COGNITIVE, PERCEPTUAL, AND PERSONAL-SOCIAL DEVELOPMENT OF PREMATURELY AND MATURELY BORN PRESCHOOLERS

By

Susan Jacob

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Counseling, Personnel Services
and Educational Psychology

1981

ABSTRACT

COGNITIVE, PERCEPTUAL, AND PERSONAL-SOCIAL DEVELOPMENT OF PREMATURELY AND MATURELY BORN PRESCHOOLERS

By

Susan Jacob

Previous research has shown that although the IQ scores of most premature children fall within the normal range at school age, these children lag behind their maturely born classmates in academic achievement, and they are more likely to receive special education services or repeat grades than their maturely born age-mates. This study was designed to determine if there are differences in the cognitive, perceptual, and personal-social development of prematurely and maturely born 3 and 4 year olds which might foreshadow later learning problems. Unlike previous studies, small-for-dates were excluded from the premature sample, and research groups were matched on post-conceptual rather than chronological age.

The sample was comprised of 40 prematurely born singletons (birth weight < 2,500 grams, < 38 weeks gestation, birth weight appropriate for gestational age) with birthdates between March 1976 and August 1977 who are graduates of a regional neonatal intensive care unit. Each premature child was matched with a maturely born control on sex, race, post-conceptual age, and socioeconomic background. Parity was matched at the group level. Subjects (N = 80) were administered the McCarthy

*4

Scales of Children's Abilities, a speech articulation screening exam, and a test devised to measure four problem-solving competence variables: self-direction, planfulness, impulsivity, and task persistence. Personal-social development was assessed by parent report.

No differences were found between the prematurely and maturely born research groups in performance on tests of higher mental processes including general cognitive ability, verbal ability, memory, problem solving, and impulse control, and no differences in personal-social development were found between the groups. Prematures did not perform as well as controls on perceptual performance tasks, particularly on items which are sensitive measures of visual-motor coordination such as copying a design. The poorer performance by prematures on perceptual performance tasks was interpreted as being due to relatively impaired visual-motor coordination. The age-appropriate developmental patterns found for prematures in this study were interpreted as being due to "parental push" as well as neurological integrity of the portions of the brain responsible for higher mental processes.

ACKNOWLEDGMENTS

Many people contributed to this research project. I have been fortunate to have the help and guidance of an excellent doctoral committee. Dr. Harvey F. Clarizio, my committee chairperson and director of this dissertation, provided guidance and encouragement throughout my doctoral studies. He has both demonstrated and demanded high standards of scholarship in school psychology. The expert assistance of Dr. Helen E. Benedict has been invaluable. Her gift for clarity and her enthusiasm for learning about children helped to translate a confusion of sketchy ideas into a completed study. Dr. Andrew C. Porter contributed his expert knowledge of statistics, along with a painstakingly thorough critique of one of the earlier drafts of this paper which proved to be very helpful. I am also grateful to Dr. Walter G. Hapkiewicz and Dr. Louise Sause for their encouragement and suggestions.

The members of Sparrow Hospital's Developmental Assessment Clinic team helped make this study possible, and their support of the project is greatly appreciated. Dr. Eugene A. Dolanski, Director of Newborn Services, rendered assistance in making subjects available. Dr. Dolanski, John Wallen, Dawn Welch, Dr. Michael Mennesson, and Dr. Padmani Karna, among others, provided me the opportunity to learn about the early development and assessment of high risk children. Joy Vanderklock, the DAC receptionist, deserves special mention for her meticulous record-keeping and time spent patiently answering the endless questions asked by study team members.

The study would still be incomplete were it not for the dedicated assistance of my two friends and research colleagues, Jeff Roach and Grace Louise Blackledge. Jeff Roach assumed responsibility for computer programming and statistical analyses, and Louise Blackledge supervised subject selection and parent contacts. Their enthusiasm and down-to-earth problem solving helped the study survive some difficult times. I look forward to working with them on future research projects.

I would also like to express my sincere thanks to eighty charming short people and their parents for their generous gift of time and energy. The hospitality extended to me by families who volunteered for the study was heart-warming.

