

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Chapter I

INTRODUCTION

According to the classification system proposed by the American Association on Mental Deficiency (1983), persons with Intelligence Quotients (IQ) five standard deviations below the mean of the general population are considered profoundly mentally retarded. In addition to their low levels of intellectual functioning, profoundly retarded individuals generally have other forms of handicap; for example, limited upper limb and hand control, difficulty in supporting their heads, cerebral palsy, muscular atrophy, and joint stiffness. Most profoundly mentally retarded individuals cannot communicate through speech, and as adults, their mental age reaches only about 2 years (Shepherd & Fagan, 1981). Some profoundly retarded individuals are also nonambulatory. This group of people can't generally be tested by traditional psychometric instruments because of their physical limitations or behavior incompatible with valid testing. But recently, habituation-dishabituation paradigms have been used successfully by various researchers to obtain some information regarding their cognitive functioning (e.g., Kelman & Whiteley, 1986; Krenn, 1986).

1.1 HABITUATION-DISHABITUATION PARADIGM

Habituation phenomena have a long and complex history starting from the eighteenth century, but their use in infancy research is relatively recent. Bornstein (1985) describes habituation and its implications as follows:

> "Habituation is attention decrement to repeated stimulation; it is not sensory adaptation, effector fatigue, or change in arousal, but rather represents a primitive kind of 'exposure learning' that reflects underlying brain plasticity. Habituation in infants implies mental representation, memory, internal comparison, and a variety of associated perceptual and cognitive behaviors driven by these processes" (Bornstein, 1985, p. 290).

Dishabituation is an increase in level of responding when a novel stimulus is presented following habituation. Dishabituation implies that the preceding response decrement was not due to sensory adaptation, effector fatigue, or change in behavioral state. It also implies discrimination of the habituating and novel stimuli.

Most of the studies on infant habituation have concentrated on visual information processing and have used looking behavior as the index of attention. Other behavioral indices of habituation have also been studied, for example, infant's non-nutritive sucking (Siqueland & Delucia, 1969) and heart rate (Berg & Berg, 1979), but these latter procedures are more difficult to implement with infants than visual attention procedures. Fantz (1964) was the first to use the habituation paradigm for infancy research. Fantz (1964) showed the same stimulus repeatedly to babies 1 to 6 months of age. He found that babies older than 4 months habituated to constant stimuli whereas babies younger than 2 months did not. Since the Fantz (1964) study, the habituation method has been widely used in infancy research.

Four types of experimental procedures have been used to familiarize the subject to the habituating stimulus. These are: (a) fixed-trial procedures (e.g., Fantz, 1964), (b) fixed-level procedures (e.g., McCall, Hogarty, Hamilton, & Vincent, 1973), (c) infant-control procedures (e.g., Horowitz, 1974), and (d) free-looking procedures (Bornstein, Ferdinandsen, & Gross, 1981). In a fixed-trial procedure, the habituating stimulus is presented to the infant for a fixed number of trials with exposures of predetermined duration. In a fixed level procedure, the habituating stimulus is presented repeatedly for a predetermined duration until the infant reaches an absolute low level of responding (e.g., 3 seconds per trial). In an infant-control procedure, the habituating stimulus is presented to the infant for the duration of one visual fixation, and the number of trials continues until the infant reaches a pre-set habituation criterion (usually 2 consecutive looks of less than 50% duration of the mean of the initial 2 looks). In a free-looking procedure, the habituating stimulus is presented to the infant for a single lengthy predetermined duration.

Each of these four procedures present methodological or conceptual difficulties. The fixed-trial procedure was introduced first and has been widely used. As the duration of the stimulus presentations are fixed, this procedure does not take the infant's looking behavior into consideration. For example, an infant may not be looking at the stimulus during its presentation, or the presentation of the stimulus may be stopped even when the infant is looking at it. The fixed-level procedure has problems dealing with those subjects having short looking times who may not reach the arbitrarily determined habituation criterion. The infant-control and free-looking procedures have attempted to meet these criticisms; however, these procedures are more complex and require online estimation of the infant's response, linkage of the infant's response to stimulus presentation, and simultaneous calculation of a habituation criterion. Moreover, the possibility of type I error must be checked because infants may reach a habituation criterion by chance.

Bornstein (1985) expressed the need to conduct methodological studies comparing the fixed trials and infant control procedures. Only one such study is cited by Bornstein (1985). Haaf, Smith, and Smitley (1983) compared the fixed-trial and infant-control procedures in a simple preference task and found that the two procedures yielded almost equal average looking times per trial or per look; however, the infant control procedure produced greater variation in looking behavior compared to the fixed-trial procedure.

A response decrement due to repeated presentation of a stimulus may be explained by some phenomena other than habituation. These are: (a) sensory adaptation, (b) effector fatigue, or (c) change in behavioral state. In a habituation-dishabituation paradigm, researchers must adopt some control measures to guard against these alternative explanations of response decrement. One such control procedure involves presentation of pretest and posttest stimuli. If the infant's level of responding remains the same from pretest to posttest, effector fatigue and change in behavioral state can be eliminated as explanations for decreased responding. Another control procedure involves the test for response recovery to a novel stimulus after habituation. If the infant shows response recovery after habituation, effector fatigue and state changes can be discarded as alternative explanations of response decrement.

Sensory adaptation can also be excluded as an explanation of response decrement if the infant shows habituation and recovery to both members of a counterbalanced stimulus pair. In addition, the habituating stimulus and test stimulus must be preselected to make them equally attractive to the infants; otherwise, response recovery in the test phase could be due to stimulus preference or a startle response (Bornstein, 1985).

Two procedures have been used to assess responsiveness to novel stimuli following habituation -- paired-comparison and sequential presentation of test stimuli. Fantz (1964) and Fagan (1970) developed the paired-comparison procedure. In this procedure the infant is first exposed to a visual stimulus and then tested for retention by presenting the familiarized and novel stimuli simultaneously. Infant's behavior in the paired-comparison task has several determinants. According to Olson and Sherman (1983), the factors that might govern infant's choice between two stimuli are: discriminability (e.g., interstimulus contrast, codability), preference (e.g., perceptual features, interpretation, novelty-familiarity), and response bias (e.g., position habits, criteria for shifting gaze, state). As the relative novelty factor is of primary importance in a memory experiment, investigators must control these other variables. They generally adopt two control measures: (a) they choose stimuli, prior to familiarization, to which infants look equally, and (b) they counterbalance novel and familiar stimuli over subjects.

There are some advantages and limitations to the paired-comparison procedure. One advantage of this technique is that evidence of memory for the familiarized stimulus can be found after very brief familiarization. For example, Fagan (1974) and Olson (1979) both found significant novelty preference in a paired-comparison procedure with familiarization periods of a few seconds. The major difficulty with this technique is that it generates a measure which has limited sensitivity. It is very rare that the observed percentage of looking time at the novel stimulus exceeds 60% to 70%.

In the sequential procedure, either the novel or familiar stimulus is presented on each test trial. As only one stimulus is presented during each test trial, the investigator need not worry about counterbalancing position of the stimulus. On the other hand, as the familiar stimulus does not appear simultaneously with the novel stimulus, the sequential procedure demands more memory capability.

The habituation-dishabituation paradigms have been used effectively for studying cognitive processes of infants. The same paradigms can also be useful for studying the cognitive functioning of the nonverbal populations, like nonambulatory profoundly mentally retarded children.

1.2 STUDIES OF VISUAL DISCRIMINATION BY PROFOUNDLY MENTALLY RETARDED PERSONS

Methods developed to test the visual-perceptual and recognition abilities of the normal infant have been successfully employed to explore similar abilities of the profoundly mentally retarded child. These studies are summarized in Table 1. Berkson (1966, Experiment 1) studied the eye fixation behavior of profoundly retarded children when they were presented with moving and stationary stimuli. In this study there were 15 profoundly retarded subjects whose median chronological age (CA) was 3 years, 5 months. The developmental level of the subjects was guessed to be less than 1 year. Subjects were tested on four days; on each day, three trials were presented randomly in each of four conditions. A sliding door was raised for 60 seconds on each trial. The four experimental conditions were: On-On, On-Off, Off-Off, and Off-On. In the On condition, the stimulus was a rotating disc and in the Off condition, it was a stationary disc. In On-On and in Off-Off conditions, the disc remained rotating or stationary, respectively, for 60 seconds. In the On-Off and Off-On conditions, the disc was rotating for 30 seconds and stationary for 30 seconds. The percentage of the duration of visual fixations to the stimulus, out of the total duration of stimulus presentation, was the dependent measure in this study. It was found that the percentage of the duration of visual fixation by the subjects decreased in On-On and Off-Off conditions (familiar stimulus only), but increased when the change occurred in the Off-On and On-Off conditions (change from familiar to novel stimulus). This study demonstrated the habituation and dishabituation phenomena in profoundly mentally retarded subjects.

Butcher (1977) studied a group of profoundly mentally retarded young children to see whether they could discriminate between faces and between colors. Stimuli were photographs of faces of two men and two women, and four colored patterns (red-square, green-square, red-diamond, and green-diamond). They were tested immediately following familiarization and after a delay interval. Subjects were 16 profoundly mentally retarded children with mean CA of 6.1 years and mean mental age (MA) of 5.3 months. MA was assessed by the Bayley Scales of Infant Development. Children were first exposed to a 2-minute familiarization period with one stimulus from either the color or face set. Following familiarization, an immediate and 2 delayed tests (40 s & 180 s) were administered using paired presentations of the familiar stimulus and a novel stimulus of the same category. Results showed that these children could discriminate the color and face stimuli in the immediate test but failed to make such a discrimination after the delay intervals, with the exception that both 40 s and 180 s delayed recognition was found for one of the colored patterns.

