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Visual Habituation Performance in Complication-Free Preterms at 4 Months Corrected Age

Denise Messmer

A Thesis

in

The Department

of

Psychology

Presented in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy at
Concordia University
Montréal, Québec, Canada

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ABSTRACT

Visual Habituation Performance in Complication-Free Preterms at 4 Months Corrected Age

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Concordia University, 1989

This study investigated the effects of prematurity in the absence of medical complications on memory and attention. The performance of 15 complication-free preterms at 4 months corrected age was compared to that of a matched sample of 4-month-old fullterms on a modified version of Cohen's (1976) visual habituation task. Infants were tested on separate occasions under the standard no delay condition, where fixation of the light led to stimulus exposure, and under 2-s and 3-s delays interposed between fixation of the light and stimulus exposure. Infants received two warm-up trials, 18 habituation trials, and two dishabituation trials. The major measures were latency to orient to the stimulus and intertrial interval both measures of attention, and fixation time, a measure of memory. It was predicted that the delays would produce more forgetting of the stimulus between trials and would thus impair attention and memory. No group effects or group x delay interactions were found on any of the measures. Effects of delay were found on latency to orient and intertrial interval but not on fixation time. Latencies to orient to the stimulus and intertrial interval became longer with the longer delays. There was a decreasing linear trend for fixation time. An analysis of data from an

increased fullterm sample (N=27) replicated the linear trend for fixation time and the effect of delay on latency to orient but not on intertrial interval. An effect of delay emerged for fixation time indicating that fixations were longer with the longer delays. Analyses comparing 9 preterms with complications to the preterms of the main study did not indicate group differences. Effects of delay were found for latency to orient to the stimulus, intertrial interval but not fixation time. The results of this study provided no evidence of impairments or differences attributable to prematurity per se but did suggest that preterm infants' performance might be more readily disrupted by factors affecting attention.

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VISUAL HABITUATION PERFORMANCE IN COMPLICATION-FREE PRETERMS AT 4 MONTHS CORRECTED AGE

Statement of The Problem

Infants born before term are subjected to unique experiences because of their immaturity at birth, early delivery, long hospitalization, and separation from their mother. Very few studies have been conducted on the developmental outcome of preterm infants free of medical complications. Most studies of the effects of prematurity have either been concerned about the impact of specific medical complications on later development or have investigated the effects of prematurity without taking into account the medical complications experienced by preterm infants.

A pervasive finding of visual information - processing studies has been that preterm infants tend to need longer periods of time to process information about an unchanging stimulus than fullterm infants, at least up to the age of 12 months corrected age (Rose, 1980, 1983; Sigman, 1976; Sigman, Kopp, Littman & Parmelee. 1977; Sigman & Parmelee, 1974). The question of whether these findings reflect the effects of the complications that infants have experienced or the effects of prematurity per se has not been clarified in these studies. The purpose of the present study was to investigate whether prematurity in the absence of medical complications

is associated with attentional or memory deficits on an information-processing task in early infancy, specifically at 4 months corrected age.

Review of The Literature

Follow-up studies

Infants born before term constitute a group at high risk for physical and psychological impairments. Since 1970, by an international agreement the term premature has been deleted from the scientific vocabulary and replaced by the term preterm which specifically refers to infants born at less than 37 weeks gestational age (GA) (Tanner, 1974). A further classification which was found to be useful is the one proposed by Battaglia and Lubchenco (1967) to differentiate infants born before term from those born at term but small for date. Under this system, infants are either born at term, before term, or post-term, and are either Large for Gestational Age (LGA), Appropriate Weight for Gestational Age (AGA), or Small for Gestational Age (SGA). This distinction is an important one since SGA preterm infants tend to be a greater risk for medical and psychological complications than AGA preterm infants (Fitzhardinge, 1984).

Follow-up studies on preterm infant development published before the mid-1970's when medical health care was not as advanced as today indicated that prematurely born children suffered from more language and mental impairments

than children born at term. Rubin and Rosenblatt (1973) assessed the psychological and educational sequelae of prematurity in a prospective study of 241 infants classified by weight, GA, and sex through the early elementary school years (from 4 to 7 years of age). The sample contained fullterm and preterm infants who were AGA and SGA. It should be noted that some preterm infants in this study were identified as being neurologically suspect or neurologically abnormal soon after birth. The incidence was greater for the SGA than for the other infant groups (18.5%). The follow-up results indicated that the children born prematurely experienced more language and mental difficulties than children born at term. This was reflected in their poorer performance on the Stanford-Binet at age 4, the ITPA (Illinois Test of Psycholinguistic Abilities) at age 5, and the WISC-R at age 7. This was especially the case for the children who were prematurely born and who were SGA.

In another study, De Hirsch, Tansky, and Langford (1966) compared the academic performance from kindergarten to grade 2 (from 5 1/2 to 8 years of age) of a sample comprised of 53 prematurely born children and 53 children born at term. At age 3, the preterm infants in the sample had probable or definite neurological deficits in 10.2% of the cases despite the fact that their IQ scores were within normal ranges of development. Although the authors noted that the prematurely born children seemed to "catch up" between kindergarten and

grade 2, they emphasized that significant lags persisted well into their eighth year of life, particularly on academic tasks that required integration, language, and reading.

In a study of children at later ages, Taub, Goldstein, and Caputo (1977) compared the intellectual, scholastic, and social functioning in 7- to 9½-year-old middle-class children who were moderately premature at birth (Mean GA was 34.4 weeks) to that of fullterm controls. The prematurely born children included in the sample had been judged to be free of visual impairments at birth and at one year chronological age. Taub et al. found no differences between groups in social functioning. Differences, however, were noted on the WISC-R and the Bender-Gestalt, with prematurely born children performing worse than fullterm controls on tasks requiring perceptual organization and visual-motor integration.

It should be noted that the findings reported in these early studies in general pertain to samples of preterm infants screened only for gross visual and neurological impairments. Furthermore, the impact of prematurity per se on scholastic and intellectual functioning in childhood is unknown since many of these studies failed to provide adequate information about their preterm sample.

Follow-up studies conducted recently on samples of preterm infants who have benefited from more advanced medical care also indicate the presence of delays in these infants' cognitive functioning. A Canadian study conducted by Pape,

Buncic, Ashby, and Fitzhardinge (1978) showed evidence of impaired physical, neurological, and intellectual functioning in a sample of 97 SGA and AGA very low birth-weight preterm infants (below 1,001 grams) followed from birth through to the age of 2 years. Although the Pape et al. sample included preterm infants who came from predominantly middle and upper-middle-classes, it nevertheless included infants who were seriously ill at birth. Of the 44 surviving infants, 26 had suffered severe neonatal asphyxia, 17 had the Respiratory Distress Syndrome (RDS) and 21 had developed apnea at birth. The authors pointed out that 37 of the survivors required some form of ventilatory assistance at birth. Furthermore, major neurological defects were detected in 9% of the sample, while minor neurological defects were detected in 37% of the surviving infants during the course of the study. In addition, severe developmental delay was noted in 21% of the sample between the ages of 18 and 24 months chronological age on the Bayley Scales of Infant Development.

Fitzhardinge (1980) followed another sample of 133 low birth-weight preterm infants born at less than 1,501 grams from birth through to the age of 6 years. The results indicated the continued existence of major neurological defects in 15% of the sample at age 6. In addition, 45% of these children suffered from scholastic difficulties and were consistently failing a major subject or required special classes. Fitzhardinge (1984) noted that these children

experienced difficulties particularly on academic tasks that required concept formation. These findings occurred despite the fact that the performance of these children on the WISC-R, on the average, had been within normal ranges of development (Mean IQ was 90.7) at age 6. It should be emphasized that Fitzhardinge did not provide any specific information about the state of health of these infants at birth. One would suspect that a considerable proportion of these infants had suffered from serious medical complications like those infants in the Pape et al. (1978) study.

Siegel (1983) conducted a similar study on a Canadian sample of preterm and fullterm infants from birth through to the age of 5. The original sample contained 13 SGA and 67 AGA preterm infants who had been born at less than 1,501 grams, and 68 fullterm infants. Many of the preterm infants contained in this sample were seriously ill at birth. The incidence of RDS and birth asphyxia as well as the degree of RDS suffered was greater among the AGA singleton preterm infants (68% and 28% respectively) (Siegel, Saigal, Rosenbaum, Young, Berenbaum, & Stoskopf, 1979). The follow-up results indicated a higher incidence of developmental delays among preterm infants. AGA preterm infants performed more poorly than fullterm infants at 8, 12, 18, and 24 months, but not at 4 months on the Motor Scale of the Bayley Scales of Infant Development, whereas SGA preterm infants performed worse than fullterm infants at all age levels. On

the Mental Scale of the Bayley both SGA and AGA infants performed more poorly than fullterm infants at 4 and 8 months of age only. It should be noted that these results pertained to scores that were corrected for degree of prematurity. No differences, however, were found between infant groups in language development at 2 years chronological age (Siegel et al., 1979). At 5 years chronological age, 44 prematurely born children from an original sample of 80, and 42 of the 68 original fullterm children were assessed for possible learning disabilities. Siegel (1983) found that the prematurely born children performed worse than the fullterm children on tasks involving attention and perceptual-motor processes (Beery Developmental Test of Visual-Motor Integration, Recognition-Discrimination, Finger Localization, and Alphabet Recitation).

Field, Dempsey, and Shuman (1979, 1981, 1983) examined the development of term and non-term groups during their first five years of life. The sample included 56 preterm infants, 57 postmaturity syndrome infants, and 81 fullterm infants. All infants came from middle-class families. The preterm infants were moderately premature at birth (Mean GA was 32 weeks) but had all experienced RDS. On the average, these infants had received 32 days of intensive care, and 3 days of mechanical ventilation. The authors found evidence of mental and motor delays in RDS preterm infants at 8, 12, and 24 months corrected age on the Bayley Scales of Infant

Development, despite the fact that the assessment dates and the test norms were corrected for degree of prematurity. The delay was more pronounced in motor development. Postmaturity syndrome infants, on the other hand, were found to suffer from a mental delay only, at the same age levels as the RDS preterm infants. The assessments of intellectual functioning carried out every year between the ages of 3 and 5 indicated that RDS preterm infants' mental age, although within normal range, lagged behind that of fullterm infants by 5 months. This lag was particularly noteworthy on items of the McCarthy Scales which tap verbal, cognitive, perceptual, and motor development. Further evidence of a developmental lag in RDS preterm infants came from assessments of expressive language carried out at 2-, 3-, and 4 years of age. The results indicated that RDS preterm infants had a smaller vocabulary, emitted fewer words, and had shorter mean lengths of utterance than fullterm infants. RDS preterm infants were also described by their parents as being more distractible and as having a shorter attention span than fullterm infants at age 5.

Ungerer and Sigman (1983) conducted assessments of play, sensorimotor behaviour, and language in 20 moderately premature infants (Mean GA was 31.3 weeks) and 20 fullterm infants at 13½-, 22-, and 36 months postnatal and corrected ages. The medical status at birth of the preterm infants was ambiguous in this study. The authors reported that the

preterm infants, on the average, had suffered three out of ten postnatal complications. These could include any of the following: RDS, ventilatory assistance, convulsions, surgery, non-infectious illnesses, physical anomalies, metabolic or temperature disturbances, or feeding problems. Thus some of the preterm infants in this sample might have suffered from serious medical complications. The authors pointed out, however, that the preterm infants included in their study were those whose general development was within normal or borderline range at 13½ months corrected age. The results of these assessments indicated that there was no evidence of delays in preterm infants' symbolic play level at 22 months corrected age, nor on receptive and expressive language by 36 months corrected age. Delays were found to persist, however, on the Stanford-Binet at 36 months corrected age, particularly on items tapping visual information processing ability and/or perceptual-motor skills. Prematurely born children were less able to discriminate pictures, trace mazes, name objects from memory, and generate opposite analogies than children born at term. It should be emphasized, however, that fullterm infants in this study were tested twice on each task at each age level within a short period of time. This might have placed them at an advantage during the second administration of the tasks.

In general, these follow-up studies indicate that preterm infants, in contrast to fullterm infants, suffer from

delays in their cognitive development, at least up to the age of 9½ years. A pervasive finding is that they differ from children born at term on cognitive tasks requiring visual attention or visual-information processing. The evidence accumulated thus far has been obtained from samples of preterm infants of various birthweights and gestational ages, despite the fact that test scores were adjusted for degree of prematurity.

It should be emphasized, however, that the lags in cognitive development reported in these studies might not only be attributed to the effects of prematurity per se, but also to the complications suffered by some or all of the preterm infants included in these studies. Thus prematurity per se has often been confounded with serious postnatal complications in these studies (Field et al., 1979, 1981, 1983; Pape et al., 1978; Siegel, 1983; Ungerer & Sigman, 1983). Field et al. (1979, 1981, 1983) found that having experienced RDS at birth, in addition to being born prematurely, places the infant at great risk for cognitive delays, at least until the age of 5 years. Fitzhardinge (1980) noted that birth asphyxia is almost always associated with adverse outcome.

Three recent studies reported on the global cognitive performance of samples of preterm infants who varied in degree of medical complications experienced at birth and in the neonatal period. Gorga, Stern, and Ross (1985) assessed

the performance of a sample of 59 sick AGA preterm infants (SPT), 17 complication-free AGA preterm infants (HPT), and 15 healthy fullterm infants (as part of a longitudinal study of neuromotor behaviour. All infants' medical histories around the time of birth had been reviewed by a neonatologist. The SPT infants had experienced one or more complications which included apnea, bleeding, respiratory problems, and intraventricular hemorrhage, or neurological abnormalities. The authors found that fullterm infants scored higher than HPT infants on the motor and mental scales of the Bayley test at 12 months corrected age. The HPT infants, however, scored higher than the SPT infants on both scales of the Bayley test. Creasey, Markowitz, and Resnick (1987) studied the developmental progress at 4-, 8-, and 12 months corrected age of 18 preterm infants who had experienced Bronchopulmonary Dysplasia (BPD), 14 RDS preterm infants, and 10 preterm infants who were either completely free of medical complications, or at least free of serious ones around the time of birth. The outcome assessed through the Bayley Scales of Infant Development showed that well and RDS preterm infants scored higher on both scales than the BPD preterm infants at all age levels evaluated. There was a tendency for well preterm infants to perform better than RDS and BPD preterm infants at 4 and 8 months corrected age only. Greenberg and Crnic (1988) conducted an assessment of 30 low birthweight preterm infants (birthweight below 1,500 grams)

and 40 fullterm infants at 24 months corrected age. The sample of preterm infants excluded infants with identifiable abnormalities but did include some infants who had experienced RDS (43% of the sample). No differences were found between preterm and fullterm infants on the Mental Scale of the Bayley Scales of Infant Development or on measures of expressive and receptive language. Preterm infants, however, had lower scores than fullterm infants on the Motor Scale of the Bayley test. As in the Creasey et al. (1987) study, no differences were found between preterm infants with RDS and preterm infants who had not experienced RDS on any of the outcome measures. These three studies suggest that preterm infants who are relatively free or completely free of medical complications tend to perform better than preterm infants with more serious complications on one hand, and sometimes even as well as fullterm infants on the other hand, on global tests of cognitive functioning. What has yet to be determined, however, is whether delays are also present in complication-free AGA preterm infants on more specific tasks of information-processing ability.

Visual information-processing tasks have been widely used since the early 1970's to study infants' cognitive development. There are several reasons for selecting visual information-processing tasks as measures of cognitive functioning to study preterm infants' performance.

First, direct links have been established between

performance on visual information-processing tasks administered in the early months of life and later social and cognitive development in preterm infants. Sigman (1983) showed that in preterm infants longer fixations at 40 weeks conceptional age (equivalent to normal term) on a visual attention task which involved presenting a 2 X 2 checkerboard for three 1-minute trials was related to poorer infant-caregiver interaction at one month corrected age. Sigman, Cohen, Beckwith, and Parmelee (1986) later found that the preterm infants' performance on the visual attention task at 40 weeks conceptional age and on a more complex visual attention task at 4 months corrected age also predicted global, verbal, and performance IQ scores on the WISC-R test at 8 years of age. The visual attention task at 4 months corrected age involved exposing infants to paired presentations of identical checkerboards varying in degree of complexity (2 x 2, 6 x 6, 12 x 12, 24 x 24) for eight 15-second trials. Rose and Wallace (1985) found that preterm infants' performance on a visual recognition memory task at 6 months corrected age predicted global, verbal, and performance IQ's on the WISC-R at 6 years of age better than the Bayley Scales of Infant Development at 6 and 12 months of age. Their visual recognition memory task involved familiarization to various pairs of identical two-dimensional stimuli for preset amounts of time followed by 10-second pairings of novel and familiar stimuli.

Visual information-processing studies

In general, visual information-processing studies indicate that preterm infants tend to perform more poorly than fullterm infants on tasks requiring the processing of novel and familiar stimuli at least during the first year of life.

Sigman, Kittman, and Parmelee (1977) compared the visual fixation responses of a sample of 28 moderately premature infants (Mean GA was 33.2 weeks) at 40 weeks conceptional age to that of a sample of 28 fullterm newborns. The visual attention task required viewing a checkerboard pattern for 60 seconds for three consecutive trials. The results indicated that preterm infants looked longer and more frequently at the unchanging stimulus than fullterm infants. Sigman et al. suggested that the longer fixation time to the stimulus might represent a more immature response reflecting an inability on the part of the preterm infant to inhibit or modulate its visual responses. It should be pointed out that the authors failed to provide detailed information about the medical status at birth of their preterm sample. Therefore, the sample might have included infants who had experienced serious medical complications.

Sigman and Parmelee (1974) compared the visual preferences of 20 preterm infants at 4 months corrected age to that of 20 fullterm infants at 4 months of age. The sample of preterm infants had been moderately premature at

birth (Mean GA was 33.6 weeks). No information concerning the status at birth of the preterm infants was provided in this study. The visual preference task administered in this study involved a test for complexity preference in which infants received paired presentations of checkerboards (6 x 6, 12 x 12, 24 x 24) followed by a test for novelty preferences in which a 24 x 24 checkerboard was paired with four patterns (four diamonds, bow tie, circular and linear patterns, and a bull's eye). All infants showed a preference for complexity. Preterm infants, however, unlike fullterm infants failed to show preferences for novel stimuli, and in contrast to fullterm infants, preferred looking at the familiar stimulus.

Sigman (1976) replicated this finding with 32 moderately premature infants (Mean GA was 33.5 weeks) and 32 fullterm infants. It should be noted that half of the sample of preterm infants had been classified as high risk by neurological, pediatric, motor, visual, and cognitive assessments carried out from birth to 9 months of age. The task administered at 8 months corrected age involved a familiarization period with an object followed by paired presentations of ten novel objects with a familiar one. No differences were found between the high risk and low risk preterm infants in total exploration time of the familiar object, either in the first two trials, or over all ten trials. Sigman found that as a whole, however, preterm

infants differed from fullterm infants in the first 2 minutes following a 6-minute familiarization period, in that they tended to look at the familiar object longer and showed less preference for novel objects.

Rose (1980) compared the visual recognition memory performance of preterm infants at 6 months corrected age to that of 6-month-old fullterm infants. There were two samples of 18 preterm infants. One had received sensorimotor stimulation during the early weeks of life, the other had not. Both groups had been moderately premature at birth (Mean GA was 33.0 weeks). The 18 fullterm infants and the 36 preterm infants came from predominantly lower class families (approximately 80% of the sample). All infants were free of visual and neurological abnormalities. Rose, however, did not provide information about the postnatal complications that the preterm infants might have experienced. The visual recognition memory task that was used in this study involved familiarization to a pair of identical stimuli for a preset amount of time (which varied from 5- to 20-seconds exposure depending on the type of stimulus) followed by a 10-second test period in which a novel stimulus was paired with the familiar. Rose found that the preterm infants who failed to receive early stimulation, unlike the two other groups, processed information at a slower rate, because evidence of visual recognition memory was found for this group only when familiarization time with the stimulus was lengthened.

Rose (1983) replicated this finding in a cross-sectional study of visual recognition memory contrasting the performance of 6- and 12-month-old fullterm infants with that of preterm infants of 6 and 12 months corrected age. The sample included 40 moderately premature (Mean GA was 34.5 weeks) and 40 fullterm infants. The infants were equally divided between the two age levels. No information was provided about the medical status of the preterm infants at birth. Rose selected infants who came from predominantly lower class families, as she did in her 1980 study. The visual recognition memory task employed in this study was similar to that reported by Rose (1980), except that it involved presentations of three-dimensional stimuli. Each trial consisted of a familiarization period followed by a 20-second test for visual recognition memory in which the novel and the familiar stimuli were paired. Infants had studied the familiar stimulus for either 10, 15, 20, or 30 seconds during the familiarization period. At 6 months corrected age, preterm infants only showed visual recognition memory when the familiar stimulus had been studied for 30 seconds. Fullterm infants, on the other hand, showed visual recognition memory at 15, 20, and 30 seconds familiarization time, but not at 10 seconds. At 12 months corrected age, preterm infants only showed visual recognition memory at 20 and 30 seconds familiarization time, as opposed to fullterm infants who showed visual recognition memory at all

familiarization times. Thus it would appear that preterm infants need longer familiarization periods with an unchanging stimulus than fullterm infants in order to show evidence of visual recognition memory. This finding was consistent with those reported in Rose's (1980) study. Also of interest was the fact the that preterm infants at 6 and 12 months corrected age, unlike fullterm infants, performed inconsistently across familiarization times. Rose argued that this finding might be due to the length of the familiarization times which might have been too brief for the preterm infants. It should be emphasized that Rose's (1980, 1983) findings were based on samples of preterm infants whose medical complications are unknown.

The evidence reviewed thus far indicates that preterm infants show delays on cognitive tasks of visual information processing ability, even when their ages at testing are corrected for degree of prematurity. Preterm infants seem to need longer periods of time to process information about an unchanging stimulus than fullterm infants. This difference has been noted at 4, 6, 8, and 12 months corrected age. Rose (1980, 1983) indicated that preterm infants' difficulties on cognitive tasks may lie at the encoding level, and not at the storage and retrieval levels, because as soon as preterm infants are allowed more familiarization time with a stimulus they are quite capable of discriminating between novel and familiar stimuli.

Recent evidence also has shown that preterm infants' performance on these visual information-processing tasks predicts global cognitive functioning up to 8 years of age (Sigman et al., 1986). Thus it is assumed that studies of information-processing ability in the early months of life are relevant. Few attempts have been made, however, to isolate the effects of prematurity from those attributable to medical complications experienced at birth and in the neonatal period. Most of the studies reviewed did not provide detailed information about the state of health at birth of the preterm infants. It could be argued that the cognitive lags noted in these studies might be in part attributed to the postnatal complications suffered by some or all of the infants in the preterm sample. In general, the effects of prematurity on the time required to process information on more specific tasks of information processing ability using a complication-free AGA preterm infant sample are largely unknown.

