CATEGORIZATION AND DISCRIMINATION OF FACIAL EXPRESSIONS BY PERSONS WITH MULTIPLE HANDICAPS

by

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Abstract

Perception of facial expressions among individuals with multiple handicaps was examined using a visual fixation procedure. Previous studies have demonstrated that these individuals can discriminate between two faces; in addition, it has been found that they can discriminate between happy and surprised facial expressions posed by a single adult model. This study explored whether individuals with multiple handicaps can categorize facial expressions. Fourteen subjects (median CA = 14.2 years, and mean MA = 4.2 months) were each tested in four sessions. Each session included a categorization problem and a discrimination problem. Order of presentation of each problem and facial expression was counterbalanced across sessions. In the familiarization phase of the categorization problems, subjects were exposed either to the happy or to the surprised expression posed by four different female models. In the test phase, subjects were exposed to the familiar expression and the novel expression posed by a fifth model. In the discrimination problems, happy and surprised expressions posed by a single model were used in both the familiarization and test phase.

Subjects looked longer at the novel expression than the familiar expression during the test phase of the discrimination problems, but no difference in looking times for the novel and familiar expressions was found for the categorization problems. These results were interpreted with reference to developmental research on discrimination and categorization of expressions by normal infants. This research suggests that the mental ages of the participants in the present study were sufficient for them to discriminate facial expressions but not to categorize expressions. Alternative interpretations addressing methodological reasons for failure to find categorization were also considered.

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Introduction

The Diagnostic and Statistical Manual of Mental Disorder-III-R (American Psychiatric Association, 1987) gives three defining features for mental retardation. First, to be diagnosed as mentally retarded, an individual must have an IQ of 70 or below on an individually administered IQ test. The second characteristic of mental retardation is a significant deficit in adaptive behavior skills, such as social skills, communication skills, daily living skills, personal independence, and self-sufficiency. Finally, onset of these problems must occur before 18 years of age. This diagnostic system identifies four degrees of severity that indicate the level of intellectual impairment. These are mild (IQ 50-55 to approximately 70), moderate (IQ 35-40 to 50-55), severe (IQ 20-25 to 35-40), and profound (IQ below 20 or 25).

Individuals with mental retardation in conjunction with physical or sensory handicaps have been described as multiply handicapped (Dunst & McWilliam, 1988). Landesman-Dwyer and Sackett (1978) used the term nonambulatory, profoundly mentally retarded to characterize those multiply handicapped individuals who are profoundly retarded, incapable of moving through space, lack adaptive behavior skills, and are extremely small for their chronological age. Persons with multiple handicaps have behavioral capabilities which are comparable to the abilities of normal infants in some respects. For example, they lack verbal communication skills and adaptive self-help skills; consequently, they are completely dependent on others for their survival.

Very little research has examined the social competence of multiply handicapped individuals. In one study (Hill & Whiteley, 1985), it was found that preschool and school-age children with multiple handicaps exhibited very few interactions with their intellectually normal classmates; and interacted less often with peers than intellectually normal children. Whiteley and Krenn (1986), using the Bayley mental scale found that multiply handicapped individuals demonstrate several social behaviors found in infants. Specifically, 64% of these individuals looked at a person momentarily; 55% responded to a voice; 52% followed a moving person with their eyes; and 39% exhibited a social smile in response to talking and smiling by the examiners. This descriptive information suggests that they are capable of responding to social cues, such as facial expressions.

Facial expressions have been identified as a major channel of interpersonal communication (Field & Walden, 1982). Recent advances in understanding the nature of emotional communication between infants and adults, where facial expressions play a very important role in the communication process, are relevant to conceptualizing this aspect of communication for multiply handicapped individuals.

Field and Walden (1982) pointed out that a meaningful infant-caretaker interaction would require at least two components: (a) the ability of the infant to perceive the caretaker's emotional expression; and (b) the ability of the infant to produce emotional expressions in response to the caretaker's expression. Tronick (1989) extended Field and Walden's (1982) description of infant-caretaker interaction to include the caretaker's role. According to this analysis, the infant-caretaker emotional communication process has at least four components: (a) perception of the caretaker's emotional expressions by the infant; (b) the infant's production of an emotional expression in response to the caretaker's expression; (c) perception of the infant's expression by the caretaker; and (d) the caretaker's production of an expression in response to the infant's expression. Thus, there is a cycle of emotional communication between the infant and the caretaker. The same analysis of communication applies to the interactions of persons with multiple handicaps and their caretakers.

The present study examined one aspect of this communication process; that is, the perception of facial expressions of others by individuals with multiple handicaps. A visual recognition memory test was used to examine whether multiply handicapped people can discriminate between happy and surprised expressions when these are posed by a single model; and whether they show evidence of categorization of these expressions when they are posed by multiple models. Discrimination refers to the person's ability to differentiate between two different stimuli; whereas, categorization refers to the person's ability to abstract common features from dissimilar stimuli. Understanding their ability to process facial expressions may assist caretakers to communicate meaningfully with these individuals.

Methodological Issues in Visual Recognition Memory Tests

Because of the similarities in behavioral characteristics between individuals with multiple handicaps and normal infants, it has been suggested that methods used to study normal infants might prove useful for the study of these handicapped persons (e.g., Shepherd & Fagan, 1981). One such method, the visual recognition memory test (Olson, 1979), is a widely used experimental method for investigating infant perception and cognition. Attention to a stimulus is affected by stimulus familiarity; and a novel stimulus elicits more attention than a familiar one (Olson & Sherman, 1983). Systematic variation of familiarity and novelty in an experimental situation can be used to study some aspects of perceptual and cognitive development.

Visual recognition memory tests require that individuals be able to attend to visual stimuli selectively and fixate on them with minimal eye movements (Butcher, 1977). A number of studies have demonstrated that many multiply handicapped individuals have these abilities (e.g., Kelman & Whiteley, 1986; Krenn & Whiteley, 1990; Shepherd & Fagan, 1980). These studies show that perceptual and cognitive functioning of multiply handicapped individuals can be studied using the visual recognition memory test paradigm. Visual recognition memory can be tested by both the habituation-dishabituation procedure and the paired-comparison procedure. Both of these procedures are discussed with regard to their applications to studying multiply handicapped individuals.

Habituation-Dishabituation Paradigm

Bornstein (1985) described 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 (p. 290).

Dishabituation is an increase in level of responding when a novel stimulus is presented following habituation. Dishabituation implies discrimination of the habituated and novel stimuli.

Most of the studies on habituation with multiply handicapped persons have been concerned with visual information processing and have used looking behavior as the index of attention (e.g., Berkson, 1966; Kelman & Whiteley, 1986; Switzky, Woolsey-Hill, & Quoss, 1979). Berkson was the first to apply the visual habituation-dishabituation paradigm with profoundly mentally retarded subjects. In one of his experiments, Berkson (1966) 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 estimated to be less than 1 year. Subjects were tested on four days; on each day, three trials were presented randomly for each of four conditions. A sliding door was raised for 60 seconds on each trial. The 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 Off-Off conditions, the disc remained rotating or stationary, respectively, for 60 s. In the On-Off and Off-On conditions, the disc was rotating for 30 s and stationary for 30 s. The percentage of time the subject fixated the stimulus during a 30-s trial was the dependent measure in this study. It was found that the percentage score 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). The results demonstrated habituation and dishabituation in profoundly mentally retarded subjects.

Two types of experimental procedures have been used to familiarize the subject to the habituating stimulus. These are fixed-trial procedures (e.g., Krenn & Whiteley, 1990), and subject-control procedures (e.g., Switzky, Woolsey-Hill, & Quoss, 1979). In a fixed-trial procedure, the habituating stimulus is presented to the subject for a fixed number of trials with exposures of predetermined duration. For example, in the Krenn and Whiteley (1990) study, vertical and horizontal patterns were presented to profoundly mentally retarded subjects for 20 s on each of 16 habituation trials. After the habituation trials, a novel stimulus (oblique or square pattern) or the familiar stimulus was presented on alternate trials over 8 test trials of 20 s duration. The results demonstrated that subjects showed response decrement during the habituation phase and response recovery during the test phase.

In the subject-control procedure, the habituating stimulus is presented for the duration of one visual fixation, and the number of trials continues until the subject reaches a pre-set habituation criterion (usually 2 consecutive looks of less than 50% duration of the mean of the initial 2 looks). For example, in the Switzky, Woolsey-Hill, and Quoss (1979) study profoundly mentally retarded subjects were repeatedly exposed to either 2 x 2 or 12 x 12 black and white checkerboard patterns until a set criterion of habituation was reached, as measured by a decrement in visual fixation time. After reaching the habituation criterion, subjects were alternately shown the habituating stimulus and the remaining checkerboard as the novel stimulus during post-habituation trials. Results on post-habituation trials demonstrated that looking times were longer to the novel stimulus than to the habituating stimulus.

Both the fixed-trials and subject-control procedures present methodological or conceptual difficulties. As the duration of the stimulus presentations are fixed, the fixed-trial procedure does not take the subject's looking behavior into consideration. For example, a subject may not be looking at the stimulus during its presentation, or the presentation of the stimulus may end while the subject is looking at it. The subject-control procedures have attempted to meet these criticisms by presenting the stimulus until the subject looks away from it; however, these procedures require on-line estimation of the subject's response, linkage of the response to stimulus presentation, and simultaneous calculation of a habituation criterion. Moreover, subjects may reach a habituation criterion by chance.

A response decrement due to repeated presentation of a stimulus may be explained by phenomena other than habituation. These are: (a) sensory adaptation, (b) effector fatigue, and (c) change in behavioral state. In a study using habituation-dishabituation procedures, 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 subject's level of responding remains the same from pretest to posttest, sensory adaptation, 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 recovery occurs, these alternative explanations of response decrement can be discarded.

However, habituation and recovery must be shown 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 subjects; otherwise, response recovery in the test phase could be caused by a stimulus preference or a startle response (Bornstein, 1985).

Paired-Comparison Procedure

The paired comparison procedure involves the presentation of a pair of identical stimuli for a fixed familiarization period, followed by a test phase involving the presentation of the familiar stimulus paired with a novel stimulus. The familiarization period may involve a fixed exposure time to the stimulus on one or more trials; or the exposure time may be a criterion amount of looking by the subject. The test phase involves two trials. The novel stimulus is presented on the right screen on one trial and on the left screen on the other trial. If the subject looks longer at the novel stimulus as compared to the familiar stimulus, it can be inferred that the subject discriminated between the two stimuli.

Shepherd and Fagan (1980) used the paired-comparison procedure to study multiply handicapped and profoundly mentally retarded children. They were exposed to sharply contrasting black and white patterns, and low contrasting gray and white patterns. The procedure of this study involved two 15-s periods of familiarization with one stimulus, followed by paired presentations of the familiar and a novel stimulus for 5 s during test trials. The results of this study demonstrated that subjects looked longer at the novel stimulus than at the familiar stimulus during the test phase.

In the paired-comparison procedure, factors that might affect the subject's choice between two stimuli include discriminability, preference, and response bias (Olson & Sherman, 1983). As the relative novelty factor is of primary importance in most experiments, investigators must control these other variables. They generally adopt three control measures: (a) they choose stimuli, prior to familiarization, at which subjects look equally; (b) they counterbalance novel and familiar stimuli over subjects or test sessions; and (c) they counterbalance right-left position of the test stimuli over two test trials.

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 periods. For example, Shepherd and Fagan (1980) found significant novelty preference in profoundly mentally retarded subjects using familiarization periods of only two

15-s trials, and Shaw (1988) found evidence of memory after only three 10-s familiarization trials. 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 70%. Shaw (1988) reviewed studies with multiply handicapped children and found scores in the 43% to 68% range.

In the habituation-dishabituation paradigm, 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 the position of the stimulus. On the other hand, as the familiar stimulus does not appear simultaneously with the novel stimulus, the habituation-dishabituation paradigm demands more memory capability.

Discrimination Research with Multiply Handicapped Persons

Various types of stimuli have been used in visual discrimination research with multiply handicapped individuals: for example, geometric figures, colors, faces, and facial expressions. Studies with nonfacial stimuli provide information about sensory and perceptual abilities. In addition, as facial stimuli have social significance, studies with these stimuli also enable us to explore the development of social perception and cognition. Discrimination of facial and nonfacial stimuli are considered separately in this section.

Discrimination Research with Nonfacial Stimuli

As mentioned earlier, Berkson (1966) found that profoundly retarded subjects could discriminate between moving and stationary stimuli; Switzky et al. (1979) found that they can discriminate between different checkerboard targets; and Shepherd and Fagan (1980) found that they can discriminate between high and low contrast patterns.

Butcher (1977) studied profoundly mentally retarded young children to see whether they could discriminate between colors. Stimuli were 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 for a 2-minute familiarization period to one stimulus from the color set. Following familiarization, one immediate and two delayed tests (40 s and 180 s delays) 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 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.

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 a mean CA of 7.8 years and a 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 s from the subject'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 h 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. These stimuli were a circle, a wide ellipse, a narrow ellipse, and a triangle. Analyses 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, Kelman and Whiteley (1986) found that, although nonambulatory profoundly retarded subjects can discriminate stimuli along a form dimension, their response to novelty was not systematically related to amount of change in the stimulus.

As mentioned earlier, Krenn and Whiteley (1990) used a fixed trial habituation-dishabituation paradigm to investigate the ability of nonambulatory profoundly retarded children to discriminate changes in orientation of a stimulus. 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. 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 degree 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 can discriminate between stimulus orientations as well as between forms.

Shaw (1988) also studied orientation discrimination by nonambulatory, profoundly mentally retarded children, but used a paired-comparison procedure. Subjects in this study were 15 profoundly mentally retarded children, whose mental age ranged from about 2 months to 6 months, as assessed by the Bayley Scales of Infant Development Mental Scale. The stimuli were a square-wave grating and a line pattern. Each type of stimulus was familiarized in three different orientations -- vertical, horizontal, or oblique. After each familiarization phase, subjects were tested with the familiar orientation and a different orientation of the same stimulus pattern. In each problem, there were three 10-s familiarization trials and two 10-s test trials. It was found that subjects looked longer at the novel orientation than at the familiar orientation, indicating that the subjects could discriminate changes in orientation of 45 degrees and 90 degrees.

In summary, the studies reviewed in this section demonstrate that 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. Profoundly mentally retarded subjects also demonstrated discrimination of changes in form (Kelman & Whiteley, 1986). In the Krenn and Whiteley (1990) and Shaw (1988) studies, they also showed sensitivity to changes in stimulus orientation. Butcher (1977) demonstrated that they can discriminate between colors. Switzky et al. (1979) and Shepherd and Fagan (1980) demonstrated showed that children with multiple handicaps could discriminate between checkerboard targets and between high or low contrast patterns. And finally, in the Berkson (1966) study, it was found that profoundly mentally retarded subjects can discriminate between moving and stationary stimuli. All these studies demonstrated that visual recognition memory methodologies can detect pattern discrimination by profoundly mentally retarded individuals.