This study was supported by a Student Research Small Grant Award to Central Michigan University from the State of Michigan Department of Mental Health.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

SCOPE AND PURPOSE OF THE STUDY

Results of studies conducted over the past thirty years strongly suggest that the prematurely born child is "at risk" for subsequent school learning problems when compared with his maturely born peers (Caplan, Bibace, & Rabinovitch, 1976; De Hirsch, Jansky, & Langford, 1966; Rubin, Rosenblatt, & Balow, 1973; Wiener, 1968; Wiener, Rider, Oppel, & Harper, 1968). While the IQ scores of most premature children fall within the normal range at school age (Wiener et al., 1968), these children do not perform as well as their maturely born classmates on tests of reading achievement (Caplan et al., 1976; De Hirsch et al., 1966; Rubin et al., 1973; Wiener, 1968; Wiener et al., 1968) and arithmetic achievement (Rubin et al., 1973; Wiener, 1968) in the elementary grades, and they are more likely to receive special education services (Rubin et al., 1973) or repeat grades (Rubin et al., 1973; Wiener, 1968) than their maturely born peers.

Subtle differences in the cognitive and perceptual development of prematurely and maturely born children have been identified in the early and middle childhood years. The IQ scores of prematurely born children average about five points lower than their maturely born counterparts at school age (Caplan et al., 1976; Caputo, Goldstein, & Taub, 1978; Wiener, Rider, Oppel, Fischer, & Harper, 1965; Wiener et al., 1968), and maturely born children outperform their prematurely born classmates on tests of visual-perceptual development throughout the elementary school years (Caplan et al., 1976; Caputo et al., 1978; De Hirsch et al., 1966; Wiener et al., 1965, 1968; Wright, Blough, Chamberlin, Ernest, Halstead, Meier, Moore, Nauton, & Newell, 1972). A higher incidence of delayed language development (De Hirsch et al., 1966; Rubin et al., 1973; Wiener et al., 1965) and speech immaturities (Fitzhardinge & Ramsay, 1972; Wiener et al., 1965, 1968) has been reported for prematurely born children when compared with their maturely born counterparts. Follow-up studies generally report no differences in verbal ability between prematurely and maturely born classmates at school age (Caplan et al., 1976; Caputo et al., 1978). Most researchers have interpreted the poorer performance of prematurely born children on psychological and educational tasks as being due to immaturities or deficits of the central nervous system (Caputo et al., 1978; De Hirsch et al., 1966; Wiener, 1968; Wiener et al., 1968).

One problem encountered in interpreting the literature on prematurely born children is the lack of consistency in definitions of "prematurity" used by researchers. Low birth weight was the sole criterion for defining "prematurity" in many of the studies which have appeared in the literature. However, this criterion fails to differentiate pre-term newborns with birth weights appropriate for their gestational age from "small-for-date" infants, and there is a growing body of literature which suggests that the small-for-date infant fares less well on assessments of later development than appropriate-for-date prematures (see Kopp & Parmelee, 1979; Towbin, 1978). A second difficulty encountered in interpreting the literature on prematurely born children is the lack of consistency in methods used to equate research groups on age at the time of follow-up evaluations. Researchers have typically matched premature and full-term children on chronological age at the time of assessment (Caplan et al., 1976; Caputo et al., 1978; Knobloch, Rider, & Pasamanick, 1956). In some studies, particularly those involving preschool children, the age of the prematurely born child is then "corrected" at the time of evaluation by subtracting the number of weeks premature from the chronological age of the child (Caputo et al., 1978; Knobloch et al., 1956). As each child's score is based on his performance relative to a same-aged norm group, this procedure is thought to effectively equate the premature and maturely born research groups on age at the time of testing. It should be noted, however, that the two research groups which result from these procedures are not matched on post-conceptual age, that is, the prematurely born children are biologically younger than their maturely born counterparts at the time of testing. Consequently, maturely born children have a "biological age" advantage on dependent measures which are not age-norm referenced. Similarly, full-term children have a biological age advantage in studies which match groups on chronological age but fail to adjust for prematurity in calculating scores.