One visual information-processing task that has received widespread attention in the past 15 years in the area of infant memory is visual habituation. The procedure involves repeatedly showing a single stimulus until attention to it decreases to a criterion level. This is followed by a presentation of a novel stimulus (dishabituation).

Visual habituation has been shown to be reliable for fullterm infants between 3 and 9 months of age (Colombo,

Mitchell, O'Brien, & Horowitz, 1986) and predictive of language comprehension and pretend play at 13 months of age (Tamis-LeMonda & Bornstein, 1989), and of cognitive performance on Piagetian-based Scales at 15 months of age (Miller, Ryan, Short, Ries, McGuire, & Culler, 1977).

The visual habituation task has been widely used with fullterm infants of various age levels (ranging from newborns to 10 month-old infants) to study various aspects of memory including short term and long term memory, concept acquisition, and the effects of interference on memory (Cohen, DeLoache, & Pearl, 1977; Cohen & Strauss, 1979; Harawitz, Gardner, & Turkewitz, 1984; McCall, Kennedy, & Dodds, 1977; Slater, Morison, & Rose, 1984). It has also been used with low and high risk preterm infants, of 4 to 10 months corrected age (Cohen, 1981; Landry, Leslie, Fletcher & Francis, 1985; Messmer, 1982), but not with a complication-free sample. In the present study AGA complication-free preterm infants at 4 months corrected age were compared to 4-month-old fullterm infants on a visual habituation task. Cohen's (1976) visual habituation paradigm was the one selected for this study.

During the procedure, at the onset of each trial, the infant is shown a blinking light to control for looking location. As soon as the infant fixates the light, a shutter is opened, a stimulus is revealed, and the infant's fixation to the stimulus is recorded. Each trial concludes when the

infant turns away from the stimulus. This automatically leads to the closing of the shutter and the re-appearance of the blinking light to mark the onset of the next trial. The Cohen paradigm involves repeating this procedure until fixation time to the stimulus for three consecutive trials decreases to a criterion level of 50% relative to the total fixation duration on the first three habituation trials. This criterion level allows infants to be equated on relative amount of habituation. The decline in fixation time is believed to reflect the infant's ability to establish a memory engram of a stimulus, and thus is believed to tap some aspect of encoding and storage (Cohen, 1976; Cohen & Gelber, 1975). Following habituation, the infant is shown a novel stimulus to verify that the decrease in fixation time during the habituation phase was not due to fatigue effects. This dishabituation phase also can be used to provide an indication of the infant's ability to discriminate between novel and familiar stimuli. This phase is thought to reflect the infant's ability to retrieve information about the familiar stimulus from storage in order to compare the novel and the familiar stimuli (Cohen, 1976).

Most researchers that have used similar versions of Cohen's task find that infants' impaired ability to process information is reflected in longer fixation to the stimulus until habituation criterion is reached, and/or longer fixation of the stimulus on each habituation trial but not in

more trials to reach habituation criterion (Bornstein & Benasich, 1986; Caron & Caron, 1981; Cohen, 1981; Cohen & Strauss, 1979; Colombo, Mitchell, O'Brien, & Horowitz, 1986; Frankel, Shapira, Arbel, Shapira, & Ayal, 1982; Miller, Ryan, Short, Ries, McGuire, & Culler, 1977; Moss, Colombo, Mitchell, & Horowitz, 1988; Pêcheux & Lécuyer, 1988; Tamis-LeMonda & Bornstein, 1989). In the modified version used in this study, the infant received 2 warm-up trials, 18 habituation trials, and 2 dishabituation trials. Because the dishabituation and warm-up stimulus were the same in this study, the dishabituation trials served not only as a test of discrimination, but as a test of fatigue effects.

The Cohen paradigm is believed to be a sensitive task of visual information-processing ability in infants. First, it employs single stimulus presentations rather than paired stimulus presentations, so that the infant's attention is not divided between novel and familiar stimuli. Second, the infant controls the onset and termination of each trial. Third, and most important according to Cohen (1972), the paradigm allows for the independent examination of two attention processes, namely "attention-getting" reflected in the infant's latency to turn from the light to the stimulus, and "attention-holding" reflected in duration of each fixation. The Cohen paradigm seemed particularly suitable for investigating memory and attention in preterm infants because it allows them to modulate the rate at which they

process information, and preterm infants are known to need longer periods of time to process information then fullterm infants. Since onset and offset of fixation of the stimulus are controlled by the infant in this paradigm, preterm infants can take all the necessary time to process the stimulus. Another aspect of the task that has not received much attention pertains to latency in turning to the blinking light after looking away from the stimulus. Thus, in this paradigm infants can pace the speed at which they turn to the stimulus from the blinking light and the speed at which they turn back to the blinking light to start a new trial. Consequently, with this paradigm preterm infants have the opportunity to modulate not only the time they take to process the stimulus but also the pace at which they are ready to respond to the task demands.

Few studies of visual habituation have been conducted with preterm infants. Furthermore, the task has not been subjected to systematic manipulation. In his 1981 study, Cohen compared a high risk sample of preterm infants at 20, 33, and 49 weeks corrected age. Landry et al. (1985) also used a similar version of the task to compare a group of IVH-RDS preterm infants and a group of RDS preterm infants tested at 7 months corrected age that were contrasted to a group of 7-month-old fullterm infants. Messmer (1982) used the visual habituation task to study the outcome of low risk preterm infants at 4 months corrected age who had or had not received

early sensorimotor stimulation in the first month at home and 4-month-old fullterm infants.

In the present study, memory and attention processes were examined in complication-free preterm infants at 4 months corrected age and in 4 month-old fullterm infants under conditions that varied the load on memory. The conditions included a no delay condition (standard condition) where fixation of the blinking light immediately led to the presentation of the stimulus, and 2-second and 3-second delay conditions, where after fixation of a blinking light infants had to wait an additional 2 or 3 seconds with the light turned off prior to exposure of the stimulus. This modified version of the task has not been used before except for a pilot study (Messmer, 1983) of 7 fullterm infants at 4 and 8 months of age to determine the appropriate length of delay for the present study.

It was felt that the delays would make the task more demanding for infants both at the attention and memory level. It was assumed that the delay conditions, at the level of attention, would significantly impair infants' ability to orient to the stimulus from the blinking light (latency to orient) and to re-orient to the blinking light after looking away from the stimulus (intertrial interval), and that this would be reflected in longer latencies to orient to the stimulus, and longer intertrial intervals. Most studies have not used latency to orient to the stimulus as a measure of

infant performance. An exception is the Landry et al. (1985) study which showed that preterm infants with intraventricular hemorrhage and Respiratory Distress Syndrome (IVH-RDS) had longer latencies to orient to the stimulus on a visual habituation task at 7 months corrected age than a group of RDS preterm infants and a group of fullterm infants. A second assumption was that the delays would produce more forgetting of the stimulus, and that this would be reflected in longer fixations of the stimulus on each habituation trial. The reasoning here was that the interval between stimulus presentations would be lengthened at least by the length of the delay and during the longer interval between stimulus presentations there would be a greater opportunity for interference and decay to affect the internal representation of the stimulus.

Rationale

In summary, the purpose of the present study was to examine the effects of prematurity, in the absence of medical complications, on attentional and memory processes. Specifically the performance of complication-free preterm infants at 4 months corrected age was compared to that of 4-month-old fullterm infants on a modified version of Cohen's (1976) visual habituation task. Infants were tested under the standard condition, where fixation of a blinking light led without delay to exposure of the stimulus, and under conditions where 2-s and 3-s delays were interposed between

fixation of the blinking light and stimulus exposure. The delay conditions were designed to increase the demands on memory and attention by producing more opportunity for interference and decay. It was felt that the delays would interfere with the infant's ability to direct its attention to the stimulus (latency to orient to the stimulus), to re-direct its attention back to the blinking light after looking away from the stimulus (intertrial interval), and would also interfere with its ability to form a memory engram of the stimulus. Five specific predictions were formulated in this study. First, that the performance of both complication-free preterm infants and fullterm infants would be affected by the delays in that their performance would become more impaired with the longer delays. Second, given that performance became impaired for infant groups under the delay conditions, it was predicted that the impairment would be more marked for preterm infants. The other three predictions related to how disruption in performance would be reflected on the measures. It was assumed that the delays would disrupt the infant's readiness to respond to the stimulus and thus reduce the speed at which it turned to the stimulus from the blinking light. In other words, it was predicted that latencies to orient to the stimulus would become longer with the longer delays. It was also assumed that the delays would disrupt the infant's readiness to respond to the task demands by reducing the speed at which the infant directed its attention

back to the blinking light after looking away from the stimulus (intertrial interval). Thus it was predicted that the intertrial interval would be lengthened by the longer delays. Finally, it was argued that the delays would disrupt the infant's ability to form a memory engram of the stimulus because there would be greater opportunity for forgetting to occur between stimulus presentations and as a result the infant would spend more time processing the stimulus on each trial. Accordingly it was predicted that lengths of fixation of the stimulus w ld increase in the delay conditions.

Method

Subjects

In the course of the study 33 preterm infants and 34 fullterm infants were tested. Among the preterm infants, 9 were dropped from the study because medical complications had been detected at a later check of their medical records, 1 refused to continue the testing, 4 had no fullterm infant matches, 4 were inadequately tested, and of these 4 infants, 1 had too many repeated tests. Among the fullterm infants, 12 could not be used as matches of preterm infants, 2 were untestable, 1 discontinued because of sickness, 1 was dropped because of inadequate testing, 1 for incomplete testing due to vacation, 2 infants were dropped because of equipment failure, and 1 infant had too many repeated tests. Participation rate was 60% for the mothers of preterm infants approached and 85% for the mothers of fullterm infants approached; 12 mothers of preterms and 6 mothers of fullterms refused to participate in the study.

The final sample comprised 30 Caucasian infants, 15 preterms of 4 months corrected age, and 15 4-month-old fullterm infants, all born at the Sir Mortimer B. Davis Jewish General Hospital in Montreal between January 1986 and November 1987. The groups were matched on sex, post-conceptional age at testing, and ethnic and linguistic background. Each sample consisted of 12 male infants and 3 female infants. Mean GA and birthweight for the preterm

sample was 34 weeks, 4 days and 2373.3 grams in contrast to 39 weeks, 5 days and 3486.3 grams for the fullterm sample. General criteria for inclusion of infants in the study included maternal consent for participation, maternal residence within a 25-mile radius of the Montreal area, and maternal ability to communicate in either English or French.

An experienced research assistant screened all hospital medical records for suitable subjects who had been looked after in the Neonatal Intensive Care and Newborn Nurseries. The infants were recruited a few weeks before they reached 16 weeks from their expected date of birth only when pediatricians had been informed about the nature of the study, and had given their consent to contact mothers for recruitment. Appendix A contains the abstract and letter sent to pediatricians as well as the maternal consent form.

Criteria for preterm infants inclusion in the study were that infants have GA's of 36 weeks or less, that they not be small for gestational age and have no congenital abnormalities or medical complications. Specific criteria were that they have no reported complications in the nursery, no known loss of vision or hearing, no history of maternal systemic disorder during pregnancy, no fetal distress or mechanical ventilation, and have a 1-minute and a 5-minute Apgar score of at least 7, a bilirubin level that remained below 15 mg/dl, and no blood glucose level value below 30 mg/kg. Infants also had to be clinically healthy between the

time of their hospital discharge and test dates. Criteria for inclusion of the fullterm infants in the study were that infants be clinically healthy, with no history of fetal distress or of maternal systemic disorder during pregnancy, and have GA's of 39 weeks, 3 days to 40 weeks, 3 days, birthweights between 2,800 and 3,700 grams, and 1-minute Apgar and 5-minute Apgar scores of at least 7. Fullterm infants also had to be reported clinically healthy between the time of their hospital discharge and test dates. Table 1 shows the means, standard deviations, and ranges for the characteristics of the sample. Despite the fact that the same criteria were used for preterm and fullterm infants, fullterm infants had significantly higher 1-min. Apgar scores than preterm infants.

Table 2 shows the parental characteristics of the sample. Mothers of preterm infants had a mean age of 29.9 years with a mean level of education of 13.8 years, while mothers of fullterm infants had a mean age of 30.0 years, and a mean level of education of 14.5 years. All mothers were married. No significant group differences were found between infant groups on either maternal or paternal age or maternal or paternal level of education. Source tables of the ANOVA's appear in Appendix B.

Visual Habituation Stimuli

Four 22.9 x 22.9 cm stimulus patterns were used during the visual habituation procedure. A bull's eye pattern was

Table 1

Characteristics of the Sample

Variable		Preterm	Fullterm
Birthweight (grams)	M	2373.3	3486.3
	SD	311.7	309.7
	range	1710-2865[a]	2940-4100
GA (weeks, days)	M	34,4	39,5
	SD	0,1.2	0,0.4
	range	32,3-36	39-40,2
1-minute Apgar score	M	7.7[b]	8.3[b]
	SD	.62	.72
	range	7-9	7-9
5-minute Apgar score	M	9.0	9.2
	SD	.38	.56
	range	9-10	8-10
Corrected age at test (weeks, days)	M	16,2	16,5
	SD	0,4.3	0,4.8
	range	15-17,3	16-18,2
Chronological age at visual test (weeks, days)	M	21,1	17,
	SD	1,4.2	0,5.3
	range	17,6-24,4	15,6-18,4
Sex		12M, 3F	12M, 3F
Bilirubin level (mg/dl)	M	9.9	
	SD	4.4	
	range	8.0-14.0[c]	
Days in hospital	M	11.6	
	SD	8.9	
	range	3-31	

[a] One infant was subsequently ascertained to be LGA. All other infants were AGA.
[b] t (28) = 7.37, $p<.01$
[c] Two infants had no bilirubin count recorded.

Table 2

Parental Characteristics of the Sample

Variable		Preterm	Fullterm
Maternal age	M	29.9	30.0
	SD	5.1	3.9
	range	24.37	24-35
Maternal education	M	13.8	14.5
	SD	3.6	4.1
	range	8-22	11-25
Paternal age	M	32.2	34.1
	SD	4.5	6.7
	range	25-38	27-52
Paternal education	M	13.6	15.4
	SD	3.4	3.6
	range	8-19	12-25
Parity	one child	8	4
	> one child	7	11
	range	1-5	1-5
Years of residence in Canada	Always	12	10
	> 15 yrs.	3	4
	< 5 yrs.	0	1
Maternal language	English	9	7
	French	2	2
	other	4	6

used both as a warm-up and dishabituation stimulus in all conditions. The other three stimuli were used once for each infant. These stimulus patterns included a 18 x 18 checkerboard pattern, a pattern of radial lines, and a pattern of concentric squares. The stimuli are shown in Appendix C. All stimuli were black and white and were equated in amount of contour density. These patterns were similar to those used by Maisel (1975). The order of presentation of the stimuli was randomized within the order of presentation of the delay conditions according to a Latin Square design, so that across subjects within a group, each pattern was used five times with each condition, and five times in the first, second, and third test session.

Apparatus

The apparatus used in the study was a modified version of the visual habituation apparatus developed by Cohen (1972). It was designed to assess latencies to orient and fixation duration to visual stimuli separately. This apparatus was used in an earlier study of preterm and fullterm infants (Messmer, 1982).

The equipment was designed to be portable and quickly assembled in the home. It consisted of a wooden stimulus chamber (58.9 x 60.2 x 64.1 cm) lined in black felt mounted on 71.8 cm long wooden legs. The viewing panel, which measured 32.4 x 60.5 cm, included a blinking light which flashed at .2-s on and .2-s off. The light was a 14.4-v bulb

with a translucent white cover 1.5 cm in diameter. It was located at the middle right side of the panel at 27.5 cm from the bottom. Visual stimuli were shown when the shutter covering the stimulus was opened, through a 22.9 x 22.9 cm opening located at the left of the panel. Closing the shutter automatically turned on the blinking light, and opening the shutter automatically turned it off. The equipment also included a grey 15 x 20 cm control box with a built-in trial counter, a switch to indicate the type of delay used, a button that timed the delays, and a button that recorded fixation time. The trial counter was activated automatically when the Experimenter completely opened the shutter. The switch, on the other hand, was operated by the Experimenter to mark the appropriate delay time used in the particular testing session. There were two switches; one was for the 2-s delay, the other was for the 3-s delay. The button that recorded the length of the delays was operated by the Experimenter who pressed it every trial. The other button, also Experimenter-operated, recorded fixation time for each trial. The main control box was wired to a second 5 x 10 cm control box. The control box had a built-in button that was operated by the second observer to record infant fixation time.

Two observers recorded the infant's head and eye movements through .6-cm peepholes. One observer (the Experimenter) was located behind the panel, and looked

through a peephole located 18.5 cm away from the light and 27.2 cm from the opening. The other observer leaned over the roof of the chamber and looked through a peephole at the front surface mirror (6 x 9 cm) located 3.5 cm to the right of the main observation hole. The duration of each fixation was recorded on one channel of a six-channel Lafayette event recorder (Model 56042). Other channels of the event recorder were set to record automatically when the light blinked (the intertrial interval), and when the visual stimulus was revealed. For the no delay condition, latencies to orient to the stimulus from the blinking light were derived by subtracting the time at which the stimulus was revealed from the time at which the infant began to fixate it. For the 2-s and 3-s delay conditions, latencies to orient to the stimulus were calculated from the stimulus onset (i.e., from the end of the delay period until the infant fixated the stimulus). A diagram of the visual habituation apparatus appears in Appendix C.

Design and Procedure

The visual habituation task was administered by two observers. One of them (the second observer) was blind with respect to whether infants were born at term or before term, and had no knowledge of the infants' GA, birthweight, and state of health at birth. Preterm infants and fullterm infants were assessed on the task 16 weeks after their expected date of birth. Preterm infants were approximately

21 weeks old in terms of chronological age at testing, while fullterm infants were 17 weeks old. (see Table 1)

The infants were tested on three separate occasions in their homes within a 2-week period and received a different condition in each test session. Both the Experimenter and Observer were present for each test session except in the case of 3 preterm infants and 8 fullterm infants where the Observer was absent during one or two test sessions. The first test session was scheduled for the earliest convenient date falling 16 weeks after the infant's expected date of birth. The order in which the delay conditions were administered was randomized within each infant group according to a Latin Square design so that across subjects within a group, each condition was given equally often in the first, second, and third test session. There were three orders of presentation of the delay conditions, and 5 infants per infant group received one particular order of presentation.

Prior to the first visual habituation testing session, the mother was informed about the nature of the study and asked to sign a consent form and to answer questions concerning her infant's state of health between the time of the infant's hospital discharge and the date of testing. Mothers were told that they should not attempt to influence their infant in any way during the presentation of the stimuli. With the exception of one mother of a fullterm

infant, all mothers wore a pair of sunglasses with the top of each lens occluded by tape to block their view of the stimulus. This procedure prevented mothers from cueing their infant during the task. During the task, the mother sat with her infant in her lap facing the viewing panel of the stimulus chamber. The infant's head was approximately 58.5 cm from the viewing panel. The onset of each trial began with presentation of the blinking light to control for looking location when the pattern was revealed. Under the no-delay condition, as soon as the Experimenter judged that the infant was fixating the light, she opened the shutter thus turning off the light and revealing the stimulus. She and the other observer then recorded lengths of fixation on each trial. The stimulus remained exposed as long as the infant wished to look at it. The shutter was closed and the blinking light automatically reactivated after .2-s delay when the Experimenter judged that the infant had turned its head and eyes away from the stimulus. The same procedure was used for the delay conditions, except that after the infant fixated the blinking light on each trial, the Experimenter slightly opened the shutter to turn off the blinking light without revealing the stimulus, activated the light switch to record delay time (either 2-s or 3-s), and once the delay time had elapsed, she opened the shutter completely and exposed the stimulus. Appendix C shows a diagram of the apparatus with the position of the observers.

In each condition, the infant received 2 warm-up trials with the bull's eye pattern to control for startle effects. These trials were followed by 18 trials with one of three habituation patterns. Each session concluded with 2 dishabituation trials with the bull's eye pattern to test for fatigue effects and for recovery of habituation. In the delay conditions, the appropriate 2-s or 3-second delay was also interposed during the warm-up and dishabituation trials.

In cases where interruptions occurred during any one testing session, it was decided that infants would not be allowed more than three interruptions for fussiness per session in order for the test to be considered acceptable. In cases where the infant had received fewer than 10 trials, the test was terminated on the fourth interruption and repeated on another day before scheduling any remaining test sessions. Only one repetition of a condition was permitted. None of the preterm infants' test sessions were repeated. Three fullterm infant tests had to be repeated because of fussiness. Two tests were repeated for the no-delay condition and one for the 3-second delay condition.

Measures

The major measures of performance were length of fixation on each habituation trial, latency to orient to the stimulus on each trial, intertrial interval, and trials to criterion. Length of fixation of the stimulus was considered a measure of stimulus processing or encoding. Latency to

orient to the stimulus was considered a direct measure of attention to the stimulus in that it reflected the speed with which the infant shifted its attention away from the light to the stimulus. The intertrial interval was considered to reflect attention in the sense of readiness to respond because it reflected the speed with which the infant redirected its attention to the blinking light to initiate a new trial. Trials to criterion was a measure of rate of habituation which used a proportional criterion of habituation defined as the number of trials the infant took to decrease fixation time to the stimulus on 3 consecutive habituation trials by 50% relative to fixation time for the 3 initial habituation trials (Cohen, 1976). All performance scores were based on the average of the Experimenter's and observer's scores. The Experimenter's performance scores were used when the observer was absent.

Reliability

The inter-observer reliability for the visual habituation task was established by calculating Pearson r correlations between the Experimenter's and the Observer's observations for the 18 habituation trials for fixation durations, for latencies to orient, and for intertrial intervals. Inter-observer reliability was obtained for each infant for at least one testing session. Inter-observer reliability was similar for each delay condition. Averaged across delay conditions inter-observer reliability for an

average of 13 preterm infants was r=.88, p<.001 for length of fixation, r=.86, p<.001 for latency to orient to the stimulus, and r=.97, p<.001 for intertrial interval. The inter-observer reliability for an average of 12 fullterm infants was r=.85, p<.001 for length of fixation, r=.84, p<.001 for latency to orient to the stimulus, and r=.97 for intertrial interval.

In addition, the level of agreement between observers was obtained. Level of agreement was defined as number of agreements on onset and offset of fixation noted by both observers within .8-s divided by the number of agreements and number of disagreements multiplied by 100. It was similar for each delay condition. For the combined delay conditions, percent agreement was 89% for preterm infants and 87% for fullterm infants.

