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The Effect of an Early Sensorimotor Intervention Program on the Development of Infants with Perinatal Intraventricular Hemorrhage

Janet Millard
Utah State University

THE EFFECT OF AN EARLY SENSORIMOTOR INTERVENTION PROGRAM ON THE DEVELOPMENT OF INFANTS WITH PERINATAL INTRAVENTRICULAR HEMORRHAGE

by

Janet Millard

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ABSTRACT

The Effect of an Early Sensorimotor Intervention Program on the Development of Infants with Perinatal Intraventricular Hemorrhage

by

Janet Millard, Doctor of Philosophy

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Major Professor: Glendon Casto, Ph.D.
Department: Psychology

Our current ability to identify and appropriately treat infants who are at risk for developing various handicapping conditions is limited. Thus, research aimed at developing early diagnostic techniques and differential intervention programs for infants at risk for handicaps needs further attention. The purpose of this study was to determine if infants who suffered perinatal intraventricular hemorrhage and who received routine medical care plus sensorimotor intervention between 3 and 12 months of age, differed from similar infants who received only routine medical care.

Twenty-four subjects (10 experimental and 14 control) who were patients in neonatal intensive care at University of Utah or Primary Children's Medical Centers constituted the study sample. Descriptive data specific to the birth and perinatal period were obtained on the infant and its mother.

All infants were evaluated with the Battelle Developmental Inventory at 3 and 12-months corrected age. In addition, the Carey

Infant Temperament Questionnaire was completed by the parent when the infant was 6 to 9 months corrected age, and the Parenting Stress Index was completed when the infants was 12 months corrected age.

Experimental subjects and their parent(s) participated in an individualized sensorimotor intervention program, directed by a licensed physical therapist, for 1 hour per week on a bi-monthly basis. Parents reported spending an average of 20 minutes per day, 5 days per week, working on exercises with their infant at home throughout the 9-month program.

A statistically significant positive relationship was found between developmental outcome and participation in sensorimotor intervention, as measured by the posttest Battelle. No significant differences between groups were found on levels of parenting stress. On each of the measures, stress levels were moderate. Continued enrollment and annual follow-up of subjects in the current study will allow for longitudinal evaluation of the effects of early sensorimotor intervention on development.

(104 pages)

CHAPTER I

INTRODUCTION

Introduction and Statement of the Problem

Since the implementation of Public Law 94-142, an act which made provisions for educational assistance to all handicapped children, there has been a dramatic increase in the availability and quality of services for handicapped infants and children (Mulliken & Buckley, 1983). This increase has been accompanied by a heightened public awareness of the importance of treating the individual once a handicap has been identified, and of directing efforts toward earlier identification, prediction, and prevention of such conditions (Hunt, 1980). With Public Law 99-457 mandating early preschool services, it is anticipated that public and professional interest will continue to grow.

Our current ability to identify and appropriately treat children who are at risk for developing various handicapping conditions is limited (Mulliken & Buckley, 1983). Thus, research aimed at developing early diagnostic techniques and differential intervention programs for infants at risk for handicaps needs further attention.

One little explored, yet potentially important, indicator of later handicapping conditions is the occurrence of cerebral intraventricular hemorrhage (IVH) during the first few days of life in low birth weight (LBW) and, on rare occasions, full-term infants (greater than 2,500 grams). Simply described, an intraventricular hemorrhage is the development of a lesion in the infant's brain which produces an abnormal bleeding from cranial capillaries which may extend into the ventricular system. The bleeding is believed to result in different degrees of neurological damage based on the severity of the hemorrhage (Volpe, 1981).

Brain-imaging procedures such as real-time ultrasonography and computed tomography (CT) scan (see Appendix D for a glossary of terms) are used to make a positive identification of IVH and to classify the hemorrhage into one of four stages of severity. Stage One IVH is the most mild form of hemorrhage, whereas Stage Four IVH is the most severe (Papile, Burstein, Burstein, & Koffler, 1978). Stage One IVH occurs in the subependyma at either the germinal matrix or the choroid plexus. Stage Two hemorrhage is a subependymal hemorrhage with extension into the ventricles, but with normal ventricular size. Stage Three IVH is a subependymal hemorrhage, with extension to the ventricles, which is accompanied by moderate to severe ventricular dilatation. Stage Four, the most severe form of IVH, is a subependymal hemorrhage with ventricular extension, with or without dilatation, plus a parenchymal lesion. Dramatic clinical symptoms such as seizures, loss of muscle tonus, cessation of breathing, and unreactive pupils may mark the onset of IVH; however, at times IVH is clinically silent (Tarby & Volpe, 1982).

Approximately 10% of all infants born in the U.S. are premature with low birth weights, and 31-55% of these infants suffer IVH (Ahmann, Lazzara, Dykes, Brann, & Schwartz, 1980; Bowerman, Donn, Silver, & Jaffe, 1984). As noted previously, IVH also has been observed on rare occasion in full-term normal birth weight (NBW) infants (Fenichel, Webster, & Wong, 1984) as well as in utero (Hill & Rozdilsky, 1984).

Thus, it is readily apparent that IVH has come to be known as one of the major health problems in the newborn intensive care unit (Pasternak, Groothuis, Fischer, & Fischer, 1983).

Of infants who suffer IVH, an estimated 50-60% survive (Volpe, 1981). However, information on the future developmental progress in this population is limited and controversial (Hynd, Hartlage, & Noonan, 1984). For example, Williamson, Desmond, Wilson, Andrew, and Garcia-Prats (1982) found that 29% of IVH Stage One and Two LBW infants exhibited moderate handicapping conditions by the age of 3, whereas Papile, Munsick-Bruno, and Schaefer (1983) found that only 15% of such children could be diagnosed as having these handicaps. Both Papile et al. (1983) and Williamson et al. (1982) found that up to 80% of premature LBW survivors who experienced Stage Three or Four IVH demonstrated moderate to severe handicapping conditions, such as cerebral palsy, by the third year of life.

The problem addressed in this study is the dearth of information which presently exists about the relationship between IVH in infants and handicapping conditions exhibited later on in childhood (Hynd et al., 1984; Stewart, 1983). More importantly, there is no published research on the differential effects of early treatment programs designed to minimize or ameliorate the effects of IVH.

Purpose and Objectives

The purpose of this study was to compare the developmental status of a control group of IVH infants who received only routine medical care between the ages of 3 and 12 months with that of an experimental group of similar infants with IVH exposed to an early sensorimotor intervention program based on individual need during the same period of time. This study served as the initial phase of a projected seven-year follow-up study. Data collected throughout the later phases of the longitudinal study will be used to determine the degree to which the later incidence of handicapping conditions (especially mild handicaps such as learning disabilities, behavioral disorders, educable mental retardation, language impairment, and hyperactivity) is associated with IVH during the neonatal period, and whether a sensorimotor intervention program begun in the first year of life prevents, or decreases the intensity of, any of these conditions.

The specific objective of this study was:

To determine whether infants who suffered IVH in the immediate period following birth, and who received routine medical care and early sensorimotor intervention between 3 and 12 months of age, differed from similar infants who received only routine medical care and intervention.

The specific hypothesis tested was:

Infants who suffered IVH immediately following birth, and who were exposed to routine medical care and early sensorimotor intervention between the ages of 3 and 12 months, have developmental scores on the Battelle Developmental Inventory (BDI) that are the same as those of similar infants who received only routine medical care and intervention.

CHAPTER II

REVIEW OF THE LITERATURE

This chapter describes, synthesizes, and critiques previous research on pre- and full-term infant development particularly as it relates to outcome based on participation in early intervention. The chapter is divided into the following major sections: (1) Pre- and full-term infant development, (2) early intervention studies, (3) incidence and etiology of intraventricular hemorrhage, and (4) intraventricular hemorrhage outcome studies.

Pre- and Full-Term Infant Development

Childbirth always has been seen as potentially dangerous to expectant mothers. However, in the last two decades, consideration also has been given to the risks infants must face and overcome if they are to survive (Stewart, 1983). In the early 1960s, it was speculated that, even in the absence of gross congenital defects, physiological events, such as hypoxia, were responsible for infant deaths. Furthermore, these same physiological events were thought to result in central nervous system damage in infants who did survive.

Premature low-birth-weight (LBW) infants, as compared to full-term normal-birth-weight (NBW) infants, are known to be particularly susceptible to abnormal physiological stressors due to the immaturity of their organ systems. In addition, many premature LBW infants are subjected to artificial means of meeting their physiological needs (e.g., assisted ventilation, supplemental oxygen, and closely regulated temperature of the external environment) until such a time that their own organ systems can take over the full responsibility (Stewart, 1983).

The remainder of this section provides a review of studies that have evaluated the long-term development of LBW survivors, as well as those which have compared the outcomes of low birth weight and normal birth weight infants.

Low Birth Weight Longitudinal Studies

Several researchers have directed longitudinal follow-up studies with the aim of assessing the impact of perinatal, social, and biological factors on subsequent development of LBW infants. For example, from 1966 through 1977, Stewart (1983) undertook a study of 694 preterm infants weighing from 500 to 1,500 grams, in order to discover the incidence of serious handicapping conditions among survivors. Although the objective of the study was to log serious handicaps, Stewart examined the data for possible relationships between perinatal events and long-term development of the infants who survived. It is instructive to further examine this study.

All infants in the study were admitted to the neonatal unit of University College Hospital, London. Three hundred thirty-eight subjects were inborn and 356 were transferred to the hospital shortly after birth. All infants were managed intensively in the perinatal period, e.g., they were promptly resuscitated at birth and subsequently, if needed, were given mechanical support of respiration, as necessary; were protected as much as possible from developing biochemical problems such as hypoglycemia, hypoxia, and hyperbilirubinemia; and, were provided with adequate nutrition and warmth. After the infants left the hospital, they were evaluated periodically as outpatients through the follow-up clinic.

During the 12-year study, 276 (39%) of the infants died within the first 28 days of life and 36 died between the ages of 29 days and 2 years. Of those 382 who survived, 166 were male and 216 female. A total of 299 infants resulted from single pregnancies, whereas the rest were from twin (n = 60) or other multiple (n = 23) pregnancies. The mean birth weight of the group was 1,209 grams (range of 638-1,500) and the mean gestation period was 30 weeks (range of 24-42). One hundred twenty-one infants (32%) received mechanical ventilation for respiratory failure, 25 infants (6%) had exchange blood transfusions, and 77 (20%) received total parenteral nutrition.

At 2-year follow-up, 335 (88%) of the children had no major handicap, 41 (11%) demonstrated a major handicap, 24 of which required attendance at a special school, and 6 (2%) were lost to follow-up. Of the 41 handicapped children, 22 (55%) had cerebral palsy; 15 (38%) had mental retardation (IQ 2 standard deviations (SDs) below the mean); 14 (35%) had sensorineural hearing losses; 4 (10%) had hydrocephalus; 3 (7%) had retrolental fibroplasia; and 1 had congenital cataracts.

Within the group of 376 children who were evaluated at 2 years of age, the incidence of handicap did not differ between the 196 children born in the University College Hospital (inborn) and the 180 who were born at home or at another hospital (outborn), nor between the 163 males and 213 females. No difference was found between the 286 children whose birth weights were appropriate for gestational age (AGA) and the 90 children who were classified as small for gestational age (SGA). The differences between the proportions of children with handicaps in various socioeconomic groups was not statistically significant. However, the incidence of major handicap was significantly related to birth weight (lower weights correlated with a higher percentage of handicaps) and period of gestation (shorter gestation correlated with a higher percentage of handicaps).

The overall results of this study (Stewart, 1983) pointed to certain perinatal variables as being associated with higher risk of handicap, and these same variables seemed to affect cognitive development. For example, convulsions and respiratory failure were found to be the most important independent predictors of a general major handicap and of cerebral palsy specifically. Convulsions were the most important predictors of level of cognitive functioning at 3-1/2 years of age for the entire study group, and socioeconomic status (SES) of parents was the most important predictor among children without major handicaps, and was predictive of intelligence at both 3-1/2 and 8 years.

Stewart concludes that although measures of functioning used in the study were variable between and within children and were sometimes rather crude, the data imply causal associations between serious perinatal hazards and major defects of cognitive and neurological performance among preterm low birth weight children.

In a similar study, Escalona (1982) investigated 114 preterm low-birth-weight (LBW) (under 2,250 grams) infants who were patients at the neonatal intensive care unit (NICU) at Jacobi Hospital, Albert Einstein

College of Medicine, during 1975 and 1976. The infants were followed until the age of 40 months with the aim of investigating the interaction between social and biological factors as they affect mental and psychosocial development of preterm LBW infants. Fifty percent of the infants were black American, 25% were hispanic, and 25% were white. The group as a whole was below national and regional norms in SES. Most families lived in slums or deteriorating housing projects. Twenty-five percent of the initial sample of 127 demonstrated neurological impairment ranging from severe brain damage at birth (n = 9) to sensory or motor deficits of varying severity exhibited later and still present at 40 months (n = 23). No data were given on the sample following attrition.

Infants and families in the study were seen twice yearly. A psychological assessment, observation, behavioral assessment, and neurological examination were performed on the infant; and a social, familial, caretaking, and demographic history was taken from the parents. Cognitive development was measured by the Bayley Scales of Infant Development (the Bayley) at 15 months of age. At 28 months, the Stanford-Binet Intelligence Scale (Stanford-Binet) was given to 1/3 of the children, and the remaining 2/3 again were assessed with the Bayley scales due to low level of performance. Thereafter, only the Stanford-Binet was administered to all subjects. Infants demonstrating severe brain damage at birth, and/or severe mental retardation at 7-months of age, were excluded from the analysis.

Overall, the children showed normal cognitive development (mean IQ of 99.8) through age 15 months. By 28 months of age, and henceforth, a decline in cognitive status appeared (mean IQ at 28 months was 85.4 and at 40 months 89.3) and was associated with SES. In addition, serious behavioral maladjustment was associated with impoverished cognitive development and this was not found to be associated with SES. Neither neurological pathology nor gestational age were associated with IQ at age 3-1/2. Escalona (1982) suggests that in addition to biological stressors, environmental deficits and stresses can impair early cognitive and psychosocial development in premature low birth weight children, a finding which also has been reported in studies of full-term normal birth weight children (e.g., Broman, Nichols, & Kennedy, 1975). Furthermore, Escalona speculates that it is likely that full-term normal birth weight children's resistance to stress and their capacity to compensate for deficits may be greater than was true for the preterm low birth weight children in her study, although it has yet to be formally evaluated.