<u>Discrimination Research with Facial Stimuli</u>

Facial stimuli have meaningful social signal value. Thus, determining the extent to which profoundly mentally retarded individuals can discriminate such social stimuli is an important component in understanding their social perception. Shepherd, Kleiner, and McMurrer (1984) tested

18 young nonambulatory, profoundly mentally retarded individuals whose MA was less than 2 years. Subjects were tested for their ability to make facial pattern discriminations using the paired-comparison test procedure. Problems involved discriminating several types of patterns; namely, facial versus non-facial patterns, properly versus improperly arranged facial patterns, male versus female faces, and two faces of the same gender and age. Their nonambulatory profoundly retarded subjects only discriminated between facial and non-facial patterns, an ability that is found in normal neonates.

Butcher (1977) studied a group of profoundly mentally retarded young children to see whether they could discriminate faces. Stimuli were photographs of faces of two men and two women. 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 the face set. Following familiarization, an immediate and two delayed tests (40 s & 180 s) were administered using paired presentations of the familiar stimulus and a novel stimulus. The subjects demonstrated longer looking at the novel than the familiar stimulus on immediate test trials, but not on delayed test trials.

Ellis and Boyd (1982) used the paired-comparison procedure to study the discrimination of faces by moderately, severely, and profoundly retarded persons. There were thirty subjects in this study: 14 were moderately retarded, 6 were severely retarded, and 10 were profoundly retarded. The mean IQs of the three groups were 44.3, 30.5, and 15.0, respectively. The stimuli were 64 photographs of faces taken from popular magazines, which were presented to the subject via 35 mm slides. During the familiarization phase subjects were presented with a pair of identical photographs. The photographs were exposed until 30 s of looking time were accumulated by the subjects. Their ability to discriminate familiar from novel faces was tested after 0-, 10-, 30-, and 180-s delay intervals. Of the 30 subjects, 20 looked significantly longer at the novel stimulus during the test phase. It was found that the subjects could discriminate between faces after each retention interval. There was no effect of level of mental retardation.

Whiteley, Shaw, and Graham (1987) familiarized 17 profoundly mentally retarded children to face stimuli using a habituation procedure. The mean CA of the subjects was 12.3 years, and the median MA was 3.5 months as measured by the Bayley Scales of Infant Development. The test stimuli in this study consisted of colored slides of a male and female face. Each subject participated in four sessions with approximately 1-week intervals between sessions. Twelve habituation trials were followed by 6 test trials in which the novel stimulus was presented 4 times and the habituating stimulus 2 times. Subjects fixated longer on novel stimuli than familiar stimuli during test trials. The results of this study indicated that nonambulatory profoundly mentally retarded subjects could discriminate between a male and a female face.

Rahman (1988) investigated whether nonambulatory, profoundly mentally retarded children and adolescents can discriminate between facial expressions of happiness and surprise posed by a female adult. There were 14 subjects whose mean MA was 4.1 months and mean CA was 13.8 years. The fixed trial habituation-dishabituation paradigm was used. 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 dependent measure in Rahman's (1988) study was the total fixation time on each trial. The results of this study revealed that there was a significant increase in total fixation time from habituation phase to test phase, indicating that these nonambulatory, profoundly mentally retarded children discriminated between happy and surprised facial expressions.

From the above review it is evident that multiply handicapped persons can discriminate among different faces, and between expressions of happy and surprise. But a study has not been conducted to find out whether they can *categorize* facial expressions when they are posed by different models. That is, do they abstract common features of a facial expression from the observation of an expression posed by different models?

Infant Research on Categorization of Facial Expressions

Research on the categorization of facial expressions by infants illustrates the methodologies that might be used to study categorization of facial expressions by individuals with multiple handicaps. In addition, research with infants shows developmental trends that may be relevant to understanding individual differences in discrimination and categorization skills among multiply handicapped persons of varying mental age.

Bornstein (1985) suggested that to demonstrate categorization using a habituation procedure, subjects must be habituated to several instances of a category during the habituation phase. They must then be tested with the familiar category (old and new instances) and with a novel category (at least one instance). Categorization can be inferred if the following results are obtained: (1) no dishabituation to the familiar instance, (2) generalization of habituation to new instances of the familiar category, and (3) dishabituation to instances of the novel category.

Categorization can also be studied using the paired-comparison procedure. In the familiarization phase, subjects are exposed to different examples of the same category over several trials. In the test phase, subjects are exposed to another version of the familiarized category along with an example of a new category. Longer looking times at the instance of the new category indicates that the subject has abstracted common features of the familiarized category. In the case of categorization of facial expressions, subjects can be exposed to one expression posed by several models during the familiarization phase. During the test phase, a new model is presented posing both the familiarized expression and a novel expression.

Whether infants can categorize invariant facial expressions across different persons was studied by Caron, Caron, and Myers (1982). They studied 4-, 5.5- and 7-month-old infants. There were 36 infants (18 boys and 18 girls) at each age group in a four-exemplar condition, and there were also 36 infants (18 boys and 18 girls) at each age group in a single-exemplar condition.

Pictures depicting the same facial expression posed by four different adult models were presented during the habituation phase in the four exemplar condition. In the test phase, two new models were presented with the familiarized expression first, and then with the novel expression. In the single-exemplar condition, the familiar expression posed by the same model was presented repeatedly during the habituation phase. But in the test phase, both the novel and familiar expressions were posed by two new models, as in the test phase of the four-exemplar condition. Half of the infants in each age group were habituated to the happy expression, and the other half were habituated to the surprised expression.

It was found that the ability to discriminate the novel expression increased with age in the four-exemplar condition, but not in the single-exemplar condition. Caron et al. (1982) calculated the percentage of infants in each group who both generalized to the familiar expression and discriminated the novel expression. The authors called it a response yielding a "conceptual pattern". They found that 75% of the 7-month-old infants in the four-exemplar condition showed a conceptual pattern; whereas, only 36% of the 5.5-month-old and 19% of the 4-month-old did so. They concluded that infants can differentiate happy and surprised expressions on a categorical basis at 7 months of age, but not at 4 or 5.5 months.

Ludemann and Nelson (1988) studied seven-month-old infants' ability to categorize the facial expressions of happy, fear, and surprise posed by multiple models. They also examined discrimination of varying intensities of each expression. In their first experiment, they studied infants' ability to discriminate two intensities of the same expression. To develop stimuli for this study, Ludemann and Nelson (1988) showed the Ekman and Friesen (1975) standard expressions of happy, fear, and surprise to a series of women between the ages of 25 and 30 years. Each model was asked to pose each expression accurately, and to pose both mild and extreme versions. Slide photographs of each pose were taken. Fifty-four undergraduate college students were asked to rate the facial expressions posed by each model. Based on these judgments, photographs of 15 models posing both intensities of at least two of the three expressions were selected as stimuli.

Ludemann and Nelson (1988) used an infant-control habituation paradigm. In their first experiment, infants were randomly assigned either to the experimental or to the control condition. Out of four different models, each infant was randomly exposed to two models. The experimental group was habituated to a mildly happy expression and tested with a very happy expression posed by the same model. After a 1-minute break, infants in this group were habituated to a mildly fearful expression and tested with a very fearful expression posed by a different model. Infants in the control group were habituated and tested with one intensity of happy posed by one model. This group was then habituated and tested with the same intensity of fear posed by a second model. Results of this study demonstrated that infants could discriminate happy and fearful expressions varying in intensity.

The purpose of Ludemann and Nelson's (1988) second experiment was to find out whether seven-month-old infants were able to generalize their discrimination of happy and fear when these stimuli varied in intensity. There were 32 seven-month-old infants in this study. Eight female models were selected. Four of these models posed mild and extreme intensities of the happy expression, and the other four models posed the same two intensities of the fear expression; the stimuli were selected from the stimulus set described above.

During the habituation phase, infants were exposed to both mild and intense poses of an expression posed by three models until the habituation criterion was reached (e.g., mild happy followed by very happy by model A; mild happy followed by very happy by model B; and mild happy followed by very happy by model C). During the test phase, infants received two trials with both intensities of the familiar expression posed by a fourth model (e.g., mild happy followed by very happy by model D), and two trials with both intensities of the novel expression posed by the same fourth model (e.g., mild fearful expression followed by a very fearful expression by model D). After a one-minute break, if an infant could accomplish this phase successfully, he or she was tested again with the reversed order of habituation and test expressions (e.g., habituated to fear and tested with happy).

They found that infants looked longer at novel fear stimuli after habituation to happy stimuli, but didn't look longer at novel happy stimuli after habituation to fear stimuli. Thus, infants could categorize between happy and fearful expressions under certain orders of presentation. These investigators speculated that this order effect might be mediated by a familiarity factor, as infants watch more positive emotions than negative ones in their social environment.

Categorization has also been studied using the paired comparison procedure (e.g., Nelson, Morse, & Leavitt, 1979; Nelson & Dolgin, 1985). Nelson, Morse, and Leavitt (1979) conducted experiments with seven-month-old infants to find out whether infants can reliably generalize the discrimination of happy and fear expressions across different models.

The purpose of one experiment by Nelson et al. (1979, Experiment 2) was to find out whether infants could discriminate between happy and fear expressions posed by two different models. The investigators tested a group of 32 seven-month-old infants. Infants were familiarized with one facial expression (e.g., happy) posed by one model, and tested with the contrast of both expression (i.e., happy and fear) posed by another model. It was found that infants in this experiment looked equally long at both the novel and familiar expressions on the test trials. Thus, these infants failed to demonstrate generalized discrimination of the two facial expressions from the first model to the second model. Nelson et al. (1979) suggested that these 7-month-olds may have responded to a change in model as well as to a change in expression on the test trials. They mentioned that an analogous finding was reported by Fagan (1976, Experiment 5) in his study of generalized discrimination of male versus female faces. Nelson et al. (1979) concluded that exposure to a single model during the familiarization phase was not sufficient for generalized discrimination of stimuli across models. They suggested that generalized discrimination of facial expressions might be facilitated by exposing infants to more than one model posing the familiar expression during the familiarization phase. According to Nelson et al. (1979), such a design should serve to familiarize or habituate the infant to the irrelevant dimensions of different faces such as hair color, and thereby, enhance the infant's attention to the more relevant dimensions of facial expression, such as shape of mouth, during the test phase.

In the final experiment reported by Nelson et al. (1979, Experiment 3), there were 32 infants ranging in age from 7 to 8 months. Happy and fear expressions posed by three female (Models A, B, and C) were selected from Ekman and Friesen (1975). Infants were first familiarized to the Model A face for 20 seconds with either a happy or fearful expression. They were than exposed for another 20 seconds to Model B posing the same expression. Then the infants received two 10-s test trials in which Model C posed the familiar expression and the novel expression. Half of the infants were familiarized with the happy expression, and half with the fear expression. Results of this study revealed that the mean length of fixations to the two test targets differed reliably when familiarized with happy and tested with fear. But such a discrimination was not found when infants were familiarized with fear and tested with happy. They concluded that 7-month-old infants are able to generalize across the happy expressions posed by different models.

Nelson and Dolgin (1985) conducted 2 experiments on seven-month-old infants to examine categorization of happy and fearful facial expressions. The aim of this study was to overcome the limitations of previous studies by Caron et al. (1982) and Nelson et al. (1979). According to Nelson and Dolgin (1985), two basic limitations of these studies were first, that only female models were used, and second, that there were no attempts to clarify why discrimination was affected by order of presentation of the expressions.

The primary purpose of Nelson and Dolgin's (1985) first experiment was to establish whether seven-month-old infants could generalize across four different female and male models. Subjects in this study were 32 seven-month-old infants. The method adopted was a paired-comparison procedure. Subjects were presented with three 30-s familiarization trials. The stimuli were color photographs of male and female models posing happy and fear. A different model was presented on each of the three trials. The identical expression by the same model was presented on both the right and left sides of the screen. After the familiarization phase, a fourth male or female model's face, posing the familiar expression on one side, and the novel expression on the other side, was presented. There was also a second test trial in which the position of the facial expressions was reversed from that of the first test trial. One-half the infants were familiarized to happy faces and tested on fearful faces, and the other half were familiarized to fear and tested on happy. Only infants familiarized to happy and tested on fear showed a significant novelty preference.

In their second experiment, Nelson and Dolgin (1985) tested another group of 32 seven-month-old infants with the same facial expressions used in Experiment 1. Subjects received two 45-s trials involving presentation of a happy or fearful expression posed by one of the four models. Analysis of the results in the second experiment indicated that infants looked longer at the fearful than the happy expression, and looked longer on Trial 1 than on Trial 2. From the results of their two experiments, Nelson and Dolgin (1985) concluded that seven-month-old infants perceive happy and fearful facial expressions in a categorical fashion;

however, this phenomenon is affected by the order of presentation of the expressions.

From the above review it is evident that infants at seven-months of age can categorize various facial expressions. Using a subject-control habituation-dishabituation paradigm with multiple models, Caron et al. (1982) found that infants can categorize happy and surprised expressions, and Ludeman and Nelson (1988) found that infants can categorize happy and fearful expressions. Using a paired-comparison procedure with multiple models, Nelson et al. (1979) and Nelson and Dolgin (1985) found that infants can categorize happy and fear at seven months of age. These researchers also found that their results were affected by the order of presentation of the facial expressions. Nelson (1987) concluded that infants can discriminate between facial expressions as early as 3-months of age but cannot categorize facial expressions before the age of 7 months.

These studies illustrate visual recognition memory procedures that are appropriate for testing discrimination and categorization of facial expressions with individuals who are multiply handicapped. Moreover, the developmental trend summarized by Nelson (1987) for infants suggests that differences in mental age between 2 and 12 months may be predictive of the discrimination and categorization abilities of individuals with multiple handicaps.

The Present Study

Previous studies have been conducted to find out whether persons with multiple handicaps can discriminate between faces (e.g., Butcher, 1977; Whiteley et al., 1987), and between two facial expressions (Rahman, 1988). The present study examined whether they could discriminate happy and surprise when they were posed by a single model, and categorize these expressions when they were posed by multiple models.

Happy and surprise were selected because these have been identified as fundamental emotions since Darwin's early investigation (Darwin, 1872/1965; Izard, 1971). Research has shown that normal infants can discriminate between these two expressions as early as 3 months of age (Barrera & Maurer, 1981), and can categorize them by 7 months (Caron et al., 1982; Nelson et al., 1979; Nelson & Dolgin, 1985). Moreover, it has also been found that happy and surprise expressions evoke a similar amount of looking by multiply handicapped persons (Rahman, 1988). Negative emotions, such as sad and anger, were avoided to guard against aversive reactions. It has been found that infants show fussy behavior during habituation trials to negative facial expressions (Barrera & Maurer, 1981).

A paired-comparison procedure was used in the present study. The paired-comparison procedure was adopted because of its advantages over the habituation-dishabituation paradigm; namely, it requires fewer trials, allows testing of multiple problems in one session, and demands less memory capacity during test trials.

In each session there were two problems--a categorization problem and a discrimination problem. In the categorization problem, subjects were familiarized to the same facial expression posed by four models consecutively. Subjects were presented with both the familiar and novel expression posed by a fifth model during the test phase. In the discrimination problem, one expression posed by a sixth model was presented on each of the four trials in the familiarization phase; and both novel and familiar expressions posed by this model were presented during the test phase. The discrimination problem was included because the discrimination of happy and surprised expressions by multiply handicapped individuals has been demonstrated using the habituation-dishabituation paradigm (Rahman, 1988), but not the paired-comparison procedure. Positive evidence of discrimination using the paired-comparison procedure was necessary to validate this testing procedure for assessing discrimination of facial expressions.