Results

THE MAIN STUDY

Overview Of The Main Study.

The design is a mixed-model Latin Square design with 2 (Infant group) x 3 (Delay Conditions) x 5 (Trial Blocks) with repeated-measures on delay conditions and trial blocks. In the main study there were 15 infants per group and 5 infants within each group received one particular order of presentation of the delay conditions. There were three orders of presentation. Each delay condition appeared once in each possible position in the sequence across the three presentation orders. Preliminary checks were conducted to verify that infant groups did not differ in the number of infants who had experienced breaks and in mean break length. No significant differences were found between preterm and fullterm infants in number of breaks experienced during testing sessions. Appendix D shows relevant information pertaining to preterm and fullterm infants' breaks. Analyses for order effects were then conducted on all measures to check for possible interactions between order and infant group, order and delay condition, and order, delay, and group.

Next, analyses were performed on the mean scores of the main measures. First, one multivariate analysis of variance (MANOVA) was conducted on the scores that related to performance from the first habituation trial to the

habituation trial that reflected that criterion was reached. These measures included first fixation time, mean fixation time to the habituation criterion, mean latency to orient to the habituation criterion, mean intertrial interval to the habituation criterion, and trials to criterion. Second, a MANOVA was performed on the scores that reflected performance throughout all 18 habituation trials. This 2 (Infant Group) x 3 (Delay Condition) x 6 (Trial Block) MANOVA was performed on fixation time, latency to orient to the habituation stimulus, and intertrial interval. Univariate analyses of variance (ANOVAs) with orthogonal tests for trend were then performed on each measure individually. It was felt that both these ways of analyzing infant groups's performance were relevant to the understanding of the habituation process.

A third set of analyses were conducted to verify whether fatigue effects were present and whether dishabituation had in fact occurred. One 2 (Infant Group) x 3 (Delay Condition) x 2 (Trial Blocks) ANOVA compared the average fixation time during the two warm-up trials to the average fixation time during the last two habituation trials to check for possible effects of fatigue. The other ANOVA assessed whether true habituation had occurred by testing for recovery from habituation (dishabituation). This was done by comparing the average fixation on the last two habituation trials (i.e. trials 17 and 18) to the average fixation on the two dishabituation trials.

When post hoc procedures were warranted, Tukey Honestly Significant Difference (HSD) tests were performed as recommended by Stevens (1986) for analyses that include repeated measures. The significance level was set at $p<.05$ since the sample size was small and one must be concerned about Type II error in such cases.

Nonparametric analyses were conducted to investigate whether there were group differences in number of infants habituating, speed of habituation, consistency in reaching habituation criterion, and type of habituation pattern.

Preliminary Analyses.

Inspection of the raw data began with a check for univariate and multivariate outliers for each variable within each infant group, within each delay condition. Raw scores were converted to Z scores, and Z scores greater than 3.0 were treated as outliers. The outlying cases were assigned values that were 3 standard deviations from the group mean for the particular delay condition to preserve the deviancy of the cases. Most of the measures were positively skewed even after treating the outlying cases. To reduce the impact of the extreme scores that created the skewness further, all measures were transformed except for trials to criterion. An examination of the relation between the standard deviations and the group means for each delay condition indicated that a reciprocal transformation was appropriate (Ferguson, 1981). To facilitate comprehension, findings in the text and related

figures are shown in seconds rather than reciprocal scores. A subsequent analysis for outliers indicated that a few univariate and multivariate outliers remained. Three multivariate outliers remained; two for fullterms, one at no delay, and one at 3-s delay N=15, p<.01; one for preterms at no delay, N=15, p<. 01. Some variables within particular conditions still remained skewed after transforming the scores. Appendix E shows the variables with significant skewness and the number of univariate outliers remaining after transforming the scores within each group.

Bartlett tests for univariate homogeneity of variance were then performed on all the measures within each delay condition. There was no evidence of violation of this assumption, except for the mean intertrial interval measure related to performance to habituation criterion F (5,9072)= 18.00, p<.001. Box M tests for multivariate homogeneity of variance-covariance matrices were also conducted on all measures. Significance was only found in the case of measures that related to performance to criterion, F (50,11329) = 2.16, p<.001. Appendix E shows the Bartlett and Box M values for these measures. It was judged that the robustness of the MANOVA for the measures related to habituation criterion should not be called into question, despite the violation of the multivariate homogeneity assumption because sample sizes were equal (Tabachnick & Fidell, 1983)

Results Of The Main Study.

Effects of order

Series of 2 (Infant Group) x 3 (Order) x 3 (Delay Condition) ANOVAs were conducted on first fixation time, mean fixation time to criterion, mean latency to orient to the habituation stimulus to criterion, mean intertrial interval to criterion, and trials to criterion. Means and standard deviations for these measures and the ANOVA source tables are presented in Appendix F. The results indicated that there were no group x order, or group x order x delay interactions for any of these measures. On the other hand, order interacted with delay condition for fixation time, latency to orient to the habituation stimulus, and for intertrial interval, but not for trials to criterion. The significant delay condition x order interactions are shown in Appendix F, Figures 1, 2, and 3 respectively. Another series of 2 (Infant Group) x 3 (Order) x 3 (Delay Condition) ANOVAs were then conducted on the measures that related to performance on all 18 habituation trials. These included mean fixation time, mean latency to orient to the habituation stimulus, and mean intertrial interval. Means and standard deviations for these measures and the ANOVA source tables appear in Appendix F. The results indicated no group x order, or group x order x delay condition interactions for any of the measures. Order interacted with delay condition for mean fixation time and mean latency to orient to the habituation stimulus, but

not for mean intertrial interval. The significant delay condition x order interactions are shown in Appendix F, Figures 4 and 5. Order was disregarded in further analyses because it did not have a systematic effect on all delay conditions and did not affect infant groups differentially. In addition, the order effects obtained are probably unreliable because of the small number of infants represented at each data point (N=10).

Analysis of the performance scores to habituation criterion.

Table 3 presents means and standard deviations of the scores related to the habituation criterion for each infant group. A 2 (Infant Group) x 3 (Delay Condition) MANOVA was first conducted on first fixation time, mean fixation time, mean latency to orient to the habituation stimulus,mean intertrial interval,and trials to criterion. The MANOVA and ANOVA source tables are shown in Appendix G. The intercorrelations of these measures are shown in Appendix G. The multivariate analysis revealed nonsignificant effects of group, delay condition, and group x delay condition. A significant group x delay condition interaction was detected on the univariate test for first fixation time, F (2,56) = 3.17, $p<.05$, however, which is shown in Figure 1. Tukey tests indicated only that preterm infants took a longer first look at the stimulus in the no delay condition than in the 2-s delay condition, $p<.05$. Although there was a tendency for preterm infants to take a longer first look at the

Table 3

Comparison of Infant Groups on the Various Performance Measures to Habituation Criterion

Measures		Delay condition: No delay Infant group Pre	No delay Full	2-s delay Pre	2-s delay Full	3-s delay Pre	3-s delay Full
First fixation time	M[c]	.310	.446	.517	.342	.380	.355
	SD[a]	.22	.33	.37	.24	.28	.17
Mean fixation time	M[a]	.344	.341	.420	.369	.391	.351
	SD[a]	.13	.17	.19	.26	.24	.21
Mean latency to orient to the stimulus	M[a]	.740	.648	.553	.559	.503	.551
	SD[a]	.35	.29	.25	.20	.25	.26
Mean intertrial interval	M[a]	.092	.129	.089	.075	.076	.067
	SD[a]	.04	.18	.04	.03	.04	.03

continued on next page...

Table 3 (continued)

Measures		Delay condition: No delay Infant group Pre	No delay Infant group Full	2-s delay Infant group Pre	2-s delay Infant group Full	3-s delay Infant group Pre	3-s delay Infant group Full
Trials to criterion[b]	M	13.0	12.4	13.7	14.3	14.2	11.7
	SD	5.4	5.5	5.7	5.1	4.6	5.4

[a] Scores in reciprocals.
[b] Criterion = 50% decrement (calculated over 3 consecutive trials) from fixation time on habituation trials 1-3.

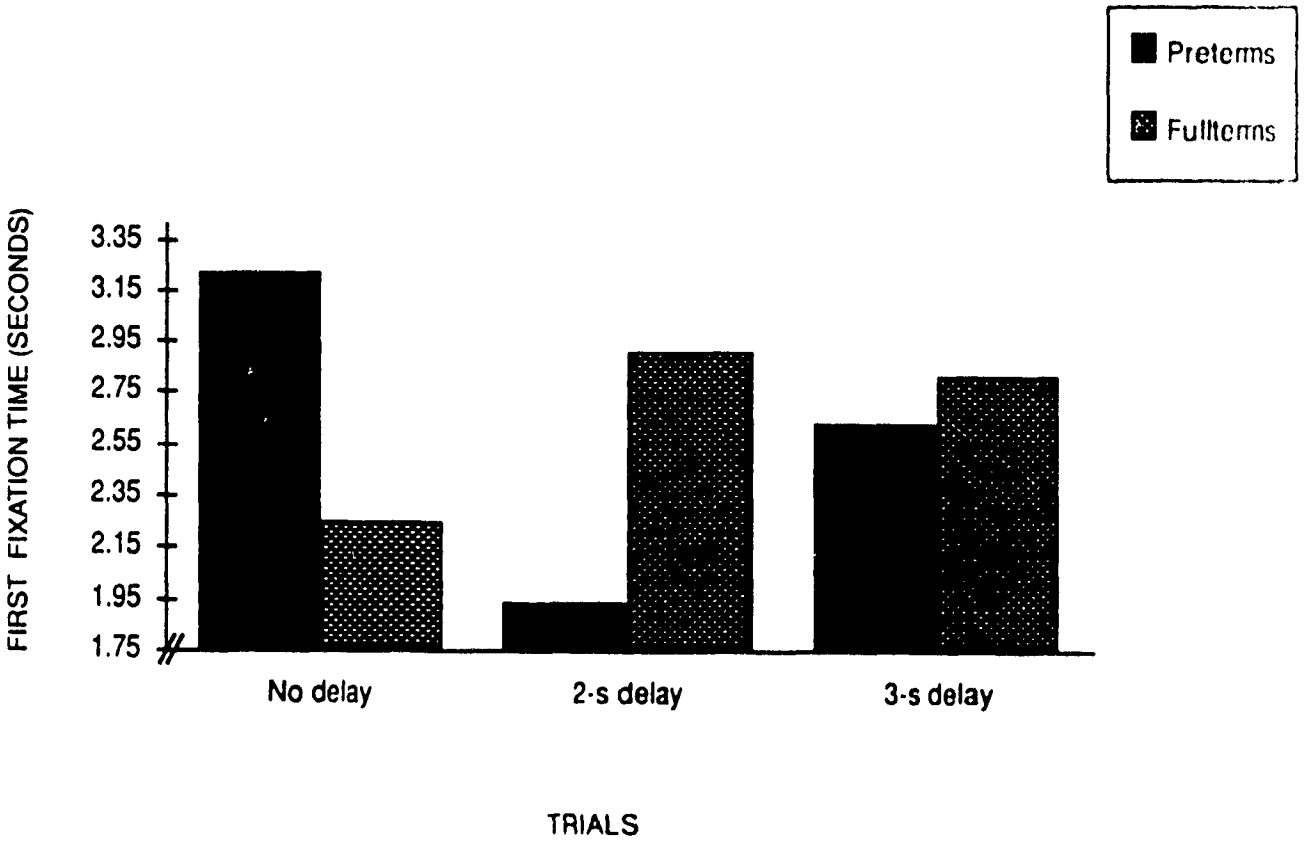

FIGURE 1. Delay condition x group interaction for first fixation time

stimulus than fullterm infants in the no delay condition and to take a shorter first look at the stimulus than fullterm infants in the 2-s delay conditions neither finding was significant. These results did not support the hypothesis that fixation time, latency to orient to the stimulus, and intertrial interval would become longer with tne longer delays for both groups.

Analysis of performance scores for all habituation trials.

Table 4 shows the means and standard deviations for each infant group on measures that reflected performance on all 18 habituation trials. A 2 (Infant Group) x 3 (Delay Condition) x 6 (Trial Blocks) MANOVA was conducted on fixation time, latency to orient to the habituation stimulus, and intertrial interval. Scores were averaged for six blocks of three consecutive trials. Appendix H contains the MANOVA and ANOVA source tables. The intercorrelations of these measures are shown in Appendix H. There were no significant multivariate effects of group, or group x delay condition. There was, however, a significant multivariate effect of delay condition, F (6,23) = 4.49, $p<.005$. Significant univariate effects of delay condition were found for latency to orient, F (2,56) = 6.82, $p<.01$, and for intertrial interval, F (2,56) = 3.31, $p<.05$, but not for fixation time.

Latencies to orient to the habituation stimulus increased significantly with the longer delays. Means were 1.35s for the no delay condition, 1.48s for the 2-s delay

Table 4

Comparison of Infant Groups on the Various Performance Measures for all Habituation Trials

Measures		Delay condition: No delay Infant group Pre	No delay Full	2-s delay Pre	2-s delay Full	3-s delay Pre	3-s delay Full
Mean fixation time	M[a]	.381	.366	.421	.393	.412	.325
	SD[a]	.14	.21	.22	.27	.24	.17
Mean latency to orient to the stimulus	M[a]	.638	.644	.534	.554	.503	.511
	SD[a]	.33	.27	.26	.22	.31	.22
Mean intertrial interval	M[a]	.084	.075	.078	.065	.068	.062
	SD[a]	.03	.05	.04	.03	.03	.03

[a] Scores in reciprocals.

condition, and 1.64s for the 3-s delay condition, respectively. Tukey tests showed that latencies to orient to the stimulus were significantly shorter at the no delay condition than at the 2-s delay and 3-s delay conditions respectively, $p<.01$ for both comparisons.

The intertrial interval also increased with the longer delays. Means for the no delay, 2-s delay, and 3-s delay conditions were 10.35 s, 10.42 s, and 12.45 s respectively. Tukey tests showed that there was no significant difference between the no delay and 2-s delay conditions, although each differed significantly from the 3-s delay condition at .01 level.

Although there was no multivariate effect of trial block, F (15,14) = 2.11, $p<.10$, there were significant univariate effects of trial blocks for fixation time, F (5,140) = 2.40, $p<.05$, for latency to orient to the habituation stimulus, F (5,140) = 2.87, $p<.05$, and for intertrial interval F (5,140) = 3.31, $p<.05$. There were no significant multivariate interactions between trial block and group, or between delay condition and trial block.

The orthogonal trend test for fixation time indicated a systematic linear decrease in fixation over trial blocks, F (1,28) = 6.45, $p<.05$, which is shown in Figure 2. There was also a significant trial block and group interaction on the univariate test of fixation time, F (5,24) = 3.78, $p<.01$, which reflected an uninterpretable difference in quintic

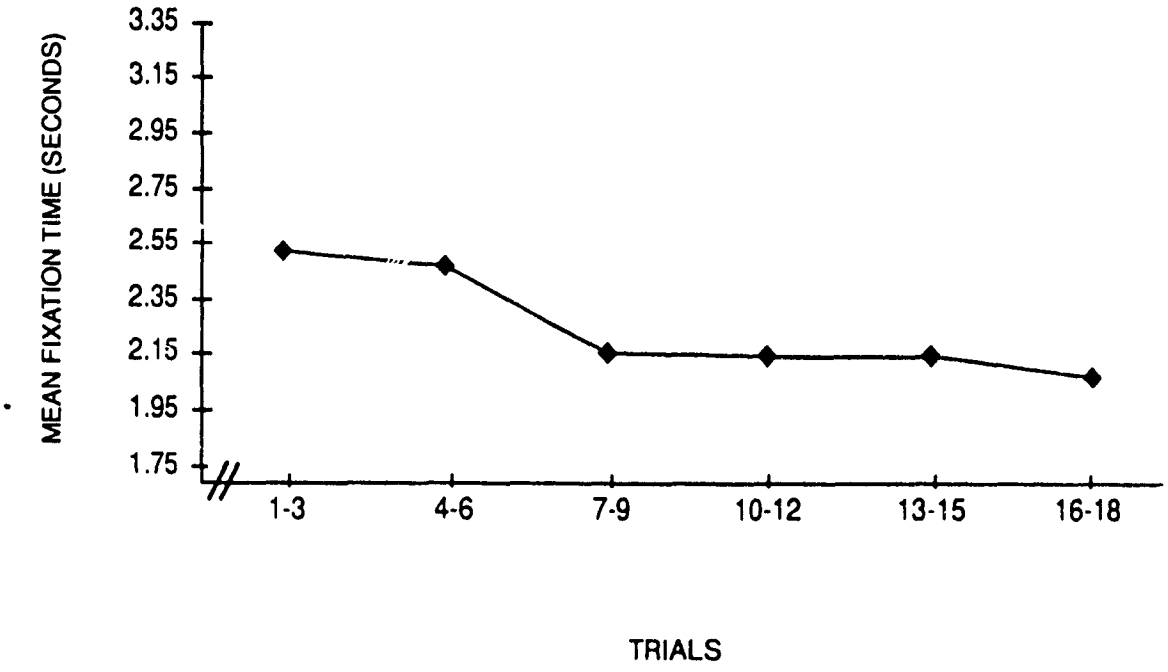

FIGURE 2. Linear trend for fixation time for infant groups combined

trend, F (1,28) = 12.97, $p<.001$, (see Figure 3). Other orthogonal trend tests indicated that latency to orient followed a quadratic trend over trial blocks, F (1,28) = 14.12, $p<.001$, which is shown in Figure 4, while the intertrial interval followed a predominantly linear trend, F (1,28) = 5.29, $p<.05$ (see Figure 5).

The significant effects of delay for latency to orient to the stimulus and intertrial interval supported the hypothesis that these performance measures would become lengthened with the longer delays. The fact that no effect of delay was found for fixation time was contrary to the prediction that fixation time would become longer with the longer delays. The lack of group x delay condition interaction on fixation time, latency to orient to the stimulus and intertrial interval was contrary to the prediction that if impairments occurred for infant groups because of the delays they would be more marked for preterm infants.

Analyses of fatigue and dishabituation effects.

Table 5 presents the mean fixation scores used in tests of fatigue and dishabituation effects for both infant groups. Appendix I contains the ANOVA source tables. A 2 (Infant Group) x 3 (Delay Condition) x 2 (Trial Blocks) ANOVA was conducted to test for fatigue effects during the testing sessions by comparing mean fixation time for the two warm up trials to mean fixation time for the two dishabituation

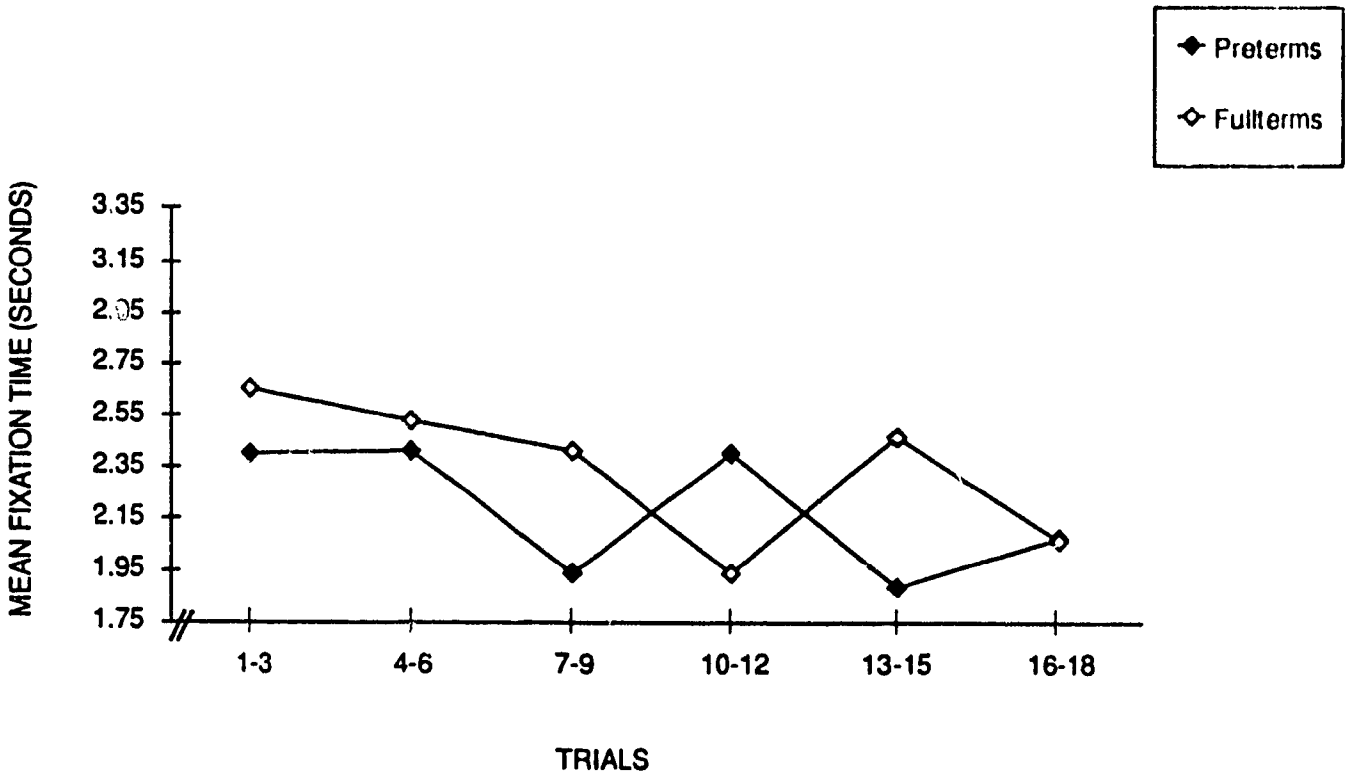

FIGURE 3. Trials x group interaction for fixation time.