TABLE 1

Summary of the Basic Features and Findings of the Studies on Visual Discrimination by Profoundly Mentally Retarded Children

Study	CA of Subjects	MA of Subjects	Method Used	Stimulus Pattern	Basic Findings
Berkson (1966)	3.4 years	< 1 years	Prolonged familiarization vs. presentation of familiar and novel stimuli	Moving and stationary stimuli	Profoundly mentally retarded showed habituation-dishabituation phenomena; and could discriminate between moving and stationary stimuli
Butcher (1977)	6.1 years	5.3 months	Familiarization and paired comparison of familiar & novel stimuli	Different colors and faces	Children discriminated color and face stimuli on immediate test.
Switzky, Woolsey-Hill & Quoss (1979)	10.3 years	6 months	Infant-control habituation-dishabituation paradigm	Two checkerboard patterns	Subjects showed habituation-dishabituation and could discriminate between checkerboard targets
Shepherd & Fagan (1980)	7 years	4 months	Familiarization & paired comparison of familiar & novel stimuli	Sharply contrasting black & white patterns, & low contrasting gray & white pattern	Subjects showed novelty preference, i.e., they could discriminate between familiar & novel contrasting stimuli

(Table Continues)

TABLE 1

Summary of the Basic Features and Findings of the Studies on Visual Discrimination by Profoundly Mentally Retarded Children

Study	CA of Subjects	MA of Subjects	Method Used	Stimulus Pattern	Basic Findings
Kelman & Whiteley (1986)	7.8 years	3.5 months	Fixed-trial habituation-dishabituation paradigm	Stimuli along form dimension, i.e., circle, ellipse & triangle	Subjects showed habituation & could discriminate among the stimuli but didn't show generalization of habituation along form dimension
Krenn (1986)	10.2 years	6.2 months	Fixed-trial habituation-dishabituation paradigm	Form orientation, i.e., vertical, horizontal, 45° oblique lines, & square	Subjects demonstrated habituation & discriminated changes in form orientation
Whiteley, Shaw, & Graham (1987)	12.3 years	3.5 months	Infant-control habituation-dishabituation paradigm	Faces (1 female & 2 male faces) & form (white circle & a white equilateral triangle	Profoundly mentally retarded discriminated between white circle & white equilateral triangle and between male and female faces
Shepherd, Kleiner & McMurrer (1984)	Not reported	< 2 years	Familiarization & paired-comparison technique	Facial & non-facial stimuli	Subjects could discriminate between facial & non-facial patterns

Switzky, Woolsey-Hill, and Quoss (1979) studied the ability of profoundly retarded subjects to discriminate between 2 x 2 and 12 x 12 black and white checkerboard targets. Subjects were 12 nonambulatory, nonverbal, profoundly mentally retarded children whose mean chronological age was 10.3 years and mean level of functioning was less than 6 months, as measured by the Denver Developmental Screening Test. Subjects were repeatedly exposed to one of the two checkerboard patterns until a set criterion of habituation was reached by the subjects, as measured by a decrement in visual fixation time. After reaching the habituation criterion, children were alternatively shown the habituating stimulus and the remaining checkerboard as the novel stimulus. Results showed that the looking time was higher for the novel stimulus during the post-habituation trials as compared to the habituating stimulus in the same phase. On the other hand, in the control habituation condition, where only the habituating stimulus was presented during the post-habituation trials, no recovery in looking times occurred. This study shows that nonambulatory profoundly retarded subjects show habituation-dishabituation and can discriminate between different checkerboard targets.

Shepherd and Fagan (1980) attempted to replicate the findings of Butcher (1977) and Switzky et al. (1979) that profoundly retarded children can demonstrate visual recognition memory for patterned targets. Subjects were 17 profoundly retarded children with mean CA of 7 years and mean Bayley mental age of 4 months. The materials used in this study were nine sharply contrasting black and white patterns, and four lower contrast gray and white patterns. Based on their previous research, Shepherd and Fagan (1980) assumed that each stimulus pattern used in this study was within the acuity limits of each child. The procedure involved two 15 s periods of familiarization with a stimulus followed by paired presentations of the familiar and a novel stimulus for 5 s during test trials. Each child participated in three experimental sessions with four memory problems in each session. Consequently, four novelty preference scores were obtained during each of the three experimental sessions, yielding 12 scores for each child. The results showed evidence of immediate recognition memory, as these children looked significantly longer at three of four novel stimuli during the test series. A secondary analysis of individual subject data indicated that 41% of the sample showed significant preferences for novelty.

Kelman and Whiteley (1986) studied the generalization of habituation along a form dimension with nonambulatory profoundly mentally retarded children. There were 12 subjects in this study with mean CA of 7.8 years and median MA of 3.5 months. Procedures of the study involved a modified fixed-trial habituation-dishabituation paradigm.

Rather than a preset trial duration, each trial lasted 15 seconds from the infant's initial fixation of the stimulus. If no fixation occurred during the first 10 s, the stimulus was presented for a total of 25 s. The intertrial interval was 5 s. Each subject participated in four sessions with at least 24 hours between sessions. In each session, there were 12 habituation trials, which were followed by 8 test trials. In each session, the habituating stimulus was either a circle or an ellipse, and in the test phase, three test stimuli and the habituating stimulus were each presented twice. The test stimuli differed from the habituating stimulus along a form dimension. Analysis of the data revealed that there were decreases in fixation times over habituation trials and that fixation times increased during test trials. Differences in fixation times to different stimuli during the test phase were not found. Kelman and Whiteley (1986) also conducted analyses of individual subject data and found that only 2 children demonstrated generalization gradients. Thus, the Kelman and Whiteley (1986) study reveals that although nonambulatory profoundly retarded subjects can discriminate stimuli along a form dimension, their response to novelty is not systematically related to amount of change in the stimulus.

Krenn (1986) investigated the ability of nonambulatory profoundly retarded children to discriminate changes in orientation of a stimulus. She used the fixed trial habituation-dishabituation paradigm, and selected 20 s as the length of each trial. Subjects were 16 nonambulatory profoundly mentally retarded children, with a mean CA of 10.2 years, and mean MA of 6.2 months, as measured by the Bayley Scales of Infant Development. Each subject participated in three experimental sessions with 24 hours between sessions. Each session consisted of two phases: the habituation phase consisted of 16 trials and the test phase consisted of 8 trials. The intertrial interval was 2 s. The four patterns were a vertical line, a horizontal line, a 45° oblique line, and a square. Each subject was habituated either to the vertical or horizontal pattern, and the remaining three patterns were used as novel stimuli. The novel stimulus was different on each day. The results showed response decrement during the habituation phase and longer fixation to the novel stimuli than to the familiar stimulus during the test phase. The results imply that nonambulatory profoundly retarded subjects are sensitive to changes in stimulus orientation as well as to changes in form.

Whiteley, Shaw, and Graham (1987) familiarized 17 profoundly mentally retarded children to face and form stimuli using infant-controlled trial durations. The mean CA of the subjects were 12.3 years, and the median MA was 3.5 months, as measured by the Bayley Scales of Infant Development. The stimuli in this study consisted of a white circle, a white equilateral triangle, and three colored faces (one female face and two male faces). Each subject participated in four sessions with approximately 1-week intervals between sessions. The habituating and novel stimuli were presented in two orders: (a) the standard order (12 habituation trials, followed by 6 test trials in which the novel stimulus was presented 4 times and the habituating stimulus 2 times), and (b) the probe order (three 6-trial blocks each consisting of 4 habituation trials followed by 2 test trials with a novel stimulus). The analysis of the standard condition data revealed that subjects fixated longer on faces than forms and fixated novel stimuli longer than familiar stimuli during test trials. These results indicate that nonambulatory profoundly mentally retarded subjects could discriminate between male and female faces, as well as simple geometric forms.

Shepherd, Kleiner, and McMurrer (1984) examined the applicability of Fagan and Shepherd's four stages of social recognition ability in normally developing human infants to profoundly retarded children. The stages are: (a) the discrimination of facial from non-facial patterns, a discrimination that is demonstrated just after birth; (b) the discrimination of facial patterns properly arranged from those improperly arranged, an ability that develops around 4 or 5 months after birth; (c) the discrimination of facial patterns of one gender or age from a different gender or age, an ability that develops around 5 to 6 months; and (d) the discrimination of facial patterns within gender or age, an ability that develops at about 6 to 7 months. Shepherd et al. (1984) studied 18 young nonambulatory, institutionalized profoundly retarded individuals whose MA was less than 2 years. Subjects were tested for their ability to make facial pattern discriminations. Preference and recognition memory were measured by Shepherd and Fagan's Visual Interest Test, which was initially developed for infants and was adapted for testing profoundly retarded subjects. This Visual Interest Test basically involved the paired-comparison test procedure. It was observed that the nonambulatory profoundly retarded subjects in this study only discriminated between facial and non-facial patterns, an ability that is found in normal neonates.

The studies reviewed in this section demonstrate that nonambulatory profoundly retarded children show habituation and dishabituation to visual stimuli (e.g., Berkson, 1966; Kelman & Whiteley, 1986; Switzky et al., 1979). The mean level of functioning (MA) of the subjects in these studies ranged from under 2 months to about 2 years. In all the studies, profoundly retarded subjects showed some form of visual discrimination ability.

Some studies successfully demonstrated that nonambulatory profoundly retarded subjects can discriminate changes in form (e.g., Kelman & Whiteley, 1986; Whiteley et al., 1987).

In the Krenn (1986) study, subjects showed sensitivity to changes in stimulus orientation. The Butcher (1977) study demonstrated that they can discriminate between colors. Switzky et al. (1979) and Shepherd and Fagan (1980) demonstrated that these children can discriminate between checkerboard targets and high and low contrast patterns, respectively. And finally, in the Berkson (1966) study, it was found that the nonambulatory profoundly mentally retarded subjects can discriminate between moving and stationary stimuli.

Some studies have found that nonambulatory profoundly mentally retarded subjects can discriminate between two faces (e.g., Butcher, 1977; Whiteley et al., 1987), as well as between facial and non-facial stimuli (Shepherd et al., 1984). The Butcher (1977) study demonstrated that nonambulatory profoundly retarded children can discriminate between the photographs of male and female faces. Similarly, the Whiteley et al. (1987) study found that these children can discriminate between a male and a female face. Only the study reported by Shepherd et al. (1984) did not find discrimination of faces. From the above review it is evident that nonambulatory profoundly retarded persons can discriminate among different faces and between nonfacial patterns and faces. But no study has been conducted to find out whether nonambulatory profoundly retarded persons can discriminate among the different facial expressions.