Hypothesis 1

A decline in fixation times was expected over the four trials of the familiarization phase because multiply handicapped persons in previous studies have demonstrated habituation when they were repeatedly exposed a visual stimulus (e.g., Berkson, 1966; Kelman & Whiteley, 1986; Switzky et al., 1979; Rahman, 1988).

Hypothesis 2

During the test phase of discrimination problems, subjects were expected to look longer at the novel expression than the familiar expression, implying that they could discriminate between happy and surprise. This outcome was predicted on the basis of Rahman's (1988) finding, using a habituation-dishabituation procedure, that multiply handicapped subjects could perceive differences between happy and surprise.

Hypothesis 3

During the test phase of categorization problems, subjects were expected to look longer at the novel expression than the familiar expression, implying that they could categorize happy and surprised expressions. This hypothesis was based on research by Caron et al. (1982) in which they found that 75% of 7-month-old infants, 36% of the

5.5-month-old-infants, and 19% of the 4-month-old infants were able to categorize happy and surprise expressions. The multiply handicapped subjects in the present study were expected to be functioning at mental ages ranging from approximately 2 to 12 months.

Hypothesis 4

A positive correlation was expected between mental age and novelty preference scores. Infant research indicates that discrimination of facial expressions is achieved as early as 3 months of age. For example, Barrera and Maurer (1981) found that infants can discriminate between happy and sad expressions at 3 months of age. On the other hand, categorization of facial expressions is achieved around 7 months of age. For example, Caron et al. (1982) found that 7-month-old infants could categorize happy and surprised expressions. Nelson (1987) concluded that infants can discriminate between two expressions at 3 months of age and categorize facial expressions by 7 months of age.

Hypothesis 5

Subjects who categorized happy and surprised facial expressions were also expected to discriminate between these two expressions. On the other hand, subjects who failed to discriminate between happy and surprise were expected to fail to categorize these expressions. This hypothesis was based on the observation that discrimination of expressions precedes categorization in normal infant development, suggesting that it is a precursor to categorization.

Method

Subjects

Subjects in this study were 14 multiply handicapped residents of the St. Amant Centre in Winnipeg. Four participants were males, and ten were females. Their chronological ages ranged from 5.8 years to 35.2 years, with a median age of 14.2 years (see Table 1).

The subject selection process was a lengthy one. Initially, the investigator visited the wards and talked with the head nurses to collect the names of potential subjects who were nonambulatory, severely or profoundly mentally retarded, and who were not seriously visually impaired. Thirty names were collected, and these were provided to the Psychology Research Coordinator at the institution. She sent letters to their parents or legal guardians, asking for consent to allow their son or daughter to participate in the research project. A second letter was sent to those who failed to reply to the initial letter. The letter consisted of general information about the objectives, procedures, and potential benefits of the research program at the institution; an information sheet about the nature of this research project, and a consent form to be returned to the Psychology Research Coordinator (see Appendix A). Seventeen parents gave their consent.

Table 1

Subject Characteristics

Subject	Sex	CA[a]	MA[b]	BRS[c]	VFB[d]
1	F	13.8	6.5	76	7
2	M	12.1	2.0	26	6
3	M	6.8	4.7	56	8
4	M	21.9	4.7	56	5
5	F	16.7	4.7	54	6
6	F	14.0	2.5	31	7
7	F	24.4	2.7	34	5
8	F	7.1	4.7	54	7
9	F	15.5	4.0	48	6
10	M	5.8	5.0	61	5
11	F	14.9	4.5	52	5
12	F	6.5	5.3	65	7
13[e]	F	35.2	*	*	*
14[f]	F	14.5	3.5	42	6

[a] CA = Chronological age in years.
[b] MA = Mental age equivalents in months.
[c] BRS = Bayley Scales of Infant Development (Mental Scale) raw score.
[d] VFB = Number of items passed on the Bayley Mental Scale requiring visual fixation.
[e] Bayley test was not administered to this subject.
[f] Bayley scores from test given to this subject at 8 years of age.

The remaining parents did not reply. It was possible to test 14 of these 17 subjects. Three subjects could not be tested for the following reasons: one subject kept her eyes closed most of the time; one subject could not look at the stimuli because his head was tilted backward so that the stimuli were not in his visual field; and one subject started crying in the second session.

Developmental Assessments

The Bayley scales of Mental Development (Bayley, 1969; Whiteley & Krenn, 1986) were administered individually to 12 subjects several months after novelty preference testing had been completed. Testing was stopped when a subject failed ten consecutive items. Subject 13 was a verbal subject, and the Bayley Mental Scale was not appropriate for her. Unfortunately, Subject 14 died before the Bayley test was administered. A Bayley score obtained when she was eight years old was used as the best available information on her level of functioning. Thus, Bayley raw scores (BRS) and corresponding mental ages (MA) were obtained for 13 subjects (see Table 1). For subjects given the test, mental ages ranged from 2 months to 6.5 months (mean MA = 4.2 months).

Ability to fixate visually was assessed by using a set of test items requiring visual fixation from the Bayley Mental Scales (see Table 2). The number of these items

Table 2

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

passed by individual subjects ranged from 5 to 8 (see Table 1). These scores indicate that subjects were suitable for the visual preference test used in this study because they could visually fixate.

In addition to the Bayley assessments, a checklist was developed using items from the Minnesota Developmental Programming System (1975) and Bruininks, Woodcock, Weatherman, and Hill's (1984), Scales of Independent Behavior. In total, there were 73 items describing the following areas of behavior: (1) gross motor development, (2) fine motor development, (3) eating, (4) dressing, (5) grooming, (6) toileting, (7) receptive language, (8) expressive language, and (9) social interaction. The items and instructions given to raters are presented in Appendix B. The checklist was completed for each subject by a registered nurse familiar with the individual.

The number of items passed and the highest item passed by each subject for each of the nine subscales, along with the total number of items passed on all subscales, are presented in Table 3. A brief description of the level of functioning of each subject based on the developmental

Table 3

Number of Items Passed and Highest Item Passed (in parentheses) by Each Subject on Sub-scales of the Developmental Checklist

Subject	Scale									
	GM	FM	ET	DR	GR	TO	RL	EL	SI	Total
1	2(3)	2(2)	6(7)	1(1)	2(2)	3(3)	9(10)	5(8)	11(11)	41
2	7(7)	3(3)	6(7)	1(1)	1(1)	2(3)	0(0)	0(0)	0(0)	20
3	3(3)	2(2)	2(3)	0(0)	0(0)	0(0)	1(1)	1(1)	2(8)	11
4	2(3)	3(3)	3(3)	1(2)	2(2)	4(6)	9(12)	2(2)	11(12)	37
5	2(3)	0(0)	2(2)	1(1)	1(1)	7(7)	11(11)	2(2)	10(12)	36
6	1(1)	4(4)	2(2)	1(1)	3(3)	2(3)	3(3)	1(1)	3(3)	20
7	2(3)	3(4)	2(2)	2(2)	2(2)	0(0)	6(12)	0(0)	3(3)	20
8	2(2)	4(4)	2(2)	0(0)	0(0)	0(0)	2(2)	0(0)	5(5)	15
9	6(10)	3(3)	3(6)	1(2)	0(0)	3(3)	3(12)	2(2)	3(6)	24
10	10(10)	4(4)	3(3)	0(0)	0(0)	0(0)	1(1)	0(0)	3(7)	21
11	1(1)	2(2)	2(2)	1(1)	1(1)	0(0)	3(3)	1(1)	3(3)	14
12	1(1)	0(0)	1(1)	0(0)	0(0)	0(0)	10(12)	8(8)	10(12)	30
13	2(3)	3(4)	4(4)	1(1)	4(4)	0(0)	6(12)	8(8)	8(10)	36
14	2(3)	2(3)	2(2)	1(1)	2(2)	2(3)	9(12)	3(4)	9(9)	32

Notes. GM = Gross Motor development; FM = Fine Motor development; ET = Eating; DR = Dressing; GR = Grooming; TO = Toileting; RL = Receptive Language; EL = Expressive Language; SI = Social Interaction; and Total = total number of items passed.

checklist can be found in Table 4. In general, subjects were more capable in the areas of receptive language and social interaction. Whereas, they did poorly in expressive language, gross motor, fine motor, eating, dressing, grooming, and toilet training.

Medical Diagnoses

Medical diagnoses and histories for the 14 subjects are presented in Table 4. From this table it can be seen that the predominant diagnoses were severe (*N* = 8) and profound (*N* = 3) mental retardation. The level of retardation of the remaining three subjects (5, 12, and 13) was not specified in medical records. Subject 5 had an MA of 4.7 months, Subject 12 had an MA of 5.3 months, and Subject 13 was not tested. Their total developmental checklist scores were 36, 30, and 36, respectively. These scores were above the mean of 25, but within the range of 11 to 41 found for this group of subjects. This information suggests that these subjects were functioning at the same level as the other subjects in the study. Thus, their level of retardation is estimated to be in the severe to profound range.

In addition to mental retardation, eight subjects had a seizure disorder. Other medical problems were present for several individuals. Most of their medical histories included a premature or traumatic birth process and prenatal or neonatal complications. Developmental problems included feeding problems, respiratory distress, irritability, low

Table 4

Medical Diagnosis, Medical History, and Assessments of Motor, Sensory, and Level of Functioning for each Subject

Subject Number	Subject Code	Diagnosis[a]	Medical History[a]	Motor[a]	Sensory[a]	Functioning[b]
1	TH	Severe mental retardation.	Born at 33 weeks gestation to a severely toxemic mother by cesarean section; developed Hyaline Membrane disease and other neonatal complications.	Spastic quadriparesis.	Pupils are equal and reactive to light; has normal fix and follow; hearing clinically intact.	Can follow simple instructions; greets others upon meeting; can say last name; reach and grasps objects; can't pick up small objects with thumb & fingers.
2	JK	Severe mental retardation; recurrent sinusitis.	Born after a normal pregnancy and delivery to a young mother; dysmorphism was noticed at birth; agenesis of corpus callosum on CT scan; had feeding problem, apnea, pneumonia.	Spastic quadriparesis; has some fine motor abilities.	Did not have optic nerve hypoplasia, but has poor visual attentiveness; can fix occasionally.	Does not respond to calling by name or to touching; no gestures to get attention; can grasp objects.

(Table 4 continues)

Subject Number	Subject Code	Diagnosis[a]	Medical History[a]	Motor[a]	Sensory[a]	Functioning[b]
3	DL	Severe mental retardation; Cerebral palsy.	He was born at 28 weeks gestation; he required resuscitation at birth; he was ventilated for 2 weeks and was on oxygen therapy until 6 weeks of age; he had moderate to severe respiratory distress syndrome.	Spastic quadriplegia.	Hearing is normal; pupils are equal and reactive to light.	Turns head towards sound; interacts with other persons; makes gestures for attention; can reach and grasp by hand but not by fingers and thumb.
4	DF	Primary microcephaly; severe mental retardation; seizure disorder.	His mother experienced spontaneous onset of labour at 38 weeks; no abnormalities were detected other than a small head circumference; at 12 mos he was spastic.	Severe spastic quadriparesis; multiple skeletal deformities.	Visually responsive; hearing normal.	Responds to non-verbal communication; greets others; responds by shaking head; can use both arms to handle objects, but can't use thumb and fingers to pick up small objects.
5	RL	Encephalopathy with microcephaly; Cerebral palsy.	Difficult breach delivery after a normal full term; seizure after birth; respiratory difficulties.	Spastic quadriplegia.	Vision and hearing clinically intact.	Responds to nonverbal communications; greets others upon meeting; shakes head in response to simple questions; can't reach or grasp objects.

(Table 4 continues)

Subject Number	Subject Code	Diagnosis[a]	Medical History[a]	Motor[a]	Sensory[a]	Functioning[b]
6	CS	Severe mental retardation; seizure disorder; significant scoliosis; microcephaly; diffuse corticoreticular dysfunction.	Her mother experienced intermittent bleeding during the last trimester of pregnancy; mild jaundice in the neonatal period.	Spastic quadriparesis.	Pupils are equal and reactive to light; can fix and follow; has exotropia of left eye; left ear normal; tympanogram on the right ear showed a hypermobile tympanic membrane.	Responds to social interaction by brief eye contact; makes gestures for attention; can use thumb and fingers to pick up small objects.
7	KD	Profound mental retardation; seizure disorder; neurogenic bladder; decubitus ulcer over coccyx.	Her problems seem to be related to prematurity as she was born at 30 weeks gestation and developed kernicterous; her birth weight was 3 lbs, 8 ozs; suffered from hyperbilirubinemia, which led to kernicteric brain damage.	Spastic quadriplegia.	Hearing and vision clinically intact; pupils are equal and reactive to light; can fix and follow with normal ocular movement.	Responds to nonverbal communication; can follow a person with eyes; can't make gestures for attention; can pick up small objects by thumb and finger.
8	YR	Severe mental retardation; seizure disorder; intestinal neuronal dysplasia; failure to thrive.	She was born at 39 weeks gestation via Cesarean section due to an intra-uterine growth retardation and poor prenatal scoring; at 9 months of age she had symmetrical growth delay with head circumference, weight and length all below the 5th percentile; her course had been that of repeated admissions in relation to severe dehydration.	Delayed motor skills.	According to brain stem audiometry, her hearing is normal; her eyes are normal with persistent squint; both pupils converge; briefly fixes and follows.	Responds when called by name; can play with toy alone for brief periods; doesn't make sounds or gestures to get attention; can pick up small objects by thumb and fingers.

(Table 4 continues)

Subject Number	Subject Code	Diagnosis[a]	Medical History[a]	Motor[a]	Sensory[a]	Functioning[b]
9	KN	Severe mental retardation; seizure disorder; recurrent pharyngitis.	She was born with forcep assisted delivery through meconium; in first two days of her life she was irritable, and then became very quiet; she was found normal up to six months of age and then was found to have delayed motor development and reduced interaction.	Mild spastic quadriparesis; progressive scoliosis.	Pupils are equal and reactive to light; divergent gaze; vision fixes briefly with poor following.	Responds to smiling; can identify friends from strangers; can use both hands to handle objects but can't use thumb and fingers to pick up small objects by thumb and fingers.
10	RA	Severe mental retardation; seizure disorder.	Cesarean birth; poor prenatal care; stormy postnatal course associated with moderate RDS requiring ventilation for 4 days, aphyxia, hypoglycemia associated with seizures and Grade 1 intraventricular hemorrage; chromosomes & metabolic screens were normal.		Pupils equal and reactive to light; fixing and following observed; visual fields seemed intact; hearing clinically intact.	Turns head towards sound; can spend some time with one or two persons; doesn't make sound or gestures to get attention; can pick up small objects by thumb and fingers.
11	SB	Profound mental retardation; seizure disorder.	She was born at term after an uncomplicated pregnancy; had encephalitis at 12 months; had severe, continuous seizures, and had respiratory compromise requiring mechanical ventilation.	Spastic quadriparesis; osteopenia; limited motion of lower extremities; scoliosis.	Pupils are equal and reactive to light; good fixing and following; visual field and hearing clinically intact.	Responds to social interaction by very brief eye contact; makes gestures for attention; can reach or grasp objects, but can't use both hands.