Wallace, Escalona, McCarton-Daum, and Vaughan (1982) reported the cognitive outcome at 5 years, as related to neurobehavioral performance at birth and parental social class, for 33 of the original 127 premature low-birth-weight (LBW) infants in the Escalona (1982) study. The mean weight of the cohort was 1,703 grams and mean gestational age was 33.8 weeks. Twenty-one percent of the subjects were small for gestational age (SGA), 42% were female, 45% were black American, 21% hispanic, and 33% were white. The mean age of the sample at posttesting was 6-1/2 years. All children were enrolled in school, 39% in kindergarten and 61% in first grade. Parents median income was $15,000.

At age 6, subjects' mean Wechsler Intelligence Scale for Children-Revised (WISC-R) Full-scale IQ (FSIQ) was 101.1 (SD = 14.5; range was 74-133), Verbal IQ (VIQ) was 99.4, and Performance IQ (PIQ) was 102.8. The difference between the verbal and performance scales was nonsignificant. Five children (15%) scored in the subnormal range (FSIQ less than 85). On the Developmental Test of Visual-Motor Integration (VMI) the group mean score was .93, which is slightly below chronological age; on the Wide Range Achievement Test (WRAT) reading subtest, the mean score was 108.2; and the group mean score on the Sentence Repetition Test (SRT) was 10. This test was used as a measure of linguistic processing and the maximum possible score is 23; so on the average, subjects repeated slightly less than one-half of the sentences correctly. Overall, data indicated that children were functioning within the normal range on cognitive measures, and there were no differences attributable to sex.

A series of multivariate multiple regression analyses were performed using canonical correlation with significance indicated by Roy's largest root. The relationship between 6 year WISC-R Verbal IQ and Performance IQ, Visual Motor Integration, WRAT-R reading score, Sentence Repetition Test, and Einstein Neonatal Neurobehavioral Assessment Scale (ENNAS) scores and SES was evaluated. A significant relationship between auditory, visual, and motility ENNAS factors and the 5 six-year outcome measures was identified. Tests of the effect of each of the three ENNAS factors revealed that only the auditory component was significantly predictive. The addition of SES contributed significantly to the overall magnitude of variances accounted for in the 5 six-year outcome measures.

The authors (Wallace et al., 1982) conclude that neonatal neurobehavioral performance can be used to predict cognitive abilities at 6 years. Since the acoustic stimulation component of the ENNAS accounted for most of the predictive power of the instrument, Wallace et al. infer that even relatively simple indices of acoustic processing in the newborn can index later language related abilities. Furthermore, since language acquisition, which underlies verbal IQ, depends on auditory processing, audition likely plays a key role in cognitive development.

Smith, Somner, and von Tetzchner (1982) investigated reproductive, perinatal, and environmental precursors of low birth weight (LBW) (less than 2,000 grams) infant status at age 3 in 38 subjects who were patients in the neonatal intensive care (NICU) at a large hospital in Oslo, Norway, between 1961 and 1962. Of an original sample of 62, 11 died before discharge, 3 were excluded due to Asian language barrier, 6 moved away and could not be followed, 1 was profoundly mentally retarded due to genetic problems, and 1 missed part of the final testing so was excluded from some data analyses. The mean birth weight of subjects was 1,664 grams.

All children were given either a high- or low-risk index rating based on occurrance of several prenatal, delivery, and postnatal complications. A high index score was representative of optimal status in all domains measured, whereas a low index score indicated a score below sample mean on two of the three domains assessed. SES was estimated by father's occupation and mother's education level.

Three year cognitive and psychological measures included: the Stanford-Binet; Reynell Developmental Language Scales (RDLS); children's mean length of utterances, as calculated from tape recordings at home with the parent and with a stranger at the assessment clinic; and a child behavior questionnaire. Children also were given the Uzgiris-Hunt Infant Psychological Development Scales (IPDS) at 3, 6, 9, 12, and 18 months. All test scores were corrected for prematurity.

At 3 years, SES, birth weight, and complications of pregnancy together yielded a high correlation with Stanford-Binet scores. Both SES and birth weight accounted for a significant majority of the variance. High risk index scores accurately predicted children who scored in the average or higher range on the Stanford-Binet at 3 years of age. However, low risk index scores failed to predict the level of Stanford-Binet performance.

Further analysis was performed to determine whether there were any systematic differences between children in four groups divided as follows: Low-Low (LL), low risk index and at least one dependent measure score one SD below the sample's mean; Low-High (LH), low risk index and no below average dependent measures; High-High (HH), high risk index and no below average dependent measures; and, High-Low (HL), high risk index and at least one dependent measure one SD below the sample's mean. Results showed that high risk scores accurately indicated children who later scored in the average range or above on the Stanford-Binet and Reynell receptive scales. However, risk index ratings did not discriminate between children with below average scores on the Reynell expressive scale, mean length of utterances test, nor on the behavior scale.

An analysis was performed to ascertain whether there were differences between LL, LH, HH, and HL children with respect to home environment factors and SES. The home environment factor (amount of parent vocalization) and SES were the sole factors that correlated significantly with outcome at 3 years, and this finding applied only to the LH group. The authors (Smith et al., 1982) concluded that environmental factors may have a mitigating effect on early biological risk factors in preterm infants.

Hirata et al. (1983) studied the outcome of 60 preterm very low birth weight (VLBW) infants who were patients in the neonatal intensive care unit (NICU) at Children's Hospital of San Francisco between January 1975 and December 1980. Twenty-five subjects were inborn, whereas 35 were outborn. Twenty-eight (47%) survived 28 days or longer, and 24 (40%, 9 inborn and 15 outborn) were alive at discharge. Of the 24 survivors, 2 inborns died after leaving the hospital so only 22 subjects were available for long-term follow-up.

All infants received endotracheal intubation and artificial ventilation. Early morbidity inclusive of the following perinatal conditions were analyzed: respiratory distress syndrome (RDS), patent ductus arteriosis (PDA), sepsis, pulmonary air leak, intraventricular hemorrhage (IVH), chronic lung disease, necrotizing enterocolitis, and retinopathy of prematurity. All infants were seen in outpatient follow-up within 1 to 6 months after discharge, at 1 year, and yearly thereafter until age 6. Each infant was given a physical and neurological examination, audiologic and speech evaluation, and an opthalmologic evaluation. Developmental assessment with the Bayley was completed up to 30 months, and the Stanford-Binet was used with older children. The Peabody Picture Vocabulary Test (PPVT) was included at 2 years and the Beery-Buktenica test of visual-motor integration at 3 years. All scores and physical measurements were corrected for gestational age until three years. SES was determined by mother's education level and occupation if a single parent, and by highest education level and occupation attained by either parent if married.

Characteristics of surviving infants were compared with nonsurvivors and no significant differences were found in maternal characteristics or mode of delivery. Significantly higher survival rates were found in infants whose mothers received betamethasone or tocolytic agents for at least 24 hours prior to delivery. Surviving infants also had significantly higher birth weights, gestational ages, and the majority of survivors were girls (1/5). Incidence of IVH was significantly increased (64%) in those who died. No maternal or infant characteristics discriminated between inborn or outborns, and there were no significant differences in hospital length of stay nor complications for these subjects.

All 7 inborn and 11 of 15 outborns returned for follow-up. The four lost to follow-up were a set of twins, one infant who had relocated to another country, and one who had dropped out for unknown reasons at 7-1/2 months. The ages of subjects at the last evaluation visit were 20 months to 7 years.

Mean heights and weights for the 15 girls was at the 5th percentile at 1 year with gradual increase to the 10-50th percentile after 3 years. Mean head circumference remained in the 10-50th percentile. Of the three male long-term survivors, one was below the 5th percentile for height, weight and head circumference at 7 years, but was growing at a normal rate. The other two were at the 25th percentile at age 3. Three children required glasses and one child had a unilateral sensorineural hearing loss.

With respect to development, 10 of 18 children were age 4 or older at the time of data analysis for this study. One inborn and three outborn children had borderline IQs and two outborns were mentally retarded (IQ less than 50) with neurologic abnormalities. Three of the five impaired outborns experienced IVH. The remaining six outborns and six inborns had normal IQs. The mean IQ for inborns was 100 whereas for outborns it was 87 (exclusive of the two borderline IQ subjects).

When age related mean scores were analyzed, there was an overall decrease in IQ at 2 and 3 years, primarily due to delayed language development. Mean IQ rose between 4 and 6 years. Four children with IQs less than 80 prior to age 2 showed improvement; however, 4 children with normal IQs dropped to below 80 after 2 years. Three of these subjects were from low SES environments. Gross motor delay was seen in the first year but improved by age 2. Developmental problems observed in children without neurologic abnormalities included impaired visual-motor integration and language delays. Overall, Hirata et al. (1983)

found that 50% of very low birth weight (VLBW) infants survive, that postneonatal growth rate for survivors was normal, that 85% of survivors were within the 5-50th percentiles in stature and head circumference, that 67% of the children evaluated had normal IQs, and that 89% were functional without physical handicaps.

Taken together, these studies found that SES, birth weight, gestational age, and specific perinatal factors, such as respiratory problems and convulsions, directly correlate with developmental outcome measures up to age 8. The overall mean IQs of low birth weight subjects across studies were in the low normal range.

Low Birth Weight and Normal Birth Weight Comparison Studies

Nobel-Jamieson, Lukeman, Silverman, and Davies (1982) directed a longitudinal study of preterm infants that took place in London and included children born between 1968 and 1975. Twenty-three children with an average birth weight of less than 1,500 grams and whom were considered normal by parents and teachers were compared to 23 apparently normal full-term children. Subjects were matched on age, sex, and social class, and were evaluated with a neurological examination, Children's Behavior Questionnaire, WISC-R, pulmonary function testing, and the Schonell Graded Word Reading test at an average age of 9 years and 1 month. Data from the neurological examination and behavioral questionnaire were analyzed using X^2 with Yates' correction for small numbers. Group IQs and estimated Reading Quotients (RQs) were compared using paired *t* tests. Results of the study revealed that preterm low birth weight (LBW) children had statistically significant minor neurological dysfunction, whereas full-term children did not show dysfunction. Preterm children also earned significantly lower though normal scores in four of five WISC-R subtests; WISC-R Full Scale IQ, Verbal IQ, and Performance IQ scores; and Reading Quotient scores.

Results obtained from the behavior questionnaire were nonsignificant and within normal limits for both groups as were the basic lung indices measured on each child. The authors (Nobel-Jamieson et al., 1982) note that the studys' generalizability is limited by the fact that the preterm subjects were highly selected at a regional hospital center and then self-selected by family's willingness to participate in the study. In addition, the study population represented only 1/3 of the group initially contacted and expected to be evaluated, and testers were not "blind" to the status of the children in the study.

Siegel (1982) likewise assessed the development of children born preterm and whose birth weights were less than 1,501 grams, as compared to a matched group of full-term normal birth weight children. The 42 preterm subjects were either born or treated in a large medical center in Ontario, Canada between July 1975 and June 1976. The 44 comparison subjects were demographically similar and matched on SES, parity, sex, and age of mother at birth of the child. The preterm group was further divided into groups of appropriate for gestational age (AGA) and small for gestational age (SGA) (birth weight $\geq$ 1 SD below mean weight for gestational age based on Usher-McLean norms for a Canadian sample), however, the number of subjects in each subgroup was not reported.

All subjects were given the McCarthy Scales of Children's Ability (the McCarthy) at 60 months. Both chronological age and scores corrected for prematurity were recorded for preterm children. A selection of reproductive, perinatal, and demographic variables also were compiled on each child. These included the amount of cigarettes smoked by the mother during pregnancy, gravidity (birth order), number of previous preterm births, number of prior spontaneous abortions, birth weight, hyperbilirubinemia, gestational age, severe respiratory distress, asphyxia, apnea, SES, and maternal and paternal educational levels.

Results of the McCarthy comparison at 60 months of age revealed no significant difference between the pre- and full-term groups on the Verbal scale. However, the full-term children did show significantly higher scores on the Quantitative, Memory, Perceptual-Performance, and Motor scales, as well as on the General Cognitive Index (GCI). When the GCI was corrected for prematurity, there was no significant difference between groups. No significant difference was found when AGA and SGA preterm infants were compared on GCI. Pre- and full-term group mean scores were within the average range on all scales despite the aforementioned existence of significant differences on select scales. However, there were significant between group differences in overall percentage of delayed children (McCarthy subscale score less than 40). Specifically, preterm children showed significantly poorer performance on Memory, Motor, and General Cognitive Index scales.

Linear stepwise multiple regression analyses were conducted to determine whether reproductive, perinatal, and demographic variables correlated with McCarthy scores at 5 years. SES and maternal education (no correlation coefficients given) were found to be the most important predictors of Verbal and General Cognitive Index scores for both pre- and full-term groups, whereas gestational age, independent of other scores, was not significantly predictive. A combination of conditions associated with prematurity (e.g., asphyxia, APGAR, and assisted ventilation status) and reproductive factors (previous spontaneous abortions and maternal smoking during pregnancy) moderately predicted subsequent perceptual and motor development in preterm children.

Hack, Merkatz, McGrath, Jones, and Fanaroff (1984) followed 182 preterm LBW (less than 1,500 grams) infants through age 2 in order to document developmental status and to identify clinical correlates that predicted outcome in this population. Infants were treated in neonatal intensive care at Rainbow Babies Children's Hospital in Cleveland, Ohio, between 1977 and 1978. The study sample came from an initial population of 308 infants of which 204 (66%) survived past age 1, 2 children died during their second year, 10 were unavailable for follow-up, and 10 had incomplete data at follow-up evaluation.