1.3 INFANT LITERATURE ON THE DISCRIMINATION OF EXPRESSIONS

Nelson (1987) points out that the human face provides an important source of information in communication between infants and adults. Many theories and studies have emphasized the importance of a parent's face as a stimulus for the infant (e.g., Bowlby, 1969; Stern, 1974). Parents and other adults convey different emotions through facial expressions. The rationale guiding research on the recognition of facial expression is that in infants such ability plays an important role in infants' socioemotional development (Nelson, 1987). Table 2 presents a summary of selected studies relevant to the purpose of the present investigation. These studies are discussed below.

At what developmental age can infants discriminate, recognize, or perceive the various expressions of emotions posed by adults? LaBarbera, Izard, Vietze, and Parisi (1976) reported that early studies did not find this ability before the age of six months. Wilcox and Clayton (1968) employed measures of visual attention while presenting motion pictures of smiling, frowning, and neutral facial expressions to 5-month-old infants. When each picture was presented for 28 s, they found that looking time was highest for smiling and lowest for the neutral expression. This difference was nonsignificant if each picture was presented for 60 s. Kreutzer and Charlsworth (1973) presented actual faces along with vocalizations expressing happy, sad, angry,

TABLE 2

Summary of the Basic Features and Findings of the Review of Infant Literature on the Discrimination of Facial Expressions

Study	CA of Subjects /Type of Expression Studied	Type of Stimuli/Method used	No. of Models	Basic Findings
Wilcox & Clayton (1968)	5 months/ Smiling, frowning & neutral	Motion pictures /Prolonged presentation of single stimuli	1	Looking time was highest for smiling & lowest for neutral expression
Kreutzer & Charlsworth (1973)	4-, 6-, 8-, & 10-months/Happy, sad, angry, & neutral	Actual face/Not mentioned in secondary source	1	Infants of 6-months & older could discriminate among faial expressions
LaBarbera, Izard, Vietze, & Parisi (1976)	4-,& 6-months /Joy, anger, & neutral	Black & white 2-dimensional slides/Prolonged presentation of stimuli	1	Looking time for joy was higher than anger & neutral expressions for both age groups. 4-month-olds looked longer than 6-month-olds
Young-Browne, Rosenfield, & Horowitz (1977)	3 months/Sad, happy, & surprise	2-dimensional colored & black & white slides/Infant control habituation-dishabituation paradigm	1	3-month-olds responded to changes from happy to surprise & surprise to happy, but didn't respond to changes from sad to happy or happy to sad

(Table Continues)

TABLE 2

Summary of the Basic Features and Findings of the Review of Infant Literature on the Discrimination of Facial Expressions

Study	CA of Subjects /Type of Expression Studied	Type of Stimuli/Method used	No. of Models	Basic Findings
Nelson, Morse, & Leavitt (1979)	7 months/Happy & fear	2 dimensional photographs/ Visual preference paired-comparison technique	2 & 3	7-months olds failed to discriminate between happy & fear under 2-model condition,but could discriminate under 3-model. Demonstrated generalization of expressions across individuals; but this was affected by order of presentation of stimuli
Barrera & Maurer (1981)	3-months/Smiling & frowning	2 dimensional colored slides/Infant-control habituation-dishabituation paradigm	2	Subjects could discriminate between smiling & frowning expressions posed by both mother & stranger
Field, Woodson, Greenberg, & Cohen (1981)	28-hours/Happy, sad, & surprise	Actual face/ Infant-control habituation paradigm	1	Neonates looked longer at the happy expression compared to sad expression, & demonstrated habtuation-dishabituation phenomenon

(Table Continues)

TABLE 2

Summary of the Basic Features and Findings of the Review of Infant Literature on the Discrimination of Facial Expressions

Study	CA of Subjects /Type of Expression Studied	Type of Stimuli/Method used	No. of Models	Basic Findings
Field & Greenberg (reported in Field & Walden, 1982)	2- & 3-months/Smiling & vocalizations	Real mother expressing emotions/Spontaneous mother-infant interaction	1	2-month-olds emitted vocalization;3-month-olds could emit vocalizations, smiles, & smiles with vocalizations
Nelson & Horwitz (1983)	2- & 5-months/Smiling & neutral	Holographic (3 dimensional) stimuli (moving or stationary)/ Infant-control habituation-dishabituation paradigm	1	2-month-olds could discriminate between smiling & neutral expression in a moving hologram but 5-month-olds failed to do so
Schwartz, Izard, & Ansul (1985)	5-months/(a) Fear, anger, & sad (b) joy, anger, & interest	Chromatic 2 dimensional photographs/Familiarization & paired-comparison novelty technique	2	(a) Infants were able to discriminate fear from sadness in any order, but infants could discriminate anger from sadness & fear in all conditions except when anger was the novel stimulus.(b) 5-month -olds as a group failed to discriminate among the facial expressions of joy, anger, & interest

and neutral emotions to 4-, 6-, 8-, and 10-month-old infants. They found that 4-month-old infants failed to discriminate, but infants of 6 months and older could discriminate sad from happy, angry, and neutral expressions.

LaBarbera et al. (1976) studied 4- and 6-month-old infants who were presented black and white slides of joy, anger, and neutral emotions. Researchers recorded the duration of the first visual fixation to each slide. Their analysis of the data revealed significant main effects for facial expression and age; with mean looking time for joy being higher than anger and neutral expressions, and looking time of 4-month-old infants being longer than looking time of 6-month-old infants. The authors concluded that both age groups could discriminate joy from anger and neutral expressions.

Young-Browne, Rosenfield, and Horowitz (1977) used the infant-control habituation-dishabituation paradigm to study the 3-month-old infants' ability to discriminate sad, happy, and surprise facial expressions. A trained male model produced the three expressions following standard descriptions from Ekman, Friesen, and Tomkins (1971). Both colored and achromatic versions of the expressions were presented on a screen. The habituation criterion was defined as two consecutive looks of less than 50% of the mean of the first two looks. In this study, 6 experimental groups received 6 counterbalanced orders of presentation of the three emotional expressions. Infants in these experimental groups were first exposed to an emotional expression. After reaching the habituation criterion to the first expression, infants were exposed to the second expression. Again after reaching the habituation criterion with the second expression, infants were shown the third one. The three control groups received one of the three emotional expressions. The dependent measures used in this study were the difference between the mean of the two habituation criterion fixations and the mean fixation time on the first two trials with the new stimulus. Analysis of the data revealed that infants responded to changes from happy to surprise and surprise to happy. Infants didn't respond to changes from sad to happy or happy to sad. Thus, applying the habituation-dishabituation paradigm, this study demonstrates that infants can discriminate some facial expressions as early as three months.

Nelson, Morse, and Leavitt (1979) examined 7-month-old infants' ability to discriminate happy from fear using the visual preference paired-comparison technique. One of the objectives of their study was to find out whether infants can generalize the discrimination of facial expressions across more than one person. In their first experiment they found that infants looked longer at the fear face during the test phase if they were familiarized to the happy face, but the reverse was not true. In their second experiment, infants were familiarized with one of the two facial expressions by Model A, and then they were tested with happy and fear expressions posed by Model B. Infants in the test phase looked equally long at the two expressions, thus failing to generalize the discrimination from Model A to Model B.

These researchers hypothesized that this failure to generalize could be overcome by familiarizing infants to irrelevant dimensions by presenting the same facial expressions on different faces, thus restoring the novelty of only the relevant dimensions (e.g., shape of mouth). Based on such logic a third experiment was conducted by Nelson et al. (1979) in which infants were familiarized for 20 seconds to two photographs of either happy or fear expressions portrayed by Model A, and then to the same expressions portrayed by Model B. Then infants were tested twice each for 10 seconds with familiar and novel facial expressions portrayed by Model C. One-half of the infants were familiarized on happy and one-half on fear expressions. The analysis of the looking times revealed that they looked longer at the novel stimulus. Examination of the data revealed that the rate of habituation for happy and fear expressions varied; infants familiarized on the fear expression didn't habituate within the given exposure time; whereas, infants familiarized to the happy expression demonstrated habituation. Researchers concluded from this series of experiments that infants at 7 months can generalize happy and fear expressions across individuals.

Barrera and Maurer (1981) used an infant-control habituation procedure to study 3-month-old infants' abilities to discriminate and recognize smiling and frowning expressions modeled by the infant's mother and a female stranger. In their first experiment, the stimuli were color slides of the smiling and frowning face of the infant's mother. Half of the infants were habituated to a smiling expression and the other half to a frowning expression. The habituation criterion was stricter than in previous studies; on each of the last three consecutive trials, the infant was required to look less than one-half of the time of the mean of the first three trials. The intertrial interval was 10 seconds. After reaching criterion, infants were tested twice with the habituated and twice with the novel expression in a counter-balanced order. Mean looking time on each trial was the dependent measure. It was found that 23 of the 24 infants looked at the novel expression longer than at the habituated expression when it was posed by their mothers. A second experiment was conducted using the same procedures, but instead of mother's face, they presented a female stranger's facial expressions of smiling and frowning. Again it was found that during the test phase, 21 of 28 infants looked longer at the novel expression as compared to the habituated expression. Thus, Barrera and Maurer's (1981) study demonstrates that 3-month-old infants can discriminate between smiling and frowning expressions. Another important observation noted by Barrera and Maurer (1981) was that 3-month-old infants demonstrated crying or fussing behavior when habituated to frowning; whereas, no infant showed any fussing behavior when they were habituated to smiling.

Field, Woodson, Greenberg, and Cohen (1982) studied the discrimination of facial expressions by 48 28-hour-old neonates. The experimenter modeled the happy, sad, and surprised expressions. Each expression was presented to the infant repeatedly until the neonate's looking at the examiner's face declined to less than 2 seconds (habituation criterion). A new expression was presented after the infants reached criterion to the familiarized expression. Analysis of the neonates' discrimination of facial expression demonstrated both habituation and dishabituation effects. Neonates also looked longer at the happy expression, compared to sad or surprised expressions. They took a longer time to habituate to a surprised expression than they took to habituate to the happy and sad expressions.

Nelson (1987) raised serious questions about Field's findings that newborn and preterm infants can discriminate different facial expressions. He pointed out that according to some authors infants younger than 4 months have limitations in their visual system, as measured by contrast sensitivity functions (Banks & Salapatek, 1983), or by scanning (Haith, Bergman, & Moore, 1977) that would make discriminations of facial expressions very difficult. He also pointed out that newborns and 1-month-old infants scan the peripheral area of the face (Haith et al., 1977), and by 2-months they scan the internal features of the face (Maurer & Salapatek, 1976). Nelson (1987) noted that it is not until 4 months that infants start to scan both the internal and the external features of the face which are involved in depicting facial expressions.