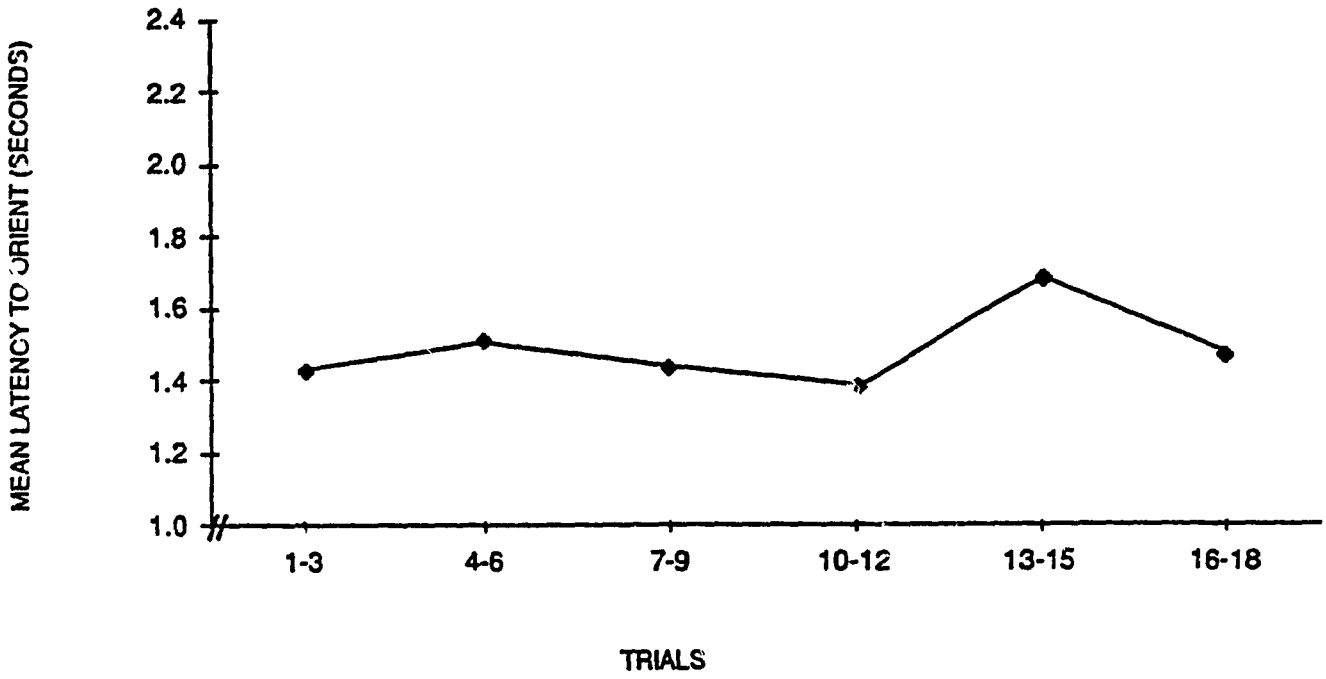

FIGURE 4. Quadratic trend for latency to orient to the stimulus for infant groups combined.

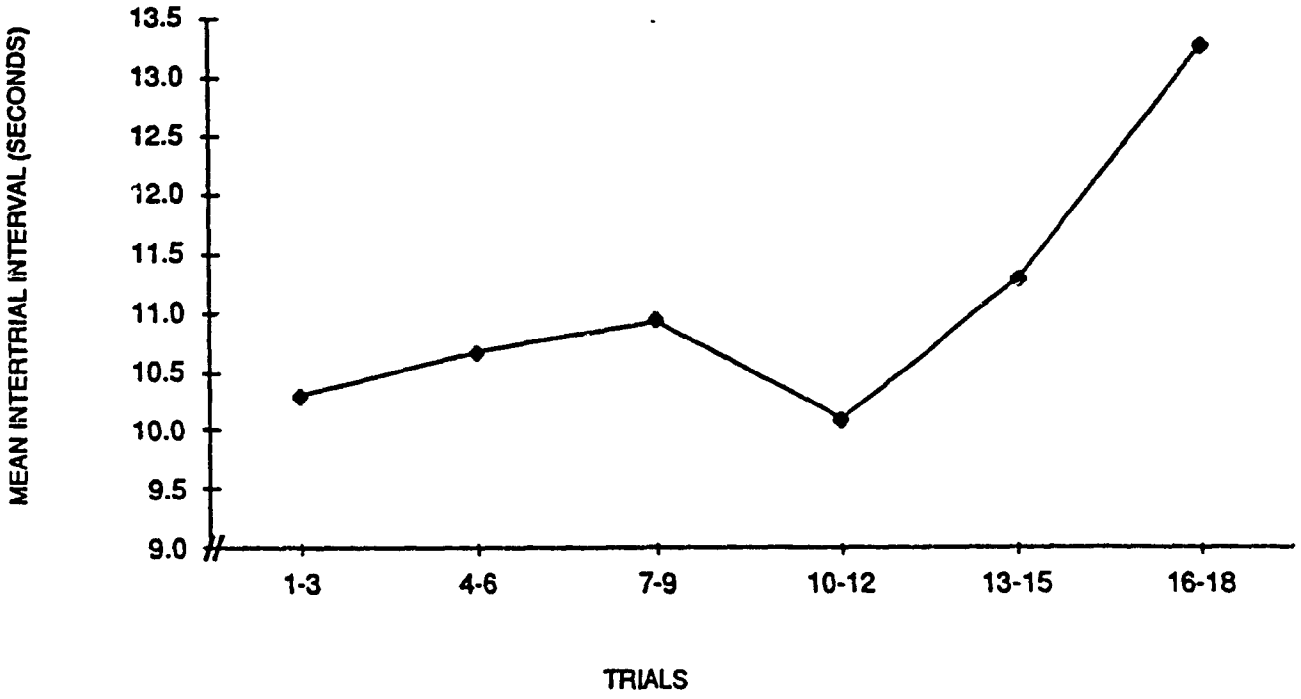

FIGURE 5. Linear trend for intertrial interval for infant groups combined.

Table 5

Means Fixation Time on Trials Used to Test for Fatigue and Dishabituation Effects

Trials		Delay condition: No delay Pre	No delay Full	2-s delay Pre	2-s delay Full	3-s delay Pre	3-s delay Full
Warm-up	M[a]	.307	.316	.350	.304	.320	.252
	SD[a]	.19	.28	.21	.16	.18	.12
Habituation	M[a]	.572	.533	.511	.474	.475	.448
17-18	SD[a]	.36	.40	.32	.33	.26	.28
Dishabituation	M[a]	.418	.307	.438	.352	.347	.427
	SD[a]	.27	.22	.34	.20	.24	.25

[a] Scores in reciprocals.

trials. The results indicated an effect of trial block, F (1,28) = 4.49, $p<.05$, but no effects of group or delay condition. Infants looked significantly less during the dishabituation trials (M=2.62s) than during the warm up trials (M=3.25s). Another 2 (Infant Group) x 3 (Delay Condition) x 2 (Trial Block) ANOVA was conducted to compare mean fixation time on the last two habituation trials to mean fixation time on the dishabituation trials. The results indicated a trial effect, F (1,28) = 14.97, $p<.001$. Fixation time increased from habituation trials 17 and 18 (M =2.00s) to dishabituation trials 1 and 2 (M=2.62s). Again, no effects of group or delay condition were detected. Thus there was clear evidence of dishabituation for both infant groups, despite evidence of fatigue effects.

Nonparametric Analyses of Habituation Characteristics.

The first question investigated was whether prematurity was associated with a greater tendency to fail to reach the habituation criterion. Table 6 shows the number of infants reaching and failing to reach habituation criterion for both infant groups. Fisher exact probability tests 2 (Infant Group) x 2 (Habituators vs Non Habituators) were calculated for each delay condition. There were no effects significant at the .05 level.

Other Fisher exact tests were conducted within delay conditions to test for an association between prematurity and

Table 6

Number of Infants who Reached and Failed to Reach Habituation criterion

Infant group	Delay condition		
	No delay	2-s delay	3-s delay
Preterms			
reached criterion	8	6	7
did not reach criterion	7	9	8
Fullterms			
reached criterion	9	7	11
did not reach criterion	6	8	4

a greater tendency toward slow habituation. Table 7 shows the number of fast and slow habituators in both infant groups. Infants were classified either as fast habituators if they reached the habituation criterion in fewer than 11 trials, or as slow habituators if they reached criterion in more than 11 trials. This classification system was used in previous research with the Cohen paradigm by DeLoache (1976) whose subjects were given up to 24 trials to reach criterion. These Fisher exact tests yielded no significant findings at the .05 level.

A Chi-square analysis with Yates's correction for continuity was also done on the number of infants within each group who reached habituation criterion in 0, 1, 2, or all 3 conditions to investigate whether prematurity was associated with greater inconsistency in reaching criterion across sessions. Table 8 shows how consistently preterm and fullterm infants reached the habituation criterion. Although no significant association between group and consistency of reaching habituation criterion was found, the only infants who never reached criterion in any of the three testing sessions were in the preterm group.

A final series of analyses examined whether qualitative differences existed in how preterm and fullterm infants reached habituation criterion. According to Bornstein and Benasich (1986) infants' habituation patterns may be classified as either exponential decrease, increase-decrease,

Table 7

Number of Infants who Were Fast and Slow Habituators

Infant group	Delay condition		
	No delay	2-s delay	3-s delay
Preterms			
Fast <11 trials	6	5	3
Slow >11 trials	9(2)	10(1)	12(4)
Fullterms			
Fast <11 trials	7	4	7
Slow >11 trials	8(2)	11(3)	8(4)

Note: The number in parenthesis indicates the number of slow habituators who actually reached criterion.

Table 8

Number of Infants Reaching Habituation Criterion in 0, 1, 2, or all 3 Testing Sessions

	Number of sessions in which infant reached criterion			
	0	1	2	3
Preterm	3	5	5	2
Fullterm	0	6	7	2

Note: Chi-square (3, N=30) = 4.10, p>.05

or fluctuating. (see Appendix J for definitions) Of these the fluctuating pattern presumably reflects the most inconsistent and least efficient response style. Habituation patterns were plotted according to this system for each infant who reached the habituation criterion in any condition. The patterns were then placed in random order and classified by a judge who was blind to the infant's group membership. Inter-rater reliability was established by calculating for each condition the number of agreements between the judge and the experimenter, dividing by the number of agreements and disagreements, and multiplying by 100. Mean inter-rater reliability was 90.6%. Table 9 presents the results of the classification.

In all, 54.5% of the preterms' habituation patterns were fluctuating, in contrast to 45.2% fluctuating patterns for fullterms. Separate Chi-square analyses with Yates's correction for continuity were conducted for each condition on the number of infants in each group demonstrating a fluctuating pattern as opposed to an exponential or increase-decrease pattern. Results for the no delay and 3-s delay conditions in which the dominant response style of the preterms was the fluctuating pattern and the dominant response style of the fullterms was the exponential and increase-decrease pattern yielded Chi-squares significant only at the .10 level; No delay Chi-square (1, N=21) = 2.97, 3-s delay Chi-square (1, N=23) = 3.67. In the 2-s delay

Table 9

Classification of Infant Habituation Patterns by the Bornstein and Benasich (1986) System

Pattern	Delay condition					
	No delay		2-s delay		3-s delay	
	Pre	Full	Pre	Full	Pre	Full
Exponential	4	3	6	3	2	5
Increase-Decrease	1	4	1	0	1	2
Fluctuating	7	2	2	8	9	4
Did not Habituate	3	6	7	4	3	4
Rater Reliability	100	88.9	88.9	100	83.0	83.0

condition, however, in which preterms predominantly exhibited exponential and increase-decrease patterns, and fullterms predominantly showed a fluctuating pattern, there was a significant association between infant group and response style, Chi-square (1, N=20) = 5.26, $p<.05$.

ANALYSIS OF THE DATA FROM A LARGER FULLTERM SAMPLE

The purpose of this analysis was to verify the findings obtained in the main study with 15 fullterm infants. The sample included the 15 fullterm infants in the main study plus an additional 12 fullterm infants who had been tested under the same conditions, but not used in the main study because of loss or unavailability of their planned preterm match. In the larger sample of 27 fullterms 9 infants had received each presentation order. The data were subjected to the same preliminary analyses and checks as in the main study. The break patterns were similar to those of fullterm infants in the main study. (see Appendix D) Analyses were performed on reciprocal scores, except for trials to criterion.

Univariate 3 (Order) x 3 (Delay Condition) x 6 (Trial Blocks) ANOVAs were performed with order as the between factor, and delay condition and trial blocks as the within factors for fixation time, latencies to orient, and the intertrial interval measures. No main effects of order or order x delay condition were found on any of the measures. Source tables are presented in Appendix K.

Analyses of performance scores

The MANOVA performed on fixation time, latency to orient to the stimulus, and intertrial interval that disregarded order as a factor but included delay condition and trial blocks is shown in Appendix K. Table 10 shows the means and standard deviations for the performance measures. The analysis indicated a multivariate effect of delay condition, F (6,21) = 5.26, $p<.01$, due to fixation time, F (2,25) = 4.09, $p<.05$, and to latency to orient, F (2,25) = 5.13, $p<.01$, but not to intertrial interval. There was no multivariate effect of trial block, and no multivariate effect of delay condition x trial block.

The subsequent ANOVA for fixation time indicated a univariate effect of delay condition, F (2,52) = 4.28, $p<.02$, that had not been obtained in the main study with 15 fullterm infants. Tukey tests indicated that fixation durations were significantly shorter in the no delay condition (M=1.80s) than in the 3-s delay condition (M=2.38s), $p<.01$ but not than in the 2-s delay condition (M=2.22s). Both trial block, F (5,130) = 2.30, and the related linear trend effect of trial block, F (1,26) = 3.82 approached significance, $p<.10$. There was no interaction between delay condition and trial block.

The ANOVA for latency to orient to the habituation stimulus showed an effect of delay condition, F (2,52) = 5.14, $p<.01$. Tukey tests indicated that latencies to orient

Table 10

Performance Scores for Habituation Trials for the Larger Fullterm Sample.

Measures		Delay condition: No delay	2-s delay	3-s delay
First fixation time	M[a]	.505	.404	.523
	SD[a]	.36	.26	.62
Mean fixation time	M[a]	.555	.451	.421
	SD[a]	.07	.04	.03
Mean latency to orient to the stimulus	M[a]	.799	.714	.641
	SD[a]	.06	.08	.06
Mean intertrial interval	M[a]	.115	.095	.084
	SD[a]	.01	.01	.01
Trials to criterion	M	12.55	14.07	12.55
	SD	5.31	5.03	5.33

[a]Scores in reciprocals.

to the stimulus were significantly shorter in the no delay condition (M=1.25s) than in the 3-s delay condition (M=1.56s), p<.01, but not than in the 2-s delay condition (M=1.40s). There was a main effect of trial block, F (5,130) = 2.85, p<.02, which was best described by a quadratic trend, F (1,26) = 5.61, p<.05. Appendix K, Figure 1 shows this trend. There was no interaction between delay condition and trial block. These delay condition and trial block effects were the same as those obtained in the main study with 15 fullterms.

The ANOVA carried out for intertrial interval did not indicate a significant effect of delay condition, but showed a main effect of trial block, F (5,130) = 2.35, p<.05, which did not reflect any significant trend. Appendix K, Figure 2 shows the trial block effect. No delay condition x trial block interaction was obtained. These results differed from those obtained in the main study where a linear trend of trial block had been found.

The ANOVAs conducted on first fixation time and trials to criterion (shown in Appendix K) failed to show any effect of delay. The finding obtained for trials to criterion supported the results obtained in the main study.

Analyses of fatigue and dishabituation effects.

A 3 (Delay Condition) x 2 (Trial Block) ANOVA was conducted to test for fatigue effects by comparing the means for fixation time at warm up and dishabituation. The results did not indicate an effect of trial block, or of trial block

x delay condition, or of delay condition. Fullterm infants looked as long during the dishabituation trials (M=2.93s) as during the warm-up trials (M=2.93s). Thus there was no evidence of fatigue effects at any level of delay. Another 3 (Delay Condition) x 2 (Trial Block) ANOVA was performed to test for dishabituation by comparing fixation time scores during the last two habituation trials to fixation time scores during the dishabituation trials. The results showed a significant effect of trial block, F (1,26) = 31.49, $p<.001$. Fixation durations increased from trials 17 and 18 (M=1.98s) to dishabituation trials (M=2.93s). There was no significant interaction between trial block and delay condition or any effect of delay condition. Thus as in the main study, there was evidence of dishabituation. Source tables for both analyses are shown in Appendix K.

In sum, the significant effects of delay on fixation time and latency to orient that emerged for the larger sample of fullterm infants only partially supported the hypothesis that fixation time and latency to orient would become longer with the longer delays because no difference was found between the no delay and 2-s delay on these measures as had been predicted. The lack of an effect of delay on intertrial interval was contrary to the prediction that intertrial interval would be lengthened with the longer delays.

ANALYSIS OF DATA FROM A HETEROGENEOUS PRETERM SAMPLE.

In order to determine whether the visual habituation

task was sensitive to medical complications and how delay conditions affected performance in a larger heterogeneous preterm sample, data from 9 preterm infants who had been tested but excluded from the main study because of complications detected either through maternal reports or through a final check of their medical records (see Appendix L) were compared to those obtained from the 15 complication-free preterm infants. Order of presentation of delay conditions was incompletely counterbalanced in the complications group : 3 infants received the first order, 4 infants received the second, and 2 the third. These additional data were also checked for outliers, skewness, and for homogeneity of the variance-covariance matrices. Preliminary checks were conducted to verify preterm infants' break patterns. (see Appendix D). The break patterns were similar to those of preterm and fullterm infants in the main study. Since the sample size of infants with medical complications was small, it was felt that ANOVAs were more appropriate than MANOVAs. Table 11 shows the means and standard deviations of the performance measures. Separate 2 (Infant Group) x 3 (Delay Condition) x 6 (Trial Block) ANOVAs with orthogonal trend tests were performed for fixation time, latency to orient to the habituation stimulus, and intertrial interval. The source tables for these analyses appear in Appendix L.

The ANOVA on fixation time did not show an effect of

Table 11

Comparison of Preterm Groups on Performance Measures for Habituation Trials.

Measures		Delay condition: No delay Pre	No delay Compre	2-s delay Pre	2-s delay Compre	3-s delay Pre	3-s delay Compre
First fixation time	M[a]	.310	.541	.517	.394	.380	.484
	SD	.22	.44	.37	.15	.28	.38
Mean fixation time	M[a]	.239	.375	.276	.207	.274	.352
	SD	.05	.11	.04	.08	.07	.12
Mean latency to orient to the stimulus	M[a]	.740	.760	.656	.689	.616	.582
	SD	.07	.06	.04	.09	.06	.12
Mean Intertrial interval	M[a]	.103	.113	.097	.098	.083	.077
	SD	.32	.02	.01	.01	.01	.01

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Table 11 (continued)

Measures		Delay condition					
		No delay		2-s delay		3-s delay	
		Pre	Compre	Pre	Compre	Pre	Compre
Trials to criterion	M	13.00	11.55	13.67	15.22	14.87	12.55
	SD	5.4	4.3	5.7	5.1	4.4	6.5

Note: Pre = Preterms with no medical complications, N=15.
Compre = Preterms with complications, N=9.
[a]Scores in reciprocals.

delay condition, group, or a delay condition x group interaction. There was an effect of trial block, F (5,110) = 3.98, $p<.01$, attributable to a linear trend, F (1,22) = 9.18, $p<.01$. (see Appendix L, Figure 1) Fixation time decreased over trial blocks. There were no significant interactions between trial block and group, or between delay condition and trial block and group. These effects are consistent with those obtained in the main study.

The ANOVA performed on latency to orient to the habituation stimulus did not reveal an effect of group. It did, however, reveal an effect of delay condition, F (2,44) = 4.51, $p<.01$. Tukey tests of differences between means were not significant. Latencies to orient to the stimulus were 1.34s for the no delay condition, 1.50s for the 2-s delay condition, and 1.66s for the 3-s delay condition. There was no effect of trial block and no significant interactions between delay condition and group, or between trial block and group, or between trial block, delay condition, and group. The delay condition effect, but not the lack of trial block effect, was similar to the results obtained in the main study. The ANOVA conducted on the intertrial interval showed an effect of delay condition, F (2,44) = 7.58, $p<.001$. Tukey tests showed that the intertrial interval was shorter in the no delay condition (M=9.37s) than in the 3-s delay condition (M=12.38s) ($p<.01$.), but not than in the 2-s delay condition (M=10.31s). There was a main effect of trial block, F

(5,110) = 2.73, $p<.02$, which reflected a cubic trend, F (1,22) = 7.08, $p<.01$. (see Appendix L, Figure 2). There were no significant interactions between delay condition and group, trial block and group, or group, delay condition and trial block. The delay condition effect, but not the trial block effect, was similar to the findings obtained in the main study.

Separate 2 (Infant Group) x 3 (Delay Condition) ANOVAs were performed on first fixation time and trials to criterion. The ANOVA conducted on first fixation time did not show an effect of delay condition nor did it show a significant group x delay condition interaction. The ANOVA performed on trials to criterion showed no effect of delay condition and no group x delay condition interaction. The findings pertaining to trials to criterion were similar to those obtained in the main study.

Appendix L contains the source tables of the analyses of fatigue and dishabituation effects for the heterogeneous sample of preterm infants. The ANOVA that compared fixation durations during the warm up trials to those during the dishabituation trials did not show any evidence of fatigue effects. Fixation durations decreased non-significantly from warm-up trials (M=2.71s) to dishabituation trials (M=2.36s). There was no delay condition x trial interaction. The ANOVA that compared the fixation durations on the last two habituation trials (M=1.84s) to those during the

dishabituation trials (M=2.56s) to test for dishabituation was significant, F (1,23) = 9.32, p<.01. There was no delay condition effect and no delay condition x trial interaction.

In sum, the results obtained from the comparison of the two preterm infant groups did not indicate group differences. The delay condition effects found on latency to orient to the stimulus and intertrial interval for the heterogeneous preterm sample supported the hypothesis that latency to orient to the stimulus and intertrial interval would be longer with the longer delays. The fact that no effect of delay was found for fixation time was contrary to the prediction that fixation time would be lengthened with the longer delays.

Discussion

The central issue addressed in this study was whether preterm infants free of medical complications showed evidence of impairment or of differences at the level of memory and attention relative to fullterm infants on a visual habituation task administered at 4 months corrected age. It was assumed that the 2-s and 3-s delays interposed between fixation of the blinking light and subsequent stimulus exposure would increase the demands on memory and attention by producing more opportunity for interference and decay to occur between stimulus exposures. It was hypothesized that the performance of complication-free preterm infants and fullterm infants would become more impaired with the longer delays and that if impairments or differences in performance occurred because of the delays, they would be more marked for preterm infants. It was predicted that impairments in performance would be reflected in longer latencies to orient to the stimulus from the blinking light, longer intertrial intervals (latency to orient back to the light after turning away from the stimulus) and longer fixations of the stimulus.