At birth, 147 of 182 infants were appropraite for gestational age (AGA) whereas 35 were small for gestational age (SGA). No infant had major congenital malformations nor intrauterine infections diagnosed prior to 8 months of age. AGA infants were born at a mean gestational age of 29 weeks and weighed an average of 1,200 grams whereas the SGA infants average gestational age was 32 weeks and mean weight 1,140 grams. The only significant perinatal differences between the SGA and AGA groups were that the SGA infants had more advanced gestational age, a higher incidence of multiple births (29% as compared to 14% in the AGA group), and pregnancy related hypertension (26% versus 8%). The mean postconceptual age (gestational age plus postnatal age) at discharge for the AGA group was 38.9 weeks and 40 weeks for the SGA group.

Infants were evaluated with a physical and neurological examination at 40 weeks, and at 8, 21, and 33 months. In addition, the Bayley was given at 8 and 21 months and the Stanford-Binet at 33 months. Demographic, neonatal, and infancy risk factors were recorded on each infant. These included maternal social class and education; Hobel cumulative neonatal risk score, which measured severity of disease during the neonatal period; and, chronic complications of prematurity such as lung disease, necrotizing enterocolitis, and jaundice.

The total sample of AGA and SGA infants were compared for growth attainment, chronic disease, neurologic sequelae, and mean Bayley and Stanford-Binet scores. The two groups of infants were further classified into subgroups according to normal or abnormal weight at corrected ages of 40 weeks and 8, 21, and 33 months. Two sample $\underline{t}$ tests or 2 X 2 Chi^2 tests were performed. In addition, Pearson's $\underline{r}$ was determined to identify factors which best correlated with subnormal weight (more than 2 standard deviations (SDs) below the mean for corrected age) at 40 weeks and 8 and 21 months.

Of the 147 AGA infants, 67 (47%) had subnormal weights at 40 weeks, but by age 21 months, this prevalence had dropped to 19%, and by 33 weeks to 17%. Of the 35 SGA infants, 32 (91%) had subnormal weight at 40 weeks, but by age 8 months this had dropped to 49% and to 46% by 33 months.

The AGA and SGA groups had similar mean IQs at 8, 21 and 33 months corrected age, and these were in the low average range. Infants who remained small had lower IQs when compared to those who were appropriately grown, however these differences were only significant in the AGA group. The incidence and type of neurologic abnormalities differed between the AGA and SGA subjects. At 8 months, 7 of 8 (87%) neurologically abnormal SGA infants had nonspecific hypotonia which resolved by 21 months of age. In contrast, 12 of 24 (50%) neurologically abnormal AGA infants had specific neurosensory deficits at 8 months which persisted so that by 21 months, more AGA than SGA infants (50% versus 13%) had neurologic sequelae. Overall, 17% of AGA and 46% of SGA infants remained subnormal in weight at 33 months. The potential for catch-up growth in the SGA population seemed limited to infancy whereas AGA infants with poor growth showed catch-up during the second year of life.

Silva, McGee, and Williams (1984) undertook a longitudinal study of intelligence and behavior of preterm low birth weight (LBW) ($\underline{n}$ = 31), small for gestational age (SGA) ($\underline{n}$ = 71), and full-term normal birth weight (NBW) ($\underline{n}$ = 748) children. Eight hundred fifty children born and treated in Queen Mary Hospital, Dunedin, New Zealand, between April 1972 and March 1973 made up the study sample. The sample was composed of children included in an ongoing longitudinal study at the Multidiciplinary Child Development Study. Of the larger sample population of 1,037 seen at age 3, only 850 had complete data available for analysis at 9 years.

Demographic data on all subjects included SES and maternal IQ using the SRA Verbal test. Childrens IQ was measured with the Peabody Picture Vocabulary Test (PPVT) at age 3, the Stanford-Binet at age 5, and the WISC-R at ages 7 and 9 years. The Rutter Child Scales A and B (for parents and teachers, respectively) were filled out at 5, 7, and 9 years.

No significant differences were found between groups on SES and maternal IQ. The sample was socioeconomically slightly above average compared to New Zealand as a whole, and only 2% Maori and other polynesian race, as compared to 10% for the country as a whole.

All child IQ scores were converted to $\underline{z}$ scores for analysis and reconverted to standard IQs (mean of 100 and SD of 15). Multivariate analysis of variance for IQ tests revealed a significant between group difference. The SGA but not the preterm group had significantly lower means than the remainder of the sample, however all IQ scores were within normal limits. A significant difference between groups also was found for the parents Rutter scale but not for the teachers Rutter scale. Again, the SGA but not the preterm group had significantly more problem behaviors than the rest of the sample. The authors (Silva et al., 1984, p. 4) concluded, "it is better to be born too early than too small."

In a review of literature aimed at identifying significant effects of low birth weight (LBW), perinatal complications, and social and environmental influences on behavioral and intellectual development, Escalona (1984) concluded that, in the absence of severe brain damage, social class and sociocultural environment were more significant predictors of cognitive outcome than perinatal factors. In addition, the author reported that when SES was controlled, preterm LBW infants as a group exhibited a low average IQ; as well as a high incidence of learning disabilities, neurological pathology, and "soft" neurological signs, as compared to full-term normal birth weight (NBW) infants.

The major findings of the current LBW versus NBW review are consistent with the results of Escalona (1984). However, the recent literature identified both perinatal variables and SES, versus SES alone, as significant predictors of developmental outcome.

Early Intervention Studies

One frequent conclusion of previous research in the area of early intervention with at-risk or handicapped infants and children is that screening and intervention should be initiated early in life (Mulliken & Buckley, 1983). For example, McDaniels (1977), in a report of several studies which evaluated the long-term effects of early intervention programs, concluded that children who had preschool experiences did better scholastically than those who needed such services but did not receive them until the age of 5 or 6.

Kurtz (1980), in a study of rural handicapped preschoolers, found that early intervention was crucial in both remediating handicapping conditions, and perhaps in minimizing or preventing the occurrance of secondary dysfunction. Likewise, studies on infants (e.g., Anastasiow, 1981; Mercer, Algozzine, & Trifiletti, 1979) have noted that babies from intensive care units, and those who are premature, considered high risk, and/or handicapped, have the greatest need for early diagnostic and preventive services.

Bush and White (1983) undertook a critical review of 65 past reviews of early intervention research in order to identify common trends and controversies in the data. They reported that most reviewers found early intervention was effective if it was implemented properly, and that subjects benefited in areas of cognitive, academic, attitudinal, and social development. Overall, the reviewers concluded that there was well documented evidence of immediate benefits of early intervention with at-risk and handicapped populations, but less support for longitudinal effects.

Of the 23 reviewers who considered the limited longitudinal data on the effects of early intervention, only five concluded that highest developmental levels were maintained. Bush and White (1983) suggested these findings be interpreted with caution because of methodological weaknesses in both primary studies and reviews. They recommended future research concerning the long-term effects of early intervention. Suggestions for correcting design weaknesses in primary research included the use of impartial data collectors and observers, collecting both short- and long-term follow-up data, and the use of clearly defined subjects, versus combining all handicapped or at-risk subjects into one group.

Casto et al. (1986) reviewed 29 primary research studies which assessed various interventions for preterm infants weighing under 2,000 grams. The studies were evaluated using meta-analysis techniques. All research that could be located through a detailed computerized search of the literature from 1964 through 1985, plus those unpublished reports solicited through contact with prominent early intervention service providers and researchers, were used in the meta-analysis.

The magnitude of the effect attributed to intervention was estimated using a standard mean difference effect size, or the difference between experimental and control groups measured in z scores. When there was no control group, effect size was calculated utilizing pretest scores as the best estimate of outcome in the absence of treatment. A single study could yield multiple effect sizes if subjects were compared on several outcome variables (e.g., one for cognitive and one for motor development). The meta-analysis produced a total of 94 effect sizes.

The interventions that were reported most frequently in the studies reviewed included: tactile-kinesthetic stimulation (n = 9), oscillating waterbeds (n = 6), and training parents in techniques of stimulating infant growth and development plus improving mother-infant interaction (n = 6). The duration of training ranged from 1 week to 12 months.

The results were consistent with reports of prior reviews of literature on preterm infant outcome with or without intervention (e.g., Cornell & Gottfried, 1976; Schaefer, Hatcher, & Barglow, 1980). Specifically, infant stimulation programs across all intervention conditions produced average gains in growth and/or development of 1/2 of a standard deviation, and the three types of intervention evaluated produced comparable results.

The authors (Casto et al., 1986) noted that although studies reporting short-term interventions on a small sample yielded the largest effect sizes, long-term evaluation of the impact of treatment was not evaluated. Furthermore, outcome measures utilized, such as weight gain and various sleep indices, have not yet been validated as important predictors of development past the neonatal period. They suggested that further investigations on intervention efficacy eliminate restrictive inclusion criteria. Infants in nearly all studies reviewed were free from serious medical complications, including neurologic impairment such as IVH. Thus, the infants most likely to be high-risk for developmental problems were not included in the intervention studies.

Incidence and Etiology of Intraventricular Hemorrhage

The incidence of intraventricular hemorrhage (IVH) in infants born before 35 weeks gestation and weighing less than 1,500 grams is estimated at 31-55% (Bowerman et al., 1984; Volpe, 1981). The hemorrhage occurs principally from capillaries in the subependymal germinal matrix at the level of the head of the caudate nucleus and foramen of Monro. In infants who are under 28 weeks of gestation, the hemorrhage often occurs at the level of the body of the caudate nucleus, and in term infants, at the choroid plexus (Lacey & Terplan, 1982).

IVH can be described in stages of severity, with Stage One being the least, and Stage Four, the most severe (Papile et al., 1983). More specifically, Stage One is a subependymal germinal matrix or choroid plexus hemorrhage. Stage Two is a subependymal hemorrhage with extension to the ventricles but with normal ventricular size. Stage Three is a subependymal hemorrhage with extension to the ventricles with moderate to severe ventricular dilitation. Stage Four is a subependymal hemorrhage with ventricular extension, with or without dilitation, plus a parenchymal lesion.

Approximately 80% of subependymal hemorrhages extend through the ependyma into the ventricles (Volpe, 1981). Blood which enters the ventricular system often collects in the posterior fossa causing an obliterative arachnoiditis. In moderate to severe lesions, such as Stage Three and Stage Four IVH, an acute post-hemorrhagic hydrocephalus (PHH) frequently develops.

The pathogenesis of IVH is believed related to the distribution and regulation of cerebral blood flow, vascular integrity, intravascular pressure, and the extravascular environment (Tarby & Volpe, 1982). It is hypothesized that these factors combine in the infant, especially those experiencing a respiratory insult, to result in IVH (Strauss, Kirz, Modanlou, & Freedman, 1985).

The clinical symptoms of IVH vary from a dramatic rapid neurologic deterioration, characterized by seizures; unreactive pupils; loss of muscle tonus; cessation of breathing; and bulging anterior fontanelle, to a subtle presentation where there is gradual and minimal neurologic deterioration over the course of several hours to days (Tarby & Volpe, 1982). The time of onset of IVH generally is within the first two to three days of life, and most commonly during the first 24 hours following birth (Bejar et al, 1980; Rumack et al, 1985).

Ultrasonography and Computed Tomography (CT) scan brain-imaging techniques have been found to be excellent means for diagnosing both the site and extent of IVH. In addition, ventricular size and the presence of major parenchymal lesions may be identified (Dolfin, Skidmore, Fong, Hoskins, & Shennan, 1983). At the present time, ultrasonography is the preferred method of documenting the severity and prognosis of the hemorrhage. The infant can be scanned in the neonatal intensive care unit (NICU) without sedation or ionizing radiation. The anterior fontanelle is used as an ultrasound window. The transducer is angled so that posterior, frontal, and sagittal sections of the brain are visualized (Bowerman et al., 1984; Grant et al., 1981). Correlations between the findings of ultrasonography and those of autopsy and CT scanning are excellent (above 90%).

Intraventricular Hemorrhage Outcome Studies

Long-term outcome of IVH survivors seems to depend on a variety of factors which correlate with the severity or extent of the hemorrhage. Recent research aimed at identifying and isolating such factors are presented in this section. The studies have been grouped according to principal outcome measure(s) utilized by the author(s).

Bayley Studies

Schub, Ahmann, Dykes, Lazzara, and Blumenstein (1981) evaluated neurodevelopmental outcome of preterm IVH children at 34 months corrected age with the Bayley, or the Stanford-Binet, plus a neurological examination. Outcome was designated 'good' if the child earned a developmental quotient (DQ) score greater than 90 and had no neurologic deficit, 'moderate' if their DQ score was between 70-90 and they showed no or minor neurologic deficit, and 'poor' if their DQ score was below 70 or if they demonstrated a significant neurologic deficit.

Thirty-three (80%) of an initial 41 infants with IVH were compared with 30 (61%) of 49 similar infants without IVH. Of the 33 IVH infants, 64% had good outcome, 24% moderate, and 12% poor. Sixty-three percent of the control infants had good outcome, 27% moderate, and 10% rated poor. Intra-IVH group comparison revealed that of 13 infants with severe IVH, 62% had good outcomes, 23% moderate, and 15% poor; whereas of 10 infants with moderate IVH, 50% had good, 30% moderate, and 20% poor outcomes. Eighty percent of the infants with mild IVH had good outcome, 20% moderate, and no infants had poor outcomes. The authors (Schub et al., 1981) conclude that by all evaluation methods, IVH infants did not differ significantly from controls and, of those with marked IVH, 60% had good outcomes at 34 months.

Gaiter (1982) reports on the presence and degree of IVH in newborns as related to subsequent Bayley scores at 12 and 18 months corrected age. The study population consisted of 96 infants who were patients in neonatal intensive care at Children's Hospital National Medical Center, Washington, D. C.; weighed less than 1,750 grams; were appropriate for gestational age (AGA); and were predominantly low middle to low SES. Fourty-two percent of the initial group died, and 18 did not participate in the study, thus 40 percent of the initial sample was assessed (19 with IVH and 19 matched controls). Of the 19 with IVH, 9 had Grade Two, and 10 Grade Three hemorrhage. Three of the

Grade Three infants had ventriculo-peritoneal (V-P) shunts inserted for management of post-hemorrhagic hypertrophy (PHH).