As reported by Field and Walden (1982), Field and Greenberg studied 2- and 3-month-old infants' ability to perceive facial expressions by using spontaneous face-to-face play interaction between mothers and infants. The interaction sessions were videotaped and the tapes were then coded. A measure of decoding or discrimination ability was defined as the proportion of maternal expressions contingently responded to by each infant with a similar facial expression by the infant within 3 seconds of the mother's expression. Infants' vocalizations and smiles in response to maternal vocalization and smiles were coded. It was found that 2-month-old infants emitted contingent vocalizations at greater than chance level. For 3-month-old infants, this contingent responding to mother occurred not only for vocalizations, but also for smiles and smiles with vocalizations. From these results, these authors suggested that a relationship between production and perception of facial expression skills emerge at a very early age.

In real life situations infants encounter three dimensional and multimodal emotional stimuli. The use of static, two dimensional, single-modal stimuli might underestimate infant's actual ability to recognize emotional expressions (Caron, Caron, & Myers, 1985). Nelson and Horowitz (1983) investigated the perception of facial expressions by 2- and 5-month-old infants using holographic stimuli. There were two facial arrays in the hologram --- one displaying a neutral expression by a women, and another displaying smiling by the same woman. An infant-control habituation procedure was employed. The habituation criterion was defined as a 50% decrement in looking time from the peak two of the first three looks. But if a longer looking time occurred after the initial three trials, the habituation criterion was recalculated based on the longest two looks. The stimuli were holograms of two facial arrays. The first array was of a woman with a neutral expression in right profile, with her in-turned hand to her lips, as if blowing a kiss. The second array portrayed her left profile, winking and smiling.

In the first experiment, 5-month-old infants failed to discriminate facial expressions using holographic stimuli either in moving or stationary conditions. But in a second experiment, 2-month-old infants were successful in discriminating the same facial expressions in moving holograms. The discrepant results for 2- and 5-month olds suggests that replication of their results is needed.

Schwartz, Izard, and Ansul (1985) studied the 5-month-old's ability to discriminate facial expressions of emotion using the paired-comparison novelty technique. The goal of their first experiment was to find out whether 5-month-old infants can discriminate between some negative emotional expressions. The stimuli were the chromatic photos of two women (one blond, one brunette) who posed fear, anger, and sad expressions which conformed to the Izard (1979) criterion. Mouth was open and teeth displayed in all expression.

Analysis of the discrimination data demonstrated that 5-month olds were able to discriminate fear from sadness in any order of presentation. Infants could discriminate anger from sadness and fear in all conditions except when anger was the novel stimulus. It was also found that infants in the control conditions, where faces were presented upside-down, didn't show discrimination among these expressions. Schwartz et al. (1985) argued that if infants discriminated facial expressions purely on the basis of contrasting patterns, rather than on the basis of facial gestalt, the stimuli rotated 180 degree would produce about the same novelty preferences as upright faces. Based on a failure to find such discrimination of rotated faces, they concluded that the discrimination of facial expressions found for nonrotated expressions was based on facial gestalt.

Nelson (1987) reported Fagan and his colleagues' studies (e.g., Fagan, 1979; McGrath, 1983) where it has been found that infants younger than 4 months can discriminate two faces presented rightside up or upside-down, but after 4 months, infants do not discriminate between two upside-down faces. Nelson attributed this inversion effect to the development of face schemes at around 4 months of age.

Based on his review of the research on infant discrimination of expressions, Nelson (1987) concluded that infants younger than 4 months lack the requisite visual skills to recognize facial expressions presented by two dimensional stimuli. He suggested that younger infants in previous studies might have attended to changes in particular features or sets of facial features and not to expressions qua expressions. Nevertheless, he pointed out that the infant's ability to discriminate the changes in some dimension of facial features, even without knowledge of what they mean, may be the basis of infant's later responding in a meaningful way.

1.4 THE PRESENT STUDY

In their day-to-day interaction with adults, profoundly mentally retarded individuals are stimulated by different facial expressions, each of which has social signal value with respect to particular situations. Studies have been conducted to demonstrate that nonambulatory profoundly mentally retarded children and adolescents can discriminate among patterns, including different faces. But no study has been conducted to find out whether they can discriminate among the fundamental facial expressions. The purpose of the present study was to investigate whether nonambulatory profoundly mentally retarded persons can discriminate between the facial expressions of happy and surprise, posed by a female adult.

The happy and surprise emotions were selected because these have been recognized as fundamental emotions since Darwin's early investigation (Darwin, 1872/1965; Izard, 1971), and because research has shown that normal infants can discriminate between these two expressions as early as 3 months of age (Barrera & Maurer, 1981). By choosing happy and surprised expressions, I also avoided negative emotions, such as sad and anger, to avoid any aversive reactions that these might have evoked in the participants. It has been found that infants show fussy behavior during habituation trials to negative facial expressions (Barrera & Maurer, 1981). A female actor modelled the happy and surprised expressions using Izard's (1971) description of these expressions. Final selection of photographs of these facial expressions for use in the experiment was determined on the basis of the degree of closeness of the posed faces to Izard's (1971) standardized expressions, as perceived by adult judges.

A fixed-trial habituation-dishabituation paradigm was used to find out whether these children could discriminate between happy and surprised facial expressions when these stimuli were presented via colored slides. The fixed-trial technique was chosen for practical considerations; for example, it required only one observer and it did not require on-line measures of fixation times. Fixed facial expressions rather than dynamic or actual faces were used to gain better control over the stimuli. The participants were expected to habituate to both the happy and surprised expressions. When the novel expression was presented during the test phase, subjects were expected to show dishabituation if they could discriminate the change in expression.

Chapter II

METHOD

2.1 SUBJECTS

The subjects in this study were 14 nonambulatory profoundly mentally retarded children and adolescents. The chronological age of the subjects ranged from 10.3 years to 20.4 years (mean CA = 13.8 years). The estimates of their mental age as assessed by the Bayley Mental Scale (Bayley, 1969) ranged from 2.0 months to 5.5 months (mean MA = 4.1 months). Table 3 presents some characteristics of the participants, including their sex, CA, MA, BRS (Bayley Raw Score), and VF (Scores on Visual Fixation items). Descriptions of the subjects, including their medical diagnoses and motor capacities, are presented in Table 4.

The participants were selected from the St. Amant Center, a public residential institution for the mentally retarded in Winnipeg. The selection of subjects proceeded following the criteria for nonambulatory, profoundly mentally retarded children (Landesman-Dwyer & Sackett, 1978); namely, inability to move through space, lacking in adaptive behavior skills, and small in size for chronological age. In addition, subjects must possess the ability to fixate

TABLE 3

Subject Characteristics

Subject No.	Sex	CA	MA	BRS	VF
01	F	11.87	5.0	56	7
02	F	10.56	4.0	46	4
03	M	16.75	3.0	34	6
04	F	13.50	4.5	52	6
11	M	11.67	5.0	56	8
12	F	14.50	3.5	43	7
13	M	11.10	3.5	42	6
22	M	20.25	3.0	36	5
23	M	10.67	5.5	66	8
24	F	20.42	4.5	51	7
31	F	12.50	3.0	34	5
32	F	10.33	2.0	18	4
33	F	10.83	3.5	41	7
53	M	18.83	7.0	79	8

<u>Note</u>.
CA = Age in years.
MA = Mental age equivalents in months.
BRS = Bayley Scales of Infant Development (Mental Scale) Raw Scores.
VF = Number of items passed on the Mental Scale requiring visual fixation.

TABLE 4

Subject Description

Subject No.	Medical History / Diagnosis	Motor	Sensory
01	Severe brain damage due to encephalitis at 1 year Seizure disorder	Spasticity of hands Quadriplegia	Sees and hears well
02	Born to Grava II Para I mother Possible encephalitis	Atheoid Cerebral palsy	Sees and hears well
03	Microcephaly Seizure disorder	Spastic Quadriplegia	Sees and hears well
04	Cornelia de Lange syndrome	Can move wheeled walker	Hearing impaired Sees well
11	Hydrocephalitis at 3 months due to aqueducal stenosis Hypernatremia	Spastic Quadriplegia Cerebral palsy	Hears normally
12	Encephalopathy Perinatal asphyxia Seizure disorder Respiratory difficulties	Spastic Paraplegia Athetoid Cerebral palsy	Vision and hearing intact
13	Hyaline membrane disease Seizure disorder	Spastic Quadriplegia	Stabismus Eye move-ments jerky

(Table Continues)

TABLE 4

Subject Description

Subject No.	Medical History / Diagnosis	Motor	Sensory
22	Hyperbilirubinemia Kernicteric brain damage	Spastic Quadriplegia Scoliosis	Eyes are not well co-ordi- nated
23	Seizure disorder from 6 months Prenatal toxemia	Spastic Cerebral palsy Quadriplegia	Sees and hears adequately
24	Hydrocephalic Seizure disorder	Diplegia	Visual im- pairment in one eye
31	Static disorder Severe retardation Forcep delivery	Spastic Quadeparesis	Sees large objects and hears well
32	Meningitis Chest congested Respiratory disorder Mother suffering from scleresis	Severe Neurological deficit Quadriplegia Spastic	Vision and hearing seems intact
33	Microcephaly Delayed development of unknown origin	Choreoathetoid Scoliosis	Hearing loss in right ear Sees well
53	Microcephaly of unknown prenatal origin Seizure disorder	Spastic Quadriplegia Scoliosis	Sees and hears well

visually, as assessed by ward staff and by test items from the Bayley Mental Scale (Bayley, 1969) requiring visual fixation. A list of these items is presented in Table 5.

TABLE 5

Visual Fixation Test Items from the Mental Scale of the Bayley Scales of Infant Development

Item Number	Item Description
5	Momentary regard of red ring
6	Regards person momentarily
7	Prolonged regard of red ring
19	Turns eyes to red ring
20	Turns eyes to light
34	Glances from one object to another
37	Reaches for dangling ring
45	Inspects own hands
46	Closes on dangling ring

2.2 STIMULI AND APPARATUS

The stimuli used in this study were colored slides of facial expressions of happy and surprise, posed by a female model. The projected faces were approximately 22 cm high X 16 cm wide. Each subject was presented with the same face posing the two expressions. The facial expressions were prepared following Izard's (1971) standardized photographs.