(Table 4 continues)

Subject Number	Subject Code	Diagnosis[a]	Medical History[a]	Motor[a]	Sensory[a]	Functioning[b]
12	AK	Developmental delay; severe perinatal asphyxia.	Born at 36 weeks by cesarian section; her neonatal course was complicated by asphyxia; she had an interpulmonary hemorrhage and significant neurological abnormalities; developmental delay was noted in the first year of life; viral infections, otitis media and pneumonia.	Spastic quadriparesis.	Pupils are equal and reactive to light; has normal fix and follow; hearing clinically intact.	Responds to nonverbal communication; greets others; can say last name; can't reach grasp.
13	AG	Mental retardation; Organic Brain Syndrome.	Her illness is the sequela of a presumed viral encephalitis which resulted in a severe organic brain syndrome; in October 1971 she had focal seizures, hemiplegia and disorientation; by 1975 she lost her writing ability.	Spastic quadriplegia.	Vision and hearing clinically intact.	Responds to nonverbal communication; can follow directions; can say last name; picks up small objects by thumb and fingers.
14	DK	Profound mental retardatation; cerebral palsy; Inactive Seizure disorder.	Born to a young mother at 28 weeks gestation; was quite fragile and had recurrent pneumothoraces and required assisted ventilation for several weeks; congestive heart failure, seizures and apnea.	Increasing spasticity due to underlying cerebral palsy.	Makes eye contact and smiles.	Responds to nonverbal communication; can take turns in a group; can name a few familiar objects; can use both hands to handle objects but can't use thumb and fingers to pick up small objects.

[a]From medical records of the St. Amant Centre.
[b]Based on Developmental Checklist.

brain weight, severe dehydration, delayed sensori-motor development, recurrent pneumothoraces, and congestive heart failure.

Their motor functioning was impaired by neuromuscular and structural abnormalities, including spastic quadriparesis, spastic quadriplegia, delayed motor skills, progressive scoliosis, and multiple skeletal deformities. Visual and auditory functioning were normal for most subjects. They could visually fixate and follow, and were reactive to sound. All but one subject was nonverbal.

Stimuli and Apparatus

Test stimuli were colored slides of happy and surprised facial expressions, posed by 6 adult female models. The size of the projected faces was approximately 22 cm high by 16 cm wide. Twelve female models were shown the Izard (1971) standarized photographs of happy and surprised expressions along with the description of facial features of the different face regions. Each model was asked to produce poses of each facial expression four times. Photographs of each pose were taken. The researcher evaluated these pictures using Izard's criteria, and found that ten models had produced poses of both happy and surprised expressions. The two best poses of each expression for these models were selected by the experimenter.

Four judges were then employed to rate the degree of closeness of these poses to Izard's (1971) standardized photographs. Instructions given to the judges can be found in Appendix C. These judges were all graduate students in the Department of Psychology at the University of Manitoba.

Judges were asked to indicate, for each pose of each model, whether or not it matched the five facial features described by Izard (1971). And finally, judges were asked to give their overall judgment about each pose on a 5-point scale, expressing to what extent a given pose matched Izard's description of the expression. Six models received a mean rating of 3.5 or above for both a happy and a surprised pose. The highest rated happy and surprised facial expressions for these models were selected as stimuli. The mean overall ratings of these poses ranged from 3.5 to 5. The pictures used in the study are presented in Appendix D.

The stimulus display (see Figure 1) consisted of two projection screens (22 cm x 27 cm) positioned 35 cm apart. A prompt light, consisting of two orange bulbs, was located behind a third screen that was centered between the projection screens. These screens were on a white display board (120 cm x 120 cm), mounted on a table. A 15-watt florescent light was mounted horizontally above the screens to provide light for the video camera. There was a circular opening above the prompt light to allow the video camera to view the subject's face. A black cloth extended from this opening to the lens of the camera to block the subject's view of the camera. In order to block the subject's

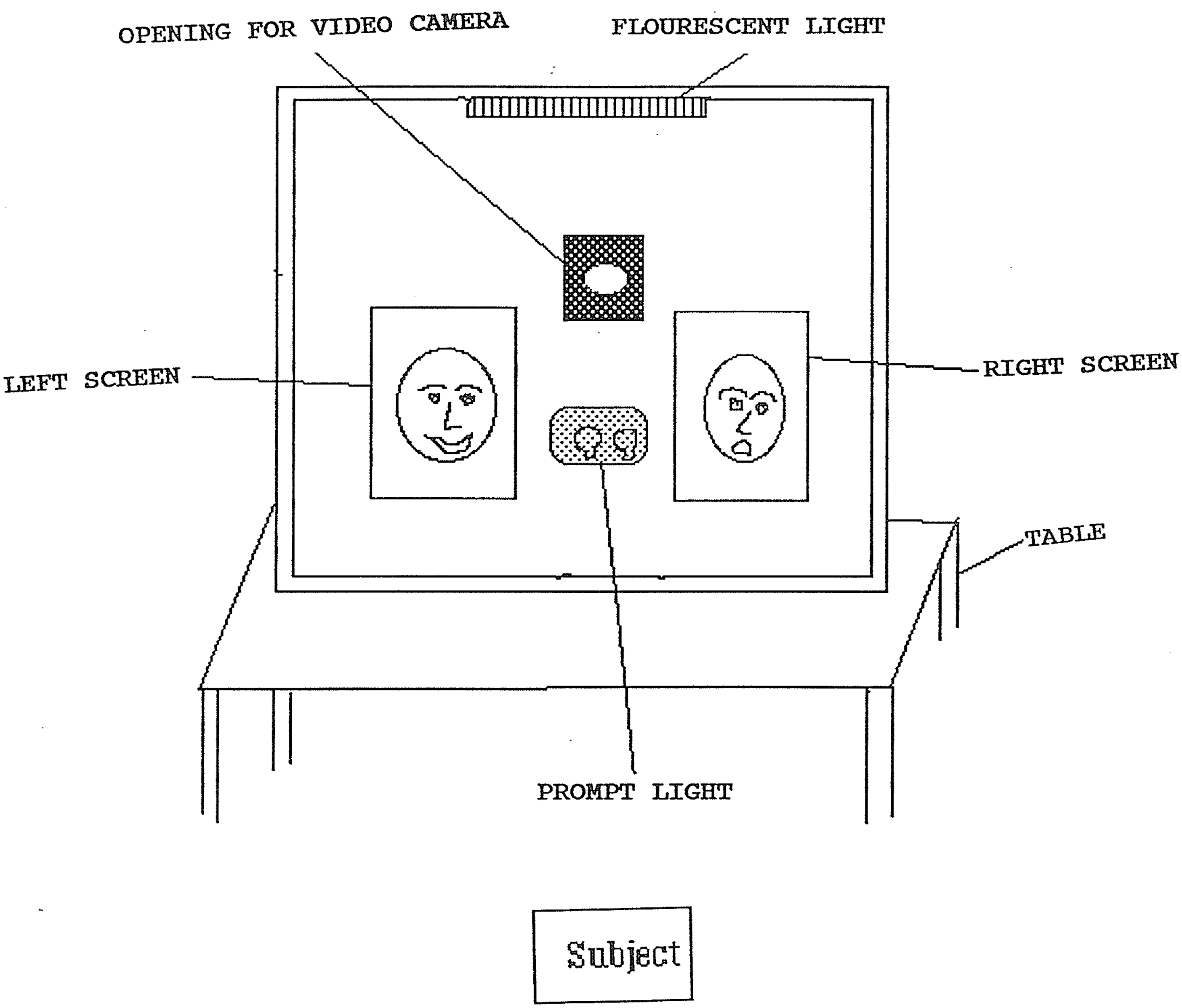

Figure 1. A schematic diagram of the front view of the stimulus display.

view of the experimenter and apparatus, two screens were attached to the right and left sides of the table, and a white cloth was draped in front of the table. The stimuli were rear projected by two Kodak Carousel 800 projectors. The screens were at the subject's eye level. A time base, counting 1/30th of a second, was superimposed on the video tape. Electromechanical equipment was used for timing the stimulus presentations.

Procedure

Subjects were tested individually, sitting in their wheelchairs. They were brought to the testing room, where they were placed facing the projection screens. The eyes of the subjects were about 1 m from the screen. After placing the subjects, the experimenter turned off the overhead lights in the room and stood behind the screen by the side of the camera. Each of the experimental sessions was recorded by the video camera. The camera was adjusted continuously so that the subject's whole face remained visible. The light and sound level of the experimental room was held constant across all subjects and sessions.

The experimenter initiated a trial by repeatedly pressing a button to cause the cue light to blink on and off. When the subject oriented towards the cue light, the experimenter turned off the cue light and presented a pair of slides. The duration of slide presentations was 30 s for each familiarization trial, and 10 s for each test trial. At the end of these intervals, the timer advanced the projector to present two blank slides. After each trial, the experimenter immediately presented the blinking cue light again; and as soon as the subject oriented to the light, the experimenter presented the slides for the next trial. During the familiarization phase, subjects were presented with identical pictures on both screens. But during the test phase, subjects were presented with a familiar stimulus on one screen and a novel stimulus on the other screen.

Each subject participated in four sessions. There were a minimum of 24 h between sessions. Each session consisted of one categorization and one discrimination problem. Each experimental problem had two phases -- a familiarization phase and a test phase. Each familiarization phase consisted of four trials, and each test phase consisted of two trials. Table 5 illustrates a session in which the categorization problem came first and discrimination problem came next. Table 6 illustrates a session with the reverse order of the two types of problems.

Table 5

Stimulus Arrangements for a Session in which a Categorization Problem is Followed by a Discrimination Problem

Problem	Phase[a]	Trial	Model[b]	Stimulus[c]
Categorization	Famil	1	1	E1-E1
		2	2	E1-E1
		3	3	E1-E1
		4	4	E1-E1
	Test	5	5	E1-E2
		6	5	E2-E1
Discrimination	Famil	7	6	E1-E1
		8	6	E1-E1
		9	6	E1-E1
		10	6	E1-E1
	Test	11	6	E1-E2
		12	6	E2-E1

[a] Famil and Test refer to familiarization and test phases of a problem.

[b] 1 to 6 represent faces of 6 different models.

[c] E1 or E2 represent the type of expression on left and right screens.

Table 6

Stimulus Arrangements for a Session in which a Discrimination Problem is Followed by a Categorization Problem

Problem	Phase[a]	Trial	Model[b]	Stimulus[c]
Discrimination	Famil	1	1	E1-E1
		2	1	E1-E1
		3	1	E1-E1
		4	1	E1-E1
	Test	5	1	E1-E2
		6	1	E2-E1
Categorization	Famil	7	1	E1-E1
		8	2	E1-E1
		9	3	E1-E1
		10	4	E1-E1
	Test	11	5	E1-E2
		12	5	E2-E1

[a] Famil and Test refer to familiarization and test phases of a problem.

[b] 1 to 6 represent faces of 6 different models.

[c] E1 or E2 represent the type of expression on left and right screens.

In the familiarization phase of the categorization problem, each subject was presented with the same facial expression posed by four of the models. In the test phase of the categorization problem, subjects were presented with two test trials. On each test trial, the familiar expression posed by a fifth model was presented on one screen; and the novel expression posed by this model was presented on the other screen. The position of the happy and surprised expressions on Trial 1 was reversed on Trial 2. In the familiarization phase of the discrimination problem, each subject was presented with the same facial expression posed by the sixth model on both screens for four trials. In the test phase of this problem, the familiar and novel expressions posed by this model were presented to the subjects. Again the position of the familiar and novel expressions were counterbalanced across the two trials.

Different models were used for the four discrimination problems. These models were randomly selected without replacement for each subject. After selecting the model for the discrimination problem, the remaining five models were assigned randomly to the familiarization and test trials of the categorization problem.

Each subject participated in four sessions. Seven subjects received happy as the familiarized expression in the first session, surprise in the second session, happy in the third session, and surprise in the fourth session (HSHS). The other seven subjects received the reverse order of presentation (SHSH). Three subjects in the HSHS and 3 subjects in the SHSH groups received the discrimination problem (D) first in Sessions 1 and 2, and the categorization problem (C) first in Sessions 3 and 4. This was called the DDCC order. Four subjects in the HSHS and 4 subjects in the SHSH group received the reverse order of presentation of the first problem (CCDD). Thus, the order of presentation of these two problems within a session was counterbalanced over the four sessions for each subject. There was no delay interval between the two problems in a session. The assignment of subjects to various experimental groups (HSHS vs. SHSH expression order, and DDCC vs. CCDD problem order), and the random assignment of models to familiarization and test trials is presented in Table 18, Appendix E. This table also shows the position of the novel stimulus on each test trial.

A session was discontinued and readministered later (a) if more than four minutes passed between two trials due to difficulty in orienting the subject to the screen; (b) if the subject cried or fell asleep; or (c) if any other event disrupted the experimental session. Out of the 56 sessions for the 14 subjects, nine sessions were repeated. Seven sessions were repeated following equipment malfunctions or experimenter error--one session for Subjects 3, 10, and 13, and two sessions for Subjects 1 and 14. In the case of Subject 2, Session 2 was terminated as the subject was very active and did not look at the projection screens. The use of the prompt light appeared to be contributing to his avoidance behavior, so he was tested without the prompt light starting from Session 2. For Subject 3, Session 1 was repeated because he did not look at the stimuli during most of the trials of the first attempt to test him.

Results

Coding Visual Fixations

Subjects' total visual fixation time to right and left stimuli were coded from videotapes using two millisecond timers. The timers were activated using two toggle switches. An observer operated one switch to record fixations on the left stimulus, and operated the other switch to record fixations on the right stimulus. Fixations were scored following the guidelines presented in Appendix F, which were used successfully in Rahman's (1988) study.

Interobserver Reliability

Two observers coded the videotapes for one randomly selected session per subject. Pearson product-moment correlation coefficients were calculated, using total fixation times, for each of the four familiarization trials, and for the first and second problem within a session. These *r* values are shown in Table 7. The mean *r* value was .88. In addition, novelty preference scores were calculated from the two observers' codings of the test phase data for these sessions. The Pearson product-moment correlation coefficients were .73 and .74 for the first and second problem, respectively.

Table 7

Pearson Product-Moment Correlations for Total Fixation Times Scored by Two Observers

Problem	Trial 1	Trial 2	Trial 3	Trial 4
1	.74	.85	.89	.90
2	.95	.92	.92	.89

<u>Familiarization Phase</u>

Total fixation time was calculated for each trial for each subject by summing total fixation time on the left stimulus and total fixation time on the right stimulus. The data set is shown in Appendix I, Table 21. These scores were transformed using $\log_{10}X+1$ to normalize their distribution. Analyses of variance were conducted to examine whether familiarization phase performance was influenced by several variables, including trials, sessions, and type of problem. The BMDP program 5V (Dixon, 1990) was used to carry out analyses of variance. This program analyzes repeated measures and factorial designs when there is missing data, as there are in this data set. The 5V program provides a Wald test of significance of fixed effects based on a Chi-Square distribution.

Table 8 presents the results of a 2 x 4 x 2 x 4 factorial analysis of variance on familiarizaton phase data. The three repeated measures variables were session (1 to 4), type of problem (discrimination vs. categorization), and trial (1 to 4). The between group variable was problem order (CCDD vs. DDCC). Hypothesis 1 predicted a decline in fixation times over familiarization trials. A significant main effect was obtained for trials. Mean fixation times were: Trial 1 = 10.84 s, Trial 2 = 9.04 s, Trial 3 = 9.28 s, and Trial 4 = 9.61 s.