No major studies were located in the literature in which the research groups were matched on post-conceptual rather than chronological age at the time of the follow-up testing. However, if differences in the performances of prematurely and maturely born children are interpreted as due to immaturities or deficits in the central nervous system, it seems most reasonable to equate research groups on "biological" or post-conceptual age at the time of the follow-up evaluation rather than matching groups on chronological age and then "correcting" scores for prematurity.

Furthermore, while "central nervous system dysfunction" or "impaired neurological integration" is typically cited as "the link" between premature birth and later school failures, few studies have appeared in the literature specifically designed to identify the nature of these "links" between pre-term birth and school learning difficulties (see Kopp & Parmelee, 1979). The notion that prematurely born children may suffer central nervous system dysfunction does little to explain what it is that they fail to do in the testing situation or classroom which results in relatively inferior performance. Researchers have described prematurely born children as more impulsive (Wiener et al., 1965), disorganized (De Hirsch et al., 1966), and field-dependent (Caplan et al., 1976) than their maturely born age-mates; however, there has been little systematic research to investigate these observations. Thus, at this time, little is known about what is "missing" in the repertoire of skills and abilities of premature children which results in "sub-optimal" test performance (Moreau, 1977), and yet it is this type of information which is most important for instruction and remediation.

Learning theorists and measurement specialists have recently begun to study the thought processes and cognitive skills which underlie correct or incorrect responses on traditional tests of mental abilities (Estes, 1974; Cohen, 1959; Kaufman, 1975; Kaufman & Hollenbeck, 1973). Successful performance on tasks designed to test, for example, visual-perceptual development requires a variety of problem-solving skills as well as a neurologically intact information processing system. A child must grasp the nature of the problem presented, identify critical elements and salient features of the task, devise problem-solving schemes, evaluate the correctness of possible solutions, and persist in self-directed efforts until mastery is achieved (see Feldhusen, Houtz, & Ringenbach, 1972). These skills are also important in reading, arithmetic, and other learning tasks in the classroom. Careful observation of the problem-solving efforts of the prematurely born child in the testing situation as well as information about his successes and failures is needed to gain insight into the mechanisms underlying his performance.

Most child development specialists and educators concur that the preschool period is an optimal time for intervention with high risk children. While the research cited above suggests that the premature child is "at risk" for later school failures, few studies have appeared in the literature designed to investigate the "early precursors" of these learning problems in the preschool years (Kopp & Parmelee, 1979).

As Hartlage and Telzrow (1981a) point out, research has generally shown that assessments prior to age two do not successfully predict IQ at school age. "The initiation of the verbal period marks a departure however, and following the onset of language, children demonstrate a type of functioning which predicts to subsequent intelligence, and which can discriminate between intact and disabled populations" (Hartlage & Telzrow, 1981a, p. 4). If differences in cognitive development and problem-solving approach can be identified between prematurely and maturely born 3 and 4 year olds, then the research foundation will be laid for determining the predictive importance of these differences and their modifiability.

This study was therefore designed (1) to determine if there are measurable differences in the cognitive, perceptual, and personal-social development of prematurely and maturely born preschoolers which might foreshadow later learning problems and (2) to investigate the mechanisms underlying the "sub-optimal" performance of prematurely born children described in the literature. The independent variable in the study was premature or mature birth; the dependent variables were general cognitive ability, language (verbal ability and speech maturity), perceptual performance, problem-solving competence (self-direction, planfulness, impulsivity, and task persistence), and personal-social development at 3 or 4 years of age. Data were also gathered to determine the incidence of special education referrals for all prematurely born preschoolers in the "at risk" research population and the reasons for referral.

Four research objectives were identified. As mentioned above, the first objective of the research study was to determine if there are differences between prematurely and maturely born 3 and 4 year olds in general cognitive ability, verbal ability, perceptual maturation, and personal-social development which may foreshadow later school learning difficulties. Unlike previous studies, however, small-for-date infants were excluded from the research sample and research groups were matched on post-conceptual age rather than chronological age at the time of assessment.