Initially two female models were shown Izard's (1971) standardized photographs of happy and surprised expressions along with the description of facial features and movements of the positions of the different face regions. Each model produced each pose five times, and photographs of each pose were taken. To obtain objectivity in selecting one happy and one surprised expression, four graduate students in psychology were asked to rate the poses produced by the two female models. These judges were shown the Izard (1971) standard photographs of happy and surprise expressions and the corresponding descriptions of facial features. Izard (1971) described the typical pattern of position or movement in eyebrows, eyes, mouth, cheeks, and nose for the happy emotion, and described eyebrows, eyes, mouth, forehead, and jaw for the surprise emotion. Judges were shown each pose produced by the two models one by one using a slide projector, and they were asked to indicate whether or not it matched Izard's (1971) description of each facial feature. After giving their judgement on each facial feature, judges were then asked to indicate whether the overall impression of each pose matched with the corresponding standard pose as found in Izard (1971). Finally, each judge was asked to indicate the best pose (judged by the degree of closeness with Izard's photographs), produced by each model for each expression. A happy and a surprise pose for one model was obtained on which 3 of the 4 judges agreed on the overall rating. In addition to these face stimuli, 35 mm slides with a white circle (diameter = 21 cm) on a black background were used for the pre- and posttest trials.

The stimuli were projected onto a 22.5 X 22.5 cm rear projection screen by a Kodak Carousel 800 projector. The screen was at the subject's eye level. The screen was located in a white frame. To provide light for the video camera, a 15-watt flourescent light was mounted on the frame above the screen. A video camera with a zoom lens was placed above and behind the screen. A recording duration timer counting 1/30th of a second was superimposed on the video tape. A black cloth screen was used to block the subject's view of the camera and experimenter. The lense of the video camera was placed through a hole in the black cloth. A white enclosure surrounded the subject on three sides when he or she was placed in front of the screen.

There was a small white cue light centered at the bottom of the screen. This cue light was used to orient the subject's attention to the screen, and it was operated manually using a switch placed by the side of the video camera. There was also a switch which permitted the experimenter to operate the projector to present the colored slides of facial expressions.

2.3 PROCEDURE

Subjects were tested individually while sitting in their wheelchairs. They were brought to the observation room and placed under the white enclosure facing the projection screen. The eyes of the subjects were about 1 m from the screen. After placing the subject, the experimenter came out of the white enclosure, closed the side of the enclosure, turned off the lights in the room, and stood behind the screen by the side of the camera. The camera was adjusted continuously so that the subject's whole face was visible.

The experimenter initiated a trial by repeatedly pressing the button to produce a blinking cue light. When the subject oriented towards the screen or the blinking light, the experimenter turned off the cue light and presented the stimulus. The duration of the stimulus presentation was set at 20 s, but varied from 19 s to 27 s across trials and subjects, due to malfunction of a timer. But the range of times was small within a session for a given subject. The within session range was 3 s for 11%, 2 s for 58%, and 1 s for 31% of the sessions. After this period was over, the timer advanced the projector to turn off the stimulus and present a blank screen during the intertrial interval. After each trial, the experimenter immediately presented the blinking light again, and as soon as the subject oriented to the screen, the stimulus was presented for the next trial.

Each subject participated in four sessions. At least a 24-hour interval was maintained between sessions. The order of presentation of the two expressions was counterbalanced over sessions for each subject and over two groups of subjects. As shown in Table 6, subjects in the HSHS group received the following sequence for the habituating stimuli; happy (H) in Session 1, surprise (S) in Session 2, happy in Session 3, and surprise in Session 4. The subjects in the SHSH group received the opposite order of presentation of the stimuli.

Each session consisted of four phases: a pretest trial, a series of 12 or 14 habituation trials, 4 test trials, and 1 posttest trial. Each subject received 12 trials in the habituation phase of one session with the happy stimulus and one session with the surprise stimulus. To permit a partial lag presentation of the test trials, the remaining sessions had 14 habituation trials. The number of subjects receiving 14 or 12 trials on a particular session was held constant across groups. In all sessions a 1-trial pretest preceded the habituation trial, and a 1-trial posttest followed the test trials. Slides of a white circle were shown on each pretest and posttest trial.

TABLE 6

Stimulus Presentation Orders for Four Sessions

Session	Group HSHS				Group SHSH			
	Pretest Phase	Experimental Phase		Posttest Phase	Pretest Phase	Experimental Phase		Posttest Phase
		Habituation Phase	Test Phase			Habituation Phase	Test Phase	
1	WC	H	S	WC	WC	S	H	WC
2	WC	S	H	WC	WC	H	S	WC
3	WC	H	S	WC	WC	S	H	WC
4	WC	S	H	WC	WC	H	S	WC

Note.
WC = White Circle; H = Happy expression;
S = Surprised expression.

A session was discontinued and readministered later: (a) if more than three minutes passed between two trials because of difficulty orienting the subject to the screen; (b) if a subject failed to fixate for more than 50% of the trials; (c) if the subject cried or fell asleep, or (d) if any other event disrupted the experimental sessions. Seven sessions were readministered. Three sessions were repeated because subjects failed to fixate on the stimulus on more than 50% of the trials. This happened because one subject had a tendency to thumb suck and another had a tendency to turn his head to the left. When head support was provided these subjects were successfully tested. One session of another subject was repeated because the subject fell asleep. Three other sessions were dropped and readministered because of disruption in experimental procedures. Of these three sessions, one was repeated due to use of the wrong order of stimulus presentation, another because the session was conducted without positioning the wheel chair correctly, and the third because the subject became very active during the experimental session.

Three of 17 subjects were dropped from the experiment. One subject didn't orient to the blinking cue light or the screen. Another subject participated in the first session, but during the second session he started crying while he was being brought to the observation room. The last subject successfully completed three sessions, but he became sick before the fourth session and was unavailable for further testing.

Chapter III

RESULTS

The video tapes were viewed to score duration of visual fixations. Fixations were scored following the guidelines presented in Appendix B. In the present study, the reflection of the stimulus over the pupil was not visible on most trials because the stimuli did not transmit sufficient light. Therefore, the cue light was used as a reference point on most trials. A button was pressed when the observer judged that the subject was fixating the stimulus and the duration of the button press was recorded by an Apple IIe computer. The number of fixations, duration of each fixation, and total duration of fixation on each trial was calculated by the computer. Reliability of this scoring method was checked by having a second observer score 25% of the sessions, one session per subject. The median Pearson Product Moment correlation coefficient between the total fixation times for the two observers was .90 (range = .59 to .99).

The total fixation time for each trial comprised the basic data in this study. To adjust for the variation in duration of stimulus presentation, each of these total fixation times was divided by the duration of the stimulus presentation on the corresponding trial to obtain the proportion of time spent looking at the stimulus. For the habituation and test phases, these scores were grouped into blocks of two trials by taking the mean of the proportion of looking for each successive pair of trials. A logarithmic transformation ($\log_{10}X + 1$) of the blocked data and the proportion of looking time on pre- and posttests was carried out.

3.1 HABITUATION PHASE

The transformed habituation phase data were analyzed to find out whether there was a decline in proportion of time spent looking at the stimulus over trial blocks. A mixed factor analysis of variance was conducted with the condition (stimulus presentation order -- HSHS vs. SHSH) as the between-subject variable. The within subject variables were lag (no-lag vs. lag), face (happy vs. surprise), and trial block (Block 1 to Block 6). The results of this analysis are shown in Table 13, Appendix A. Only the main effect for trial blocks was significant, F (1, 12) = 4.66, p = 0.001.

Figure 1 shows that the subjects' proportion of looking time declined from Block 1 to Block 6. But there was an exception in this trend; after declining up to the third trial block, subjects' fixation times increased at Block 4, and then declined again on Blocks 5 and 6. A trend analysis (see Table 14, Appendix A) revealed significant linear and cubic trends over trial blocks, F (1, 12) = 10.19, p = 0.01 and F (1, 12) = 6.37, p = 0.03, respectively.

An analysis of variance was conducted to examine possible changes in performance over sessions during the habituation phase. Here, the between subject variable was condition (HSHS vs. SHSH). The within subject variables were session (Session 1 to Session 4), and trial blocks (Block 1 to Block 6). The results of this analysis are presented in Table 15, Appendix A. The results show that subjects' habituation didn't differ significantly over sessions in the habituation phase, F (3, 36) = 0.41, p = 0.75.