Within the IVH group, 12-month Bayley scores of Grade Two and Three infants were not significantly different. However, when the IVH and control groups were compared there was a significant difference, in favor of the controls, on the Bayley Psychomotor Development Index (PDI). Thirty-seven percent of the IVH samples motor scores were greater than one standard deviation (SD) below the mean whereas only 10% of control infants had comparably low scores. Bayley Mental Development Index (MDI) scores were normal and did not differ significantly. When Bayley data on infants also diagnosed as having bronchopulmonary dysplasia (BPD) were examined (n = 5 for both IVH and control groups) results suggested that BPD plus IVH yields significant severely depressed scores (mean MDI = 75; mean PDI = 70) whereas control infants with BPD were indistinguishable from unaffected controls.

At 18-month follow-up, Bayley data was available for 14 (74%) of the original 19 IVH and 13 (68%) of the 19 controls. No significant difference was found between groups on either the Bayley Mental Development Index (MDI) or the Psychomotor Developmental Index (PDI) scores. Of the IVH group, 43% were developing normally, 43% had discrepant Bayley MDI versus PDI scores, and 14% were either abnormal or suspected of risk. In the control group, 54% were normal, 31% had discrepant scores, and 15% were either abnormal or at risk.

Papile, Munsick, Weaver, and Pecha (1979) studied 100 preterm LBW infants prospectively to determine whether IVH was associated with developmental and/or neuromotor handicaps at 12 months corrected age. Sixty-five percent of the original sample survived the neonatal period. Twenty-one of the 22 surviving infants with IVH and 40 of 43 similar infants without IVH were alive at 12 months (61% of original sample).

Eighty percent (17) of the IVH infants and 65% (26) of the controls were evaluated with the Bayley and a neurodevelopmental examination. Of survivors, 100% ($\underline{n}$ = 3) of the Grade One IVH infants were normal and without handicaps at 1 year. All 6 Grade Two IVH infants had normal developmental indexes (DIs), however 2 (33%) demonstrated minor neuromotor handicaps. Of the 5 infants with Grade Three IVH, 80% had normal DIs, 40% demonstrated a major handicap and 40% had a minor handicap. All 3 Grade Four IVH infants evaluated at posttesting earned DI scores below 80, and 66% showed major and 33% minor neuromotor problems. Ninety-two percent of the surviving control subjects had normal DIs, 8% showed major handicaps, and 12% exhibited minor handicaps. A significant relationship was found between Grade Three and Four IVH, and poor Bayley and neuromotor outcome at 1 year.

In a later study, Papile, Munsick-Bruno, and Schaefer (1983) compared the developmental outcomes of 197 preterm infants with and without IVH, at 12 or 24 months corrected age. Study subjects were patients in neonatal intensive care at the University of New Mexico Hospital, Albuquerque, between July 1976 and July 1981, and weighed less than 1,501 grams at birth. Infants with major congenital anomolies, documented TORCH infection (toxoplasmosis, rubella, cytomegalovirus, and herpesvirus), and documented encephalitis were excluded.

Neuromotor findings classified as suspect included mild disturbances in quality of posture or movement. Those considered abnormal were moderate to severe disturbances in posture or movement that interferred with the child's ability to achieve age appropriate motor milestones. If the child had normal neuromotor and normal Bayley Mental Development Index (MDI) and Psychomotor Index (PDI) scores, they were classified as normal. Minor handicap was defined as having either suspect neuromotor or suspect Bayley scores. If the child demonstrated abnormal neuromotor findings, blindness, severe sensorineural hearing loss, seizure disorder, or abnormal Bayley scores, they were classified as having a major handicap. Children with both abnormal Bayley and neuromotor scores were classified as multihandicapped.

Two-hundred sixty infants survived the neonatal period. Of 232 infants (89% of initial sample) who were still alive at 1 year, 197 (85%) were evaluated. Sixty-seven (34%) were assessed at 12 months and 130 (66%) were tested at 24 months.

Bayley assessment of the 82 surviving infants with IVH revealed normal scores in 53%, suspect in 37%, and abnormal in 10%. On neuromotor testing, 50% of IVH subjects had no evidence of a handicap, 40% demonstrated mild handicaps, and 10% major handicaps. Twenty percent of the overall IVH sample were multihandicapped.

Of the 138 infants without IVH who survived, 115 (83%) were evaluated. Bayley assessment revealed normal scores in 53%, suspect in 37%, and abnormal in 10%. On neuromotor testing, 50% earned normal scores, 40% demonstrated mild handicaps, and 10% major handicaps.

Fifty-eight percent of those handicapped, or 6% of the total non-IVH sample, had multihandicaps.

Intra-IVH group comparisons showed that Grade One and Two subjects did not differ. In addition, they were comparable to non-IVH subjects in that developmental scores were in the average range. A direct significant relationship was found between Grades Three and Four IVH infants and poor developmental outcome. Seventy-eight percent of the total IVH sample with multihandicaps had Grade Three or Four hemorrhage. A subsample of 17 IVH infants with post-hemorrhagic hypertrophy (PHH) showed significantly high risk for developmental and/or neuromotor problems. Fourty-three percent of the total IVH multihandicapped sample had PHH (8.6% of the total 20% of IVH subjects who were multihandicapped).

Landry et al. (1984) evaluated the effects of early medical complications on the intellectual and motoric development of premature low birth weight (LBW) infants. Twenty-nine infants had IVH with respiratory distress syndrome (RDS), 48 had RDS without IVH, 17 had bronchopulmonary dysplasia (BPD) with IVH, 10 had BPD without IVH, and 22 had IVH with post-hemorrhagic hypertrophy (PHH). All subjects had birth weights less than 1,501 grams, and were under 36 weeks gestation. At 6, 12, and 24 months chronological age, subjects were given the Bayley. Scores reported at 6 and 12 months were for both chronological and corrected ages. Attrition for each follow-up was under 22%. No infants with gross sensory handicaps nor cerebral palsy were enrolled in the study.

Results revealed that IVH with RDS and IVH without RDS groups earned average IQ scores for chronological age at the 12 and 24 month testings, and there was no significant difference between groups. Infants in the BPD and PHH groups had significantly lower corrected and uncorrected IQ scores which remained in the delayed range through 24-month follow-up. Overall Bayley Psychomotor Developmental Index (PDI) scores tended to differentiate between groups more than Mental Developmental Index (MDI) scores, suggesting that motor development is more impaired than mental development for premature infants with IVH. Children with IVH plus post-hemorrhagic hypertrophy (PHH) demonstrated the highest proportion of significant delay in corrected and uncorrected IQ scores (both MDI and PDI less than 70). There was no evidence at any point in time for differences in performance between infants with varying grades of IVH.

Scott, Ment, Ehrenkranz, and Warshaw (1984) followed 88 preterm LBW infants with or without IVH until 18 months corrected age in order to determine developmental status and neurologic outcome. All infants were patients in neonatal intensive care at Yale-New Haven Hospital between June 1979 and June 1981 and were survivors of an initial sample of 102 qualifying infants. All subjects were given a neurologic examination and the Bayley at 6, 12, and 18 months.

Of 46 infants with IVH, 25 had Grade One, 17 Grade Two, 2 Grade Three, and 2 had Grade Four hemorrhage. Twenty-two percent of all IVH infants experienced neonatal seizures, whereas of the 56 infants without IVH, 9% had seizures. Two infants with and 2 infants without IVH demonstrated spasticity on neurological examination. A significant downward trend of Bayley scores over time was found in the IVH group but not in the non-IVH group. However, both groups' mean scores were in the low average range.

Tekolste, Bennett, and Mack (1985) studied preterm infants who were treated in the neonatal intensive care unit at University of Washington Hospital, Seattle, between January 1980 and June 1981. Twenty males and 18 females had IVH, whereas 20 males and 23 control infants did not. Infant growth, neurologic status, and development were evaluated at 4, 8, 12, 24, and 36 months corrected age. The Bayley was used up until age 28 months, and thereafter, development was assessed with the Stanford-Binet. Neurodevelopmental outcome was classified as normal if the child had normal neurologic and cognitive scores. Children with mild disturbances of muscle tone or motor milestone delays and/or Bayley or Stanford-Binet scores 1-2 standard deviations (SDs) below the mean were classified as having minor abnormalities. Children demonstrating cerebral palsy, progressive hydrocephalus, seizures, blindness, deafness, or cognitive score greater than 2 SD below the mean with labeled as having a major abnormality.

The sample mean birth weight was 1,362 grams and mean gestational age was 30 weeks. The mean age of both groups at follow-up was 22.3 months. Of the 81 children, 9 (seven IVH and two control) were evaluated with the Stanford-Binet and the remaining 72 with the Bayley. The IVH group showed significantly lower, yet normal cognitive scores as compared to the control group. Significant differences were attributed to lowered motor scores. There was no difference between cognitive scores of IVH infants with mild versus severe degrees of hemorrhage. However, the Grade Four infants showed significantly depressed motor scores as compared to those with Grades One through Three hemorrhage, whose scores did not vary significantly.

Overall results suggest that children with IVH are more likely to have major neurodevelopmental abnormalities than controls (34% versus 12%) and are slightly more likely to have multihandicaps than infants without IVH (11% versus 7%). Normal neurodevelopmental outcome was observed in 19 (50%) of the overall IVH group and 29 (67%) of the control group and this difference was significant.

Catto-Smith, Yu, Bajuk, Orgill, and Astbury (1985) studied 56 infants born between 23 to 28 weeks gestation and diagnosed as having IVH, in order to evaluate developmental outcome at 2 years. All children were patients in Queen Victoria Medical Center, Melbourne, during 1981. The mean birth weight of the initial infant sample was 938 grams. Thirty-four of these subjects had periventricular hemorrhage, 12 had germinal matrix hemorrhage, 18 had IVH, and 4 had IVH with parenchymal extension. Thirty-three (59%) subjects were discharged from the hospital, one died thereafter, and one was lost to follow-up.

Six of the 31 survivors (19%) had cerebral palsy, 6 exhibited developmental delay (greater than 2 SD below the mean on the Bayley), 2 were blind, 2 had epilepsy, and 1 had post-hemorrhagic hypertrophy (PHH) with a ventriculo-peritoneal shunt (V-P shunt). Three infants had more than one handicap. Eight of the 12 infants with major disability were considered to have moderate to severe functional handicaps. Therefore, of 56 infants 24 (43%) died, 8 (14%) survived with serious functional handicaps, 1 (2%) was lost to follow-up, and 23 (41%) were normal on developmental testing with the Bayley. Survivors with periventricular or germinal matrix hemorrhage were compared with those experiencing either IVH or IVH with parenchymal extension. Only 3 of 19 (16%) of infants with lessor hemorrhage exhibited developmental delays whereas 9 of 12 (75%) of those with severe hemorrhage showed marked deficits.

Across studies utilizing the Bayley, infants with Grades One, Two, or mild IVH, and controls, earned similar and low normal mean cognitive and motor scores. In contrast, infants with more severe hemorrhage, post-hemorrhagic hypertrophy (PHH), IVH plus bronchopulmonary dysplasia (BPD), and/or intraparenchymal lesions (IPLs), were found to exhibit significant neuromotor impairment, and were more likely to exhibit multihandicaps. The cognitive abilities of the more severe IVH as well as control subjects were similar and in the low normal range.

McCarthy Outcome Studies

Williamson et al., (1983) report on developmental outcome of 29 preterm LBW infants with IVH followed prospectively to a mean age of 3-1/2 years. The subjects were patients in neonatal intensive care at Texas Children's Hospital, Houston, between January 1977 and December 1978. The mean birth weight of subjects was 1,167 grams and gestational age was 28.9 weeks. Seventeen were male and all infants were diagnosed as having IVH via computed tomography (CT) scan. The McCarthy was used to evaluate cognitive development, and a battery of language tools was used to assess comprehension, expression, and articulation. Outcome data was presented in three domains including: Neurologic structural and functional abnormalities, McCarthy General Cognitive Index (GCI), and, enrollment in special education at age 3.

Results revealed that 10 subjects (34%) had normal neurological outcomes, 4 (14%) had minimal abnormality, 9 (31%) showed moderate abnormality, and 6(21%) severe neurological problems. Cognitive performance was normal for 14 (48%) of the subjects, 7 (24%) showed mild delay, and 8 (28%) scored in the retarded range. At age three, 12 children (41%) demonstrated handicaps severe enough to require special education placement.

Grade of IVH was not significantly related to neurological outcome, however, severe grade of IVH and low birth weight were significantly correlated with need for special education placement at three years. McCarthy performance was significantly correlated with severity of IVH, birth weight, and SES.

Krishnamoorthy, Kuehnle, Todres, and DeLong (1984) studied 12 Grade Two IVH infants with post-hemorrhagic hypertrophy (PHH) for 3-7 years. All children were patients in neonatal intensive care at Massachusetts General Hospital, Boston, between 1973 and 1979. The mean birth weight of the sample was 1,800 grams and gestational age 32 weeks. Subjects were initially treated for PHH by serial lumbar punctures (LPs). Five of these children stabilized whereas the other 7 required ventriculo-peritoneal shunts (V-P shunts). No children required long-term anticonvulsant treatment for recurrent seizures. A neurological examination was used to classify children into mild, moderate, and severe categories. Two children were given the Bayley and 10 were evaluated with the McCarthy. In addition, parents completed a behavioral questionnaire. The average age of subjects at last testing was 4.6 years (range was 3.2 to 7 years).

Sixty-six percent of children had a normal IQ and were free of neuromotor abnormality. The remaining children demonstrated neuromotor abnormalities and had a mean IQ in the borderline range. Neuromotor abnormality was present in 2 of 7 (29%) children with and 2 of 5 (40%) without V-P shunts. The mean IQs of the shunt and no shunt groups were normal and did not differ. All subjects were ambulatory and only one demonstrated moderate motor impairment secondary to spastic diplegia. In addition, all children were rated by parents as having attentional problems.

Krishnamoorthy et al. (1984) concluded that Grade Two IVH children with post-hemorrhagic hypertrophy (PHH) have a good prognosis for normal development, as only 25% of the study sample demonstrated moderate motor disability and IQ scores under 80. The authors did not comment on the functional importance of minor motor dysfunction nor observed perceptual and attentional problems that may lead to school or social problems.