The results of the main study did not indicate that the performance of complication-free preterm infants was impaired relative to that of fullterm infants or different from that of fullterm infants, even for the delay

conditions. No group effects or group x delay interactions were found on latency to orient to the stimulus, intertrial interval, fixation time or trials to criterion. The analyses conducted to study the possibility of group differences on qualitative measures showed minimal evidence of group differences. Preterm and fullterm infants did not differ in number of infants experiencing breaks, break length, and type of break experienced in the course of the testing sessions. No significant group differences were found in number of infants reaching or failing to reach habituation criterion across testing sessions. There were some suggestions,however, of better performance on the part of fullterm infants. This was reflected in a greater proportion of fullterm infants reaching criterion, and reaching it more consistently. The analysis of habituation patterns showed a significant association between infant group and habituation pattern at the 2-s delay only, and this in fact reflected better response styles on the part of the preterm infants who exhibited more exponential or increase-decrease habituation patterns than fullterm infants.

These findings supported recent evidence obtained by Piekkala et al. (1988) in their follow-up study of 325 unselected preterm infants tested at 2 ye. corrected age on a modified version of the Denver Developmental Screening Test. The authors found that the prognosis of preterm

infants without medical complications was near that of fullterm controls if preterm infants had been born at 2,000 grams with gestational ages of more than 34 weeks, and 5-min. Apgar scores of 8 or more. In this study, however, it is difficult to assess whether the lack of group differences merely reflects the lack of sensitivity of the Denver test, it being a more traditional measure of functioning. The findings of the present study are consistent with those of Piekkala et al. What is of interest, is that the results of the present study suggest a favorable prognosis for complication-free preterm infants who were less mature at birth (M GA = 34 weeks, 4 days) and had lower birthweights (M birthweight = 2373.3 grams) than the preterm infants in the Piekkala et al. study, when a refined task of information-processing ability is used.

The failure to find evidence of group differences between complication-free preterm infants and fullterm infants taken in conjunction with the information-processing delays reported by Rose (1980, 1983) with her sample of lower-class high risk preterm infants indicate that the degree of medical complications associated with prematurity plays an important role in determining preterm infant performance on visual information-processing tasks. It is difficult to assess whether the findings of the present study truly reflect that prematurity per se in not associated with impairments or differences in attention and

memory, since very little research has been conducted using information-processing tasks with this type of preterm sample. What is clear from the main study is that there are no major performance differences between complication-free preterm infants at 4 months corrected age and 4-month-old fullterm infants. In fact, complication-free preterm infants performed as well as fullterm infants on the task despite the fact that their general state of health at birth was poorer than that of fullterm infants. This was reflected in preterm infants' significantly lower 1-min. Apgar scores.

What is clear from the findings of the main study is that if differences between complication-free preterm infants and fullterm infants exist they are subtle. It is possible that some indications of less mature performance on the task on the part of complication-free preterm infants would have emerged had the sample size been larger (N=25). It should be emphasized that accumulating a reasonable sample size of preterm infants, particulary a complication-free sample within a reasonable period of time is a practical problem for researchers who work in this area. It could also be that subtle differences would be more detectable on other visual information-processing tasks. Future studies should be conducted with various types of infant information-processing tasks to resolve the issue as to whether or not prematurity per se affects subsequent

cognitive functioning. Another type of task that could be used in future studies is the mobile conjugate reinforcement paradigm which has been widely used with fullterm infants ranging from 8 to 20 weeks chronological age and more importantly once with preterm infants at approximately 2 months corrected age (Gegoski, Fagen, & Pearlman, 1984; Rovee-Collier & Fagen, 1981). This operant conditioning paradigm which involves training infants to produce movement of a overhead mobile by kicking provides a direct test of memory acquisition, long term retention and retrieval.

With respect to the effect of the delays, the findings of the main study indicated that the 2-s and 3-s delays did alter the performance of infants as predicted but not for all measures. The delays slowed down the speed at which infants oriented to the stimulus from the blinking light as reflected in their longer latencies to orient to the stimulus. The delays also slowed down the speed at which infants re-oriented to the blinking light after turning away from the stimulus as reflected in the longer intertrial intervals. But contrary to what had been predicted, the delays did not significantly lengthen fixation durations. The lack of effect of delay on fixation duration could indicate that the delays did not produce as much forgetting of the stimulus as had been expected despite the fact that the delays provided greater opportunity for interference or decay or that forgetting occurred but infants did not

compensate for it by looking longer on trials. Infants continued to look at the stimulus for the same lengths of time despite the longer delays in stimulus presentations. They were also quite capable of establishing a memory engram of the stimulus even with the longer delays since their fixation durations decreased in a linear fashion at all levels of delay and there was evidence of recovery of habituation too (dishabituation).

The results of the study with the larger fullterm infant sample confirmed the predicted effect of delay on one measure of attention, latency to orient to the stimulus. Contrary to what had been predicted, no effects of delay were found on intertrial interval, although a significant effect of delay on intertrial interval had emerged in the main study. What was of interest was the significant effect of delay on fixation duration that emerged with this larger fullterm sample that did not appear in the main study. As had been predicted fullterm infants' fixation durations were lengthened with the longer delays. The delays produced more forgetting of the stimulus for the larger fullterm sample but did not interfere with infants' capacity to establish a memory engram of the stimulus because fixation durations decreased in a linear fashion over habituation trials and there was recovery of habituation (dishabituation).

The effects of delay found for fullterm infants showed that the delays impaired their attention to the stimulus

(latency to orient to the stimulus) but not their general readiness to respond to the task (intertrial interval). The fact that fullterms were slower to orient from the light to the stimulus with the longer delays might suggest that their motivation to turn to the stimulus was reduced because with the longer delays viewing the light was not immediately reinforced by exposure of the stimulus. What is of interest in the findings for fullterm infants was that the delays produced some amount of forgetting for them but they were able to compensate for it by looking for longer periods of time at the stimulus, and the forgetting that occurred did not prevent them from establishing a memory engram because there was evidence of habituation and recovery of habituation.

In general, when the fullterm sample was increased, it was found that the delays impaired fullterm infants' readiness to attend to the stimulus (latency to orient to the stimulus), but not their general readiness to respond to the task demands (intertrial interval), and produced forgetting but did not prevent them from forming a memory of the stimulus. The results obtained with the larger fullterm sample are perhaps more reliable than those obtained in the main study. What has yet to be determined are the reasons why the effect of delay on fixation time did not emerge for fullterm infants in the main study. Perhaps the lack of effect in the main study was due to the reduced sample size.

The results of the analyses that compared the performance of 9 preterm infants with medical complications to that of 15 complication-free preterm infants showed no evidence of group effects or group x delay interactions on latency to orient to the stimulus, intertrial interval, fixation time. Thus there was no evidence that the delays affected preterm infant groups differentially. This finding of no group differences between preterm groups is consistent with the findings reported by Sigman (1976) that did not indicate differences in total exploration time of a familiar stimulus between a high risk and low risk sample of preterm infants on a visual preference task at 8 months corrected age. A possible explanation for the findings of the present study could be that the complications experienced by the preterm infants were with few exceptions not severe. Both groups of preterm infants in this study were fairly mature at birth and had originally been screened according to the same criteria. The sample of preterm infants with complications, like the preterm infants free of complications, had 1-minute and 5-minute Apgar scores of at least 7, were fairly mature at birth (M GA 34 weeks, 2 days), and had birthweights over 2,000 grams (M 2310 grams).

There were effects of delay on some measures for this heterogeneous preterm sample in the main study. Effects of delays were found on latency to orient to the stimulus and intertrial interval but not on fixation time. The delays

significantly impaired preterm infants' performance at the attentional level. Preterm infants took longer periods of time to orient their attention to the stimulus from the blinking light and redirect their attention back to the light (intertrial interval) with the longer delays. On the other hand, preterm infants continued to look at the stimulus for the same lengths of time despite the longer delays in stimulus presentations that presumably created more opportunity for forgetting to occur. However, they were capable of forming a memory of the stimulus since fixation durations decreased in a linear fashion over habituation trials, and there was recovery of habituation.

One interpretation of these findings is that preterm infants were not as motivated to direct their attention to the stimulus after turning away from the blinking light (latency to orient) nor were they as motivated to redirect their attention to the blinking light after turning away from the stimulus (intertrial interval) when the delays were lengthened. It could be that preterm infants lost focus of the sequences of the task and thus became less involved and less interested in the task as the delays between fixation of the light and stimulus exposure were lengthened. What is noteworthy is that the delays affected the attentional components of the task but not the memory component, fixation time. The breakdown in attention resulting from the longer delays did not produce less fixation of the

stimulus. Preterm infants looked as long at the stimulus in the 2- and 3-s delay conditions as in the no delay conditions. It cannot be claimed that preterm infants did not establish some kind of memory of the stimulus, however, because fixation durations decreased over habituation trials and there was recovery of habituation. The question that remains unclear is what the decrease in fixation time reflects for preterm infants. From the present findings it cannot be determined how much active stimulus processing occurred relative to "blank" passive looking (resulting from a lack of interest in the task) for preterm infants when the delays were lengthened.

The findings of this study indicate that differences in visual habituation performance between low risk preterm infants at 4 months corrected age and 4-month-old fullterm infants are quite subtle and cannot be addressed by using the present version of the task. The visual habituation task in its present state does not provide any direct way of measuring what is stored in memory as a result of active stimulus processing, and what is forgotten under conditions such as the delay conditions that create a load on memory. The procedure used in the present study needs to be modified to provide some way of assessing what has been encoded and stored in memory. Since approximately half of the infants in each group habituated to criterion one cannot be reasonably confident of the extent to which information

about the stimulus was represented in memory for all infants. The infants who failed to reach habituation criterion and thus establish a memory of the stimulus could have lacked the motivation to keep attending to the stimulus or could have looked at the stimulus without processing any information about it. Future research should attempt to resolve the issue of what fixation of a repeatedly shown stimulus reflects, particularly in preterm infants. This research question appears to be the most important one because it would provide valuable information about the extent to which preterm infants can process information in their environment relative to fullterm infants. A task that could be used to resolve this issue could be one in which infants are habituated to a stimulus that has several components like the one used by DeLoache (1976) (four geometric shapes). Infants could later be tested on post-habituation trials with each component separately. Infants' visual preference for the components would have to be similar, however. If fixation durations on the individual components were the same as fixation durations on the habituation stimulus then it could be assumed that infants have encoded information about the stimulus because they see the components as being part of what they have seen before. Infant groups could be compared in relative amount of looking to each component.

In terms of the manipulations used in the study it

appeared that the effects of the 2-s delay were not as clear as the effects of the 3-s delay, particularly for fullterm infants. This finding could perhaps be due to greater random fluctuation in the fullterm infant group at the 2-s delay. Future research conducted in this area with this task should be based on larger samples with longer delays, perhaps 3-s and 4-s delays, to force differences between groups. Since all infant groups experienced breaks during the task at all levels of delay, it is felt that future studies should be conducted with 12 habituation trials since most infants who habituated in the study did so in approximately 12 habituation trials. The results of this study also indicated that a fixed-trial approach to visual habituation can be more informative than an approach based on performance to habituation criterion, since the former includes valuable information about how infants who fail to reach criterion process information about a stimulus. What would also have to be evaluated in future studies is whether introducing a delay between fixation to the light and stimulus exposure is the only way in which one can systematically tax the demands on memory and attention in infants. A future study could incorporate a period of distraction during the intertrial interval prior to fixation of the blinking light. This manipulation could cause an added stress on memory and attention, and could be systematically manipulated in conjunction with delays

interposed between fixation of the light and target exposure.

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Appendix A

Consent Forms, Abstract and Letter Sent to Pediatricians, and Maternal Questionnaire

Appendix A

Dear Dr. _____,

We are currently investigating memory in 4-month-old babies who were born at term and in babies of 4 months corrected age, who were born at least 3 weeks prematurely; and would like to include one of your patients: _____ as a subject in our study. The purpose of the research is to determine the effects of premature birth, in the absence of complications, on infant memory and attention. An abstract of the study is enclosed.

The research, which is a joint project of members of the Department of Psychology of Concordia University and the Department of Neonatology of the Jewish General Hospital, has been approved by the Ethics and Research Committee of the Jewish General Hospital. Principal investigators are Denise Messmer, M.A.; Nancy D. Taylor, Ph.D., and Dr. A. Papageorgiou. Subjects are selected from babies born at the Jewish General Hospital. The Ethics and Research Committee has requested that we approach a mother to obtain her consent only after the child's pediatrician has mentioned the study to her and obtained her approval for one of the researchers to explain the study. We hope you will be willing to speak to Mrs. _____ either by telephone or in the course of an office visit before the following date _____ which is 2 weeks before the first experimental session could take place.

Your cooperation is important to the successful completion of the research project. Any assistance you can provide us would be deeply appreciated. You would, of course, receive a summary of the findings of the study as soon as the data collection is complete. Denise Messmer will be telephoning you in about 10 days to answer any questions and find out if you are willing to help us.

Sincerely,

Denise Messmer, M.A.
Department of Psychology

Appendix A

Consent Form

This study is a joint project of members of the Department of Psychology of Concordia University and Department of Neonatology of the Jewish General Hospital. The purpose of the research is to compare memory in two groups of healthy babies 4 months after their expected date of birth. The groups being compared are babies who were born at least three weeks prematurely, and babies who were born at the expected time. The information obtained will tell us whether there are effects of premature birth on infant memory.

The memory task will be given in 3 short visits to your home on different days during a 2-week period. Visits will be scheduled at your convenience around the date that is 16 weeks after the baby's expected date of birth. You (or the main caregiver) will be asked to sit and hold the baby in your lap in front of a viewing box. A small light will blink on and off to attract the baby's attention. The light will be turned off after the baby looks at it, and then a large black and white pattern will be shown. The pattern will be shown as soon as the light goes off in Session 1, and after 2-second and 3-second delays in Sessions 2 and 3. When the baby looks away from the pattern, the pattern will be covered, and the blinking light will go on again to start the next trial. There will be 22 trials in a session. Two observers will record how long the baby looks at the pattern each time it is shown. Each test session will last about 15 minutes.

I, _____, have read the above description fo the study of the effects of prematurity on memory and had the study explained to be. I am willing to participate in the study with my baby. I realize that I am free to withdraw my child at any time.

Date: _____ Mother's signature: _____

Signature of Witness: _____

Mother's Name: _____

Telephone No.: _____

Place of Employment: _____

Infant's Name: _____

Address: _____

I, _____ like to have a summary of the main findings of the study sent to me when the research is finished.

Appendix A

Formule de Consentement

Cette étude est un projet conjoint des membres du Département de Psychologie de l'Université Concordia et du Département de Néonatologie de l'hôpital Général Juif de Montréal. Le but de cette étude est de comparer la mémoire de deux groupes d'enfants en bonne santé 4 mois après leur date prévue de naissance. Les groupes qui seront comparés sont des bébés prématurés d'au moins trois semaines et des bébés nés à leur date prévue de naissance. L'information obtenue nous dira si la prématurité a des effets sur la mémoire de bebés.

Le test de mémoire sera réparti sur 3 visites brèves à votre maison. Les visites auront lieu des journées différentes et s'échelonneront sur une période de deux semaines. Les visites seront planifiées selon votre disponibilité et auront lieu 16 semaines après la date prévue de la naissance du bébé. On demandera soit à vous (ou à la personne en charge de garder l'enfant) de vous asseoir en face d'une boîte de visionnement. Une petite lumière dans la boîte clignotera pour attirer l'attention du bébé. La lumière s'éteignera au moment où le bébé arrêtera de la regarder, et un gros dessin noir et blanc lui sera ensuite montré. Lors de la première session, le dessin sera montré aussitôt que la lumière sera éteinte, et sera montré après 2-secondes et 3-secondes de délai pour la deuxième et troisième session. Quand le bébe cessera de regarder le dessin, le dessin sera couvert et la lumière clignotante s'allumera de nouveau pour marquer le début d'un nouvel essai. Chaque session comportera 22 essais. Deux observatrices enregistreront chaque durée de fixation du dessin du bébé. Chaque session durera approximativement 15 minutes.

Je sousigné, _____, reconnais avoir lu la description ci-haut mentionnée sur l'étude des effets de la prématurité sur la mémoire, et déclare avoir reçu les explications concernant cette étude. J'aimerais participer à cette étude avec mon enfant. Je suis conscient(e) que je suis libre de retirer mon enfant du projet n'importe quand.

Date: _____ Signature de la Mère: _____

Signature du Témoin: _____

Nom de la Mère: _____

Numéro de Téléphone: _____

Lieu de Travail de la Mère: _____

Nom de l'Enfant: _____ _____

Adresse: _____

Je, _____ qu'un résumé des résultats de cette étude me soit envoyé à la fin du projet de recherche.

Appendix A

Abstract Mailed to Pediatricians

The Effects of Prematurity per se on Attentional and Memory Processes.

Although much is known about the early development of preterm infants with complications, little is known about the early development of babies who were born prematurely, but escaped all complications. In a study just completed on such a sample of infants at 2 and 3 months corrected age (Taylor and Potvin, 1984), the results suggested that such babies follow a pattern of early development that differs from that of fullterms at an equivalent postconceptional age. The pattern, which includes transient hyperirritability, suggests relative immaturity of the central nervous system possibly because of a slower rate of neural maturation. One implication of these data is that differences may also be found in somewhat older complication-free preterm infants in cognitive processes. The purpose of the present study is to investigate the effects of prematurity, in the absence of complications, on memory and attentional processes at 4 months corrected age.

Subjects will be 15 complication-free infants born at a gestational age (GA) of less than 37 weeks and 15 fullterm infants matched on sex, race, and maternal education. Memory and attention will be assessed through performance on a visual habituation task (Cohen, 1976) administered on 3 separate visits to each infant's home over a 2-week period (15-17 weeks after the infant's expected date of birth). The mother will be asked to sit with the baby on her lap in front of a viewing box in which a large black and white pattern will be shown. At the beginning of each trial a small blinking light in the box will be turned on to attract the baby's attention. The light is turned off after the infant looks at it and then a pattern is shown. The pattern is shown as soon as the light goes off in Sessions 1, and after 2-second and 3-second delays in Sessions 2 and 3. As soon as the infant looks away from the pattern, it is covered up and the blinking light will reappear to mark the onset of the next trial. There will be 22 trials per session. Each session will last approximately 15 minutes. Tests sessions are discontinued if the baby shows signs of fatigue or irritability. Each tests session is conducted by two female observers who record how long the infant looks at the pattern on each trial.

Appendix A

QUESTIONNAIRE

Mother's Name: _____

Maternal Age: _____ Maternal Education: _____

Occupation: _____

Mother Tongue: _____

Number of years of residence in Canada? _____

Marital Status: _____

Father's Name: _____

Paternal Age: _____ Paternal Education: _____

Occupation: _____

Mother Tongue: _____

Number of years of residence in Canada? _____

Is your child your first-born? _____

What is your child's position in family (2nd, 3rd, 4th, 5th)?

Was your child ever sick or hospitalized between the time of his/her hospital discharge and time of testing? _____

Appendix B

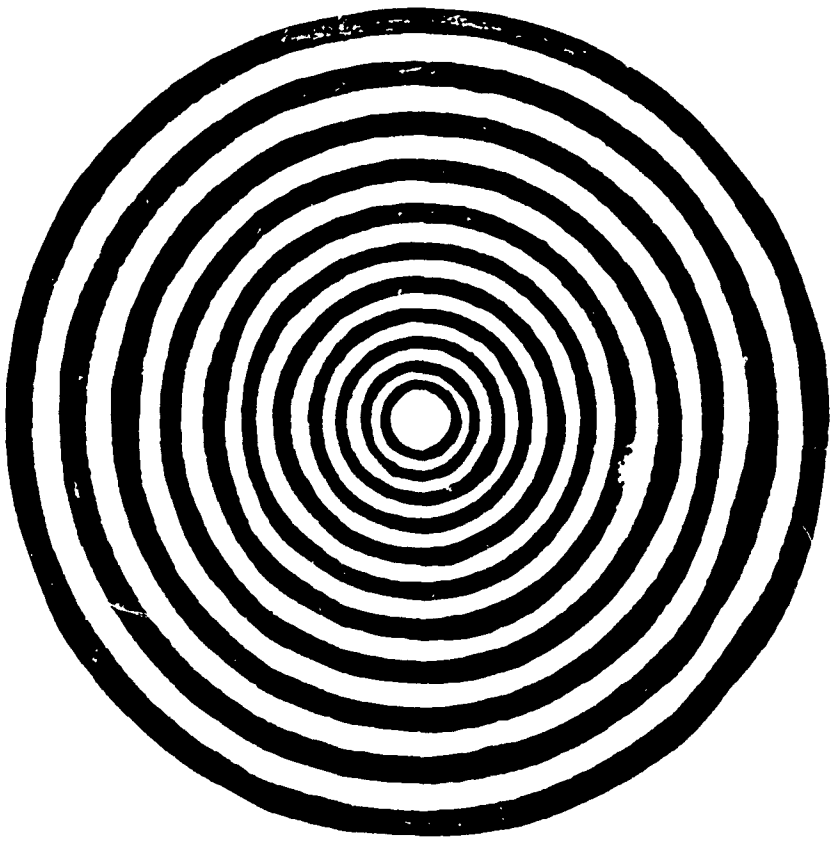
Source Tables of the Analyses of Variance of Parental Characteristics of the Sample

Appendix B

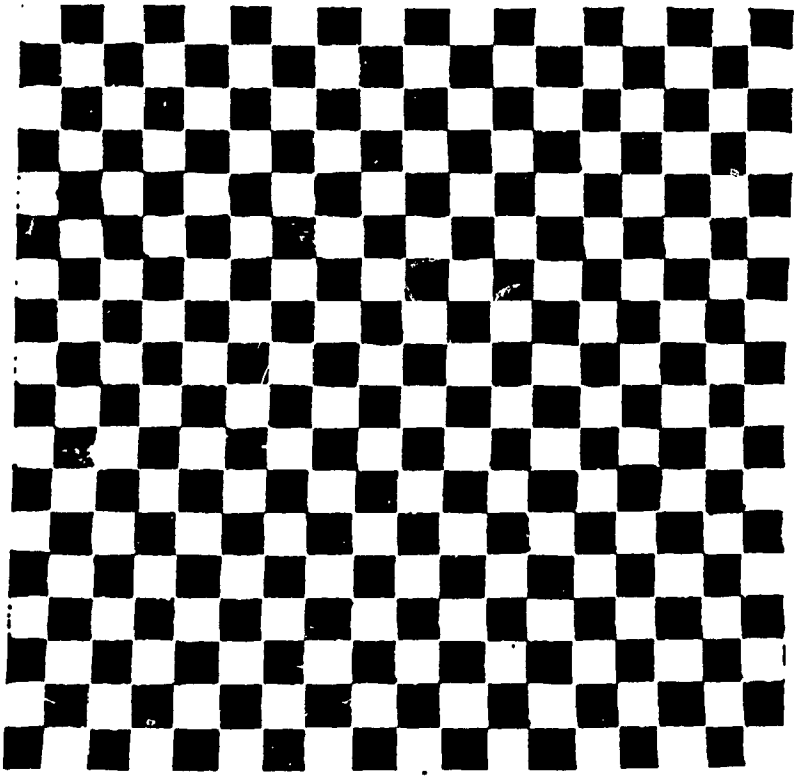
Source	SS	df	MS	F
Maternal Age	.03	1	.03	.00
Error	586.9	28	20.96	
Maternal Education	4.03	1	4.03	.27
Error	414.1	28	14.79	
Paternal Age	24.30	1	24.30	.74
Error	919.1	28	32.82	
Paternal Education	24.30	1	24.30	1.96
Error	347.2	28	12.40	