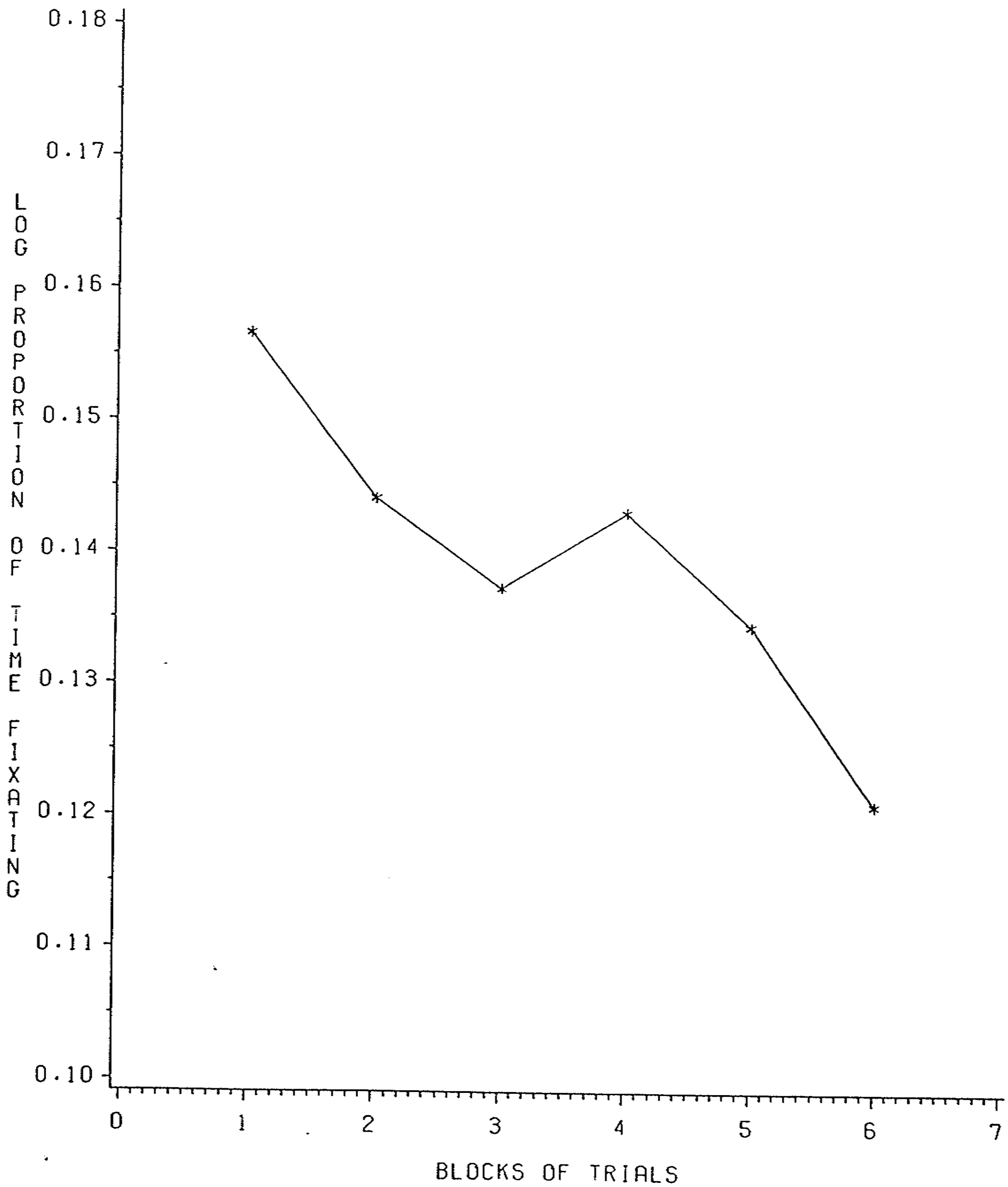

Figure 1: Log proportion of time fixating per trial block during habituation.

3.2 TEST PHASE

The data in the test phase were analyzed to see whether the profoundly mentally retarded subjects discriminated between the facial expressions of happy and surprise. For this analysis, data from the last two blocks in the habituation phase and the two blocks in the test phase were utilized. For the no-lag condition, trials 9 through 16 were used, and for the lag condition, trials 11 through 18 were used. A mixed factor analysis of variance was conducted with stimulus presentation order (HSHS vs. SHSH) as the between-subject variable, and lag (no-lag vs. lag), novel face (surprise vs. happy), phase (habituation vs. test), and trial block (Block 1 vs. Block 2) as the within subject variables. A summary of the results of this analysis is presented in Table 16, Appendix A. A significant main effect for phase was obtained, F (1, 12) = 12.82, p = 0.004. Log proportion of time looking at the stimulus when the new face was presented during the test phase was greater than the log proportion of looking at the end of the habituation phase (test phase mean = 0.15, habituation phase mean = 0.13).

The Lag x Face x Block x Condition interaction was also significant, F (1, 12) = 4.81, p = 0.049. The means involved in this interaction are presented in Table 7. They suggest a decline in proportion of time fixating the stimulus from Block 1 to Block 2 for subjects in the SHSH,

TABLE 7

Means Involved in the Lag x Face x Block x Condition Interaction

BLOCKS	HSHS CONDITION			
	No-Lag		Lag	
	SURPRISE	HAPPY	SURPRISE	HAPPY
BLOCK 1	0.17	0.16	0.17	0.14
BLOCK 2	0.16	0.15	0.17	0.15

BLOCKS	SHSH CONDITION			
	No-Lag		Lag	
	SURPRISE	HAPPY	SURPRISE	HAPPY
BLOCK 1	0.12	0.11	0.12	0.14
BLOCK 2	0.09	0.10	0.12	0.11

Note.
Tukey's HSD critical value = 0.18 for $p = 0.05$.

No-Lag condition, when the surprise stimulus was the novel stimulus and in the SHSH, Lag condition, when the happy stimulus was the novel stimulus. The statistical significance of the difference between these means was calculated using Tukey's HSD technique (Kirk, 1982). The critical difference (p = 0.05) was found to be 0.18. None of the pairwise comparisons were significant.

Another analysis of variance was conducted to examine changes in subjects' performance over sessions during the test phase. The between subject variable was condition (HSHS vs. SHSH), and the within subject variables were session (Session 1 to Session 4), phase (habituation vs. test), and trial blocks (Block 1 vs. Block 2). Results of these analyses are presented in Table 17, Appendix A. The main effect for sessions was nonsignificant, F (3, 36) = 0.83, p = 0.49. But the Session x Phase interaction was significant, F (3, 36) = 4.90, p = 0.006. The means involved in the Session x Phase interaction are presented in Table 8. The difference between habituation and test phase means were probed using Tukey's HSD. The HSD critical value was found to be 0.03 for p = .05. Consequently, the difference between habituation and the test phase means was significant for sessions 1, 2, and 4 but not for session 2.

TABLE 8

Means Involved in the Session x Phase Interaction

PHASE	SESSION 1	SESSION 2	SESSION 3	SESSION 4
HABITUATION	0.13	0.13	0.12	0.12
TEST	0.16	0.13	0.15	0.15

Note. Tukey' HSD critical value = 0.03 s for *p* = 0.05.

3.3 PRETEST VS. POSTTEST

In order to check the stability of subjects' level of responding independent of experimental stimuli, the pre- and posttest data were analyzed. The transformed pre- and posttest data were entered into an analysis of variance with condition (HSHS vs. SHSH) as the between subject variable, and lag (no-lag vs. lag), face (happy vs. surprise), and trial (pretest vs. posttest) as the within subject variables. This analysis used data from 12 subjects because pretest data for 2 subjects were not obtained due to experimenter error. The results of the analysis of variance are presented in Table 18, Appendix A. There was no significant difference in proportion of time fixating the stimulus between pretest and posttest, F (1, 10) = 0.52, p = 0.49. Other main effects and interactions were also nonsignificant.

3.4 SUBJECT CHARACTERISTICS AND PERFORMANCE

Subjects' chronological ages (CA) and Bayley mental scale raw scores (BRS) were correlated with three performance indices derived from habituation and test phase data: (a) The mean proportion of time spent in looking (GMTOT) was obtained using the habituation data for all four sessions (GMTOT = Sum of the proportion of time fixating the stimulus over the four habituation sessions divided by the total number of trials in the four sessions); (b) Amount of habituation was defined as the difference between the proportion of subjects' looking on the first and last block of habituation phase trials; mean amount of habituation (MAMHB) was the mean of these scores over the four sessions; (c) Novel-familiar difference was defined as the difference between subjects' mean proportion of looking during test phase blocks and mean proportion of looking during the last two blocks in the habituation phase, and the mean novel-familiar difference (MNFD) was the mean of these scores over the four sessions. The intercorrelations among the two subject characteristics and three performance variables are presented in Table 9. Only the correlation between BRS and MNFD was significant, $r = 0.61$, $p = 0.05$.

TABLE 9

Correlational Analysis of Subject Characteristics and Habituation and Discrimination Indices

	CA	BRS	GMTOT	MAMHB	MNFD
CA		0.18	-0.19	-0.25	0.34
BRS			-0.10	-0.07	0.61*
GMTOT				0.14	-0.05
MAMHB					0.44

* $p = 0.05$, df = 13

Note.

CA = Chronological Age
BRS = Bayley Mental Scale Raw Score
GMTOT = Mean of the proportion of time looking during habituation
MAMHB = Mean of the difference between the proportion of time looking on the first and sixth trial block during habituation
MNFD = Mean of the difference between the proportion of looking during the last two habituation trial blocks and the two test trial blocks

3.5 STABILITY OF MEASURES

Stability of the habituation and discrimination measures over sessions was examined. The three measures were:

1. mean total amount of looking during habituation in each session (MTOT 1, MTOT 2, MTOT 3, and MTOT 4);
2. amount of habituation in each session (AMHB 1, AMHB 2, AMHB 3, and AMHB 4); and
3. novel-familiar difference in each session (NFD 1, NFD 2, NFD 3, and NFD 4).

It was found that the MTOT measures were the most stable over four sessions as these measures were intercorrelated at the .001 level of significance (see Table 10). The intercorrelations for the amount of habituation and novel-familiar difference measures across the four sessions were not significant (see Tables 11 and 12).

TABLE 10

Intercorrelations of Mean Total Amount of Looking for the four Sessions

	MTOT 1	MTOT 2	MTOT 3
MTOT 2	0.78 **		
MTOT 3	0.93 **	0.88 **	
MTOT 4	0.94 **	0.77 **	0.87 **

** p = .001

Note.
MTOT = Mean total amount of looking during habituation for Session 1 to Session 4.

TABLE 11

Intercorrelations of Amount of Habituation for the Four Sessions

	AMHB 1	AMHB 2	AMHB 3
AMHB 2	0.26		
AMHB 3	-0.24	-0.18	
AMHB 4	0.003	-0.08	-0.27

Note. AMHB = Amount of habituation for Session 1 to Session 4.

TABLE 12

Intercorrelations of Novel-familiar Difference for the Four Sessions

	NFD 1	NFD 2	NFD 3
NFD 2	-0.12		
NFD 3	0.43	-0.05	
NFD 4	0.41	0.26	0.40

Note. NFD = Novel-familiar difference for Session 1 to Session 4.

Chapter IV

DISCUSSION

This study investigated the discrimination of facial expressions by nonambulatory profoundly mentally retarded children and adolescents. More specifically, the purpose of the present study was to see whether they could discriminate between facial expressions of happy and surprise posed by a female adult. To study the discrimination ability of the mentally retarded subjects in the present study, a fixed-trial habituation-dishabituation paradigm was used. In this paradigm, discrimination ability is inferred from greater visual fixation to a novel stimulus than to the habituating stimulus after familiarization to the habituating stimulus. The results of the present study demonstrated that subjects looked at the novel expression longer than they looked at the habituated expression. Their proportion of time fixating the stimulus during the test phase (mean = 43%) was greater than during the last two blocks of the habituation phase (mean = 36%). This finding was independent of the number of habituation trials, as there was no difference between lag and no-lag conditions. Thus, these nonambulatory profoundly mentally retarded children discriminated between happy and surprised facial expressions.