Table 8

Summary of Analysis of Variance of Familiarization phase Data Involving Problem Order, Session, Type of Problem, and Trials

TEST	DF	CHI-SQUARE	P-VALUE
ORDER (O)	1	2.06	0.152
SESSIONS (S)	3	19.82	0.000
TYPE OF PROBLEM (P)	1	0.00	0.956
TRIALS (T)	3	15.95	0.001
O X S	3	8.31	0.040
O X P	1	0.22	0.638
S X P	3	3.27	0.351
O X T	3	1.84	0.606
S X T	9	11.16	0.265
P X T	3	0.35	0.950
O X S X P	3	17.50	0.001
O X S X T	9	6.34	0.705
O X P X T	3	2.65	0.448
S X P X T	9	6.03	0.737
O X S X P X T	9	8.94	0.443

Note. Order = Problem order (DDCC vs. CCDD).

A significant effect for session was also found. The mean total fixation times for sessions 1 to 4 were 10.29 s, 10.70 s, 8.55 s, and 9.13 s, respectively. There were significant Problem Order x Session and Problem Order x Session x Type of Problem interactions. To examine the three-way interaction, two analyses of variance were carried out at each level of problem order with session and trials as repeated measures variables. Results of these analyses are presented in Table 9 and Table 10. There was a significant main effect for Sessions for both problem orders. But the Session x Type of Problem interaction was significant only for the DDCC condition.

Table 9

Summary of Analysis of Variance of Familiarization Phase Data Involving Session, Type of Problem, and Trials for Problem Order CCDD

TEST	DF	CHI-SQUARE	P-VALUE
SESSION (S)	3	10.09	0.018
TYPE OF PROBLEM (P)	1	0.15	0.701
TRIALS (T)	3	11.00	0.012
S X P	3	5.33	0.149
S X T	9	4.29	0.892
P X T	3	2.52	0.472
S X P X T	9	4.55	0.871

Table 10

Summary of Analysis of Variance of Familiarization Phase Data Involving Session, Type of Problem, and Trials for Problem Order DDCC

TEST	DF	CHI-SQUARE	P-VALUE
SESSION (S)	3	18.80	0.000
TYPE OF PROBLEM (P)	1	0.09	0.768
TRIALS (T)	3	7.56	0.056
S X P	3	15.89	0.001
S X T	9	13.57	0.138
P X T	3	0.66	0.883
S X P X T	9	10.74	0.294

The means involved in the Session x Type of Problem interaction found for the DDCC problem order are shown in Figure 2. Figure 2 shows that in the DDCC problem order, fixation times tended to increase over the first three sessions for the categorization problems and decrease for discrimination problems.

Another analysis was conducted on the familiarization phase data with expression order (EXPORD: HSHS vs. SHSH) as the between subjects variable. The within subjects variables were session (1 to 4), type of problem (discrimination vs. categorization), and trials (1 to 4). The results of this analysis are presented in Table 11. In addition to the significant main effect for trials and session, the Expression Order x Session, and the Expression Order x Trials interactions were significant.

Figure 3 illustrates the Expression Order x Session interaction. Fixation times for expression order HSHS were higher for Sessions 2 and 4, as compared to Sessions 1 and 3. In other words, fixations were longer for the surprise stimulus than the happy stimulus in the HSHS order. The fixation times of subjects in the SHSH expression order gradually declined from Session 1 to Session 4.

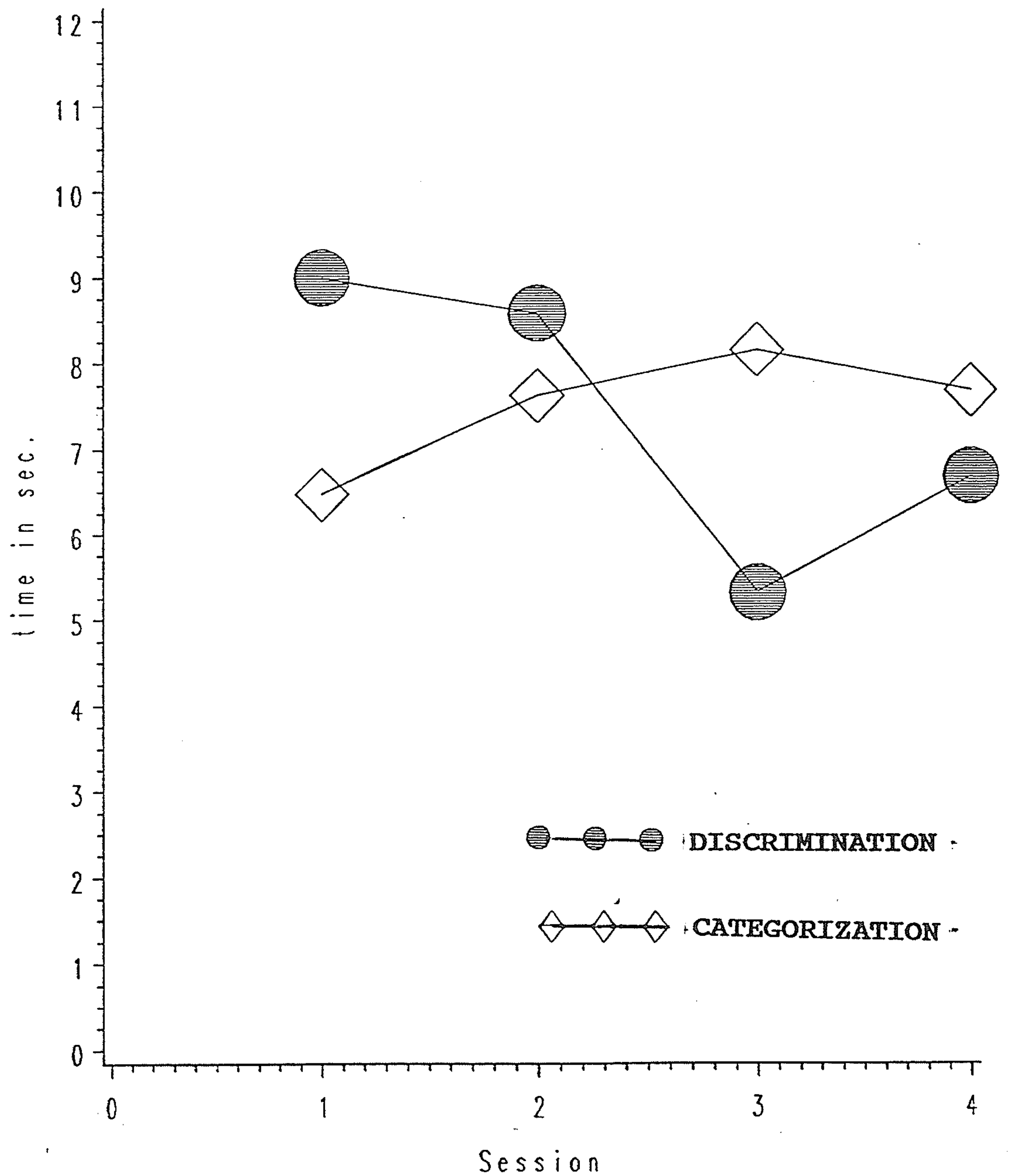

Figure 2. Visual fixation times for each session and type of problem in the DDCC problem order condition.

Table 11

Summary of Analysis of Variance of Familiarization Phase Data Involving Expression Order, Session, Type of Problem, and Trials

TEST	DF	CHI-SQUARE	P-VALUE
EXPORD (E)	1	0.81	0.367
SESSIONS (S)	3	19.84	0.000
TYPE OF PROBLEM (P)	1	0.02	0.881
TRIALS (T)	3	17.18	0.001
E X S	3	41.93	0.000
E X P	1	0.13	0.715
S X P	3	2.26	0.521
E X T	3	8.19	0.042
S X T	9	10.51	0.311
P X T	3	0.76	0.859
E X S X P	3	0.06	0.996
E X S X T	9	5.08	0.828
E X P X T	3	2.27	0.518
S X P X T	9	5.63	0.776
E X S X P X T	9	6.21	0.719

Note. EXPORD = Expression order (HSHS vs. SHSH).

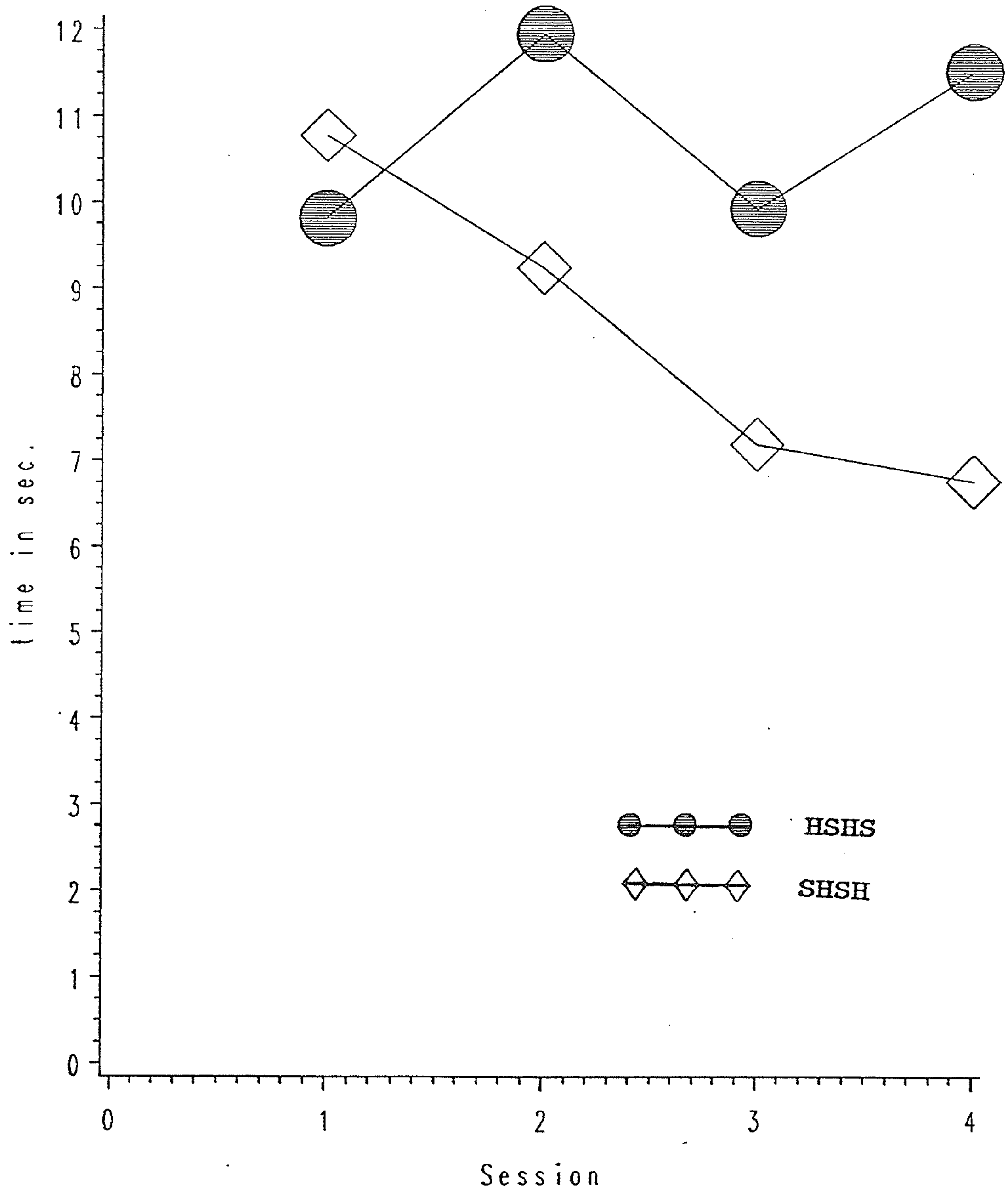

Figure 3. Visual fixation times for each session for the HSHS and SHSH conditions.

Figure 4 illustrates the Expression Order x Trial interaction. For the HSHS condition, fixation times declined from Trial 1 to Trial 2; whereas for the SHSH condition, they remained stable over the 4 trials. Fixation times were longer in the HSHS condition than the HSHS condition. But this difference declined over trials.

Test Phase

The total fixation times for the novel expression were summed over the two trials of each test phase. Similarly, the total fixation times for the familiar expression were summed over the two trials of each test phase. A novelty preference score (NP) was calculated for each problem by dividing the total fixation time for the novel expression (N) by the total fixation time for both the familiar expression (F) and novel expression (N) (cf., Ellis & Boyd, 1982; Shepherd & Fagan, 1980).

$$NP=\frac{N}{N+F}$$

A novelty preference score of .50 indicated equal fixation times on novel and familiar stimuli during the test trials. A score above .50 indicated that subjects looked longer at the novel expression than the familiar expression; and a score below .50 indicated that they looked longer at the familiar stimulus than the novel stimulus. The novelty preference scores are shown in Appendix G, Table 19.

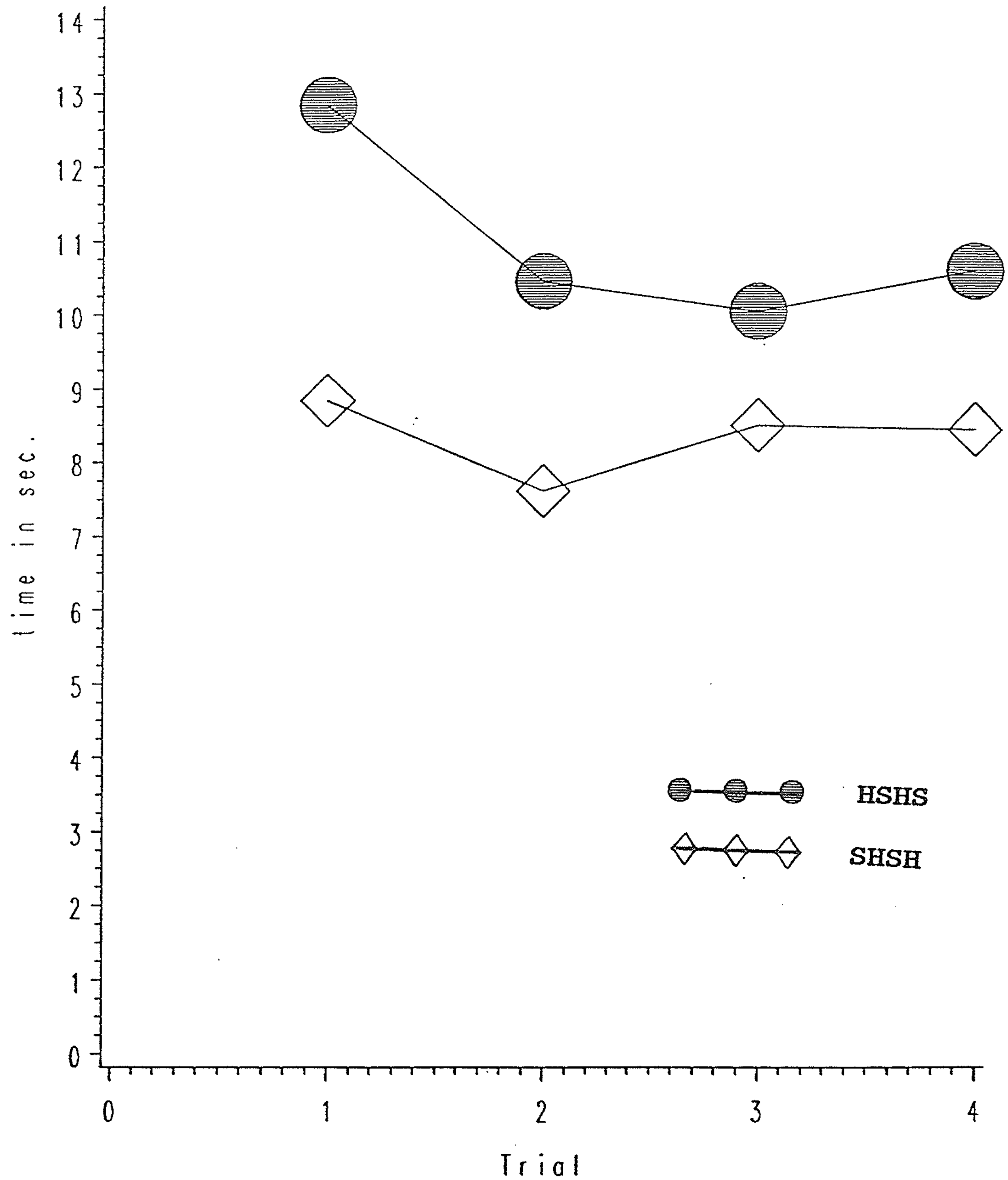

Figure 4. Visual fixation times for each familiarization trial for the two expression orders.