Appendix C

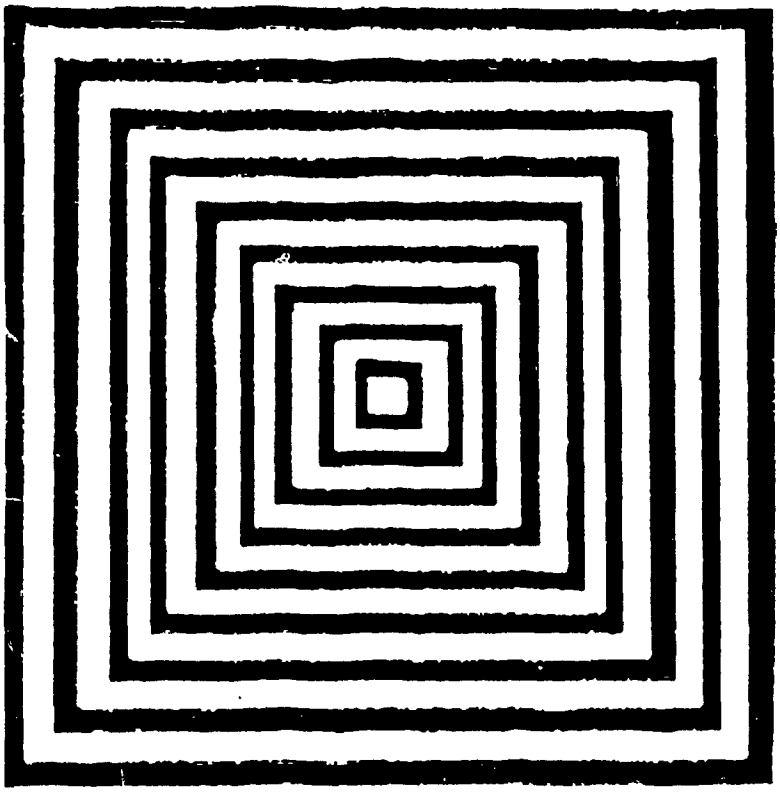
Stimuli, Diagrams of the Visual Habituation Apparatus and Schematic Representation of the Procedure



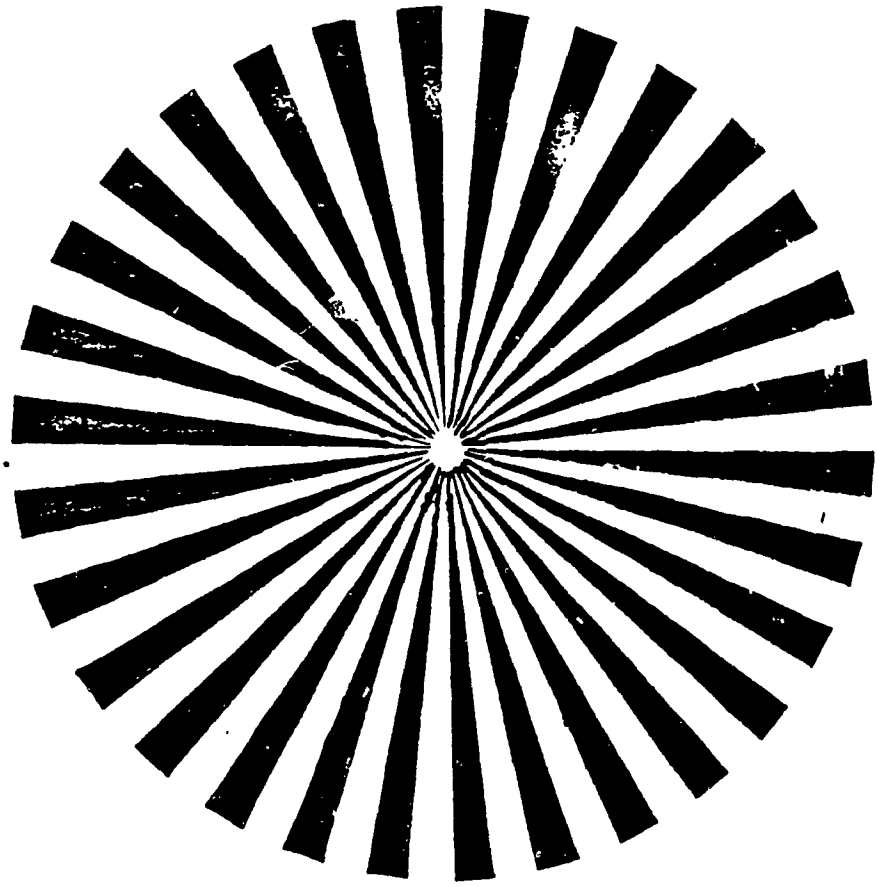
Warm-up and dishabituation stimulus



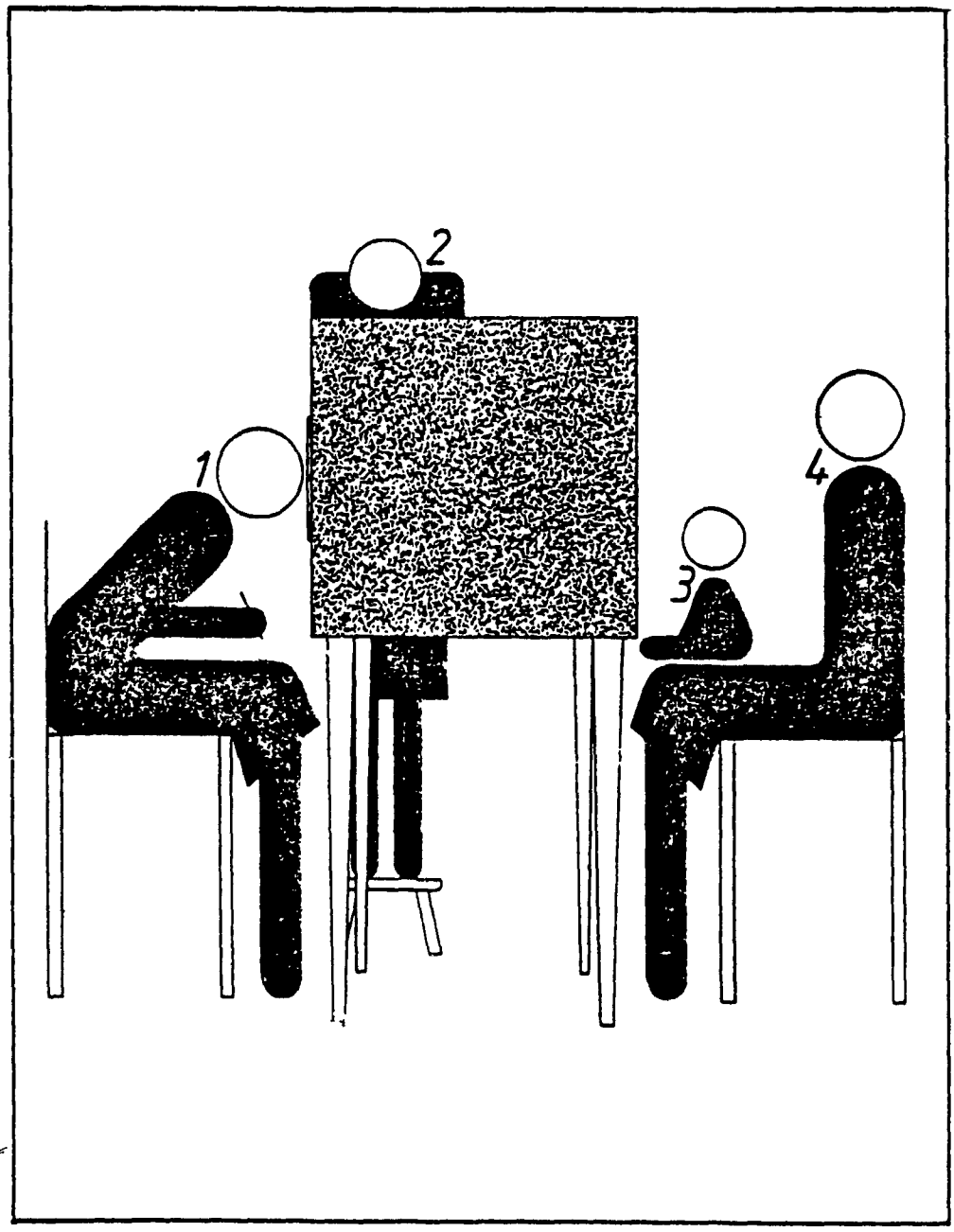
Visual habituation stimulus, 1 cm = 2.16 cm



Visual habituation stimulus scale, 1 cm = 2.16 cm



Visual habituation stimulus scale, 1 cm = 2.16 cm



1: Observer 1
2: Observer 2
3: Infant
4: Mother

Schematic representation of visual habituation apparatus showing the positions of the observers, the infant, and the mother.

1. Shielded light on stimulus
2. Mirror
3. Blinking light
4. O_1 peephole
5. O_2 peephole

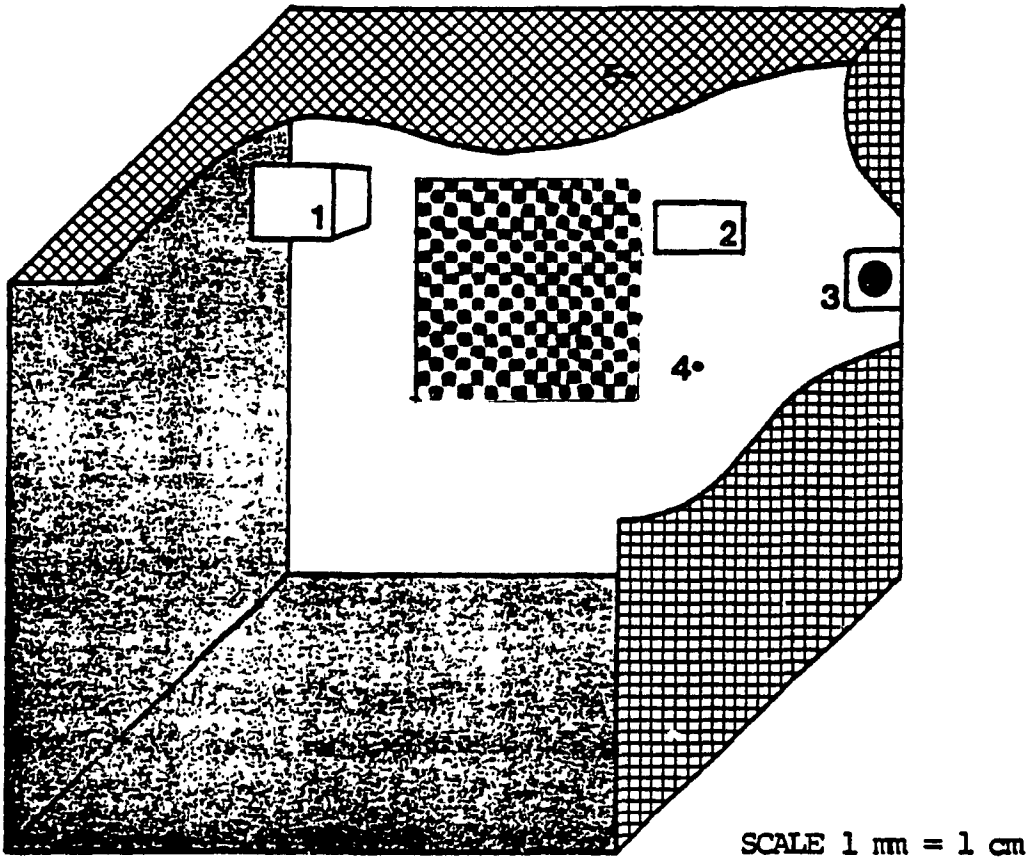
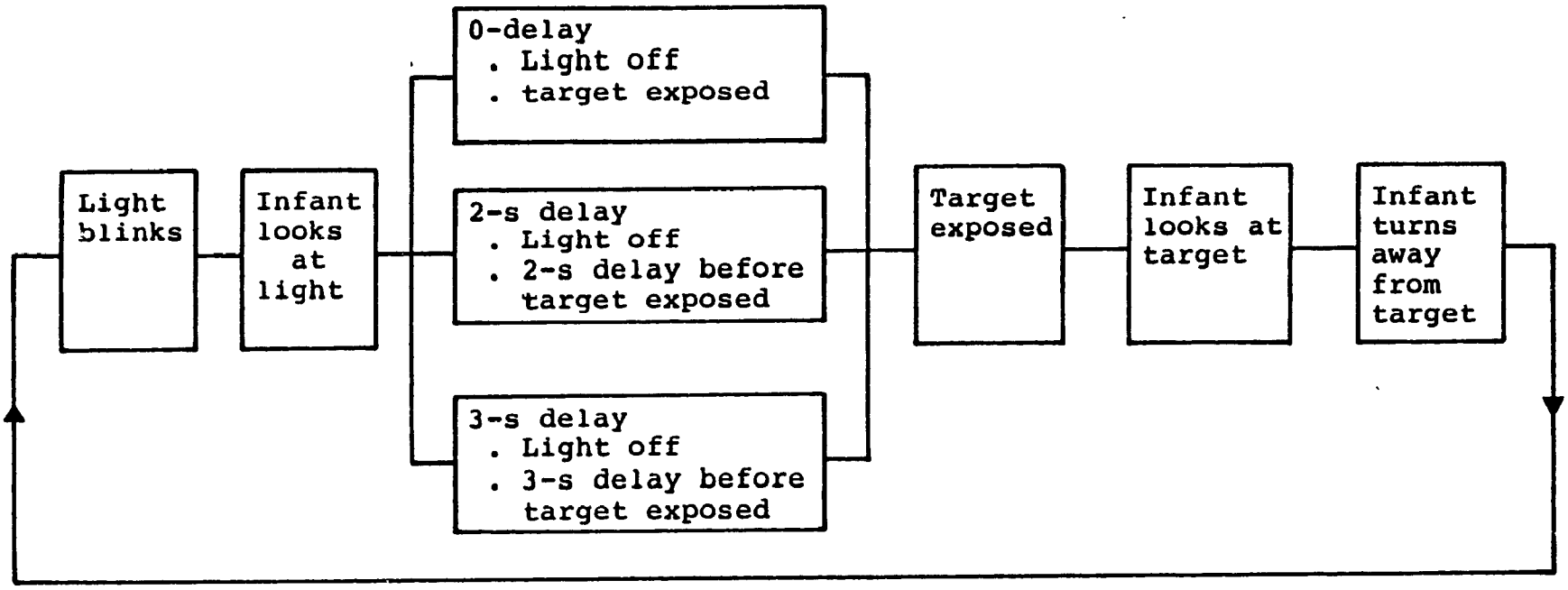


Diagram of visual habituation apparatus drawn to scale



Modification of Cohen's paradigm used in the study

Appendix D

Mean Break Length and Number of Habituators and Nonhabituators Experiencing a Break During Warm-up, Habituation and Dishabituation Trials in Each Delay Condition for Each Infant Group.

Appendix D-1

Break Length and Number of Preterm Infants Experiencing a Break During Visual Habituation

Preterm Infants		Delay Condition No delay	2-s delay	3-s delay
Break Length(s)	M	286.3	50.3	113.6
	SD	363.9	15.3	126.5
Habituators		8	6	8
Infants with one break		2	1	2
Infants with > one break		1	0	0
Warm-up		0	0	0
Hab. pre-criterion		0	0	0
Hab. post-criterion		3[a]	1	2
Dishabituation		1	0	0
Non Habituators		7	9	7
Infants with one break		1	3	3
Infants with > one break		0	1	0
Warm-up		0	0	0
Habituation 1-18 trials		1	7[b]	3
Dishabituation		0	0	0

Note.

N = 15.

[a] one infant had two breaks.

[b] one infant had three breaks.

Appendix D-2

Break Length and Number of Fullterm Infants Experiencing a Break During Visual Habituation

Fullterm Infants		Delay Condition No delay	2-s delay	3-s delay
Break Length(s)	M	299.6	121.5	202.8
	SD	447.7	44.9	175.5
Habituators		9	7	11
Infants with one break		2	4	1
Infants with > one break		1	2	1
Warm-up		1[a]	1[a]	1[b]
Hab. pre-criterion		1	1	0
Hab. post-criterion		2	3	4
Dishabituation		0	0	0
Non Habituators		6	8	4
Infants with one break		3	1	3
Infants with > one break		0	1	0
Warm-up		0	0	0
Habituation 1-18 trials		3	4[c]	3
Dishabituation		0	0	0

Note.

N = 15.

[a] one infant had a subsequent post-criterion break.

[b] one infant had three subsequent post-criterion breaks.

[c] one infant had three breaks during habituation trials.

Appendix D-3

Break Length and Number of Fullterm Infants in the Larger Sample Experiencing a Break During Visual Habituation

Fullterm Infants		Delay Condition No delay	2-s delay	3-s delay
Break Length(s)	M	194.3	62.9	77.1
	SD	311.3	49.2	83.8
Habituators		16	13	17
Infants with one break		2	6	4
Infants with > one break		1	1	1
Warm-up		1[a]	2[a]	1[b]
Hab. pre-criterion		1	4	0
Hab. post-criterion		2	3[c]	7
Dishabituation		0	0	0
Non Habituators		11	14	10
Infants with one break		4	3	4
Infants with > one break		1	1	1
Warm-up		0	1	0
Habituation 1-18 trials		6[d]	5[e]	6[d]
Dishabituation		0	0	0

Note.

N = 27.

[a] one infant had one subsequent post-criterion break.

[b] one infant had three subsequent post-criterion breaks.

[c] one infant had two post-criterion breaks.

[d] one infant had two breaks during habituation trials.

[e] one infant had three breaks during habituation trials.

Appendix D-4

Break Length and Number of Preterm Infants with Complication Experiencing a Break During Visual Habituation

Preterm Infants		Delay Condition No delay	2-s delay	3-s delay
Break Length(s)	M	103.8	12.7	34.6
	SD	57.5	4.3	16.7
Habituators		7	3	4
Infants with one break		3	1	0
Infants with > one break		0	1	2
Warm-up		0	1	0
Hab. pre-criterion		1	1	0
Hab. post-criterion		2	0	5[a,b]
Dishabituation		0	0	0
Non Habituators		2	6	5
Infants with one break		0	1	1
Infants with > one break		0	1	2
Warm-up		0	0	0
Habituation 1-18 trials		0	1[c]	6[c,d]
Dishabituation		0	0	0

Note.

N = 9.

[a] one infant had two post-criterion breaks.

[b] one infant had three post-criterion breaks.

[c] one infant had two breaks during habituation trials.

[d] one infant had three breaks during habituation trials.

Appendix E

Preliminary Analyses of the Data

Table E-1

Variables in Each Infant Group With in Delay conditions with Significant Skewness

Infant Groups	Delay Conditions	Measures	Skew
Preterms	No delay	First fixation time	1.96
Fullterms	No delay	First fixation time on trial block 1	1.83
		Mean intertrial interval to habituation criterion	2.62
	2-s delay	Fixation time on trial block 2	2.13
	3-s delay	Intertrial interval on trial block 6	2.15

Note: Significance of skew, $p<.01$

Table E-2

Number of Outlier Values

Measures	Infant Groups: Preterms, Delay Conditions: No delay	Preterms: 2-s	Preterms: 3-s	Infant Groups: Fullterms, Delay Conditions: No delay	Fullterms: 2-s	Fullterms: 3-s
First fixation time	1					
Mean intertrial interval to habituation criterion				1		
Fixation time on trial block 1				1		
Fixation time on trial block 2					1	
Latency to orient at trial block 3						1
Intertrial interval at trial block 6						

Table E-3

Bartlett Scores for Significant Univariate Tests of Homogeneity of Variance

Measures	Bartlett Scores
First fixation time	F(5,9072) = 2.04
Mean fixation time to habituation criterion	F(5,9072) = 1.43
Mean latency to orient to the habituation stimulus to criterion	F(5,9072) = .91
Mean intertrial interval (to criterion)	F(5,9072) = 18.00*
Trials to criterion	F(5,9072) = .85

*$p<.001$.

Appendix F

Means, Standard Deviations, Summary Tables and Figures Relating to Order Effects

Table F-1

Major Performance Measures to Criterion: Means and Standard Deviations for Each Presentation Order for Infant Groups Combined

Measures		Delay Conditions: No Delay, Order of Presentation 1st	No Delay 2nd	No Delay 3rd	2-s Delay 1st	2-s Delay 2nd	2-s Delay 3rd	3-s Delay 1st	3-s Delay 2nd	3-s Delay 3rd
Mean fixation time	M^a	.338	.403	.285	.233	.473	.478	.299	.378	.437
	SD^a	.13	.19	.09	.18	.25	.10	.31	.15	.19
Mean latency to orient to the habituation stimulus	M^a	.597	.906	.581	.487	.645	.535	.437	.524	.619
	SD^a	.24	.29	.33	.25	.20	.22	.22	.24	.30
Mean intertrial interval	M^a	.083	.181	.068	.095	.086	.065	.055	.080	.079
	SD^a	.04	.18	.02	.03	.03	.04	.03	.03	.02

Note: N = 30.

[a]Scores in reciprocals.

Table F-2

Summary Tables of the Analyses of Variance of Mean Performance Scores to the Habituation Criterion

Source	SS	df	MS	F
First fixation time				
Group	.010	1	.010	.08
Order	.341	2	.170	1.40
G x O	.070	2	.035	.29
Error	2.92	24	.122	
Condition	.066	2	.033	.58
C x G	.363	2	.181	3.18*
C x O	.409	4	.102	1.79
C x G x O	.058	4	.015	.26
Error	2.74	8	.057	

*$p<.05$.

Table F-2 (continued)

Summary Tables of the Analyses of Variance of Mean Performance Scores to the Habituation Criterion

Source	SS	df	MS	F
Mean latency to orient to the stimulus				
Group	.003	1	.003	.04
Order	.171	2	.085	.89
G x O	.044	2	.022	.23
Error	2.30	24	.095	
Condition	4.81	2	.240	4.05*
C x G	.078	2	.039	.66
C x O	.799	4	.199	3.36*
C x G x O	.081	4	.020	.34
Error	2.85	48	.059	

*$p<.02$.