Previous studies have found that profoundly mentally retarded subjects can discriminate between different faces (Butcher, 1977), between male and female faces (Whiteley et al., 1987), and between facial and nonfacial stimuli (Shepherd et al., 1984). The findings of the present study extend our knowledge of the discriminative skills of these individuals by showing that they can also discriminate between the facial expressions of happy and surprise posed by the same model.

This demonstratation of discrimination of facial expressions provides new information relevant to understanding the development of social cognition in profoundly mentally retarded individuals. Each facial expression has a definite social signal value, with specific emotional connotation. Perception of facial expressions during the early developmental years helps toward the production of socially appropriate emotions. Facial expression is thus a means of communication between parents and infants, a way of enhanced interaction for socialization. As the profoundly mentally retarded individuals in the present study could discriminate between two facial expressions, happy and surprise, we might expect that facial expressions are a means of communication with this handicapped population.

A further theoretical question is whether profoundly mentally retarded individuals really understand the meaning of different facial expressions. From the findings of the present study, it is not possible to say whether the subjects discriminated the facial expressions on a conceptual basis. It may be that subjects in the present study discriminated the two facial expressions on the basis of isolated features of the faces, rather than on the basis of an organized set of features that define an expression. Further studies are needed to see whether subjects from this population discriminate expressions qua expressions. Whether or not profoundly retarded children deal with expressions as an organized whole can be tested by using facial expressions from several models in habituation and test phases. If the subjects show habituation to one facial expression and dishabituation to a novel expression irrespective of the model, then we can conclude that they can abstract the meaning of a particular facial expression.

The study of facial expressions with nonambulatory profoundly mentally retarded children is worthwhile for practical reasons. If we can develop a catalog of facial expressions to which these individuals show sensitivity, then these expressions could be used as stimuli for controlling and shaping the behavior of these children, thereby facilitating management by their caretakers. In other words, we could develop a nonverbal means of communication with this population which lacks verbal comprehension by using appropriate facial expressions.

There was strong evidence of habituation in this study. The proportion of time fixating the stimulus declined from Block 1 (46%) to Block 6 (35%). As no significant difference was found between pre- and posttest data and dishabituation was found on test trials, this decline can not be explained by nonspecific factors such as motor fatigue, sensory adaptation, or changes in behavioral state. This finding is consistent with results obtained by Kelman and Whiteley (1986) and Krenn (1986) who also used fixed-trial procedures. But the stimuli in these two studies were less complex than those used in the present study. The stimuli in the present study were photographs of facial expressions, whereas the Kelman and Whiteley (1986) and Krenn (1986) study used simple geometric patterns as habituating and test stimuli. This study demonstrates that habituation also occurs to complex facial expressions.

A linear decline in total fixation times during habituation was found in previous studies with profoundly mentally retarded children (e.g., Kelman & Whiteley, 1986; Krenn, 1986). But in the present study, both linear and cubic trends were found. Subjects' level of eye fixation followed a declining trend from Block 1 to Block 3, but it increased on Block 4, and then declined over Blocks 5 and 6. This pattern might be due to the use of complex stimuli in the present study. The previous studies which found only a linear trend used less complex stimuli that had fewer defining features. On the other hand, in the present study, the facial expression of happy and surprise were relatively complex as they had many defining features. When a profoundly mentally retarded subject is exposed to complex stimuli he or she may initially attend to only some of its features because of limitations in visual scanning or attentional capacity. Over repeated presentations, these subjects may habituate to these features of the stimulus. Subsequently, they may attend to other features of the visual display. When the new features are processed, an increase in fixation times may occur. If it was possible to identify the features of a stimulus to which the individual attends during the initial, middle, and later periods of the habituation phase, this interpretation of the trend over habituation trials could be verified. This could be done by studing the scanning pattern of subjects' eye fixations during habituation trials (e.g., Haith, Bergman, & Moore, 1977; Maurer & Salapatek, 1976).

Data were analyzed to see whether subjects' duration of eye fixation changed across sessions. No significant changes were found for habituation phase data. Previous studies by Kelman and Whiteley (1986), Krenn (1986), Abraham (1987) also maintained 24-hour intervals between sessions and have not found changes in performance. One exception in this study was the Session x Phase interaction found for test phase data. Larger fixation times were found for the novel expression than for the familiar expression on Sessions 1, 3, and 4, but not on Session 2. When the interval between sessions was calculated for each subject, it was found that the interval between Session 1 and Session 2 was the shortest (mean interval = 2.14 days). The interval between Session 2 and Session 3 was 4.64 days, and the interval between Session 3 and Session 4 was 2.93 days. The nonsignificant difference between familiar and novel expression in Session 2 might be due to the shorter interval between Session 1 and Session 2, as compared to the intervals between other sessions. This shorter interval might have produced some carry over effect from Session 1 to Session 2. Systematically varying intervals between sessions might reveal whether or not intersession interval is a factor affecting dishabituation.

The correlational analyses relating subject characteristics to discrimination indices revealed that Bayley Mental Scale Raw Scores (BRS) were significantly positively correlated with the index of discrimination, Mean Novel-Familiar Difference (MNFD). These results suggest that more developmentally advanced individuals were more sensitive to changes in facial expression. Abraham (1987) found a nonsignificant positive correlation between BRS and amount of recovery to the novel stimulus. In contrast to these findings, Kelman and Whiteley (1986) did not find any correlation between MA and amount of recovery during their test phase. Kelman and Whiteley (1986) and Abraham (1987) found a significant negative correlation between CA and amount of recovery, but the present study didn't find a significant correlation between these variables.

In the present study a nonsignificant negative correlation was found between mean amount of habituation (MAMHB) and CA, but no relation was found between amount of habituation and Bayley Raw Score. Abraham (1987) found that CA and BRS were significantly negatively correlated with amount of habituation. In Kelman and Whiteley (1986), no significant relationship was found between habituation and CA, or between habituation and MA. Further investigation is required to explain these contradictory findings.

CONCLUSION

The main purpose of the present study was to investigate whether nonambulatory profoundly mentally retarded children can discriminate between happy and surprised facial expressions. Results indicated that these individuals can discriminate between two dimensional photographs of these facial expressions posed by an adult female. A secondary purpose of the study was to investigate whether these individuals show habituation to facial expressions. It was found that they showed habituation to both happy and surprise stimuli. One interesting finding of the study was that their fixation times showed a decline over the first three habituation trial blocks, increased at the fourth trial block, and further declined over the fifth and sixth trial blocks. This effect might have been due to the complexity of the stimuli in conjunction with limited attentional capacity of the participants. Further studies could be undertaken to find out whether the habituation curve changes from linear to cubic as stimuli became more complex. Studies can also be conducted to investigate whether nonambulatory profoundly mentally retarded children can habituate to facial expressions when several models are presented.

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Appendix A

ANALYSIS OF VARIANCE SUMMARY TABLES

TABLE 13

Habituation Phase Data: Summary of Analysis of Variance on Condition x Lag x Face x Block

Source	df	Mean Square	F	P
Condition (C)	1	0.1750	1.29	0.277
Error	12	0.1350		
Lag (L)	1	0.0046	1.11	0.314
L x C	1	0.0004	0.11	0.751
Error	12	0.0042		
Face (F)	1	0.0009	0.21	0.651
F x C	1	0.0026	0.59	0.457
Error	12	0.0043		
Block (B)	5	0.0078	4.66	0.001
B x C	5	0.0016	0.93	0.469
Error	60	0.0017		
L x F	1	0.0037	0.38	0.549
LF x C	1	0.0079	0.82	0.384
Error	12	0.0097		
L x B	5	0.0011	0.54	0.747
LB x C	5	0.0033	1.57	0.183
Error	60			
F x B	5	0.0007	0.41	0.840
FB x C	5	0.0004	0.27	0.930
Error	60	0.0016		
L x F x B	5	0.0004	0.29	0.795
LFB x C	5	0.0017	1.11	0.364
Error	60	0.0015		

TABLE 14

Habituation Phase Data: Summary of Trend Analysis

Source	df	Mean Square	F	P
Linear (Li)	1	0.0323	10.19	0.01
Li x C (cond)	1	0.0011	0.33	0.58
Error	12	0.0032		
Quad (Qd)	1	0.0001	0.07	0.80
Qd x C	1	0.0016	1.13	0.31
Error	12	0.0014		
Cubic (Cb)	1	0.0056	6.37	0.03
Cb x C	1	0.0019	2.14	0.17
Error	12	0.0009		

TABLE 15

Habituation Phase Data: Summary of Analysis of Variance on Condition x Session x Block

Source	df	Mean Square	F	P
Condition (C)	1	0.1702	1.24	0.287
Error	12	0.1371		
Session (S)	3	0.0025	0.41	0.749
S x C	3	0.0040	0.64	0.593
Error	36	0.0062		
Block (B)	5	0.0071	4.28	0.002
B x C	5	0.0013	0.81	0.545
Error	60	0.0017		
S x B	15	0.0015	0.92	0.548
SB X C	15	0.0005	0.30	0.995
Error	180	0.0017		

TABLE 16

Test Phase Data: Summary of Analysis of Variance on Condition x Lag x Face x Phase x Block

Source	df	Mean Square	F	P
Condition (C)	1	0.1164	1.41	0.258
Error	12	0.0826		
Lag (L)	1	0.0021	1.23	0.288
L x C	1	0.0053	3.16	0.101
Error	12	0.0017		
Face (F)	1	0.0020	0.58	0.462
F x C	1	0.0048	1.35	0.268
Error	12	0.0035		
Phase (P)	1	0.0265	12.82	0.004
P x C	1	0.0007	0.32	0.580
Error	12	0.0021		
Block (B)	1	0.0049	3.71	0.078
B x C	1	0.0016	1.22	0.292
Error	12	0.0013		
L x F	1	0.0009	0.36	0.561
LF x C	1	0.0014	0.56	0.467
Error	12	0.0025		
L x P	1	0.0003	0.65	0.437
LP x C	1	0.0011	2.06	0.177
Error	12	0.0005		
L x B	1	0.0012	1.18	0.300
LB x C	1	0.0003	0.27	0.615
Error	12	0.0010		
F x P	1	0.0007	0.93	0.354
FP x C	1	0.0035	4.56	0.054
Error	12	0.0008		
F x B	1	0.00007	0.06	0.814
FB x C	1	0.00005	0.04	0.843
Error	12	0.00120		