Bergman et al. (1985) reviewed clinical and radiologic features of 18 full-term children who suffered IVH at birth, in order to identify etiologic factors as well as acute and long-term developmental outcome related to hemorrhage. Children were born at either MaGee Women's Hospital or Children's Hospital of Pittsburg since 1975, and were from 11 months to 7-1/2 years at last follow-up.

Of the 18 subjects, 10 were male, 17 white, and 1 black. All children had neurologic and developmental evaluations, and 13 of 18 had cognitive testing; 7 with the Bayley, and 6 with a battery including the McCarthy, the Peabody Picture Vocabulary Test (PPVT), and the Expressive One-Word Picture Vocabulary test. Of 17 survivors ages 1 to 7-1/2 years, 9 (53%) were normal and the other 8 demonstrated intellectual retardation with or without neurological deficits. Specifically, three (18%) had severe neurologic and IQ deficits with spastic quadreplegia and seizures; two (11%) exhibited hemiplegia and an IQ under 50; and three (18%) had IQ impairment without neurological deficits. The abnormal outcomes were observed in five of six infants suffering post-hemorrhagic hypertrophy (PHH), three of four with widespread intraparenchymal lesions, and eight of nine subjects with hypoxic-ischemic insults at birth.

In the McCarthy studies reviewed, Williamson et al. (1983) noted that scores significantly correlated with severity of IVH, birth weight, and SES. Krishnamoorthy et al. (1984) reported that infants with IVH plus PHH had a good prognosis for normal development, which is in contrast to the major findings of the Bayley studies and that of Bergman et al. (1985). In the later, Bergman et al. found that IVH subjects with post-hemorrhagic hypertrophy, intraparenchymal lesions, and/or hypoxic-ischemic episodes at birth exhibited significant developmental impairment.

Miscellaneous Outcome Measure Studies

Palmer, Dubowitz, Levene, and Dubowitz (1982) evaluated the neurologic and developmental status of 39 preterm infants at 6, 9, and

12 months. There were 14 IVH infants with post-hemorrhagic hypertrophy (PHH), 11 without PHH, and 14 control infants. All infants were evaluated with the Griffiths scales from which a developmental quotient (DQ) was derived and corrected for prematurity. A higher incidence of neurologic abnormality at each follow-up age was found in infants with PHH when compared to other groups. At one-year, 60% of infants in the IVH with PHH group, versus none in the other groups, exhibited major handicaps. A similar significant difference was found in developmental milestones reflective of gross and fine motor and social and verbal skill development. Neurologic and developmental deficits were most related to presence of PHH rather than size of initial hemorrhage.

Hynd et al. (1984) investigated 13 low birth weight (LBW) children with IVH from a minimum of 1 to a maximum of 5 years, in order to evaluate the relationship between IVH, perinatal complications, and developmental status as measured by the Cattell Battery. Seven of the 13 subjects were male, 46% suffered respiratory distress syndrome (RDS), and 39% experienced neonatal seizures shortly after birth. The mean APGAR scores at 1 and 5 minutes were 5 and 7, respectively. The mean gestational age for the group was 34 weeks, and the mean birth weight was 2,321 grams.

Subjects were evaluated for cognitive development at six month intervals until age 2. Those over age 2 were assessed annually until age 5 with the Stanford-Binet. Ten of the 13 infants were evaluated at 6 and 12 months; at 24 months, 8 of these subjects again were tested. Eight children were assessed at age 3, and 3 children were evaluated at age 4.

Hynd et al. (1984) reported that 6 out of 10 children evaluated at 6 months evidenced levels of cognitive development which ranged from severely retarded to below average (DQ < 85). The remaining 4 subjects scores were normal. At 12 months, the mean DQ was 89, and 6 of the 10 children had DQs in the normal range. The 2, 3, and 4 year follow-ups indicated a decline in cognitive status. The mean DQ at 24 months was 78 whereas at 4 years it was 72. The variability in scores may have been due to imperfect validity when predicting Stanford-Binet scores based on Cattell scores, as noted by the authors. Also, only 6 of the 13 children received a minimum of 5 follow-up assessments, thus the means are not based on a continuous follow-up of the same subjects.

McMenamin, Shackelford, and Volpe (1984) evaluated outcome of 64 preterm infants with IVH plus intraparenchymal lesions (IPLs). The mortality rate was 94% for those with large IPLs and birth weights under 1,000 grams, and 76% for those with large IPLs and birth weights under 2,250 grams. Infants with small IPLs and birth weight under 1,000 grams had a mortality rate of 38%, and for those over 2,250 grams mortality was 29%. Of survivors, 24 infants had small IPLs and 8 had large IPLs.

Neuromotor status was measured by the Denver Developmental Screening Test and a quotient of development (DQ = [developmental age - age postterm] X 100). All survivors with large IPLs, regardless of birth weight, had moderate to severe neuromotor deficits on follow-up at 3, 6, 12, and 18 months. In contrast, infants with small IPLs did not show signs of neuromotor deficits. Overall outcome appeared most related to severity of parenchymal involvement, however no data was given on severity of IVH nor other perinatal conditions which may have contributed to the findings.

In summary, these studies found that infants with IVH plus post-hemorrhagic hypertrophy (PHH) and/or large intraparenchymal lesions (IPLs) demonstrate significant developmental delays, as compared to subjects with less severe IVH and controls.

Summary

Taken together, the low birth weight (LBW) and normal birth weight (NBW) development studies identified SES, birth weight, gestational age, and specific perinatal variables, such as respiratory insults and convulsions, as significant predictors of long-term outcome. However, it is noteworthy that overall group mean IQs of LBW subjects were found to be in the low average range at the time of follow-up.

Studies which evaluated the efficacy of early intervention programs reported that a variety of interventions aimed at minimizing or preventing handicapping conditions showed positive results. The authors suggested that future intervention research (1) be initiated early in life, (2) provide well defined, versus ambiguous descriptions of subjects (especially in relation to their diagnoses), (3) avoid excluding subjects with various medical problems, such as perinatal infections or cerebral palsy, and (4) provide for longitudinal follow-up.

Across IVH follow-up studies, regardless of the outcome measure(s) utilized, infants with IVH and controls earned average to low average

IQ scores and low average neuromotor ratings. Within the IVH group, infants with Grade Three or Grade Four hemorrhage; post-hemorrhagic hypertrophy; bronchopulmonary dysplasia; and/or parenchymal involvement exhibited significant impairment in neuromotor development, whereas their cognitive scores were in the low average range. This finding strongly suggests that severe IVH may be linked causally with the onset of handicapping conditions.

IVH can be definitively diagnosed in the neonatal period, and early intervention following diagnosis has been shown to be effective in altering the severity and occurrance of handicapping conditions. Until the present study was undertaken, no known attempts had been made to evaluate the short- and long-term developmental status of IVH infants exposed to early intervention programs. The IVH population was seen as ideal for investigating issues related to age at start and intensity of intervention programs.

CHAPTER III

PROCEDURES FOR COLLECTION OF DATA

This study was exploratory in nature and utilized a two-group pre-post experimental design. The effect of an early sensorimotor intervention program on development of infants with perinatal IVH was compared with a control group. The following sections of this chapter will include a description of the setting, population, and sample, as well as the methods and instruments used in data collection and analysis.

Setting and Population

The setting for this study was a moderately large metropolitan city with a population of 300,000 persons. The study population consisted of infants with perinatal IVH who were patients in neonatal intensive care (NICU) at the University of Utah Medical Center (UUMC) or Primary Children's Medical Center (PCMC) between January 1985 and June 1986.

The UUMC had an average annual population of 513 infants with a 15% incidence of IVH during the study period, whereas PCMC had an average annual population of 336 infants with a 12% incidence of IVH.

Enrollment Criteria and Procedures

All infants in UUMC and PCMC neonatal intensive care units with a gestational age less than or equal to 40 weeks, and who were diagnosed as having IVH by ultrasonography, were eligible for the study.

Severity of hemorrhage was classified by a radiologist utilizing Papile's four stage system (Papile et al., 1983) wherein Stage One IVH is the most mild and Stage Four is the most severe degree of hemorrhage.

Parents of infants eligible for the study were contacted about participation in the project via a letter from the respective NICU medical director (see Appendix A). This letter contained general information on the nature and purpose of the study, as well as a return postcard on which the parent indicated whether or not they were willing to be contacted by the investigator for more detailed information about the study.

Those parents who gave consent were contacted by the investigator and were given an oral explanation of the study (see Appendix B). Parents were reassured that all data would be kept confidential; that they could obtain final results, upon request, at the end of each evaluation session, as well as at the completion of the study; and, that they could withdraw their infant from the study at any time without prejudice. Informed consent was obtained after all parent questions were answered (see Appendix C).

Infants of parents who agreed to participate were matched according to severity of hemorrhage (Stages One and Two IVH were labeled "mild", and Stages Three and Four IVH were labeled "severe") and birth weight (infants who weighed 1,000 grams or less were matched with subjects who weighed not more than 1,999 grams; infants who weighed 3,000 grams or more were matched with subjects who weighed more than 1,000 grams). The treatment groups to which the infants were then randomly assigned consisted of: (1) a minimal intervention program consisting of routine medical care and referral to the NICU follow-up clinic, or (2) a more intensive intervention program which included routine medical care, referral to the NICU follow-up clinic, and an individual sensorimotor stimulation program (the Curriculum and Monitoring System (CAMS) Motor Program) beginning at 3 months corrected age (prematurity corrected to 40 weeks plus 3 months).

Sample

All subjects were not old enough for 12-month posttesting at the time of this pilot data analyses. As a result, there were unequal numbers of subjects in experimental and control groups. The initial study sample was composed of 15 infants from UUMC and 10 infants from PCMC. One subject from PCMC was excluded from the final analyses because he experienced a respiratory arrest after discharge from the hospital which left him profoundly impaired. The control group contained 14 subjects and the experimental group contained 10 subjects. Eleven (46%) subjects had a diagnosis of severe IVH (7 Grade Threes and 4 Grade Fours) and 13 (54%) subjects had mild IVH (5 Grade Ones and 8 Grade Twos). All subjects were white and there were a total of 12 (50%) males and 12 (50%) females in the study sample. The sample mean birth weight and gestational age were 1,470 grams (SD = 669) and 31 weeks (SD = 4.0), respectively.

Parents of subjects from both sites represented a cross-section of socioeconomic groups. One (4%) was unemployed, 6 (25%) were in the unskilled labor category, 9 (38%) were in the semi-skilled and blue collar category, 2 (8%) were in the semi-professional and technical category, and 6 (25%) were in the high level executive and professional category according to Duncan Socioeconomic Index (Duncan SEI) ratings (Miller, 1983).

Data Collection

Demographic data for each subject was obtained by the investigator and all diagnostic evaluations were completed by examiners who were blind to the experimental and control group assignments. Information collected by the investigator from the medical records and questionnaires completed by the parent included: Birth weight; gestational age; 1- and 5-minute APGAR scores; sex; race; mother's age; mother's parity (number of previous live births); number of abortions; type of birth (single, twin, or triplet); inborn/outborn status; type of delivery (vaginal versus cesarean); appropriate for gestational age (AGA) versus small for gestational age (SGA); presence or absence of hyaline membrane disease (HMD), bronchopulmonary dysplasia (BPD), ventriculo-peritoneal shunt (V-P shunt), patent ductus arteriosis (PDA), retinopathy, seizures, perinatal hearing impairment, and/or sepsis; total number of days on assisted ventilation; total days intensive care unit (ICU) status; total days intermediate care status; severity of IVH (One, Two, Three, or Four); total bilirubin above or below 15.0; parent socioeconomic status; marital status of mother; and total number of adults and children living in the home.

At 3- and 12-months corrected age, initial and follow-up developmental assessments, using the Battelle Developmental Inventory

(BDI) (Newborg, Stock, & Wnek, 1984) were completed by blind examiners, and answer protocols were checked for accuracy by the investigator. Mothers also completed the Parental Anxieties and Attitudes Scale (PAAS) (Field, 1978) when their infant was 3-months corrected age; the Carey Infant Temperament Scale (the Carey) (Carey & McDevitt, 1978) when their infant was between 6- and 9-months corrected age; and the Parenting Stress Index (PSI) (Abidin, 1983) when their infant was 12 months corrected age.

Instrumentation

The Battelle Developmental Inventory (BDI) (Newborg et al., 1984) is a new, individually administered norm-referenced test. The test consists of 341 items grouped into the following domains: Personal-Social, Adaptive, Motor, Communication, and Cognitive. The BDI is behaviorally based and is primarily designed for identifying developmental strengths and weaknesses of handicapped and nonhandicapped children in infant, preschool, and primary programs; assessment of infants who are considered to be at-risk in any developmental area; and monitoring progress on a short- and long-term basis, as the test can be used to assess children from birth to age 8.

The development of the BDI was based on the concept of milestones; that is, a child normally attains critical skills or behaviors in a certain developmental sequence, and the acquisition of each skill generally depends on the acquisition of a preceeding skill. The BDI was selected for use in this study so that the infants may be followed over time to the age of 7 without the need to change instruments.

Measures of reliability and validity on component, subdomain, and Total BDI scores that were computed for each age range included: Standard error of measurement; test-retest, and interrater reliabilities; and, content, construct, and criterion-related validities (Newborg et al., 1984, p 52-66). The standard errors of measurements were very small indicating accuracy of measurement, and the test-retest and interrater reliabilities were very high overall, indicating stable scores over time and accuracy of rater judgement. Overall correlations between the BDI and the Vineland Social Maturity Scale, the Developmental Activities Screening Inventory, and the Stanford Binet Intelligence Scale were moderate to high and support concurrent validity.

In addition to the BDI, the CAMS Motor Placement criterion-referenced test (Casto, 1979) was administered to those infants in the intensive sensorimotor intervention group, by a licensed physical therapist. It was given when the infant was 3-months corrected age, and was used to determine at what step the infant should begin in the individualized sensorimotor intervention program. The test items are the actual criteria from the final step of each of the 98 CAMS Motor Program objectives. At the completion of the intensive intervention program, when the infant was 12 months corrected age, the criterion test was readministered to this group of subjects. Control subjects were not given the CAMS Motor Placement test.