Table F-2 (continued)

Summary Tables of the Analyses of Variance of Mean Performance Scores to the Habituation Criterion

Source	SS	df	MS	F
Mean fixation time				
Group	.022	1	.022	.39
Order	.232	2	.116	1.97
G x O	.075	2	.037	.64
Error	1.41	24	.059	
Condition	.041	2	.020	.68
C x G	.009	2	.005	.16
C x O	.324	4	.081	2.71*
C x G x O	.107	4	.026	.89
Error	1.43	48	.030	

*$p<.05$.

Table F-2 (continued)

Summary Tables of the Analyses of Variance of Mean Performance Scores to the Habituation Criterion

Source	SS	df	MS	F
Trials to criterion				
Group	24.54	1	24.54	.79
Order	91.35	2	45.68	1.47
G x O	14.95	2	7.48	.24
Error	745.47	24	31.06	
Condition	25.49	2	12.74	.53
C x G	58.29	2	29.14	1.22
C x O	123.91	4	30.98	1.30
C x G x O	206.71	4	51.68	2.17
Error	1144.93	48	23.85	

Table F-2 (continued)

Summary Tables of the Analyses of Variance of Mean Performance Scores to the Habituation Criterion

Source	SS	df	MS	F
Mean intertrial interval				
Group	.000	1	.000	.06
Order	.007	2	.003	.52
G x O	.017	2	.009	1.31
Error	.162	24	.007	
Condition	.025	2	.012	2.09
C x G	.012	2	.006	1.00
C x O	.077	4	.019	3.27
C x G x O	.033	4	.008	1.39
Error	.283	48	.006	

*$p<.02$.

Table F-3

Major Performance Measures for all Habituation Trials: Means and Standard Deviations for each Presentation Order

Measures		Delay Conditions: No Delay Order of Presentation 1st	No Delay 2nd	No Delay 3rd	2-s Delay 1st	2-s Delay 2nd	2-s Delay 3rd	3-s Delay 1st	3-s Delay 2nd	3-s Delay 3rd
Mean fixation time	M[a]	.349	.487	.283	.250	.496	.475	.323	.350	.433
	SD[a]	.15	.20	.08	.06	.21	.31	.20	.16	.26
Mean latency to orient to the habituation stimulus	M[a]	.555	.831	.537	.463	.647	.522	.441	.478	.602
	SD[a]	.32	.25	.26	.21	.26	.24	.29	.26	.24
Mean intertrial interval	M[a]	.081	.093	.064	.071	.085	.058	.061	.059	.070
	SD[a]	.04	.06	.02	.01	.03	.04	.03	.03	.03

Note: N = 30.

[a]Scores in reciprocals.

Table F-4

Summary Table of the Analyses of Variance of Mean Fixation Time for all Habituation Trials Including Order

Source	SS	df	MS	F
Group	.41	1	.041	.59
Order	.353	2	.176	2.51
G x O	.011	2	.006	.08
Error	1.68	24	.070	
Condition	.026	2	.013	.45
C x G	.022	2	.011	.38
C x O	.300	4	.075	2.57*
C x G x O	.055	4	.014	.47
Error	1.40	48	.029	

*$p<.05$.

Table F-4 (continued)

Summary Table of the Analyses of Variance of Mean Latency to Orient to the Stimulus for all Habituation Trials Including Order

Source	SS	df	MS	F
Group	.003	1	.003	.02
Order	.229	2	.115	.87
G x O	.006	2	.003	.02
Error	3.14	24	.131	
Condition	.287	2	.143	3.34*
C x G	.000	2	.000	.01
C x O	.634	4	.158	3.69**
C x G x O	.034	4	.008	.20
Error	.061	48	.043	

*$p<.05$

**$p<.01$

Table F-4 (continued)

Summary Table of the Analyses of Variance of Mean Intertrial Interval for all Habituation Trials Including Order

Source	SS	df	MS	F
Group	.002	1	.002	.83
Order	.004	2	.002	.79
G x O	.002	2	.001	.53
Error	.057	24	.002	
Condition	.003	2	.001	2.10
C x G	.000	2	.000	.12
C x O	.005	4	.001	1.86
C x G x O	.002	4	.000	.87
Error	.036	48	.000	

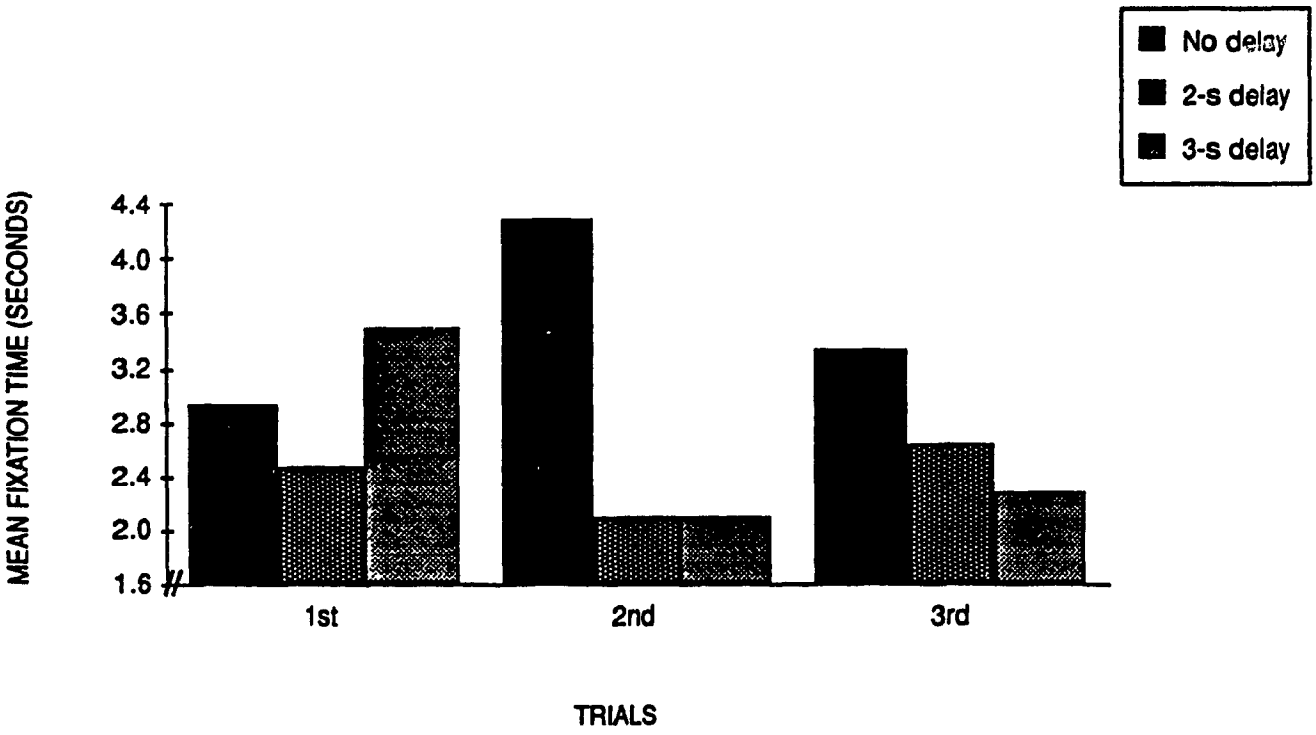


FIGURE F-1. Presentation order x delay condition for fixation time to criterion.

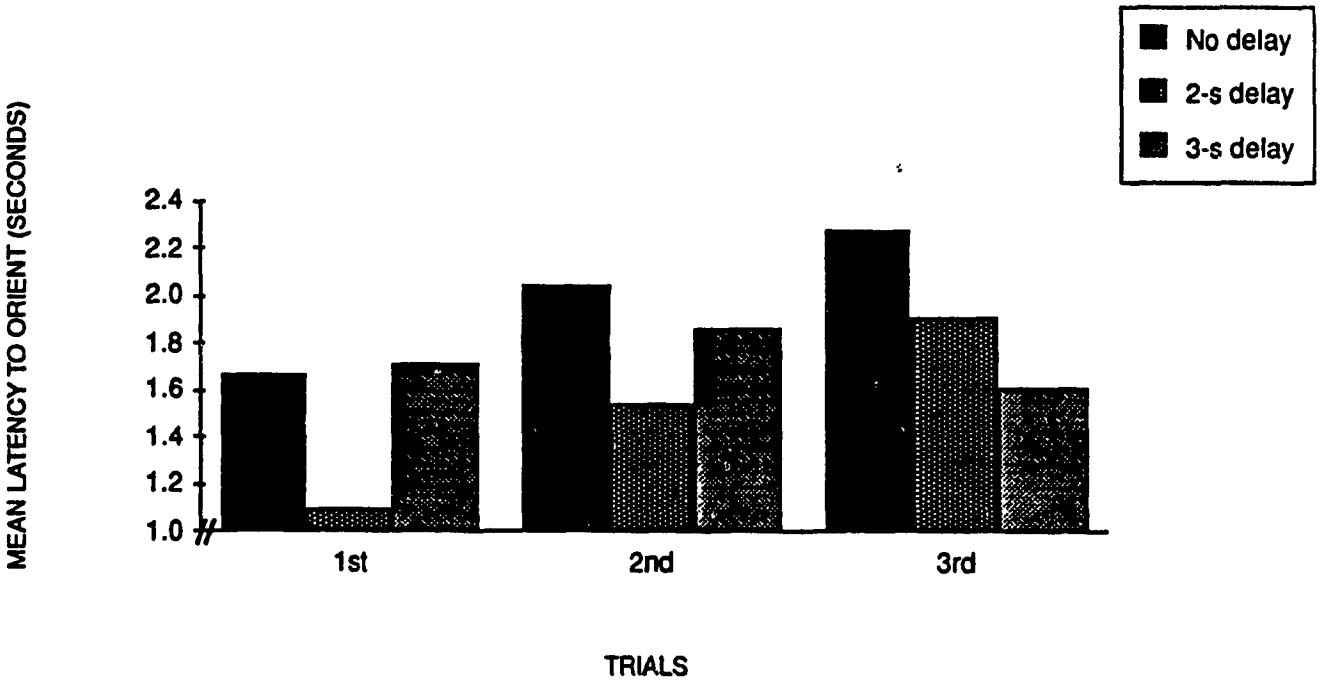


FIGURE F-2. Presentation order x delay condition interaction for latency to orient to the stimulus to criterion.

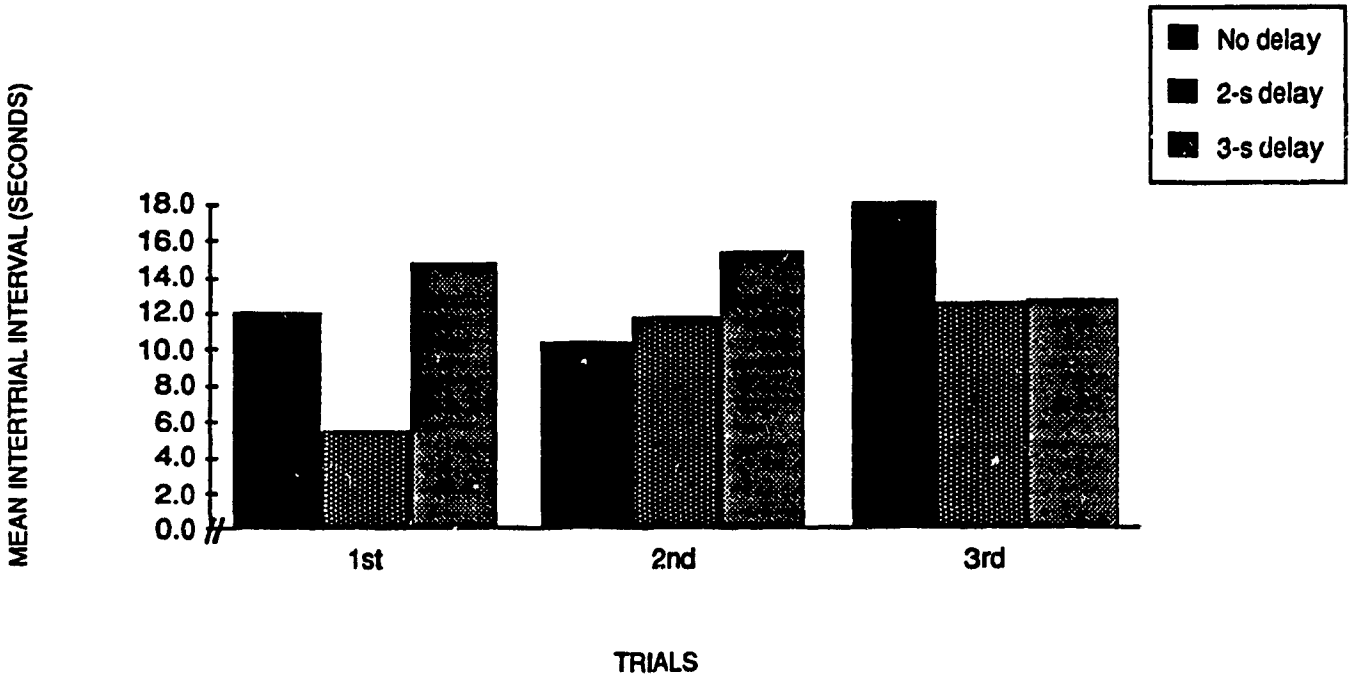


FIGURE F-3. Presentation order x delay condition interaction for intertrial interval to habituation criterion.

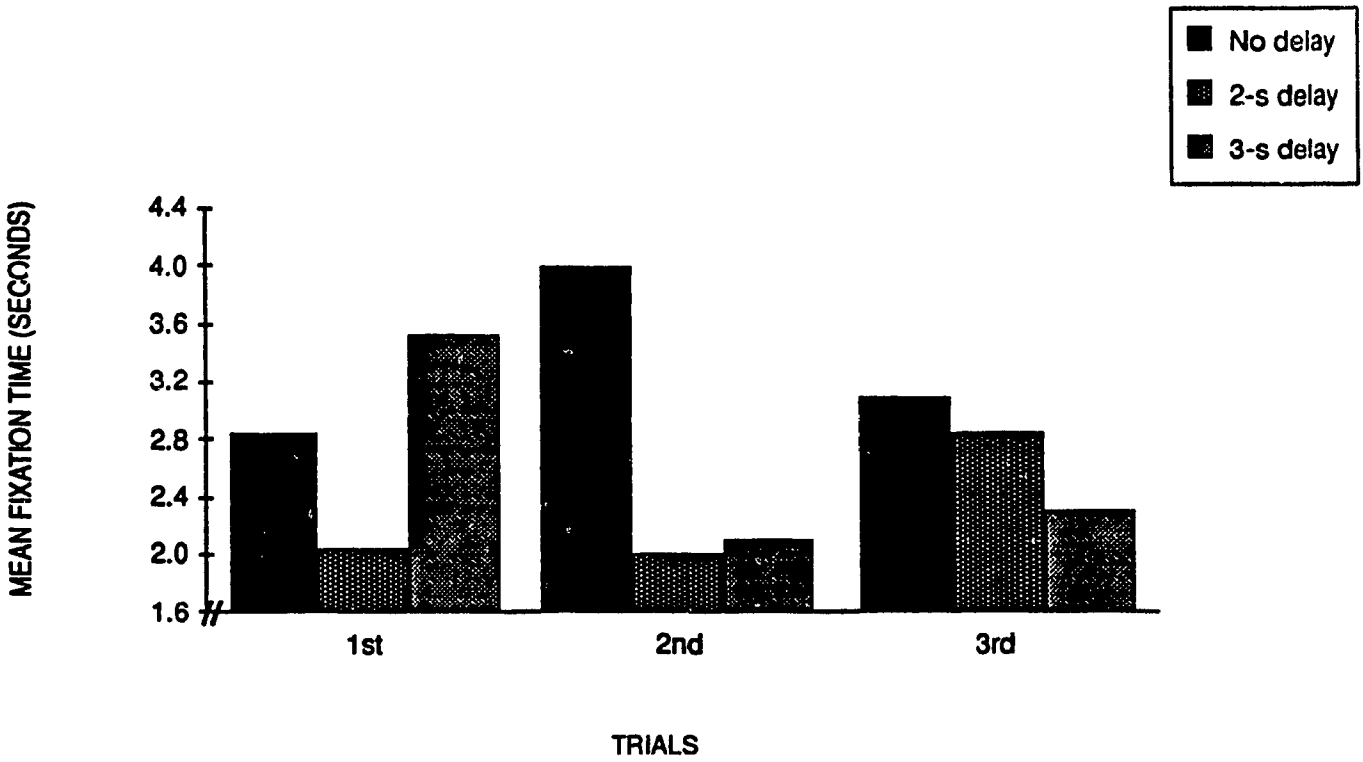


FIGURE F-4. Presentation order x delay condition interaction for fixation time for all habituation trials.

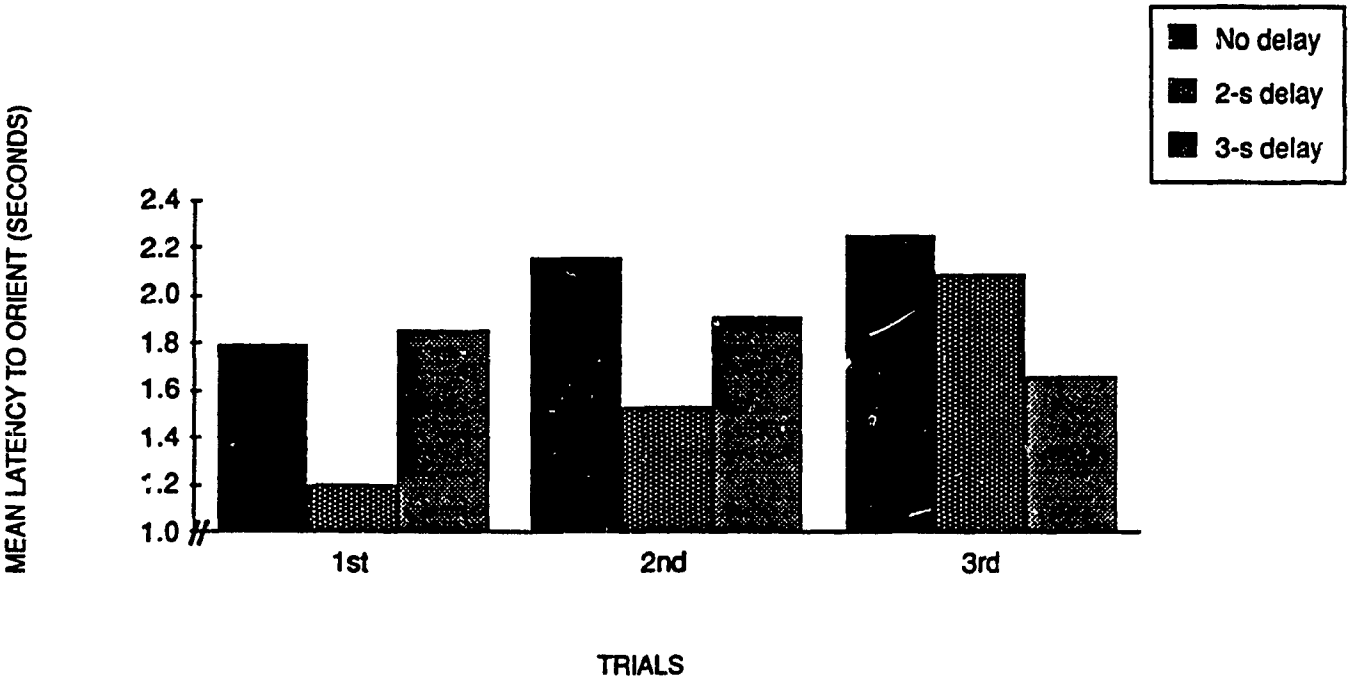


FIGURE F-5. Presentation order x delay condition interaction for latency to orient for all habituation trials.

Appendix G

Summary Table of the Analyses of Variance of Mean Performance Scores to Habituation Criterion and Table of Intercorrelations of the Measures

Table G-1

Source	SS	df	MS	F
Between Group				
Hotelling's T=1.65				.28
First fixation time	.01	1	.01	.09
Error	3.33	28	.12	
Mean fixation time	.02	1	.02	.37
Error	1.71	28	.06	
Mean Latency to orient	.003	1	.003	.04
Error	2.51	28	.089	
Mean intertrial interval	.0004	1	.0004	.06
Error	.186	28	.006	
Trials to criterion	.002	1	.002	.99
Error	.083	28	.002	
Within delay condition				
Hotelling's T=13.13 for C				.89
T=16.02 for C x G				1.09

(continued on next page)

Table G-1 (continued)

Source	SS	df	MS	F
First fixation time				
C	.065	2	.032	.57
C x G	.362	2	.181	3.17
Error	3.21	56	.057	
Mean fixation time				
C	.040	2	.020	.61
C x G	.009	2	.004	.14
Error	1.87	56	.033	
Mean latency to orient				
C	.048	2	.240	3.61
C x G	.077	2	.039	.58
Error	3.73	56	.067	
Mean intertrial interval				
C	.024	2	.012	1.75
C x G	.011	2	.005	.84
Error	.394	56	.007	
Trials to criterion				
C	.001	2	.000	.24
C x G	.006	2	.003	1.16
Error	.149	56	.002	

Table G-2

Intercorrelations of Performance Measures

to Habituation Criterion for Infant Groups Combined

Measures	No delay				2-s delay				3-s delay			
	1	2	3	4	1	2	3	4	1	2	3	4
First fixation time												
Mean fixation time	.27				.54*				.75**			
Mean latency to orient to the stimulus	-.18	.18			.07	.31			-.14	-.04		
Mean intertrial interval	.35	.12	.31		-.31	.13	.33		-.02	.12	.01	
Trials to criterion	.28	.01	-.03	.15	.53**	.29	-.01	-.26	.35*	.36*	.25	-.18

Note: N = 15 per group.