A second objective was to determine if there are differences in the problem-solving style and skills of prematurely born children and their maturely born age-mates in the testing situation. The problem-solving "competence" variables chosen for the study were self-direction, planfulness, impulsivity, and task persistence. It was hoped that careful and systematic observation of the problem-solving efforts of premature children might provide insight into the reasons for their "sub-optimal" performance on psychological and educational tasks. Identification of "what is missing" in their repertoire of skills and abilities would provide guidelines for early intervention.

A third objective of the study was to provide developmental data for a target group of preschoolers for follow-up in second grade. Identification of similarities and differences in problem-solving competence, cognitive functioning, perceptual maturation, and personal-social development of "at risk" and "normal" preschoolers was seen as an important first step in investigating the onset and possible precursors of later school failures. A follow-up of the study children in second grade may answer research questions concerning the early identification of children at risk for school failures and the developmental course of learning problems.

A fourth objective was to provide medical and mental health-care givers up-to-date information about the early development of premature children who benefited from advances in neonatal care made in the late 1960's and early 1970's. The prematurely born children who participated in the study were selected from the population of all children referred to the Developmental Assessment Clinic from the Regional Neonatal Intensive Care Unit in Sparrow Hospital, Lansing, Michigan. The Developmental Assessment Clinic (also located in Sparrow Hospital) monitors the health and development of children who required placement in neonatal intensive care at birth. The interdisciplinary team includes a neonatologist, nurse, physical therapist, social worker, and psychologist. The information gathered therefore provides the staff at Sparrow with some feedback about the developmental progress of prematurely born children they helped through difficult times in the intensive care unit. Results of the study may also help the Developmental Assessment Clinic team evaluate the appropriateness of screening procedures used to identify children with developmental delays. More specifically, identification of developmental areas in which prematurely born children show strengths and delays allows the Developmental Assessment Clinic team to select screening strategies which are sensitive measures of "at risk" skills and abilities. The findings also provide physicians and mental health workers with up-to-date information about the developmental patterns of prematurely born children which may be particularly helpful in counseling new mothers and fathers faced with the uncertainties of parenting a pre-term infant.

The "transactional" model of child development outlined by Sameroff and Chandler (1975) provides the conceptual framework for the study. The transactional model is based on a dynamic theory of development which allows for "a continual and progressive interplay between the organism and its' environment" (p. 234). One important premise of the model is that non-adaptive patterns of development set in motion by biological deficits may be offset or minimized by factors in the environment. The child is viewed as an active participant in his own growth according to this model (p. 235), and research attention is focused on the processes underlying adaptation and growth, i.e., the ways in which the child interacts with his environment.

CHAPTER II

THEORY AND RESEARCH

Theoretical Perspectives on Developmental Risk Research

Sameroff and Chandler published an article on theory in risk research in 1975 which has had a marked impact on subsequent thinking about the causes of healthy and deviant development. The authors first identified two models of development which provided the theoretical underpinnings for most of the studies of "at risk" groups prior to the mid-seventies, namely, the "main effects" model and the "interactional model," and they then outlined a new theoretical perspective, the "transactional model," which takes into account current knowledge about developmental processes. The first two models will be described briefly, and the transactional model, which provides a conceptual framework for this study, will then be described in some detail.

The "main effects" or "unifactor" model (Sameroff, 1979) is perhaps primarily of historical interest now. The basic premise of this model is that developmental deviance can be linked to a single causal factor in the environment or the biological make-up of the individual, and that "constitution and environment exert influences which are independent of each other" (Sameroff & Chandler, 1975, p. 232). According to this model, a deficit in the constitution of the individual will "produce a defective adult irrespective of environmental influences, and a pathogenic environment will produce a defective adult independent of his constitution" (p. 232). The main effects model is thus a "static" model which emphasizes continuity rather than discontinuity in development. The interaction of biological and social factors as they affect development is not recognized, and the role of biological deficits in shaping developmental outcomes cannot be modified or offset by environmental forces according to this view.

Much of the early research, particularly the retrospective studies, was based on the main effects model. Results from more recent studies have shown, however, that this model is too simplistic; it does not satisfactorily explain or predict developmental outcomes (Sameroff & Chandler, 1975, p. 233). Furthermore, research has shown that the role of biological deficits in shaping developmental outcomes can be tempered by environmental factors (p. 233). Stedman and Eichorn (1974), for example, have demonstrated improved cognitive development for Down's syndrome children reared in a supportive home environment, and early diet therapy has improved the IQ's of children born with phenylketonuria (Sibinga & Friedman, 1972). Many other examples could be cited.