The Perinatal Anxieties and Attitudes Scale (PAAS) (Field, 1978) is a research instrument which was originally developed for the assessment of teenage mothers. It provides an assessment of attitudes and anxieties of the mother about herself and her infant during the pregnancy, labor, delivery, and postpartum periods. Examples of the 59 dichotomous "yes-no" questions were: "Were you angry when you found out you were pregnant?" and, "Did you want to be awake during the birth?" Mean scores reported by the author for teen (n = 90) and adult (n = 60) mothers were 20.3 and 16.5, respectively (Field, Widmayer, Stringer, & Ignatoff, 1980). Low scores represent low anxiety.

The Carey Infant Temperament Questionnaire (the Carey) (Carey & McDevitt, 1978) was used to assess temperament at 6- to 9-months corrected age. The authors of the scale define "infant temperament" as the emotional reactivity, or behavioral style (regardless of origin) that is displayed by an infant in the early months of life. Carey speculates that temperament is an important variable in infant development in that it requires adjustment by caretakers, particularly if the infant's temperament is opposite of what parents expected, or what they are used to. Infant temperament is believed to have lasting effects on development, for example, infants who have temperamental qualities that are at extremes may be at risk for conflicts with their parents.

The 95-item questionnaire is aimed at obtaining descriptions about an infant's behaviors, and particularly how each infant responds in specific situations. Mothers who complete the questionnaire are asked to select from six possible choices (from "almost never" to "almost always") that best describes the infant's behavior in each of nine categories of infant temperament. These categories include: Activity level, regularity, adaptability to change in routine, response to new situations, level of sensory threshold, intensity of response, positive or negative mood, distractibility, and persistence and attention span. The questionnaire was designed for use as an adjunct in planning, implementing, and fostering more effective interactions between infants and parents.

The Carey (Carey & McDevitt, 1978) was standardized on 203 infants between 4 and 8 months of age. Internal consistency for the nine categories assessed by the scale ranged from .49 to .71. The median value was .57, and internal consistency for the whole instrument was .83. The range for test-retest reliability was .66 to .81 and the median value was .86 for the whole instrument.

The Parenting Stress Index (PSI) (Abidin, 1983) is a 151-item questionnaire which samples three domains: Child characteristics, Parent characteristics, and Situational/Demographic characteristics of stress. The purpose of the questionnaire is to identify and diagnose individual mother-child systems under stress and to make gross predictions about the course of the developing parent-child relationship, as well as the child's later adjustment. The questionnaire was normed on 534 parents who visited small pediatric clinics in central Virginia. Both normal children and those with special health or behavior problems were represented in the norm group.

Reliability for the Child domain was .89, for the Parent domain it was .93, and the Total test reliability coefficient was .95. The average test-retest coefficient for the Child domain was .69, it was .75 for the Parent domain, and .83 for the Total test. Content validity was determined via expert opinion as well as through a comparison of the items with those included in other studies of stress. Factor analysis supported the factor structure, and numerous concurrent validity studies are reported in the manual.

Intensive Sensorimotor Intervention Curriculum

The CAMS Motor Intervention curriculum (Casto, 1979) was utilized with the intensive sensorimotor intervention group. The infant, and one or both parents, met bi-monthly with a licensed physical therapist for one-hour sessions. The parent(s) were taught specific exercises appropriate for enhancing their infant's current level of sensorimotor development, and they provided a repeat demonstration of the exercises learned prior to leaving the session. The physical therapist contacted the parent(s) by telephone on the week between appointments to check progress, as well as answer any questions that the parents had about the intervention program. Parents were instructed to work with their infants a minimum of 20-minutes each day, 5 days per week, throughout the 9-month program. Infants and parent(s) attended an average of 14 appointments (range 7 to 20) with the physical therapist, and reported missing an average of 2.1 days total time (range 0 to 10 days) of the 20-minute per day home intervention. Parents reported that they were unable to provide intervention on a daily basis when their infants were either ill or rehospitalized.

In this study, parent compliance with treatment was higher than expected. This findings was attributed to characteristics of the physical therapist who conducted the intervention. Parents reported experiencing an exceptionally strong positive relationship with the intervenor, and this likely influenced their participation in the program.

CHAPTER IV

ANALYSIS OF DATA AND RESULTS

This study was conducted for the purpose of examining the relationship between early sensorimotor intervention and developmental outcome of infants with perinatal IVH. The study was designed to determine whether or not infants with IVH in the perinatal period, demonstrated improved development, after participation in an intensive sensorimotor intervention program, when compared to a control group.

Description of the Sample

At the onset of this study, infant and maternal demographic and perinatal data were collected from the infant's medical record and from questionnaires completed by the mother. These data were analyzed in terms of the incidence by group; differences between control and experimental groups; and in terms of their relationship to control and experimental group subject's performance on the posttest Battelle Developmental Inventory (BDI), and the Parenting Stress Index (PSI), as appropriate.

Table 1 presents a summary of infant and maternal demographic and perinatal variables by group, and related $\underline{t}$ test probabilities. There were no statistically significant differences between groups on any of these measures. Table 2 summarizes the incidence of infant demographic and perinatal characteristics by group, whereas Table 3 presents the incidence of maternal characteristics by group. The control group had a 2:1 ratio of subjects with mild versus severe IVH. In the

Table 1

Means and Standard Deviations of Infant and Maternal Demographic and Perinatal Variables by Group

Variables	Control Group (n=14)		Experimental Group (n=10)		*t* test Probability
	Mean	SD	Mean	SD	
Infant					
Birthweight (grams)	1652	814	1214	248	.12
Gestational Age (weeks)	31	4.0	30	4.0	.51
1′ APGAR	5	3.0	3	3.0	.10
5′ APGAR	6	2.0	5	2.0	.24
Days Assisted Ventilation	29	41	32	25	.84
Age at Pretest (months)	3.5	.6	3.7	.7	.68
Age at Posttest (months)	12.4	.9	12.0	.6	.18
Maternal					
Age (years)	25	4.0	26	6.0	.61
Parity (prior live births)	2.0	1.0	3.0	2.0	.20
Number of Abortions	.5	.65	.1	.31	.09
Number Living in Home (adults and children)	4.2	1.3	4.8	2.2	.42
PAAS	13.2	5.3	14.4	5.2	.64

Table 2

Incidence of Infant Demographic and Perinatal Characteristics by Group

Characteristics		Control Group (n=14) N	Control Group (n=14) %	Experimental Group (n=10) N	Experimental Group (n=10) %
IVH	-Mild*	10	71	3	30
	Severe*	4	29	7	70
Race	-White	14	100	10	100
	Black	--	--	--	--
Sex	-Male	7	50	5	50
	Female	7	50	5	50
Birth	-Single	10	71	8	80
	Twin	4	29	1	10
	Triplet	--	--	1	10
Location	-Inborn	8	57	4	40
	Outborn	6	43	6	60
Delivery	-Vaginal	5	36	6	60
	Cesarean	9	64	4	40
Size	-AGA	14	100	10	100
	SGA	--	--	--	--
HMD		11	79	8	80
BPD		6	43	8	80
PDA		7	50	5	50
Hyperbilirubinemia		2	14	1	10
Retinopathy		4	29	3	30
Hearing Impairment		5	39	4	80
Sepsis		--	--	2	20
Seizures		2	14	--	--
V-P Shunt		1	7	2	20

* = Significant difference ($p \leq .05$)

Table 3

Incidence of Maternal Characteristics by Group

	Control Group (n=14)		Experimental Group (n=10)	
Characteristics	N	%	N	%
Marital Status				
Single	1	7	1	10
Married	13	93	9	90
SES (Duncan SEI)				
Unemployed	1	7	--	--
Semi-skilled	5	36	1	10
Blue collar	5	36	4	40
Semi-professional	--	--	2	20
Professional	3	21	3	30

experimental group there was a 2:1 ratio of subjects with severe versus mild IVH. These differences were statistically significant ($p = .05$). In addition, the control group had almost twice as many cesarean versus vaginal births, which was in direct contrast to the experimental group which had more vaginal births. The experimental group had twice as many subjects with bronchopulmonary dysplasia (BPD) and perinatal hearing problems when compared to the control group. None of these group differences reached statistical significance.

With respect to parent socioeconomic status, the control group had a higher percentage of subjects in the unemployed (level 1) and the semi-skilled (level 2) categories, and the experimental group had a higher percentage represented in the semi-professional (level 3) and professional (level 4) categories. Neither of these group differences were statistically significant.

An analysis of covariance (ANCOVA) was performed on pretest Battelle Developmental Inventory (BDI) scores by group. Table 4 summarizes, for each pretest BDI score, the order in which predictor variables entered the regression equation, and the total cumulative amount of variance accounted for by these variables. ANCOVA F values and associated significance for the pretest BDI Total and subdomain scores by group are presented in Table 5. Table 6 summarizes the adjusted and observed pretest BDI Total and subdomain scores, observed score standard deviations (SDs), and observed score developmental quotients (DQs) for the control and experimental groups. All subject's earned average DQ scores on all tests. There were statistically significant differences between groups, in favor of the experimental subjects, on the Total Motor and Cognitive subdomains as well as on the Fine Motor component.

Infant Temperament and Parenting Stress Ratings

Table 7 presents the incidence of infant temperament ratings, at 6- to 9-months corrected age (prematurity corrected to 40 weeks plus 6- to 9-months) by group. There were no statistically significant differences between groups on any of these ratings. Carey, Fox, and McDevitt (1977) report that children rated as "difficult" as infants were found to be significantly more impulsive than those who earned "easy" or "intermediate" temperament ratings. With respect to school adjustment scores, children labeled "easy" in infancy had significantly

Table 4

Pretest Stepwise Multiple Regression Predictor Variables and Cumulative Variance by Outcome Measures

	Demographic and Perinatal Predictor Variables				
Outcome Measures	Var.	Var.	Var.	Var.	Cum. r^2
Total BDI	BIR	SES	SEP	ABPR	.84
Personal-Social	BIR	SES	GA	AUD	.85
Adaptive	BIR	SEP	LIH	ICU	.78
Total Motor	BIR	INT	BILI	SEP	.76
Gross Motor	BIR	MAG	SES	---	.65
Fine Motor	BIR	VENT	ABPR	ICU	.66
Communication	SEX	SEP	BILI	ICU	.74
Cognitive	BIR	SES	---	---	.77

BDI = Battelle Developmental Inventory
SES = mother's socioeconomic status
GA = gestational age
LIH = # living in the home
INT = days intermediate care
MAG = mothers age
SEX = male or female
BIR = single, twin, or triplet
ABPR = age at pretest
AUD = hearing problems
ICU = days intensive care unit
BILI = hyperbilirubinemia
VENT = days assisted ventilation
SEP = sepsis

Table 5

Analysis of Covariance F Values and Associated Significance by Pretest BDI Outcome Measures

Outcome Measures	Source of Variance	ANCOVA	
		F	Sig
Total BDI	Group	.99	.34
	IVH	.21	.65
	Interaction	4.86	.04
Personal-Social	Group	.00	.96
	IVH	.04	.85
	Interaction	.70	.42
Adaptive	Group	.54	.47
	IVH	1.31	.27
	Interaction	.03	.87
Total Motor	Group	4.38	.05
	IVH	.84	.37
	Interaction	.02	.88
Gross Motor	Group	.03	.87
	IVH	.25	.62
	Interaction	3.97	.06
Fine Motor	Group	5.38	.03
	IVH	.64	.43
	Interaction	1.78	.20
Communication	Group	2.94	.11
	IVH	3.82	.07
	Interaction	2.48	.14
Cognitive	Group	6.06	.02
	IVH	.17	.68
	Interaction	1.09	.31

Table 6

Pretest BDI Total and Subdomain Adjusted and Observed Mean Raw Scores, Observed Score Standard Deviations, and Observed Score Mean DQs by Group

Score	Control Group (n=14)				Experimental Group (n=10)			
	Adjusted	Observed	SD	DQ	Adjusted	Observed	SD	DQ
Total BDI	60	58	14.0	98	63	66	11.1	108
Personal-Social	17	17	4.2	97	17	18	4.8	99
Adaptive	13	12	3.4	102	12	13	3.2	104
Total Motor*	12	12	2.9	95	14	14	3.2	98
Gross Motor	9	9	1.8	96	9	9	1.7	96
Fine Motor*	4	4	1.7	99	5	5	2.1	102
Communication	10	9	2.8	103	11	11	1.6	115
Cognitive*	7	7	2.8	104	9	9	1.6	113

* Significant difference ($p < .05$)

Table 7

Incidence of Infant Temperament Ratings at 6 to 9 Months by Group

	Control Group (n=14)		Experimental Group (n=10)	
Rating	N	%	N	%
Easy	3	21	3	30
Difficult	4	29	2	20
Slow-to-Warm	1	7	--	--
Intermediate	6	43	5	50

poorer adjustment as compared to other groups. Children in the "intermediate" group were found to have the best school adjustment.

A summary of the control and experimental group results on the Parenting Stress Index (PSI) is presented in Table 8. No significant difference was found between groups on level of stress on any of the measures. The overall intensity of stress indicated on the Total, as well as on the Child and Parent subdomains, was moderate. Parents who received intervention did not experience significantly less stress than those who were in the control group.