Mean novelty preference scores were tested to determine if they differed significantly from .50 using 2-tailed t-tests (cf., Shepherd & Fagan, 1981; Ellis & Boyd, 1982). The overall mean novelty preference score for both discrimination and categorization problems for all 14 subjects was .58. The t-test revealed that this value was significantly above .50, $t(13) = 3.07$, $p = .008$, indicating that subjects looked longer at the novel expression than the familiar expression. In addition, the mean novelty preference scores for discrimination and categorization problems were examined separately to test Hypotheses 2 and 3, which stated that subjects would look longer at the novel expression in both discrimination and categorization problems. The mean novelty preference in the discrimination problems of .60 was significantly above .50, $t(13) = 3.53$, $p = .003$; whereas, the mean novelty preference score for the categorization problems of .55 was not significantly above .50, $t(13) = 1.67$, $p = .11$. Thus, a novelty preference was found for discrimination problems but not categorization problems.

Subject 7 had three missing scores in the discrimination problem condition, and one missing score in the categorization problem condition. Due to the number of missing scores for this subject, the above analyses were repeated excluding Subject 7. The same outcomes were found; namely, (a) the overall novelty preference of .56 was significantly greater than .50, $t(12) = 3.30$, $p = .006$; (b) the mean novelty preference of .60 in the discrimination condition was significantly greater than .50, $t(12) = 3.14$, $p = .008$; and (c) the mean novelty preference of .53 in the categorization condition was not significantly greater than .50, $t(12)= 1.39$, $p = .19$.

Analyses of variance were conducted using BMDP 5V to examine whether subjects' novelty preference scores were influenced by several variables, including type of problem, session, and familiarized expression. The data set used for these analyses is presented in Appendix H, Table 20. Data for Subject 7 were included in these analyses.

In the first analysis, expression-order (EXPORD: HSHS vs. SHSH) was the between group variable. Type of problem (discrimination vs. categorization) and session (1 to 4) were within subject variables. Only the session main effect was significant (see Table 12). The mean novelty preference scores for Sessions 1 to 4 were .59, .49, .53, and .67, respectively. Pairwise comparisons using Tukey's HSD test revealed that the novelty preference scores in Session 2 were significantly lower than in Session 4, $\underline{HSD} = .17$, $p = .05$.

In the second analysis of variance of the test phase data, problem-order (CCDD vs. DDCC) was the between subject variable, and the within subject variables were type of problem (discrimination vs. categorization), and session (1 to 4). There were no significant effects other than the main effect for sessions described above (see Table 13).

In the third analysis, the within subject variables were type of problem (discrimination vs. categorization), type of familiar stimulus (happy vs. surprise), and instance (first vs. second). The between subjects variable was expression order (HSHS vs. SHSH). Each subject received two

Table 12

Summary of Analysis of Variance of Test Phase Data Involving Expression Order, Type of Problem, and Sessions

TEST	DF	CHI-SQUARE	P-VALUE
EXPORD (E)	1	0.31	0.575
TYPE OF PROBLEM (P)	1	1.27	0.260
SESSION (S)	3	13.36	0.004
E X P	1	0.00	0.947
E X S	3	3.00	0.391
P X S	3	2.55	0.466
E X P X S	3	1.21	0.750

Note. EXPORD = Expression-order (HSHS vs. SHSH).

Table 13

Summary of Analysis of Variance of Test Phase Data Involving Problem Order, Type of Problem, and Session

TEST	DF	CHI-SQUARE	P-VALUE
ORDER (O)	1	0.35	0.553
TYPE OF PROBLEM (P)	1	1.65	0.200
SESSION (S)	3	14.69	0.002
O X P	1	0.03	0.853
O X S	3	3.42	0.331
P X S	3	2.86	0.413
O X P X S	3	0.15	0.985

Note. ORDER = Problem-Order (DDCC vs. CCDD).

instances of happy and two instances of surprise as the familiar stimulus. Thus, happy vs. surprise was considered as one factor, while first vs. second instance was considered as another factor in this analysis. Table 14 shows that this analysis yielded no significant main effects or interactions.

Table 14

Summary of Analysis of Variance of Test Phase Data Involving Type of Problem, Type of Familiar Stimulus, and Instance

TEST	DF	CHI-SQUARE	P-VALUE
TYPE OF PROBLEM (P)	1	0.96	0.326
FAMSTIM (F)	1	1.95	0.162
INSTANCE (I)	1	2.41	0.121
P X F	1	0.28	0.596
P X I	1	0.03	0.866
F X I	1	0.31	0.577
P X F X I	1	0.39	0.534

Notes. Famstim = familiar stimulus (happy vs. surprise); Instance = first vs. second occurrence.

Relations among Measures of Subject Characteristics and Measures of Performance on the Visual Recognition Task

Pearson product-moment correlation coefficients were calculated involving four subject characteristics: (a) CA: chronological age of the subjects; (b) MA: mental age of the subjects derived from Bayley mental scale performance; (c) DS: total number of items passed on the developmental checklist; and (d) VFB: visual fixation scores from the Bayley mental scale items requiring visual fixation. Outcome measures were five measures of performance on the visual recognition task: (a) MNP: mean novelty preference score, combining both discrimination and categorization problem conditions, (b) MTOTF: mean of the total fixation times for the four familiarization trials averaged over the four sessions, (c) DIS: mean novelty preference score for discrimination problems, (d) CAT: mean novelty preference score for the categorization problems, and (e) SUCC: number of successes in discrimination and categorization problems. Number of successes was defined as the number problems in which novelty preference scores were above the mean of all the novelty preference scores in all sessions for all subjects (cf., Rose & Feldman, 1987). This score was .56.

The intercorrelations among these measures are presented in Table 15. Hypothesis 4 predicted a positive correlation between mental age and novelty preference scores. MA was positively correlated with mean novelty preference scores on discrimination problems; but it was not correlated with mean novelty preference scores, novelty preference scores on categorization problems, or number of successes. Subject 14 did not have a current Bayley test score, so the correlations involving MA were recalculated after deleting her data. The same correlations were significant when Subject 14 was omitted from the analysis. Developmental checklist scores were significantly positively correlated with number of successes. CA and Visual Fixation scores were not significantly correlated with any of the measures of task performance.

Intercorrelations of subject charateristic variables revealed a significant negative correlation between CA and visual fixation scores. CA, MA, and Developmental checklist scores were not significantly correlated with one another. Intercorrelations of measures of task performance indicated that mean novelty preference scores were significantly positively correlated with the other three measures of novelty preference.

Hypothesis 5 predicted that subjects who failed to discriminate facial expressions would also not categorize them; whereas, subjects who categorized would also discriminate. This was examined by testing whether the subjects' response patterns followed a Guttman scale

(Dunn-Rankin, 1983). The cut-off point of .56 was used to designate each subject's performance on discrimination and categorization problems as a success or failure. If a subject's mean novelty preference score for the discrimination or categorization problems was .56 or above, the subject was assigned a pass on that type of problem.

The pass and fail pattern for each subject for discrimination and categorization problems is presented in Table 16. As shown in the summary of this data in Table 17, three of fourteen subjects passed both categorization and discrimination problems, seven subjects passed discrimination but failed categorization, and two subjects failed both discrimination and categorization tests. These twelve subjects were consistent with the expected pattern. Two subjects passed the categorization test and failed the discrimination test. The coefficient of reproducibility, which measures degree of matching with the Guttman scale pattern, was .86. Dunn-Rankin (1983) suggest that a value of .93 is required to reach a .05 significance level (Dunn-Rankin, 1983). Hence, performance on the discrimination and categorization tasks used in this study did not significantly conform to a Guttman scale pattern.

Table 15

Correlations Among Subject Characteristics and Measures of Performance on the Visual Recognition Task

	MA	DS	VFB	MNP	MTOTF	DIS	CAT	SUCC
CA	-.33	.47	-.56*	.03	-.05	.01	.17	.25
MA		.47	.21	.24	-.24	.58*	-.16	.29
DS			-.11	.31	-.13	.40	.19	.71**
VFB				.30	-.22	-.17	.43	-.23
MNP					-.17	.73**	.80***	.53*
MTOTF						.08	-.39	-.09
DIS							.21	.50
CAT								.43
VFB								-.23

* $p < .05$

** $p < .01$

*** $p < .001$

Note. CA = chronological age; MA = mental age derived from Bayley mental scale performance; DS = developmental checklist score; MNP = mean novelty preference score; MTOTF = mean of total fixation times; DIS = mean novelty preference score for discrimination problems; CAT = mean novelty preference score for categorization problems; VFB = visual fixation scores from the Bayley mental scale items requiring visual fixation; SUCC = number of successes.

Table 16

Pass and Fail Patterns for Each Subject on Discrimination and Categorization Problems

Subject	Discrimination	Categorization	Error
1	Pass	Pass	0
2	Fail	Pass	2
3	Fail	Fail	0
4	Pass	Fail	0
5	Pass	Fail	0
6	Pass	Fail	0
7	Fail	Pass	2
8	Pass	Fail	0
9	Pass	Pass	0
10	Pass	Fail	0
11	Pass	Fail	0
12	Fail	Fail	0
13	Pass	Fail	0
14	Pass	Pass	0

Table 17

Number of Subjects Exhibiting Each Pattern of Success and Failure

Discrimination	Categorization	
	Success	Failure
Success	3	7
Failure	2	2

Discussion

Hypothesis 1 predicted that subjects would show a decline in looking during the familiarization phase. There was a decline in looking times from Trial 1 to Trial 2. Fixation times increased slightly over Trials 2 to 4, but remained below the level of Trial 1. The overall decline in visual fixations over the course of repeated exposures to the same stimulus pattern is consistent with previous studies of individuals with multiple handicaps (e.g., Kelman & Whiteley, 1986; Krenn & Whiteley, 1990; Rahman, 1988; Shaw, 1988).

There was also a significant main effect for session during the familiarization phase. The fixation times for Sessions 1 and 2 were higher than the fixation times for Sessions 3 and 4. This decline in fixation times over sessions might be an indication that subjects remembered the stimuli over the intersession intervals. Shaw (1988) also found a session effect using a paired-comparison procedure with multiply handicapped subjects; however in her study, the mean fixation time for Session 3 was significantly lower than in Sessions 1 and 4. These two studies show carry-over effects from session to session, suggesting that intersession intervals longer than 24 hours are needed in future studies to reduce such effects.

The session effect must also be viewed in the light of an interaction among session, problem-order, and type of problem. Follow-up analyses revealed a decline over sessions for the CCDD condition. However, in the DDCC condition looking times increased over sessions for the categorization problems and decreased over sessions for the discrimination problems. In the DDCC condition, fixation times were longer for discrimination than categorization problems in Sessions 1 and 2; whereas, they were longer for categorization problems than discrimination problems in Sessions 3 and 4. Subjects in the DDCC condition received the discrimination problem first and categorization problem second in Sessions 1 and 2; whereas in Sessions 3 and 4, they received the categorization problem first and the discrimination problem second. Thus fixation times were longer during the first problem of each session. Such a result suggests a carry-over of habituation from the first problem to the second problem within each session. To guard against such a carry-over effect, future experiments should include an inter-problem interval. For example, Ludemann and Nelson (1988) gave infants a 1-minute break between two problems presented within a session.

An interaction between expression order and session was also found for looking times during the familiarization phase. In the HSHS expression order condition, the fixation times to the familiar stimulus were longer in Sessions 2 and 4 (surprised expression) than in Sessions 1 and 3 (happy expression). So the longer looking in Sessions 2 and 4 might be due to the presentation of the surprise stimulus; however, this difference was not found in the SHSH condition. In Rahman's (1988) study no difference was found between looking times for happy and surprised expressions during the habituation phase.

The major purpose of this study was to investigate discrimination and categorization of facial expressions by persons with multiple handicaps. More specifically, the present study investigated whether they could discriminate between facial expressions of happy and surprise when these expressions were posed by a single adult, and whether they could categorize happy and surprise when they were posed by several adults.

Hypothesis 2 predicted that multiply handicapped individuals would discriminate between happy and surprised expressions. The results of the present study supported this hypothesis by showing that subjects looked longer at the novel expression than at the familiar expression when they were presented with discrimination problems. In previous studies it has been found that multiply handicapped persons can discriminate between facial and non-facial stimuli (Shepherd et al., 1984), between different faces

(Butcher, 1977), and between happy and surprised facial expressions (Rahman, 1988). The present study confirmed the findings of Rahman's (1988) study using a different methodological paradigm; that is, a familiarization and paired-comparison procedure was employed instead of a fixed-trial habituation-dishabituation procedure.

Hypothesis 3 predicted that individuals with multiple handicaps would categorize happy and surprised facial expressions. Novelty preference scores were not significantly above chance for categorization problems. Thus, persons with multiple handicaps in this study demonstrated discrimination between happy and surprised facial expressions, but failed to show evidence of categorization of these two expressions.

Why did subjects in this study fail to show evidence of categorization? One explanation is that they were functioning below the mental age required for this type of processing. Studies by Caron et al. (1982), Nelson et al. (1979), and Ludemann and Nelson (1988) have shown that infants demonstrate evidence of categorization between two facial expressions at about 7 months of age. The mental ages of subjects in this study ranged from 2 months to 6.5 months. In order to examine this interpretation, a future study could be undertaken with multiply handicapped persons having mental ages ranging from 4 months to 12 months.

Subjects with MAs above 7 months would be expected to categorize expressions; whereas, subjects below 7 months should discriminate but not categorize expressions.

The relevance of MA to the discrimination of facial expressions is demonstrated in the present study by the positive correlation between MA and novelty preference scores for discrimination problems. Rahman (1988) reported a positive correlation between amount of dishabituation to a change in expression and Bayley raw scores. These findings are consistent with the expectation that subjects would be increasingly likely to discriminate expressions as their MA increased from 2 to 7 months. The failure to find a correlation between MA and novelty preference scores on categorization problems in the present study would be expected if these subjects did not categorize the expressions.