A second, more sophisticated model of development is the "interactional" or "multi-factoral" model (Sameroff, 1979). This model is based on the premise that both biological and social factors and their interaction affect developmental outcomes (Sameroff & Chandler, 1975, p. 234). Werner and Smith's longitudinal study of the growth and development of children born on the Island of Kauai is an example of research based on this model (Werner, Bierman, & French, 1971; Werner, Honzik, & Smith, 1968; Werner & Smith, 1977). The researchers found that developmental outcomes for biologically at risk children were associated with both neurological integrity at birth and parental socioeconomic status. The interactional model is more satisfactory than the main effects model in explaining and predicting developmental outcomes; however, it is also a "static" model that does not take into account changes in the child or environment over time.

The "transactional" model developed by Sameroff and Chandler provides a conceptual framework for this research investigation. The model stresses "the plastic character of the environment and the organism as an active participant in its own growth" (1975, p. 235). It is based on a dynamic theory of development which allows for "a continual and progressive interplay between the organism and its environment" (p. 234). Deviant development is not seen solely as a function of fixed traits within the child; deviant development is seen as a continuing dysfunction in the child-environment transaction across time "which prevents the child from organizing his world adaptively" (p. 235). This model clearly focuses research attention on process variables, i.e., the ways in which the child interacts with his environment.

The transactional model is compatible with the theories of cognitive development put forth by Piaget. Both perspectives on development seem to have been shaped by a biological model of adaptation and change. Consistent with Piaget's theories, the transactional model suggests that the child is an active participant in his own growth, continually engaged in adaptive transactions with his environment. This notion of "continual and progressive" interplay between the child and his environment seems to deal with the same phenomenon as Piaget's "equilibration." Both perspectives focus research attention on process variables.

Two possible factors are cited by Sameroff and Chandler which may set deviant patterns of development in motion. One possible factor is insult to the organism's integrative mechanisms (1975, p. 235). Birth trauma, for example, may result in insult to the integrative mechanisms of the newborn child. Passamanick and Knobloch (1966) introduced the phrase "continuum of reproductive casualty" to describe the range of biological deficits associated with pregnancy and delivery complications. Possible outcomes range from death, to abnormalities such as cerebral palsy and mental retardation, to minor motor and perceptual problems, to subtle learning disabilities. A second factor identified by Sameroff and Chandler which may set deviant patterns of development in motion is environmental factors. Adversive environment factors such as family disturbance or child abuse may also prevent development of normal integrative capacities. The authors introduce the phrase "continuum of caretaking casualty" to describe the range of healthy to deviant adaptation patterns associated with the impact of environmental factors.

The transactional model is a "bi-directional" one. The caretaking environment is seen as having an impact on the developing child, and the child, in turn, impacts on the caretaking environment (see Bell, 1968).

The role of biological insult in shaping development may be maximized or minimized by environmental factors according to this model. If a child is biologically at risk, a highly supportive caretaking environment is needed to achieve normal developmental patterns (Sameroff & Chandler, 1975, p. 235). Similarly, some children thrive despite disorganized, aberrant homes, perhaps in part because of a biological make-up which heightens their capacity to adapt. Thomas, Chess, and Birch's studies of temperament, parenting, and their interaction is an example of research consistent with the transactional model of development (Thomas & Chess, 1977; Thomas, Chess, & Birch, 1968; Thomas, Chess, Birch, Hertzig, & Korn, 1963). These researchers found that both parenting and temperament and their "interplay" influenced the developmental patterns of the children studied.