*p<.01
**p<.001

Appendix H

Means, Standard Devations, Summary Table of the Analyses of Variance of Scores Including Trial Blocks and Table of Intercorrelations of the Measures

Table H-1

Summary Tables of the Analyses of Variance of Habituation Performance Including Trial Blocks

Source	SS	DF	MS	F
Between group				
Hotelling's T = .609				.19
Fixation time	1.26	1	.126	.27
Error	13.241	28	.472	
Latency to orient	.008	1	.008	.03
Error	8.33	28	.298	
Intertrial interval	.006	1	.006	.37
Error	.450	28	.016	
Within delay condition, Block				
Hotelling's T = 32.8 for C				4.49
Hotelling's T = 5.26 for C X G				.72
Hotelling's T = 63.23 for B				2.11
Hotelling's T = 41.94 for B X G				1.40
Fixation time				
C	.114	2	.057	.29
C X G	.278	2	.138	.71
Error	11.01	56	.196	
B	.592	5	.118	2.40*

(continued on next page)

Table H-1 (continued)

Source	SS	DF	MS	F
B X G	.721	5	.144	2.92*
Error	6.92	140	.049	
C X B	.210	10	.021	.54
C X B X G	.149	10	.015	.39
Error	10.87	280	.039	
Latency to orient				
C	1.62	2	.809	6.82**
C X G	.060	2	.030	.25
Error	6.64	56	.118	
B	.872	5	.174	2.87*
B X G	.128	5	.025	.42
Error	8.51	140	.060	
C X B	.544	10	.054	1.02
C X B X G	.293	10	.029	.55
Error	14.99	280	.053	

* $p < .05$

** $p < .001$

Table H-2

Means and Standard Deviations Over Trial Blocks Across Delay Conditions for the Measures for Infant Groups Combined

		Trial blocks					
		Block 1	Block 2	Block 3	Block 4	Block 5	Block 6
Fixation time	M[a]	.397	.405	.465	.466	.466	.482
	SD[a]	.26	.26	.29	.32	.28	.30
Latency to orient to the habituation stimulus	M[a]	.698	.663	.692	.724	.595	.679
	SD[a]	.26	.27	.26	.26	.30	.29
Intertrial interval	M[a]	.097	.094	.092	.099	.089	.076
	SD[a]	.05	.05	.05	.06	.05	.04

Note: N = 30.

[a]Scores in reciprocals.

Table H-3

Intercorrelations of Performance Measures

for all Habituation Trials for Infant Groups Combined

Measures	No delay			2-s delay			3-s delay		
	1	2	3	1	2	3	1	2	3
Mean fixation time									
Mean latency to orient to the stimulus	.45**			.46**			-.33		
Mean intertrial interval	.72***	.36*		.36*	.54**		.28	.08	
Trials to criterion	-.03	.01	-.07	.24	.14	-.06	.34	-.10	.13

*p<.05
**p<.01
***p<.001

Appendix I

Summary Tables of the Analyses of Variance of Fatigue and Dishabituation Effects

Table I-1

Summary Table of the Analyses of Variance of Fatigue Eeffects

Source	SS	df	MS	F
Between				
Group	.062	1	.062	.68
Error	2.55	28	.091	
Within				
C	.024	2	.012	.25
C X G	.043	2	.021	.44
Error	2.73	56	.049	
Trial	.242	1	.242	4.49*
T X G	.000	1	.000	.00
Error	1.51	28	.054	
C X T	.019	2	.009	.26
C X T X G	.143	2	.071	1.94
Error	2.07	56	.037	

*$p < .05$

Table I-2

Summary Table of the Analyses of Variance of Dishabituation Effects

Source	SS	df	MS	F
Between				
Group	.060	1	.060	.32
Error	5.24	28	.187	
Within				
C	.033	2	.017	.18
C X G	.091	2	.045	.48
Error	5.26	56	.094	
Trial	.655	1	.655	14.07*
T X G	.000	1	.000	.01
Error	1.30	28	.047	
C X T	.112	2	.056	1.13
C X T X G	.073	2	.036	.73
Error	2.79	56	.050	

*$p < .001$

Appendix J

Definitions of Patterns of Habituation According to the Lornstein and Benasich (1986) Classification System

Appendix J

Exponential Decrease:

A function that declines from baseline to habituation criterion and has no peak after the baseline greater than the first trial or greater than the baseline.

Increase-Decrease:

A unimodal function in which at least the first two consecutive trials after the first trial are greater than the first trial before descent to the habituation criterion.

Fluctuating:

A complex function that is minimally bimodal, has minimally two reversals of direction, and has at least one peak higher than the baseline and/or one valley lower than the habituation criterion.

(Bornstein and Benasich, 1986, p.90)

Appendix K

Summary Tables of all Analyses of Variance and Related Figures Pertaining to the Larger Fullterm Infant Sample

Table K-1

Summary Table of the Analysis of Variance of Fixation Time Scores for Fullterm Infants Including Order

Source	SS	df	MS	F
Order	.77	2	.39	.72
Error	12.85	24	.53	
Delay Condition	1.60	2	.80	4.60*
C X O	1.37	4	.34	1.97
Error	8.36	48	.17	
Block	.58	5	.12	1.92
B X O	.20	10	.02	.34
Error	7.28	120	.06	
C X B	.37	10	.04	.70
C X B X O	1.15	20	.06	.32
Error	12.30	240	.05	

*$p<.02$

Table K-2

Summary Table of the Analysis of Variance of Latency to Orient to the Stimulus Scores for Fullterm Infants Including Order

Source	SS	df	MS	F
Order	.47	2	.23	.98
Error	5.74	24	.24	
Delay Condition	2.01	2	1.00	5.15**
C X O	.81	4	.20	1.04
Block	1.08	5	.22	2.79*
B X O	.55	10	.05	.71
Error	9.30	120	.08	
C X B	.83	10	.08	1.04
C X B X O	.85	20	.04	.53
Error	19.20	240	.08	

*$p<.02$

**$p<.01$

Table K-3

Summary Table of the Analysis of Variance of Intertrial Interval Scores for Fullterm Infants Including Order

Source	SS	df	MS	F
Order	.03	2	.01	.29
Error	1.19	24	.05	
Delay Condition	.08	2	.04	1.72
C X O	.09	4	.02	1.03
Error	1.07	48	.02	
Block	.03	5	.006	2.28
B X O	.02	10	.001	.61
Error	.34	120	.002	
C X B	.03	10	.003	1.17
C X B X O	.07	20	.003	1.41
Error	.62	240	.002	

Table K-4

Summary Tables of the Analyses of Variance of Habituation Performance for Fullterm Infants Including Trial Blocks

Source	SS	df	MS	F
Within				
Delay Condition, Trial Blocks				
Hotelling's T = 39.0 for C				5.26
Hotelling's T = 38.3 for B				1.18
Hotelling's T = 28.91 for C X B				1.00
Fixation Time				
C	1.60	2	.80	4.28**
Error	9.73	52	.19	
B	.58	5	.12	2.03
Error	7.48	130	.06	
C X B	.37	10	.04	.72
Error	13.45	260	.05	
Latency to Orient				
C	2.00	2	1.00	5.14***
Error	10.16	52	.19	
B	1.08	5	.22	2.85**
Error	9.85	130	.07	
C X B	.83	10	.08	1.08
Error	20.05	260	.08	

Table K-4 (continued)

Source	SS	df	MS	F
Intertrial Interval				
C	.08	2	.04	1.72
Error	1.16	52	.02	
B	.03	5	.006	2.35*
Error	.36	130	.002	
C X B	.03	10	.003	1.13
Error	.69	260	.002	

*p<.05

**p<.02

***p<.01

Table K-5

Summary Table of the Analysis of Variance of First Fixation Time for Fullterm Infants

Source	SS	df	MS	F
Delay Condition	.24	2	.12	.79
Error	7.88	52	.15	

Table K-6

Summary Table of the Analysis of Variance of Trials to Criterion for Fullterm Infants

Source	SS	df	MS	F
Delay condition	41.51	2	20.75	.74
Error	1457.2	52	28.02	

Table K-7

Summary Table of the Analysis of Variance of Fatigue Effects for Fullterm Infants

Source	SS	df	MS	F
Delay Condition	.061	2	.03	1.06
Error	1.51	52	.03	
Trial	.00	1	.00	.00
Error	1.32	26	.05	
C X T	.02	2	.01	.26
Error	2.02	52	.04	

Table K-8

Summary Table of the Analysis of Variance of Dishabituation Effects for Fullterm Infants

Source	SS	df	MS	F
Delay Condition	.17	2	.08	1.15
Error	3.81	52	.07	
Trial	1.08	1	1.08	34.49*
Error	.89	26	.03	
C X T	.09	2	.05	.95
Error	2.52	52	.05	

*$p < .001$

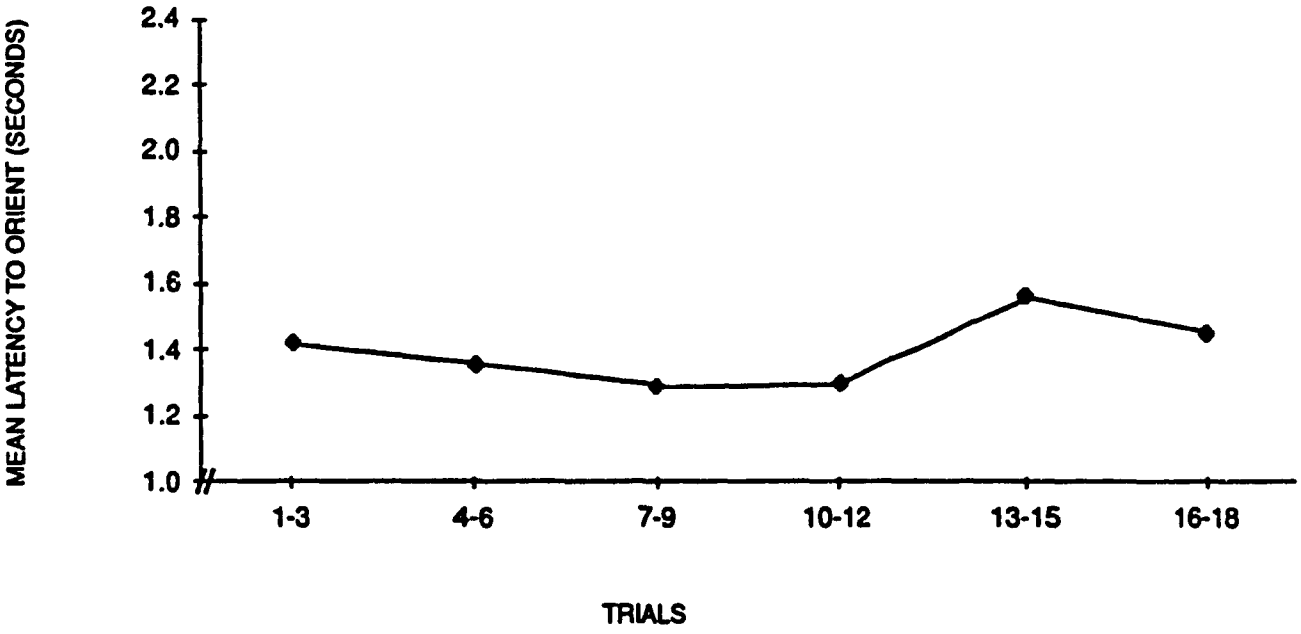


FIGURE K-1. Quadratic trend for latency to orient to the stimulus for *fullterm infants*

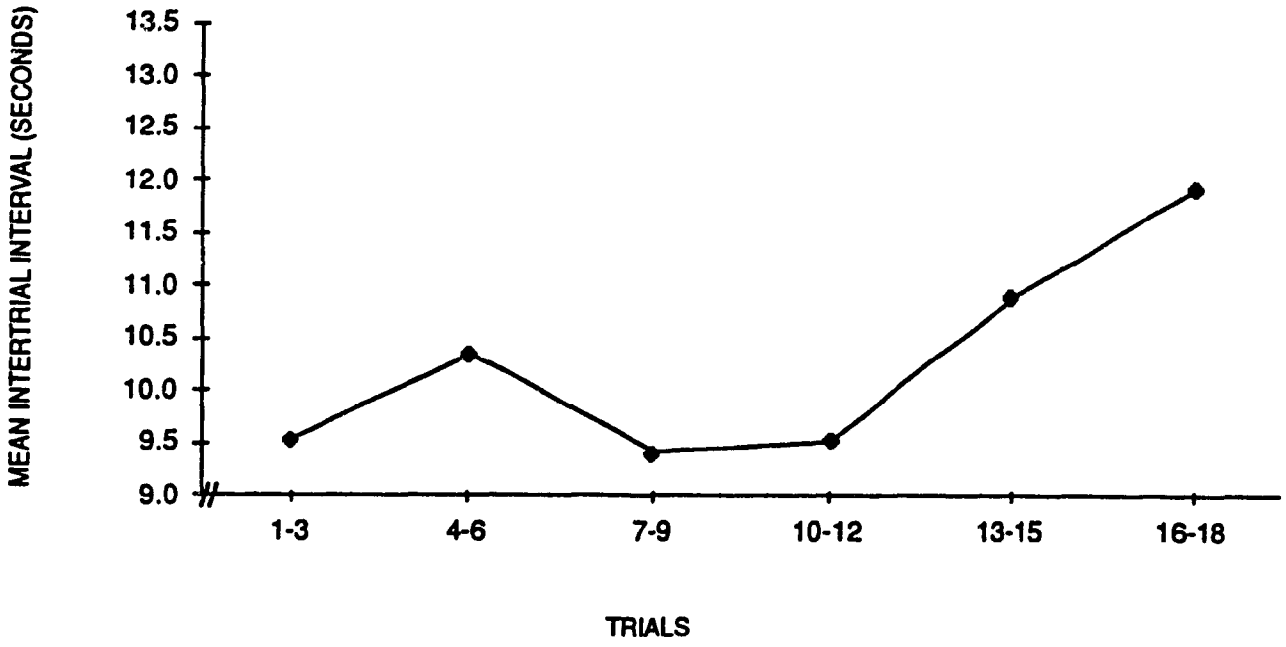


FIGURE K-2. Trial block effect for intertrial interval for fullterm infants.

Appendix L

Sample Characteristics, Summary Tables of all Analyses of Variance and Related Figures for the Heterogeneous Preterm Infant Sample

Table 4-1

Characteristics of the Sample of Preterm Infants With Medical Complications

Complications	Subject number 1	2	3	4	5	6	7	8	9
Around Birth									
Bilirubin Level > 15 mg/dl	X	X	X						
Blood Glucose Level <30 mg/kg				X	X	X			
C Section							X		
Mild RDS								X	
Tachypnea							X		
Detected Later Through Maternal Report									
Congenital Malformation[a]							X		
Failure to Thrive								X	
Pneumonia Post Discharge									X

Note: The sample was comprised of 8 males, 1 female
M GA was 34 weeks, 2 days (SD = 12.8, Range 32 - 36 weeks)
M Birthweight was 2310 grams (SD = 420.1, Range 1740 - 2980 grams)
[a] only one enlarged k[illegible] present.

Table L-2

Summary Tables of the Analyses of Variance of Fixation Time Including Trial Blocks for Preterm Infant Groups

Source	SS	df	MS	F
C	.14	2	.07	.43
C X G	.94	2	.47	2.86
Error	7.26	44	.16	
B	.97	5	.19	3.98*
B X G	.45	5	.09	1.83
Error	5.37	110	.05	
C X B	.25	10	.025	.64
C X B X G	.53	10	.053	1.38
Error	8.53	220	.04	

* $p<.01$

Table L-2

Summary Tables of the Analyses of Variance of Latency to Orient to the Stimulus Including Trial Blocks for Preterm Infant Groups

Source	SS	df	MS	F
C	1.53	2	.77	4.51*
C X G	.08	2	.04	.25
Error	7.49	44	.17	
B	.46	5	.09	1.48
B X G	.00	5	.00	.02
Error	6.85	110	.06	
C X B	.73	10	.07	1.21
C X B X G	.88	10	.09	1.46
Error	13.28	220	.06	

*$p < .02$

Table L-2

Summary Tables of the Analyses of Variance of Intertrial Interval Including Trial Blocks for Preterm Infant Groups

Source	SS	df	MS	F
C	.05	2	.03	7.58**
C X G	.00	2	.00	.72
Error	.16	44	.00	
B	.03	5	.00	2.73*
B X G	.02	5	.00	1.65
Error	.21	110	.00	
C X B	.01	10	.00	.61
C X B X G	.01	10	.00	.64
Error	.37	220	.00	

* $p < .02$

** $p < .001$

Table L-3

Summary Table of the Analysis of Variance of First Fixation Time for Preterm Infant Groups

Source	SS	df	MS	F
Group	.08	1	.08	.50
Error	3.73	22	.17	
Delay Condition	.01	2	.00	.08
C X G	.36	2	.18	2.72
Error	2.91	44	.07	

Table L-4

Summary Table of the Analysis of Variance of Trials to Criterion for Preterm Infant Groups

Source	SS	df	MS	F
Group	9.07	1	9.07	.24
Error	824.58	22	37.48	
Delay Condition	54.65	2	27.32	1.20
C X G	46.31	2	23.15	1.02
Error	998.49	44	22.69	

Table L-5

Summary Table of the Analysis of Variance of Fatigue Effects for the Heterogeneous Preterm Sample

Source	SS	df	MS	F
Delay Condition	.01	2	.01	.11
Error	3.11	46	.07	
Trial	.02	1	.02	.20
Error	1.97	23	.09	
C X T	.02	2	.01	.23
Error	1.43	46	.03	

Table L-6

Summary Table of the Analysis of Variance of Dishabituation for the Heterogeneous Preterm Sample

Source	SS	df	MS	F
Delay Condition	.15	2	.07	.75
Error	4.57	46	.10	
Trial	.82	1	.82	9.32*
Error	2.03	23	.09	
C X T	.05	2	.02	.50
Error	2.13	46	.05	

*$p<.01$

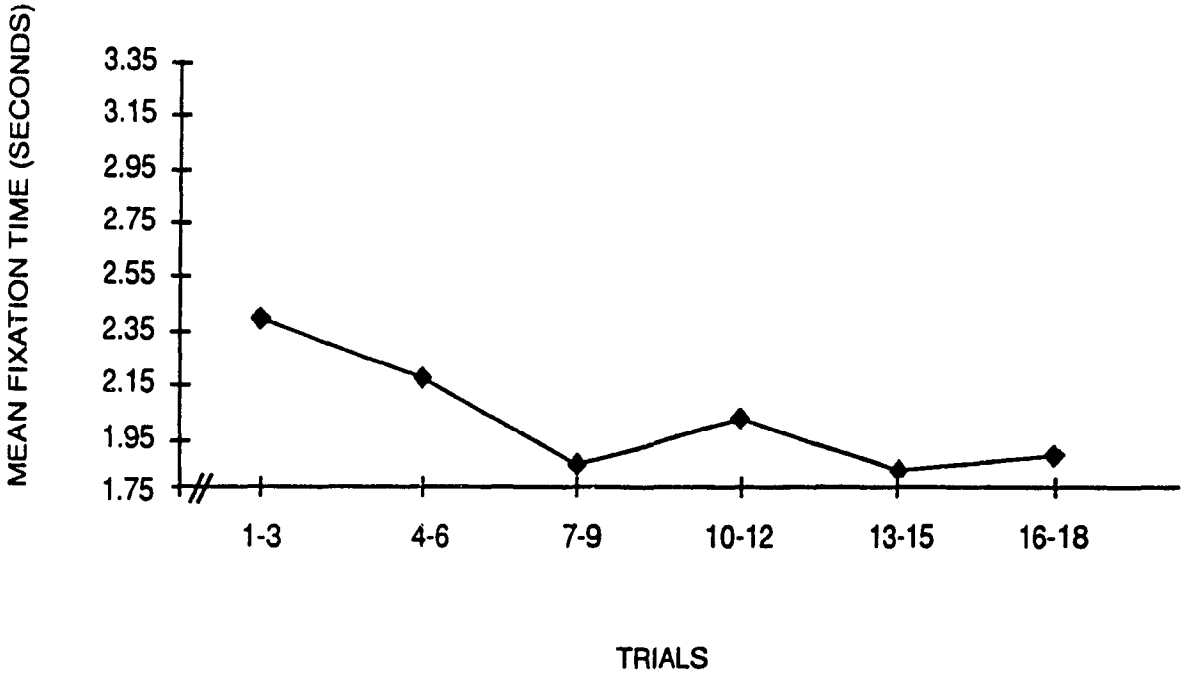


FIGURE L-1. **Linear trend for fixation time for the heterogeneous preterm sample.**

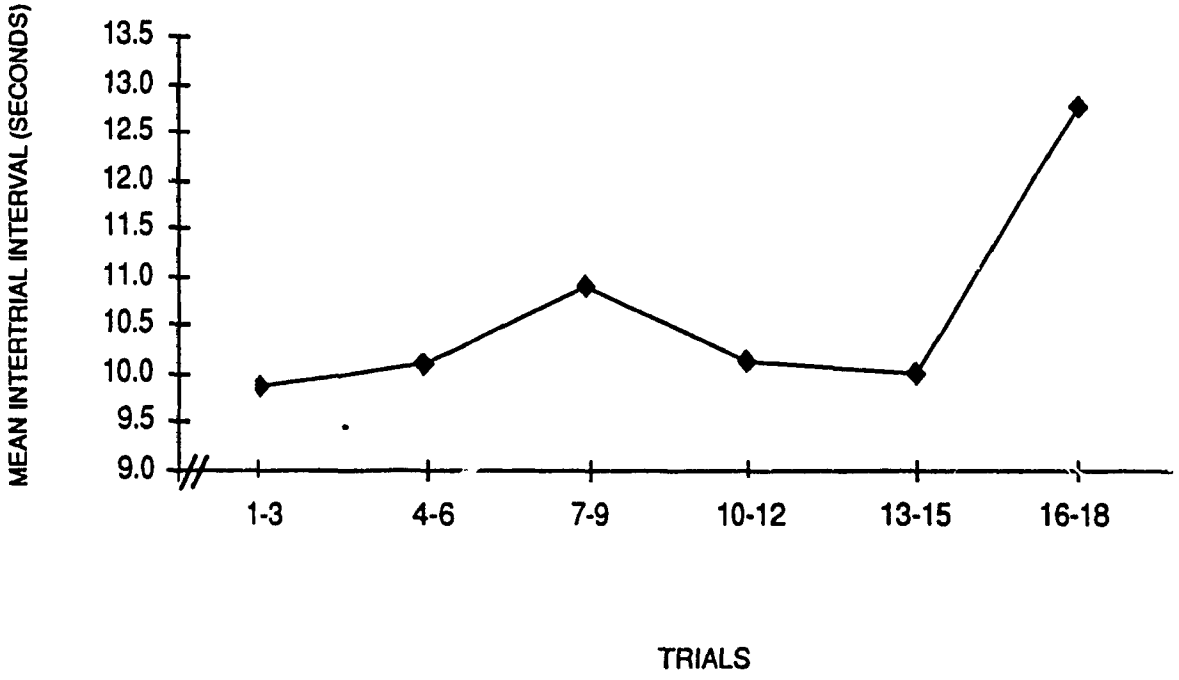


FIGURE L-2. Cubic trend for intertrial interval for the heterogeneous preterm sample.