Another reason for the lack of evidence of categorization of expressions could be the low power of the statistical test. The small number of subjects and problems contributed to this lack of power. In other words, this study may have failed to detect evidence of categorization, even though the participants had this ability. Including more subjects and categorization problems in a future study would address this problem.

Whether subjects in this study received sufficent training to learn the categories is another issue. Nelson et al. (1979) found that infants' ability to categorize facial expressions was enhanced when the number of models was increased from one to two models. In the present study there were four familiarization trials in which subjects were exposed to the expressions exhibited by four models. Introducing a larger number of models during the familiarization phase might provide the experience needed for persons with multiple handicaps to extract common features of the expressions.

A fourth possible reason for the failure to find categorization is that the 30 s trial duration during the familiarization phase and 10 s trial duration during the test phase may have been inappropriate for some subjects. For example, it was observed that some subjects had stopped looking at the stimuli by the test trials. For these subjects, 30 s familiarization trials might have been too long. On the other hand, some subjects only looked at the screens occasionally after long intervals. For these subjects, 10 s test trials may have been too short in duration. Introducing a longer test trial duration (e.g., 15 s or 20 s) might provide such subjects with a better opportunity to compare novel and familiar stimuli during test trials. Future studies could be undertaken in which trial durations are varied systematically over sessions and subjects. Ellis and Boyd (1982) adopted a technique in which they ensured a fixed amount of total looking by the subjects during the familiarization trials (30 s). This type of subject-controlled trial could also be employed for test trials. For example, instead of two trials of predeterimined duration, subjects could be presented with the test pair until they looked for a predetermined time period, such as 10 s. Subjects' preference for novel stimuli could then be estimated by the proportion of this 10 s time they looked at the novel stimulus.

Whether novelty preference scores were influenced by expression-order, problem-order, type of problem, session, familiarized expression, or first versus second instance of the problem, was also examined. The major finding was that novelty preference was influenced by session. It was found that novelty preference scores declined from Session 1 to Session 2, then increased in Session 3, and were highest in Session 4. There is no obvious explanation of this effect.

Hypothesis 4 predicted a developmental trend in test phase performance. This was analyzed by correlating MA, CA, and Developmental Checklist Score (DS) with several measures of test phase performance. A significant positive correlation between DS and number of successes on novelty preference tests was found. There was also a significant positive correlation between MA and novelty preference scores on discrimination problems. These two results provide some evidence for the view that discriminating expressions is more likely as subjects' developmental level increases. The two developmental measures, mental age and the developmental scale score, were not significantly correlated with each other; although, there was a nonsignificant positive correlation of .47 between the two measures.

Hypothesis 5 predicted that subjects who categorized facial expressions would also discriminate expressions; whereas, subjects who failed to discriminate would also fail to categorize. Each subject's performance was classified in one of four ways: (a) failed both discrimination and categorization, (b) succeeded in discrimination but not categorization, (c) succeeded in categorization but not discrimination, or (d) succeeded in both discrimination and categorization. Only two subjects (Subjects 2 and 7) violated the predicted pattern, as they passed categorization but failed discrimination. Nevertheless, the Guttman scale pattern was not demonstrated to be statistically reliable, so the hypothesis was not confirmed.

The mental ages of the two subjects who were exceptions to the expected order (Subjects 2 and 7) had Bayley mental ages of 2 months and 2.7 months, respectively. In addition, both of these subjects scored below the group mean on the developmental checklist. Considering their low mental ages and developmental checklist scores, it is plausible to hypothesize that their success on categorization problems was a false positive score obtained due to chance.

Summary and Conclusions

Research on communication between nonverbal persons with multiple handicaps and others is important for both theoretical and practical reasons. This study extended the theoretical analysis of the communication process described by Field and Walden (1982) and Tronick (1989) to individuals with multiple handicaps. This study dealt with one aspect of this communication process -- the perception of emotional expressions by persons with multiple handicaps. Perceiving facial expressions is necessary for acquiring an understanding of the meaning of such stimuli. It is essential that a person discriminate between social stimuli and group similar social stimuli into the same category. These skills are prerequisites for responding with appropriate expressions or gestures in reciprocal interactions. By including categorization of facial expressions, this study extended the scope of research on the perception of social stimuli by persons who are multiply handicapped.

Tronick (1989) has outlined how the establishment of successful emotional communication between a mother and her infant can lead to positive social and emotional outcomes; whereas, failure to do so can produce negative outcomes, such as withdrawl and low self-esteem. According to Tronick (1989), such outcomes depend upon an affective communication system in which the infant experiences success or failure in his or her social-emotional interactions. Individuals with multiple handicaps are at greater risk for such failure in social-emotional interactions if they cannot understand the emotional expressions of their caretakers. Such interactive errors might lead to poor affective development (Gianino & Tronick, 1988). Only one aspect of interpersonal communication was examined in the present study -- the perception of emotional expressions by persons with multiple handicaps. Further research is needed on all four components of the communicative process described by Tronick (1989).

Practically, the present study shows that the visual recognition memory methodology can be used to test discrimination and categorization of facial expressions by persons with multiple handicaps. These methods may provide sensitive measures for discriminating higher functioning individuals from lower functioning ones, as developmentally, categorization is a more advanced ability than simple discrimination of two expressions (Nelson, 1987). Such measures might supplement traditional developmental measures, whose validity is questionable for these individuals. Identification of individuals who discriminate and categorize facial expressions also provides important information for caretakers about possible means of nonverbal communication.

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Appendix A

Parental Permission Letter and Consent Form

St. Amant Centre Inc.
440 River Road Winnipeg, Manitoba R2M 3Z9

Centre St. Amant Inc.
Telephone: 256-4301 Area Code 204 Code Regional

Date

NAME
ADDRESS
CITY, PROVINCE
POSTAL CODE

Dear

One of the services available to individuals residing at St. Amant Centre is the opportunity to participate in the Psychology Research Program. The Psychology Research Program has been in existence at the Centre for many years. The program is directed at developing effective procedures designed to evaluate and develop language, social, and self-help skills with developmentally delayed persons. Research programs selected are designed to benefit individuals directly or indirectly - through further development of ongoing programs - while at the same time contributing to the body of knowledge in this important area of study.

The research project begins upon approval by the Research Ethics Committees of both the participating university and the St. Amant Centre, in addition to the person's parents. The project is conducted in the Psychology Department or in the individual's living unit. Sessions are conducted by Psychology students from an academic teaching facility. They are supervised by their assigned professor and monitored by the Research Coordinator at the Centre.

Since the program has a research component we require the consent of the individual's parents or guardian prior to participation. Attached to this letter you will find a consent form, a letter from the university professor supervising the project and a brief description of the proposed project for which your child is being considered. Please sign the consent form indicating whether you wish your child to participate and return it directly to me. We wish to assure you that all information obtained is strictly confidential and that your child will not be identified in any way in published scientific reports.

If you have any further questions regarding this program please feel free to contact me at the Centre on Fridays between 8 a.m. and 4 p.m.

I look forward to hearing from you.

Sincerely,

Valdine Huyghebaert, Psyc. Assoc.
Research Coordinator
Coordinator of Psychology

VH/

Enclosure

PARENT INFORMATION AND CONSENT FORM

1. Title of Project

Discrimination and Conceptualization of Facial Expressions by Children with Multiple Handicaps

2. Name(s) of Researcher(s)

Miss. Sandra Robertson, Mr. M. Rahman

3. Name of Project Supervisor:

John Whiteley, Department of Psychology, University of Manitoba

4. Times child will participate:

Children will participate between 9:30 and 11:30 am or 1:30 and 4:30 pm when they are not engaged in other programmes or activities. Each child will participate in about ten sessions with at least 24 hours between sessions.

5. Skills to be taught:

This study involves assessing discrimination of facial expressions (happy and surprise) rather than teaching skills.

6. Procedures to be used:

Children become less interested in a picture after they have looked at it for a short period of time. If a new picture is shown, children look longer at the new picture than the familiar picture. In our study, each child will be shown a picture, such as a picture of a happy face. They will then be shown the same expression along with a new expression, such as a surprised face. We expect that the children will look longer at the new picture when they perceive a change in the expression. We will be measuring how long the child looks at each picture. In addition, each child will be given a developmental test This test will be used to provide a description of the child's developmental level.

7. Possible benefits to the child:

This study will give us information about the child's sensitivity to social cues in facial expressions. This information may assist staff in their interactions with the children. The testing should be enjoyable for the children and they will engage in positive interactions with the researchers during the test sessions.

8. Any possible risks to the child:

There are no risks.

CONSENT FORM

Please complete this form and return it in the attached envelope.

I ____________________ hereby give ________, do not give _______ my consent for my son/daughter ______________________ to be screened and if selected to participate in the research project entitled ______________ ____________________________________. I understand that the above project has been approved by the Ethics Committees of both the University of Manitoba and the St. Amant Centre. I also understand that my consent once given, can be withdrawn at any time.

Please check if you wish to be notified if your child was selected _______ and if you wish to receive a research summary report ______.

Parent Signature ____________________________ Date: _________________

Appendix B

Developmental Checklist

DEVELOPMENTAL CHECKLIST

Name of the Individual:________________ Ward:____________

Name of the Observer:__________________ Date:____________

INSTRUCTIONS:

Assessment is based on direct observation. Most of the behaviors will occur in routine daily life where you can easily observe them. If you cannot observe the behavior, make your decision based on all evidence that is available to you. Do not consult other people.

Please circle "YES":

(1) if the person can perform the behavior, or

(2) if no additional training is required for the person to perform the behavior, or

(3) if the behavior is too simple and consequently inappropriate.

Please, circle "NO":

(1) if the person cannot perform the behavior, or

(2) if additional training is required for the person to perform the behavior, or

(3) if the person cannot perform the behavior due to physical handicap or absolutely no opportunity to perform the behavior.

Gross Motor Development (Scale 1)

1. Holds head up for five seconds when lying on stomach .... yes no
2. Rolls over on flat surface from back to stomach or stomach to back.................. yes no
3. Holds head erect when in sitting or standing position (body may be supported)............ yes no
4. Sits....................................... yes no
5. Changes from lying on stomach to a sitting position.................................. yes no
6. Pulls self to standing position using something to hold onto...................... yes no
7. Crawls..................................... yes no
8. Stands..................................... yes no
9. Walks five feet (may use braces or crutches) yes no
10. Moves five feet using walker or wheel chair yes no

Fine Motor Development (Scale 2)

1. Closes hand around an object placed in hand yes no
2. Reaches for and grasps objects yes no
3. Uses both hands at the same time when needed to handle an object........................ yes no
4. Picks up small objects using thumb and fingers only............................... yes no

Eating (Scale 3)

1. Swallows soft foods that do not require chewing .... yes no
2. Drinks from a glass or cup with assistance yes no
3. Picks up food with fingers and puts food in mouth....................................... yes no
4. Chews solid food .... yes no
5. Picks up a glass and drinks from it .... yes no
6. Uses a spoon to pick up and eat food ...... yes no
7. Eats a complete meal with little or no spilling (may use only fingers and spoon).. yes no

Dressing (Scale 4)

1. Offers little or no resistance while being dressed and undressed..................... yes no
2. Extends and withdraws arms and legs while being dressed and undressed............... yes no
3. Removes socks, underpants, unzipped outer pants and unbuttoned shirt or dress....... yes no
4. Removes slip-over shirt.................. yes no
5. Undresses self completely (may need help with belt or bra)...................... yes no

Grooming (Scale 5)

1. Offers little or no resistance while being washed .... yes no
2. Turns head and extends hands while being washed.................................. yesno
3. Puts hands under running water for washing yes no
4. Dries hands with a towel.................. yes no
5. Places a toothbrush in mouth and begin brushing motion........................... yes no
6. Wipes face with a wet washcloth........... yes no
7. Soaps and rinses hands .... yes no
8. Wipes nose with an arm, hand or tissue when nose is running...................... yes no
9. Soaps and rinses arms and upper body...... yes no
10. Blows nose in a tissue or handkerchief.... yes no
11. Runs a comb or brush through hair with several strokes........................... yes no

Toileting (Scale 6)

1. Stays dry for two hours .... yes no
2. Sits on the toilet for thirty seconds..... yes no
3. Eliminates when on the toilet (bowel or bladder)................................. yes no

6. Has bowel control at night .... yes no

9. Has bowel control......................... yes no

10. Indicates by a gesture or words when needing to use the toilet................ yes no

12. Has bowel and bladder control............ yes no

Receptive Language (Scale 7)

1. Turns head toward the source of a sound.... yes no

2. Responds when name is called............... yes no

3. Responds to the instruction, "Look at me," with two seconds of eye contact............ yes no

4. Responds to a simple instruction such as, "Come here"............................... yes no

5. Performs the appropriate action when the word "me" is used such as, "Give me the ball" .. yes no

6. Stops an activity upon request such as, "No," or "Stop"................................. yes no

7. Points to fifteen common objects such as a ball, spoon, etc., upon request............ yes no

9. Listens to a story for three minutes....... yes no

10. Follows instructions such as, "Put the ball in the box"......................... yes no

12. Responds to non-verbal communications from others such as frowning, crying, smiling, etc. .... yes no

Expressive Language (Scale 8)

Note: If the person uses sign language or signboards (e.g., bliss symbols) to communicate, these methods should be considered the same as speaking.

1. Makes sounds or gestures to get attention... yes no
2. Shakes head or otherwise indicates "yes" or "no" in response to a simple question such as, "Do you want some milk?"............... yes no
3. Repeats three common words presented one at a time, such as "cat", "dog", and "car"..... yes no
4. Names three familiar objects such as cup, bed, and ball............................. yes no
5. Says at least ten words that can be understood by someone who knows him or her.. yes no
6. Asks simple questions (for example, "what's that?")............................ yes no
7. Speaks in three or four-word sentences...... yes no
8. Says last name when asked.................. yes no

Social Interaction (Scale 9)

1. Responds when touched by reaching toward or moving away............................ yes no
2. Looks toward or otherwise indicates a person in the immediate area............... yes no
3. Follows a person with eyes or otherwise responds to a person moving................ yes no
4. Imitates arm movement such as clapping hands or waving good-bye .... yes no
5. Spends time alone with toys or objects for two minutes........................... yes no
6. Identifies friends and acquaintances from strangers................................. yes no
7. Spends five minutes doing something with one or two other persons.................. yes no
8. Spends ten minutes doing something with one or two other persons sitting at a table.... yes no
9. Waits for turn in a group.................. yes no
10. Follows directions from others............. yes no
12. Greets others upon meeting................. yes no

Appendix C

Instructions given to the Judges for the

Rating of Facial Expressions

Please read the description of happy (enjoyment-joy), and surprise expressions as defined by Izard (1971) and watch the sample picture. You will be shown these expressions posed by several female models. Please indicate for each expression whether it matches with Izard's description in terms of the changes in each facial region. Please indicate using a check (✓) mark that it matches, and cross (x) mark that it doesn't.