Major Analyses of Group Differences at Posttest

Zero-order correlations were run between all infant and maternal demographic and perinatal variables; infant pretest Battelle Developmental Inventory (BDI) Total, subdomain, and Gross and Fine

Table 8

Parenting Stress Index Total and Subdomain Mean Raw Scores, Standard Deviations, and Percentile Rank Ratings by Group

	Control Group (n=14)			Experimental Group (n=10)		
Score	Mean	SD	PR	Mean	SD	PR
Total PSI Score	234	45	65	225	35	55
Child Domain	105	22	65	101	20	60
Parent Domain	129	32	65	125	17	60

Motor component scores; infant posttest BDI Total, subdomain, and Gross and Fine Motor component scores; and Parenting Stress Index (PSI) scores (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975). Predictor variables (pretest BDI Total, subdomain, and Gross and Fine Motor component raw scores; gestational age; birth weight; sex; mothers age; type of birth; inborn/outborn status; appropriate for gestational age versus small for gestational age (AGA vs. SGA); hyaline membrane disease (HMD); bronchopulmonary dysplasia (BPD); patent ductus arteriosis (PDA); hyperbilirubinemia; retinopathy; perinatal hearing problems; sepsis; hospital; days intensive care status; days intermediate care status; days on assisted ventilation; number of persons living in the home; maternal socioeconomic status; marital status of mother; infant age at pretest; and, infant age at posttest) were entered into a stepwise multiple regression equation with posttest Battelle Developmental Inventory (BDI) and Parenting Stress Index (PSI) scores as the dependent variables. Table 9 summarizes, for each

Table 9

Posttest Stepwise Multiple Regression Predictor Variables and Cumulative Variance by Outcome Measures

	Demographic, Perinatal, and Pretest BDI Predictor Variables					
Outcome Measures	Var.	Var.	Var.	Var.	Var.	Cum.r^2
Total BDI	FMRS	SEX	PDA	BILI	BIR	.91
Personal-Social	FMRS	LIH	ARS	BPD	GA	.92
Adaptive	BTRS	RET	GA	GMRS	CORS	.93
Total Motor	FMRS	SEP	PDA	ICU	RET	.85
Gross Motor	PDA	FMRS	SEP	SEX	BIR	.85
Fine Motor	FMRS	ICU	IO	SEP	---	.82
Communication	SEX	SEP	BILI	---	---	.81
Cognitive	INT	SEX	FMRS	CORS	---	.72
Total PSI	HMD	GMRS	ARS	ABPO	BIR	.80
Child Domain	HMD	ABPO	GMRS	ARS	PSRS	.77
Parent Domain	---					

BDI = Battelle Developmental Inventory
SEX = male or female
BIR = single, twin, or triplet
LIH = # living in home
BPD = bronchopulmonary dysplasia
SEP = sepsis
ICU = days intensive care unit
INT = days intermediate care
HMD = hyaline membrane disease
PSI = Parenting Stress Index
RET = retinopathy
FMRS = pretest Fine Motor score
PDA = patent ductus arteriosis
BILI = hyperbilirubinemia
ARS = pretest Adaptive score
GA = gestational age
BTRS = pretest Total BDI score
GMRS = pretest Gross Motor score
IO = inborn vs. outborn status
ABPO = age at posttest
PSRS = pretest Personal-Social score
CORS = pretest Communication score

dependent variable, the order in which predictor variables entered the regression equation, and the associated amount of variance accounted for.

Separate analysis of covariances (ANCOVAs) were then run with the respective predictor variable(s) as covariates of posttest BDI outcome by group. Table 10 presents the adjusted and observed posttest BDI Total and subdomain scores, observed score standard deviations (SDs), and observed score developmental quotients (DQs) for control and experimental groups. A summary of the ANCOVA $\underline{F}$ values and associated significance by posttest BDI outcome measures is presented in Table 11.

There was a significant difference between groups in posttest Battelle Developmental Inventory (BDI) Total scores. Subjects who participated in early sensorimotor intervention, in addition to receiving routine medical follow-up, earned higher scores than those subjects who received only the routine medical follow-up. Given the small sample sizes in this study, it is noteworthy that subjects in the experimental group earned scores in the BDI Personal-Social subdomain ($p = .065$) and Fine Motor component ($p = .10$) that were close to being significantly superior to those earned by control subjects.

Subjects in the experimental and control groups earned similar observed score mean DQs on the BDI Total, subdomain, and Fine and Gross Motor component scores. BDI Personal-Social and Cognitive subdomain scores were in the average range; Total BDI, Fine Motor component, and Adaptive and Communication subdomain DQ scores were in the low average range; and BDI Total Motor subdomain and Gross Motor component scores were in the borderline range.

Table 10

<u>Adjusted and Observed Posttest BDI Total and Subdomain Mean Raw Scores, Observed Score Standard Deviations, and Observed Score Mean DQs by Group</u>

Score	Control Group (n=14)				Experimental Group (n=10)			
	Adjusted	Observed	SD	DQ	Adjusted	Observed	SD	DQ
Total BDI*	153	152	19.4	74	159	164	22.0	81
Personal-Social	40	39	8.0	85	43	46	7.3	98
Adaptive	32	31	5.1	82	32	34	3.6	86
Total Motor	41	41	6.5	69	39	40	7.9	65
Gross Motor	25	26	4.6	69	24	24	6.0	65
Fine Motor	15	16	3.0	85	16	16	3.1	85
Communication	21	21	3.8	79	23	23	4.7	82
Cognitive	21	21	1.9	91	20	20	1.8	86

* Significant difference ($p < .05$)1

Table 11

Analysis of Covariance F Values and Associated Significance by Posttest BDI Outcome Measures

		ANCOVA	
Outcome Measures	Source of Variance	F	Sig
Total BDI	Group	4.49	.05
	IVH	6.52	.02
	Interaction	.24	.63
Personal-Social	Group	3.96	.065
	IVH	4.62	.048
	Interaction	.08	.78
Adaptive	Group	.08	.78
	IVH	.02	.89
	Interaction	3.37	.09
Total Motor	Group	.00	.99
	IVH	1.87	.19
	Interaction	.20	.66
Gross Motor	Group	.31	.59
	IVH	10.34	.01
	Interaction	.01	.93
Fine Motor	Group	3.04	.10
	IVH	1.71	.21
	Interaction	.05	.81
Communication	Group	1.76	.20
	IVH	.45	.51
	Interaction	.02	.88
Cognitive	Group	.61	.44
	IVH	.35	.56
	Interaction	1.83	.20

There was a decline in overall level of developmental functioning from pre- to posttest in both groups (see Table 12). This drop was greatest (a 2 standard deviation decline) in the BDI Total Motor subdomain and Gross Motor component for both groups.

Table 12

Pre- Versus Posttest BDI Observed Score DQs by Group

	Control Group (n=14)		Experimental Group (n=10)	
Rating	Pre DQ	Post DQ	Pre DQ	Post DQ
Total	98	74	108	81
Personal-Social	97	85	99	98
Adaptive	102	82	104	86
Total Motor	95	69	98	65
Gross Motor	96	69	96	65
Fine Motor	99	85	102	85
Communication	103	79	115	82
Cognitive	104	91	113	86

Table 13 presents the incidence of pre- and posttest observed BDI DQ scores by group and Table 14 summarizes the incidence of posttest observed BDI DQ scores by severity of IVH. There was a greater range of scores on posttesting as compared to pretesting, and a larger proportion of experimental subjects demonstrated low average to average DQ scores on posttesting as compared to control subjects, who earned a

Table 13

Incidence of Pre- and Posttest BDI Observed Score Total DQs by Group

	Control Group (n=14)				Experimental Group (n=10)			
	Pre		Post		Pre		Post	
DQ Score	N	%	N	%	N	%	N	%
65-70	--	--	6	43	--	--	1	10
71-85	--	--	7	50	--	--	5	50
86-118	14	100	1	7	10	100	4	40

Table 14

Incidence of Posttest BDI Observed Score Total DQs by Severity of IVH

	I		II		III		IV	
DQ Score	N	%	N	%	N	%	N	%
65-70	--	--	3	38	1	14	3	75
71-85	4	80	4	50	3	43	1	25
86-102	1	20	1	12	3	43	--	--

greater proportion of borderline DQ scores. No subjects with Grade One IVH earned borderline DQ scores whereas no subjects with Grade Four IVH earned average or above DQ scores. No differences between proportions by group or severity of IVH were statistically significant.

CHAPTER V

DISCUSSION

This experimental study was undertaken to determine the effect of an intensive sensorimotor intervention program on the development of infants with perinatal intraventricular hemorrhage (IVH). The following sections of this chapter will include: A summary of the study, discussion of the findings, conclusions and implications of the findings, and recommendations for further research.

Summary

This study, conducted over a 9-month period of time, used a two-group pre-post experimental design. The purpose was to examine the relationship between early sensorimotor intervention and development in infants with perinatal IVH. The major research hypothesis of the study was: Participation in an early sensorimotor intervention program will improve the development of infants with perinatal IVH, as compared to a similar group of infants who do not receive the intensive intervention.

Fourteen subjects with perinatal IVH who were patients in the neonatal intensive care unit (NICU) at University of Utah Medical Center (UUMC) or Primary Childrens Medical Center (PCMC) served as the control group. These subjects received minimal intervention consisting of routine medical care plus referral to the NICU follow-up clinic.

The experimental group was composed of 10 subjects with perinatal IVH who, prior to random assignment, were matched with subjects in the control group, on mild or severe IVH, and birth weight. The experimental subjects received routine medical care, were referred to the NICU follow-up clinic, and participated in an intensive sensorimotor intervention program.

The intensive sensorimotor intervention sessions in which the infants and their parent(s) participated, took place in a clinic office, and were presented by a licensed physical therapist. Initially, the infant was tested with the CAMS Motor Placement test (Casto, 1979) at 3-months corrected age. Thereafter, the subject and their parent(s) met with the therapist bi-monthly for one-hour sessions. The parent(s) were taught specific exercises to enhance their infant's current sensorimotor development, and they were required to give a repeat demonstration of the exercises learned prior to leaving the session. The physical therapist contacted the parent(s) by phone to answer questions on the weeks between appointments. Parents worked with their infant at home an average of 20 minutes each day 5 days per week throughout the 9-month program.

At the initiation of this study, when the infant was 3-months corrected age, demographic and perinatal variables on the infants and mothers were collected from the medical records and parent questionnaires. The infant also was given the Battelle Developmental Inventory (BDI) by an examiner who was blind to the experimental and control group assignment. Parents completed the Carey Infant Temperament Questionnaire when their infant was between 6- and 9-months corrected age, and when the infant was 12-months corrected age, they again were tested with the BDI, and their mother completed the Parenting Stress Index (PSI).

Scores on infant and maternal demographic and perinatal variables, the infant 3-month pretest BDI, the 6- to 9-month Carey, the infant 12-month posttest BDI, and the 12-month PSI were analyzed by the investigator in the following manner:

1. Means and standard deviations or incidence of each infant and maternal demographic and perinatal variable, and Carey and PSI ratings, were calculated for each group. Appropriate statistics (t tests and tests of proportions) were used to evaluate the significance of the differences between groups.

2. Zero-order correlations were run between all demographic, perinatal, pretest BDI, posttest BDI, and PSI scores.

3. Appropriate predictor variables were entered into stepwise multiple regression equations with pretest BDI, posttest BDI, and PSI scores as dependent variables.

4. ANCOVAs were run on pretest BDI Total and subdomain scores by group. The first four predictor variables which entered on the respective multiple regression equation were used as covariates.

5. ANCOVAs were run on posttest BDI Total and subdomain scores, and Parenting Stress Index scores by group. The first five predictor variables which entered on the respective multiple regression equation were utilized as covariates.

The major results of these data (group by posttest BDI Total score ANCOVA) revealed the existence of a statistically significant positive relationship between intensive sensorimotor intervention and developmental outcome. Therefore, the research hypothesis was accepted. Although no other Battelle Developmental Inventory (BDI) scores were significantly different between groups, it is noteworthy that scores on the Personal-Social subdomain and the Fine Motor component approached significance. Experimental subjects earned slightly higher scores than control subjects.

Discussion of Findings

The major analyses of this study revealed a statistically significant difference between groups in performance on the posttest Total BDI which favored the experimental subjects. It is instructive that although subjects received differential treatment with respect to sensorimotor development, no significant differences were noted between groups with respect to Total Motor or Gross Motor scores, and Fine Motor scores only approached significance.

Experimental subjects earned slightly higher pretest BDI Motor scores as compared to control subjects, whereas at posttest, the control group had slightly superior Motor scores. These results may be explained in part by the limited ability of the Battelle Developmental Inventory (BDI) to make fine discriminations between subjects at 3-months of age. In addition, the overall posttest data indicates that 36.5% of subjects with severe IVH earned borderline DQ scores whereas only 23% of subjects with mild IVH earn similarly low scores. There were more than twice as many subjects with severe versus mild IVH in the experimental group, and the control group had more than twice as many mild IVH subjects.

An overall decline, from pre- to posttest, on observed BDI Total and subdomain DQ scores was noted. This drop was less than 1/2 standard deviation (SD) on the Personal-Social subdomain, and observed mean DQ scores remained in the average range at posttest. Observed mean DQ scores fell between 1 and 1-1/2 SDs on the BDI Adaptive subdomain and Fine Motor component, and scores dropped from the average to the low average range. Observed mean DQ scores on the BDI Total, Communication, and Cognitive subdomains fell between 1-1/2 and 2 SDs from pre- to posttest. Cognitive subdomain scores remained in the average range whereas BDI Total and Communication subdomain scores dropped from average to low average at posttest. The drop from pre- to posttest in observed mean DQ scores on the Total Motor subdomain and Gross Motor component was 2 SDs or more. Both of these scores dropped from an average to borderline DQ range.

These findings are consistent with the results of general low birth weight (LBW) and IVH outcome studies in the current literature (e.g., Escalona, 1982; Gaiter, 1982; Siegel, 1982; & Hack et al., 1984) wherein infants demonstrated a general decline in developmental scores at 12 to 18 months when compared to an earlier assessment on which they had earned normal DQ scores.

In the IVH outcome literature, there were mixed results with respect to overall developmental outcome at 12 months or longer follow-up. Schub, Ahmann, Dykes, Lazzara, and Blumenstein (1981), at 34-month evaluation, found no significant difference between IVH and control LBW subjects, and only 12% of all subjects earned DQ scores below 70. Papile, Munsick-Bruno, and Schaefer (1983) report similar results; that is, approximately 10% of their LBW IVH sample demonstrated borderline or lower Bayley scores. Furthermore, they found that subjects with

Grades Three or Four IVH had significantly lower Bayley scores than either subjects with Grades One or Two IVH or controls.

Other authors (e.g., Catto-Smith et al., 1985; Landry et al., 1984; Tekolste et al., 1985) investigating IVH outcome noted a significant difference between IVH and control subjects, in favor of the later. This difference was attributed to lower motor domain scores, which is consistent with the findings of general LBW research as well as those of the current study. Tekolste et al. (1985), at 36-month evaluation, noted that IVH subjects had significantly lower (though low normal) DQ scores, with differences attributed to lower motor domain scores in the IVH group. No significant differences were found between mild versus severe IVH subjects, although subjects with grade Four IVH demonstrated lower motor scores than those with Grades One through Three IVH.