(Table Continues)

TABLE 16

Test Phase Data: Summary of Analysis of Variance on Condition x Lag x Face x Phase x Block

F x B	1	0.0000	0.00	0.999
FB x C	1	0.0026	1.87	0.196
Error	12	0.0014		
L x F x P	1	0.00005	0.06	0.811
LFP x C	1	0.00064	0.70	0.419
Error	12	0.00091		
L x F x B	1	0.0004	0.53	0.481
LFB x C	1	0.0039	4.81	0.049
Error	12	0.0008		
L x P x B	1	0.0005	0.23	0.639
LPB x C	1	0.0005	0.26	0.617
Error	12	0.0020		
F x P x B	1	0.0005	0.26	0.619
FPB x C	1	0.0023	1.20	0.295
Error	12	0.0019		
L x F x P x B	1	0.0042	3.08	0.105
LFBP x C	1	0.0008	0.63	0.444
Error	12	0.0013		

TABLE 17

Test Phase Data: Summary of Analysis of Variance on Condition x Session x Phase x Block

Source	df	Mean Square	F	P
Condition (C)	1	0.1164	1.64	0.258
Error	12	0.0826		
Session (S)	3	0.0022	0.83	0.487
S x C	3	0.0028	1.08	0.368
Error	36	0.0026		
Phase (P)	1	0.0265	12.82	0.004
P x C	1	0.0007	0.32	0.580
Error	12	0.0021		
Block (B)	1	0.0049	3.71	0.078
B x C	1	0.0016	1.22	0.292
Error	12	0.0013		
S x P	3	0.0028	4.90	0.006
SP x C	3	0.0012	2.01	0.131
Error	36	0.0006		
S x B	3	0.0006	0.75	0.529
SB x C	3	0.0008	0.75	0.530
Error	36	0.0010		
P x B	1	0.0000	0.00	0.999
PB x C	1	0.0026	1.87	0.196
Error	12	0.0014		
S x P x B	3	0.0031	1.84	0.157
SPB x C	3	0.0006	0.35	0.790
Error	36	0.0017		

TABLE 18

Pre-Post Test Data: Summary of Analysis of Variance on Condition x Lag x Face x Trial

Source	df	Mean Square	F	P
Condition (C)	1	0.0820	3.38	0.596
Error	10	0.0243		
Lag (L)	1	0.00003	0.01	0.941
L x C	1	0.00010	0.02	0.897
Error	10	0.00549		
Face (F)	1	0.00001	0.00	0.952
F x C	1	0.00707	2.15	0.174
Error	10	0.00329		
Trial (T)	1	0.0046	0.52	0.488
T x C	1	0.0018	0.20	0.662
Error	10	0.0088		
L x F	1	0.0016	0.55	0.476
LF x C	1	0.0007	0.25	0.626
Error	10	0.0029		
L x T	1	0.00001	0.00	0.946
LT x C	1	0.00032	0.12	0.738
Error	10	0.00272		
F x T	1	0.00912	3.99	0.074
FT x T	1	0.00002	0.01	
Error	10	0.00229		
L x F x T	1	0.0006	0.29	0.599
LFT x C	1	0.0075	3.64	0.086
Error	10	0.0021		

Appendix B

DEFINITION OF A FIXATION

If the stimulus is reflected over the pupil, score a fixation. If the stimulus reflection cannot be seen, use the cue light as a reference point. If the cue light is between slightly above the pupil to one-half way down the pupil and centered over the pupil, then score a fixation.

When both the reflection from the stimulus and the cue light are not visible over the subject's pupil, then score fixation on the basis of subject's general orientation and gazing pattern.

The eye that seems to be looking directly in front of the subject should be used if eye movements are not coordinated. A quick blink does not terminate a fixation.

Appendix C

RAW DATA

The data files were organized as follows with 25 lines for each subject:

Line 1:

Subject number; Chronological age in years; Bayley Raw Score; Sex (1 = female; 2 = male); Condition (1 = HSHS, 2 = SHSH).

Line 2:

Session number (1 to 4); habituating stimulus (1 = happy, 2 = surprise); Lag (1 = no lag, 2 = lag); total fixation time in pretest trial; total fixation time per habituation trials (trials 1 to 10).

Line 3:

Total fixation time per habituation trials (for no lag condition: trials 11 and 12, for lag condition: trials 11 to 14).

Line 4:

Total fixation time in the last four habituation trials (for no lag condition: trials 9 to 12, for lag condition: trials

11 to 14); total fixation time in the four test trials (trials 1 to 4); total fixation time in posttest trial.

Line 5:

Same as Line 2 (but different session/stimulus/condition).

Line 6:

Same as Line 3.

Line 7:

Same as Line 4.

Line 8:

Same as Line 2 (but different session/stimuli/condition).

Line 9:

Same as Line 3.

Line 10:

Same as Line 4.

Line 11:

Same as Line 2 (but different session/stimuli/condition).

Line 12:

Same as Line 3.

Line 13:

Same as Line 4.

Line 14:

Session number (1 to 4); habituating stimulus (1 = happy, 2 = surprise); lag (1 = no lag; 2 = lag); total stimulus presentation time in pretest trial; total stimulus presentation time per habituation trials (trials 1 to 10).

Line 15:

Total stimulus presentation time per habituation trials (for no lag condition: trials 11 and 12, for lag condition: trials 11 to 14).

Line 16:

Total stimulus presentation time in the last four habituation trials (for no lag condition: trials 9 to 12, for lag condition: trials 11 to 14); total fixation time in the four test trials (trials 1 to 4); total fixation time in posttest trial.

Line 17:

Same as Line 14 (but different session/stimulus/condition).

Line 18:

Same as Line 15.

Line 19:

Same as Line 16.

Line 20:

Same as Line 14 (but different session/stimulus/condition).

Line 21:

Same as Line 15.

Line 22:

Same as Line 16.

Line 23:

Same as Line 14 (but different session/stimulus/condition).

Line 24:

Same as Line 15.

Line 25:

Same as Line 16.

01 1187 56 1 1

3 1 1 1979 1365 1436 1822 1779 1779 1416 1773 2011 1603 1720 1817 2075

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4 2 1 * 1897 1975 1691 1838 1734 1955 1331 1866 1660 1702 1613 1397

1660 1702 1613 1397 2000 1622 1984 1730 1860

1 1 2 2153 2184 2108 2150 2118 1856 2335 1621 2040 1914 1686

2016 1723 1741 2346

2016 1723 1741 2346 2435 2289 2324 1983 2443

2 2 2 2047 2062 1628 1934 1809 1961 2006 2059 1889 2028 2054

1909 1849 1492 1789

1909 1849 1492 1789 1879 1752 1894 1707 2054

3 1 1 2100 2200 2100 2000 2000 2000 1900 2100 2000 2000 2100

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4 2 1 * 2100 2100 2000 2000 2000 2000 2100 2100 2000 2000

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02 1056 46 1 1

1 1 1 2111 2227 1946 1890 1979 1178 1528 1016 0888 1721 2313

1508 0479

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4 2 1 1169 1816 1377 1535 1075 1368 0546 1270 1219 1149 1811

1587 1409

1149 1811 1587 1409 1214 1428 1408 1262 1638

3 1 2 1523 1846 1818 1664 2113 1568 1249 1666 1626 1059 2107

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2 2 2 1465 2256 0079 2316 2330 1958 2167 2420 2163 1810 1885

1400 2314 0886 1187

1400 2314 0886 1187 0003 1873 2495 0988 1842

1 1 1 2400 2300 2400 2400 2300 2400 2400 2400 2400 2400 2400

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03 1675 34 2 1

1 1 1 1641 1654 2397 2312 0924 0862 2381 2014 1219 2375 1393

0808 2376

2375 1393 0808 2376 1670 0377 1440 2444 0240

2 2 1 2530 2523 0085 2448 0104 0120 0089 0103 0074 0122 2340

2340 2239

0122 2340 2340 2239 1374 2253 1449 2325 0176

3 1 2 1953 1341 1072 1402 1164 1311 1848 1217 2084 1325 0648

1264 1479 1016 1984

1264 1479 1016 1984 0404 1997 0642 1966 0423

4 2 2 1895 2130 2089 2151 2119 2108 2117 2078 2108 2199 1798

1481 1583 1222 1903

1481 1583 1222 1903 1785 1335 1256 1628 2112

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0115 0085

0207 0131 0115 0085 0839 0093 0189 0224 0895

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0215 0995 0133 0173 0440 0176 0282 0579 0314

1 2 1 0364 0070 0298 0274 0197 0297 0354 0399 0132 0102 0246

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3 2 2 0071 0133 0174 0293 0084 0167 0042 0168 0163 0124 0047

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1 2 1 0717 0784 1313 0788 1404 0470 0264 1349 0375 0127 0241

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4 2 1 0998 0506 0652 0403 0676 0281 0796 0243 0162 0817 0124 0271 0646

0817 0124 0271 0646 0936 0248 0632 0421 1210

3 1 2 0496 0632 0231 0279 0454 0012 0225 0264 0278 1363 0654 0131 0326 0410 0491

0131 0326 0410 0491 0174 0692 0623 0386 1005

2 2 2 0112 0122 0825 0312 0204 0160 0431 0270 0183 0323 0533 0362 0163 0503 0315

0362 0163 0503 0315 0231 0153 0542 0162 0933

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0366 0140 0220 0115 0060 0168 0289 0169 0447

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4 1 1 0194 0447 0575 0729 0155 0052 0168 0047 0612 0145 0102

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2 1 1 0792 0223 1303 0420 1547 0383 0961 1705 1589 0986 0751
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4 1 2 1142 0595 0777 1701 1239 0478 0954 1174 0763 0685 1253 0711 0820 1777 1812

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4 1 2 2100 2100 2100 2100 2100 2100 2100 2000 2000 2100 2100
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