Then, please give an overall judgement of each expression on a 5-point rating scale indicating whether the overall expression of the model matches with the sample overall expression outlined by Izard (1971). The 5-point scale should look like this:

```
1            2            3            4            5
+------------+------------+------------+------------+
Doesn't match  Not very   Somewhat    Verymuch     Fully
  at all       closer     closer      closer      matches
```

Appendix D

Facial Expressions of Happy and Surprise For the Six Models

Appendix E

Assignment of Conditions for each Subject and Trial

APPENDIX E

Table 18

Grouping of Subjects and the Selection of Different Models in Familiarization and Test Trials of Four Sessions Along With the Position of the Novel Expression During Test Trials

		Session 1						Session 2						Session 3						Session 4					
Subj.	Group	MD	TC	F1	F2	F3	F4	MD	TC	F1	F2	F3	F4	MD	TC	F1	F2	F3	F4	MD	TC	F1	F2	F3	F4
1	SD	4L	6R	5	2	3	1	1R	2L	6	5	3	4	3R	4R	6	2	5	1	2L	1L	4	6	5	3
2	SC	5L	2R	3	4	6	1	4R	3L	2	1	5	6	1L	5L	3	4	6	2	2R	1R	6	3	5	4
3	SC	4L	6L	2	3	1	5	2L	1R	6	4	3	5	6R	5L	2	4	1	3	1R	3R	4	5	6	2
4	HC	1L	2R	6	5	3	4	5L	2R	1	6	4	3	2R	1L	4	3	5	6	3R	5L	4	6	2	1
5	SC	1R	5R	3	2	4	6	6L	4L	1	5	2	3	2L	6R	4	1	5	3	4R	1L	3	5	2	6
6	HD	5R	2L	4	6	3	1	3L	1R	2	5	4	6	1R	4R	5	3	6	2	2L	6L	5	3	1	4
7	HC	6R	1L	3	2	4	5	2L	4R	3	6	1	5	3L	5R	4	6	2	1	5R	3L	1	6	2	4
8	SD	4R	6R	1	3	5	2	6R	5L	1	3	4	2	5L	2R	1	6	3	4	3L	5L	4	6	1	2
9	SD	2R	5L	3	1	6	4	1L	6R	3	4	2	5	5L	2R	3	6	4	1	6R	3L	4	5	2	1
10	HC	6L	1L	4	5	2	3	1L	3R	5	6	4	2	4R	6L	1	5	3	2	3R	5R	1	4	6	2
11	SC	3R	4R	5	1	2	6	5R	6L	3	4	2	1	4L	3R	2	1	6	5	2L	4L	3	6	5	1
12	HD	2L	3R	4	1	6	5	6R	4R	3	2	5	1	1R	2L	5	3	4	6	4L	1L	6	5	2	3
13	HD	6L	5L	1	4	2	3	4L	3R	1	6	2	5	3R	1R	5	6	2	4	5R	4L	6	3	1	2
14	HC	3L	2R	4	1	5	6	5R	6L	2	1	4	3	4L	1L	6	2	3	5	6R	2R	3	1	4	5

Note. SD = Subject in SHSH expression order and DDCC problem order, SC = Subjects in SHSH expression order and CCDD problem order, HC = Subjects in HSHS expression order and CCDD problem order, HD = Subjects in HSHS expression order and DDCC problem order, MD = Model selected for test trial of the discrimination problem condition, and the same model was used during the four familiarization phase of this problem condition, TC = model selected for the test trial of the categorization problem condition, F1 = model selected for the first familiarization trial of the categorization problem condition, F2 = model selected for the second familiarization trial of the categorization problem condition, F3 = model selected for the third familiarization trial of the categorization problem condition, F4 = model selected for the fourth familiarization trial of the categorization problem condition, L = the novel stimulus presented on the left screen during the first test trial, it was presented on the right screen in the next test trial, R = the novel stimulus presented on the right screen during the first test trial, it was presented on the left screen in the next test trial.

Appendix F

Scoring Criteria for a Visual 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 fixations on the basis of subject's general orientation, eye movement, 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 G

Test Trial Data Used for Analyzing Discrimination and Categorization

Explanation for column headings for Table 19

Subj. = Subject number

D1 = Novelty preference score in Session 1 for Discrimination problem

D2 = Novelty preference score in Session 2 for Discrimination problem

D3 = Novelty preference score in Session 3 for Discrimination problem

D4 = Novelty preference score in Session 4 for Discrimination problem

MD = Mean of the Novelty preference scores for Discrimination problems across four sessions

C1 = Novelty preference score in Session 1 for Categorization problem

C2 = Novelty preference score in Session 2 for Categorization problem

C3 = Novelty preference score in Session 3 for Categorization problem

C4 = Novelty preference score in Session 4 for Categorization problem

MC = Mean of the Novelty preference scores for Categorization problems across four sessions

Table 19

Novelty Preference Scores (NP) Data by Type of Problem and Sessions for Fourteen Subjects

Subj.	D1	D2	D3	D4	MD	C1	C2	C3	C4	MC
1	.94	.66	*	.71	.77	.29	.56	.80	.64	.57
2	.45	.23	.56	.65	.47	.74	.85	.25	.73	.64
3	.43	.18	*	.82	.48	.30	.42	.49	*	.40
4	.85	.74	.70	.60	.72	.69	.39	.70	.44	.55
5	.52	.78	.41	.60	.58	.37	.46	.44	.76	.51
6	.51	.30	.65	.82	.57	.49	.48	.35	.39	.43
7	.08	.29	.33	.83	.38	.29	.68	*	.87	.61
8	*	.51	.35	1.00	.62	.61	.22	.09	1.00	.48
9	*	*	.73	*	.73	.93	.84	*	.88	.88
10	1.00	.86	.38	.44	.67	*	.51	.61	.51	.54
11	.80	.55	.89	.57	.70	.52	.40	.49	.48	.47
12	.78	.30	.62	.43	.53	.52	.30	.64	.71	.54
13	.67	*	.54	.64	.62	.64	.39	.35	.75	.53
14	.84	.40	.78	.55	.64	.55	.50	.60	.63	.57

Note. * = missing values

Appendix H

Test Trial Data Used for Analyzing Effects of Type of Familiar Stimulus on Novelty Preference Scores

Explanation for column headings for Table 20

Subj. = Subject number

DH1 = Novelty preference score for Discrimination problem after first Happy familiar stimulus

DH2 = Novelty preference score for Discrimination problem after second Happy familiar stimulus

DS1 = Novelty preference score for Discrimination problem after first Surprise familiar stimulus

DS2 = Novelty preference score for Discrimination problem after second familiar stimulus

CH1 = Novelty preference score for Categorization problem after first Happy stimulus

CH2 = Novelty preference score for Categorization problem after second Happy stimulus

CS1 = Novelty preference score for Categorization problem after first Surprise stimulus

CS2 = Novelty preference score for Categorization problem after second Surprise familiar stimulus

Table 20

Novelty Preference Scores (NP) by Type of Problem and Type of Familiar Stimulus for Fourteen Subjects

Subj.	DH1	DH2	DS1	DS2	CH1	CH2	CS1	CS2
1	.66	.71	.94	*	.56	.64	.29	.80
2	.23	.65	.45	.56	.85	.73	.74	.25
3	.18	.82	.43	*	.42	*	.30	.49
4	.85	.70	.74	.60	.69	.70	.39	.44
5	.78	.60	.52	.41	.46	.76	.37	.44
6	.51	.65	.30	.82	.49	.35	.48	.39
7	.08	.33	.29	.83	.29	*	.68	.87
8	.51	1.00	*	.35	.22	1.00	.61	.09
9	*	*	*	.73	.84	.88	.93	*
10	1.00	.38	.86	.44	*	.61	.51	.51
11	.55	.57	.80	.89	.40	.48	.52	.49
12	.78	.62	.30	.43	.52	.64	.30	.71
13	.67	.54	*	.64	.64	.35	.39	.75
14	.84	.78	.40	.55	.55	.60	.50	.63

Note. * = missing values

Appendix I

<u>Data Used for Analyses of Total Fixation Times During the Familiarization Phase</u>

Explanation of column headings for Table 21

Subj. = Subject no.
Ses. = Session no.
D11 = Fixation in Trial 1, Session 1, for Discrimination
D12 = Fixation in Trial 2, Session 1, for Discrimination
D13 = Fixation in Trial 3, Session 1, for Discrimination
D14 = Fixation in Trial 4, Session 1, for Discrimination
C11 = Fixation in Trial 1, Session 1, for Categorization
C12 = Fixation in Trial 2, Session 1, for Categorization
C13 = Fixation in Trial 3, Session 1, for Categorization
C14 = Fixation in Trial 4, Session 1, for Categorization
D21 = Fixation in Trial 1, Session 2, for Discrimination
D22 = Fixation in Trial 2, Session 2, for Discrimination
D23 = Fixation in Trial 3, Session 2, for Discrimination
D24 = Fixation in Trial 4, Session 2, for Discrimination
C21 = Fixation in Trial 1, Session 2, for Categorization
C22 = Fixation in Trial 2, Session 2, for Categorization
C23 = Fixation in Trial 3, Session 2, for Categorization
C24 = Fixation in Trial 4, Session 2, for Categorization
D31 = Fixation in Trial 1, Session 3, for Discrimination
D32 = Fixation in Trial 2, Session 3, for Discrimination
D33 = Fixation in Trial 3, Session 3, for Discrimination
D34 = Fixation in Trial 4, Session 3, for Discrimination
C31 = Fixation in Trial 1, Session 3, for Categorization
C32 = Fixation in Trial 2, Session 3, for Categorization
C33 = Fixation in Trial 3, Session 3, for Categorization
C34 = Fixation in Trial 4, Session 3, for Categorization
D41 = Fixation in Trial 1, Session 4, for Discrimination
D42 = Fixation in Trial 2, Session 4, for Discrimination
D43 = Fixation in Trial 3, Session 4, for Discrimination
D44 = Fixation in Trial 4, Session 4, for Discrimination
C41 = Fixation in Trial 1, Session 4, for Categorization
C42 = Fixation in Trial 2, Session 4, for Categorization
C43 = Fixation in Trial 3, Session 4, for Categorization
C44 = Fixation in Trial 4, Session 4, for Categorization

Table 21

Duration of Visual Fixation During Four Familiarization Trials in Four Sessions for Fourteen Subjects (in Seconds)

Subj.	Ses.	D11	D12	D13	D14	C11	C12	C13	C14
1	1	6.81	3.97	1.55	9.36	7.30	4.10	5.71	4.11
2	1	19.40	21.77	14.15	23.67	19.06	8.85	24.62	22.90
3	1	9.34	4.70	15.34	3.20	9.69	4.20	8.47	3.57
4	1	23.72	13.95	11.88	18.28	19.65	15.22	14.92	14.88
5	1	13.68	8.81	10.33	2.28	14.88	18.26	17.90	12.46
6	1	22.50	22.20	10.20	22.84	10.36	14.30	13.63	17.86
7	1	5.45	2.21	.28	.00	2.56	2.01	.00	2.37
8	1	7.40	1.33	3.63	1.69	.62	.67	1.79	.00
9	1	2.94	4.27	.00	6.67	1.49	1.31	.00	4.90
10	1	.00	1.12	1.34	2.46	8.81	3.62	1.31	1.35
11	1	28.36	23.52	27.27	28.77	25.93	23.30	26.06	26.91
12	1	22.36	16.96	13.00	18.91	16.82	9.82	20.24	5.74
13	1	5.23	5.98	2.98	3.56	6.00	3.47	3.15	1.99
14	1	11.23	19.97	9.74	14.83	6.10	8.60	1.39	20.18

Subj.	Ses.	D21	D22	D23	D24	C21	C22	C23	C24
1	2	4.04	2.33	2.96	6.03	5.22	.95	4.67	4.07
2	2	18.37	8.67	14.01	9.73	8.89	16.62	11.48	10.26
3	2	7.78	7.57	5.28	4.29	3.00	4.65	10.54	6.13
4	2	24.92	20.43	19.80	16.37	19.03	20.65	26.94	20.04
5	2	7.60	7.01	8.56	3.62	11.87	8.26	6.13	8.99
6	2	24.91	25.51	24.78	18.50	22.42	5.03	2.77	1.83
7	2	.44	2.26	1.91	.23	7.73	.00	3.30	*
8	2	.00	.78	1.92	.47	.21	.26	.62	.52
9	2	.00	.34	3.12	.00	.00	.00	3.30	*
10	2	.87	1.38	1.05	7.32	16.20	4.12	2.30	2.64
11	2	22.45	16.53	24.22	22.42	27.80	28.57	28.45	28.85
12	2	26.45	11.69	24.22	16.38	16.31	6.10	1.15	3.76
13	2	5.33	.83	4.57	.75	3.09	1.90	1.28	2.28
14	2	16.97	16.84	16.17	10.68	11.00	17.27	20.23	14.24

(Table 21 continues)

Subj.	Ses.	D31	D32	D33	D34	C31	C32	C33	C34
1	3	1.40	.90	4.45	3.52	.78	.00	1.29	.30
2	3	16.16	7.34	17.15	.73	12.66	.00	4.59	5.24
3	3	4.52	6.84	3.83	6.21	.00	9.35	4.76	3.49
4	3	16.93	7.57	19.23	15.91	24.06	7.54	21.13	3.49
5	3	16.54	2.28	6.01	1.52	10.72	20.39	12.23	1.87
6	3	23.92	21.58	24.72	9.81	22.30	24.69	20.86	25.53
7	3	3.44	2.15	1.17	.00	1.47	.31	1.05	1.61
8	3	.00	1.26	2.20	.73	.41	4.52	1.88	1.87
9	3	.97	.00	.29	.24	2.54	3.29	.00	.44
10	3	5.37	4.34	5.28	.30	2.26	1.36	1.84	1.41
11	3	26.06	26.91	22.45	16.53	24.22	24.42	27.80	28.57
12	3	9.09	10.46	2.84	4.38	20.69	24.80	17.85	10.81
13	3	1.36	1.85	1.17	.55	4.19	1.26	2.99	2.33
14	3	15.29	17.12	13.68	18.35	20.77	9.13	6.33	8.57

Subj.	Ses.	D41	D42	D43	D44	C41	C42	C43	C44
1	4	3.01	.76	.00	1.90	3.54	1.19	2.61	1.84
2	4	10.11	8.28	3.44	4.39	7.01	2.89	2.13	1.60
3	4	3.81	2.46	7.42	8.75	2.07	2.43	1.67	3.64
4	4	17.81	20.86	13.30	17.30	18.46	18.37	13.25	16.20
5	4	4.72	7.61	7.15	3.98	8.85	12.66	11.83	7.60
6	4	25.57	23.44	24.29	24.13	27.57	23.37	23.94	25.18
7	4	7.69	4.04	5.95	3.13	3.30	5.30	7.88	1.60
8	4	.40	.00	.63	2.17	.00	.00	.21	.60
9	4	2.32	.64	.00	.38	2.51	.00	3.22	2.39
10	4	14.10	3.87	10.77	2.75	13.94	7.60	4.98	6.57
11	4	27.00	24.63	25.76	26.87	27.03	28.06	25.49	26.67
12	4	14.22	10.59	7.72	7.85	13.84	14.23	9.99	13.00
13	4	2.78	1.20	1.50	4.56	7.30	3.10	3.19	1.34
14	4	14.44	7.03	11.80	18.39	10.55	9.75	8.54	10.94

Note. * = missing values