As mentioned previously, the BDI has a limited number of items for assessing development in the birth to 11 month age range. As a consequence, there is a limited ability to make discriminations between subjects, in terms of development in each of the five domains. In the present study, 100% of control and experimental subjects earned average DQ scores (between 86 and 118) on the pretest BDI, and no subjects earned low average (between 71 and 85) or borderline (Between 65 and 70) DQ scores. However, on the posttest BDI, subjects in both groups earned average, low average, and borderline DQ scores. Differences between subjects may have been present at the time of pretesting, but were not identified because of the limitations of the BDI for this age group.

In the present study, subjects in both groups earned borderline DQ Motor scores, and low average to average DQ scores in other subdomains at posttest. When looking at outcome at 12-months corrected age by severity of IVH, no subjects with grade One IVH had DQ scores below 71, and no subjects with grade Four IVH earned DQ scores above 85. Although the number of subjects evaluated in each of these categories was small, the trend is consistent with results of past research with IVH subjects (e.g., Gaiter, 1982; Tekolste et al., 1985). In addition, this study did not find significantly delayed scores in subjects with ventriculo-peritoneal shunts nor post-hemorrhagic hypertrophy (PHH) treated with lumbar punctures. This finding is in contrast to that of Landry et al. (1984) who found that those with PHH had the most significant delays in both mental and motor domains.

When looking at major infant and maternal perinatal and demographic correlates of developmental outcome, at 12-months corrected age, the current study found that severity of intraventricular hemorrhage, sex, patent ductus arteriosis, hyperbilirubinemia, type of birth (single, twin, or triplet), number of persons living in the home, bronchopulmonary dysplasia, gestational age, retinopathy, sepsis, days intensive care status, days intermediate care status, and inborn/ outborn status were the only significant predictors. These results are in contrast with those of prior studies on the LBW and IVH populations (e.g., Hack et al., 1984) wherein birth weight, days on assisted ventilation, and presence of hyaline membrane disease or ventriculo-peritoneal shunt significantly predicted outcome. This study also contrasted with the findings of Smith, Somner, and von Tetzchner (1982) in that a significant relationship between SES and/or birth weight and developmental outcome was not found.

Finally, this study found that subjects who participated in the sensorimotor intervention program, in addition to receiving routine medical follow-up, had significantly superior posttest Total Battelle Developmental Inventory (BDI) scores when compared to control subjects. This finding is congruent with the results of the early intervention research (e.g., Barrera, Rosenbaum, & Cunningham, 1986; McDaniels, 1977). Both of these studies presented well documented evidence of immediate benefits resulting from early intervention with at-risk populations. However, as noted by Bush and White (1983), it is essential to follow subjects longitudinally in order to evaluate the impact of participation in early intervention. Subjects in the current study will continue to receive sensorimotor stimulation and will be evaluated annually until the age of 7 in order to ascertain the benefits of participation in this particular program.

Conclusions

The following conclusions were derived from the data of this study:

1. A significant positive relationship was found between participation in intensive sensorimotor intervention, and developmental outcome of subjects with perinatal intraventricular hemorrhage (IVH) at 12-months corrected age, as measured by the Battelle Developmental Inventory (BDI).

2. Subjects in experimental and control groups earned similar scores on pre- and posttest BDI scores. At pretest, all mean developmental quotient (DQ) scores were in the average range, whereas on posttest, DQ scores dropped by 1/2 to 2 1/2 standard deviations (SDs) into the low average or borderline range. Posttest Personal-Social and Cognitive subdomain scores were in the average DQ range; Total BDI, Adaptive and Communication subdomain, and Fine Motor component scores were in the low average DQ range; and, Total Motor subdomain and Gross Motor component scores were in the borderline DQ range at posttest.

3. No significant relationship was identified between participation in intensive sensorimotor intervention and parenting stress measures taken when the infants were 12 months corrected age. The overall intensity of stress reported by parents in both groups was moderate (60%).

4. The infant and maternal demographic and perinatal variables that correlated with developmental outcome at 12-month postesting were: Severity of intraventricular hemorrhage, patent ductus arteriosis, hyperbilirubinemia, type of birth (single, twin, or triplet), number of persons living in the home, bronchopulmonary dysplasia, gestational age, retinopathy, sepsis, days intensive care status, days intermediate care status, and inborn/outborn status. Socioeconomic status, birth weight, and ventriculo-peritoneal shunt did not correlate significantly with outcome.

5. The severity of hemorrhage in subjects with perinatal IVH may influence developmental potential.

6. Developmental scores in early infancy do not accurately represent the child's potential for future development.

7. Participation in intervention is not likely to have a significant influence on level of parenting stress.

Recommendations for Further Research

Based on the results of this study, the following recommendations are made:

1. Continue enrollment of subjects in the current study so as to increase the sample size and to obtain equal representation of all grades of IVH in each group. This will allow for re-evaluation of the effects of early sensorimotor intervention on development and provide subjects necessary for comparison of groups by severity of IVH.

2. Continue the sensorimotor intervention program with the current study subjects. In addition, continue to follow these subjects annually in order to evaluate development by groups as well as the predictability of infant and maternal perinatal and demographic measures in relation to development at later ages.

3. Include additional measures of motor development, such as videotaping of milestones, at 6- and 12-months corrected age. These can be scored qualitatively by a licensed physical therapist, and provide information that may not be obtained by standardized evaluation.

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APPENDICES

Appendix A

Initial Contact Letter

Date

Dear:

The University of Utah's Medical Center is collaborating with the Early Intervention Research Institute at Utah State University in a research study designed to compare the developmental status of low birth weight infants who receive standard medical care during the first twelve months of life with similar low birth weight infants who are exposed to an early motor intervention program based on individual need.

Since your infant was in our neonatal intensive care unit during 1985, we are asking your permission to have the research team contact you, explain the purpose of the study, and give you an opportunity to participate if you so desire. The research study is expected to add considerably to our knowledge about low birth weight infants.

If you do not want the research team to contact you, please let me know by returning the enclosed postcard by and your name will not be released to the team and they will not contact you.

Please be assured that all information concerning you and your child will be kept confidential, and only group results will be reported should you agree to participate in the study.

Sincerely,

Gary Chan, M.D.
Medical Director for Infant Care Services

Enclosure

Appendix B

Summary of Oral Explanation of Study

SUMMARY OF ORAL EXPLANATION OF STUDY

1. Purpose of the study is to evaluate development of infants who experienced medical complications associated with birth and who were treated in NICU at either PCMC or UUMC. Infants will be evaluated at 3 and 12 months corrected age.

2. Half of the children will receive routine medical care and be referred to the NICU follow-up clinic; the other half will participate in an individualized sensorimotor stimulation program, in addition to the routine follow-up and referral to NICU clinic. Subjects are randomly assigned to treatment conditions. There will be no $ charge for participation in the assessments or in the sensorimotor program.

3. We are investigating whether or not infants who participate in sensorimotor intervention will have improved development. At this point in time we do not know if there will be significant benefits from this type of intervention. (Subjects and parent(s) in the sensorimotor group will meet every other week for one-hour with a licensed physical therapist to learn exercises aimed at enhancing the infants current development. The P.T. will call parents on the phone to answer questions during the week between appointments.) Infants who do not receive sensorimotor intervention will be assisted in enrolling their infant in an intervention program at the end of the 9-month study, if desired. Subjects in sensorimotor stimulation also will be referred for continued intervention, if desired.

4. Parents are free to enroll their infant in other service programs in the community, if desired.

5. The developmental evaluation will take approximately 1-hour, and will be completed at the parents' convenience in their home. Results of the evaluaton and parent questionnaires will be shared with the parents after each evaluation as well as at the end of the study, upon request.

6. All test and questionnaire materials will be kept confidential. Parents may withdraw their infant from the study at any time without prejudice.

7. Prior to any testing, the parent will be given a written consent form to read and sign, and they will be given a copy of this for their records.

Appendix C

Parent Consent Form

PARENT CONSENT FORM

This certifies that I have been informed of the purpose of the proposed research which involves the random assignment of my infant to one of two treatment conditions. Condition one will involve the enrollment of my infant in a nine month intervention program which will focus on the motor development of my infant. Condition two will involve continued medical care without the motor intervention program. My voluntary participation will be for a period of nine months. At the end of the nine-month period, or when my infant reaches 12 months of age, I understand I will be assisted in enrolling my infant in an available intervention program if I so desire.

I understand that the risks to my child are minimal as my infant will be receiving a tested intervention program if he/she is in the experimental group and will continue to receive medical follow-up if he/she is in the control group.

The possible benefits to my infant from this research have been explained as possible improved motor functioning if my infant is in the experimental group and assistance in getting my infant into an established intervention program at the conclusion of the study if my infant is in the control group. I further understand that my infant will receive two developmental assessments, one at three months, one at twelve months, and the results will be shared with me. I understand my child will be assessed with the Battelle Developmental Inventory, an individually administered instrument designed to assess developmental progress in personal-social, adaptive, motor, communication, and cognitive domains of children from birth to age eight. I understand the total testing time will be one hour.

I understand that my infant will be identified by number and that all records pertaining to my infant will be kept in a locked file at Primary Children's or University of Utah Medical Center. The investigators have assured me that all information collected as part of the study will be kept confidential and that my infant will not be identified by name. I further understand that I may request and receive the results of the study when it is completed.

If I decide to withdraw from the study, I understand that I may do so without prejudice. I have been given the following numbers to call should I have any questions about the research, my rights, and any other related matters.

Jack Dolcourt, M.D. (801) 521-1400
Gary Chan, M.D. (801) 581-7052
Glendon Casto, Ph.D. (801) 752-7982 (24-hour number)

I understand that I may contact the Institutional Review Board at (801) 581-3655 in those cases where a problem cannot be discussed with the research team.

______________________________ ________________

Parent Signature   Date

____

Witness of Parent Signature and Title of Signee

Appendix D

Glossary of Terms

GLOSSARY OF TERMS

Basal ganglia-a group of forebrain nuclei located deep within the cerebral hemispheres.

Caudate nucleus-one of the basal ganglia with a long tail or extension.

Computed tomography (CT) scan-a technique for examining brain structure in intact humans through a computer analysis of x-ray absorbtion at several positions around the head. The technique provides a virtual direct view of the brain.

Ependyma-innermost layer of the neural tube. The membrane which lines the cerebral ventricles and central canal of the spinal cord.

Foramen of Monro-the opening between the third and lateral ventricles of the brain.

Hydrocephalus-increased accumulation of cerebrospinal fluid within the ventricles of the brain.

Hyperbilirubinemia-high amounts of bilirubin (bile pigment) in the blood which may be due to excessive destruction of red blood cells.

Hypoglycemia-low blood sugar.

Hypoxia-lack of an adequate amount of oxygen in inspired air.

Intensive Care Unit (ICU) status-requiring a 1:1 or 2:1 nursing care ratio because of all or some of the following special needs: respirator ventilation, central intravenous infusions, chest tubes, or frequent laboratory tests.

Intermediate Care Status-requiring a 3:1 nursing care ratio because of all or some of the following special needs: head box oxygen administration, frequent lung/chest therapy including suctioning, intravenous infusions, isolette crib, bilirubin light treatment, gavage feedings, and routine laboratory tests.

Normal APGAR-APGAR is a system of scoring infants conditions one and five minutes after birth. The heart rate, respirations, muscle tone, color, and response to stimuli are scored 0, 1, or 2. The maximum score for a normal baby is 10.

Normal birth weight-approximately 2,500 grams or five and one-half pounds.

Normal gestational age-40 weeks.

Obliterative arachnoiditis-complete occlusion and inflammation of the thin delicate membrane located between the pia mater and dura mater. The layer of membranes enclose the brain and spinal cord.

GLOSSARY OF TERMS (continued)

Parenchymal lesions-lesions occurring in the essential parts of an organ. The parenchyma is concerned with organ function versus its structural framework.

Retrolental fibroplasia-a condition in which an opaque fibrous membrane develops on the posterior surface of the lens of the eye.

Subependymal germinal matrix-a richly vascular network of cells that are the source of cells which participate in formation of the cerebral cortex, basal ganglia, and other forebrain structures. This matrix is located beneath the lining of the cerebral ventricles and is most pronounced in the fetus at six to eight months gestation.

Ultrasonogaphy-inaudible sounds of a high frequency which have different velocities in tissues with differing densities and elasticity. This property allows the use of ultrasound in outlining the shape of various tissues and organs in the body.

VITA

JANET MILLARD

DISSERTATION

The Effect of an Early Sensorimotor Intervention Program on the Development of Infants with Perinatal Intraventricular Hemorrhage.

EDUCATION

Ph.D. (Psychology) Utah State University, Logan, Utah 1987

M.S. (Nursing) Texas Women's University, Denton, Texas (Houston Campus) 1980

B.S. (Nursing) Westminster College, Salt Lake City, Utah 1977

A.S. (Nursing) Weber State College, Ogden, Utah 1975

PROFESSIONAL EXPERIENCE

1986-1987 Research Associate, Early Intervention Research Institute, Utah State University, Logan, Utah.

1985-1986 Clinical Medical Psychology Intern, Baylor College of Medicine, Houston, Texas.

1984-1985 Shift Coordinator and Staff Nurse, Logan Regional Hospital, Logan, Utah.

1981-1983 Clinical Nurse Specialist, Salt Lake City V.A.M.C., Salt Lake City, Utah. Adjunct Clinical Instructor, University of Utah, College of Nursing, Salt Lake City, Utah.

1979-1981 Staff Nurse, Methodist Hospital, Houston, Texas.

1978-1978 Staff Nurse, Hermann Hospital, Houston, Texas.

1977-1978 Staff Nurse, St. Patrick's Hospital, Missoula, Montana.

1975-1976 Staff Nurse, Holy Cross Hospital, Salt Lake City, Utah.

PROFESSIONAL AFFILIATIONS

APA, Utah Psychological Association, International Neuropsychological Society.

PERSONAL DATA

Born November 18, 1954, Logan, Utah. Parents: John Burton and Mary Jane Millard.