The literature which will be reviewed in the next section suggests that prematurely born children demonstrate performance deficits on psychological and educational tasks when compared with their maturely born peers. Most of the early studies of prematurely born children were based on the main effects model, and the performance differences observed were interpreted as being due to central nervous system dysfunction (e.g., De Hirsch et al., 1966; Lubchenco, Horner, Reed, Hix, Metcalf, Cohig, Elliot, & Bourg, 1963). Other studies, based on an interactional model, nevertheless concluded that impaired neurological integration was the primary causal link between prematurity and developmental outcomes (e.g., Caputo et al., 1978; Wiener, 1968; Wiener et al., 1965, 1968).

One purpose of this study, as previously mentioned, was to attempt to identify what it is that prematurely born children fail to do in the testing situation and perhaps the classroom which results in their relatively inferior performance on psychological and educational tasks. The transactional model, which provides a conceptual framework for the study, emphasizes the plastic character of the developing child, as previously mentioned. According to this model, biological insult (such as insult associated with prematurity and its complications), may set non-adaptive patterns of development in motion, but these non-adaptive patterns may be offset or minimized by factors in the caretaking environment. Thus, in line with this model, it may be possible to teach prematurely born children to adapt more effectively to the testing situation or the classroom if "what is missing" in their repertoire of skills can be identified.

Review of the Literature

The review of the literature is divided into two sections. Five studies designed to investigate differences in cognitive functioning, perceptual performance, social development, and academic achievement between prematurely and maturely born children will be reviewed in the first section. These studies were selected for in-depth review because they are similar in scope and design to this investigation. Research findings for each of the dependent variables under investigation are then summarized in the second section.

Cognitive Functioning, Perceptual Performance, Social Development, and Academic Progress of Prematurely and Maturely Born Children

The research literature on the sequelae of premature birth is somewhat overwhelming. Consequently, five studies were selected for extensive discussion (Caplan et al., 1976; Caputo et al., 1978; De Hirsch et al., 1966; Harper, Fischer, & Rider, 1959; Knobloch et al., 1956; Rubin et al., 1973; Wiener, 1968; Wiener et al., 1965, 1968) and the remaining studies located will be given briefer treatment in the second section of the literature review. The five studies chosen for in-depth review were selected because (1) all are comparative studies with a control group of maturely born children, (2) developmental progress is described in terms of a variety of outcomes measures, and (3) all are relatively sound methodologically. The studies given briefer treatment (Abrams, 1969; Dann, Levine, & New, 1964; Douglas, 1956, 1960; Drillien, 1964; Francis-Williams & Davies, 1974; Lubchenco et al., 1963; McDonald, 1964; Robinson & Robinson, 1965; Wright et al., 1972) typically report a limited range of developmental outcomes measures (often only IQ). Others suffer from methodological shortcomings which obscure interpretation of the results.

One of the difficulties encountered in reviewing the literature on prematurely born children is the lack of consistency in definitions of "prematurity" used by researchers. Birth weight (< 2,500 g) and gestational age (less than 37 or 40 weeks) are commonly used indices of "prematurity" in the studies to be reviewed, particularly the older ones. In the early 1960's, however, Drillien (1961) reported that birth weight alone was not a satisfactory measure of prematurity because it resulted in too heterogeneous a sample. Based on her longitudinal research on "prematurely" born children, she identified three distinct "subgroups" of low-birth-weight children: (1) small-for-dates, i.e., infants with low birth weights due to intrauterine growth retardation, (2) infants born of small mothers, and (3) pre-term infants with weights appropriate for their gestational age. Different developmental outcomes have been reported for each of the three subgroups of low-birth-weight infants. Small-for-date infants fared less well on follow-up assessments of neurological status and intellectual development than children of small mothers or appropriate-for-dates in studies conducted in the 1960's (see Caputo & Mandell, 1970; Kopp & Parmelee, 1979). Children of small mothers have been found to develop similarly to their normal birth-weight counterparts (Douglas, 1956). Most researchers now suggest that both birth weight and gestational age be used as criteria for selecting "prematures" in research studies (Caputo et al., 1978).

In each of the studies reviewed here, the subject selection criteria used will be carefully described. The reader should bear in mind, however, that the comparability of the findings across studies is limited by the lack of consistency in the definitions of "prematurity" used.

As mentioned in the introductory chapter, a second problem encountered in reviewing the literature on the sequelae of prematurity is the lack of consistency in methods used to equate research groups on age at the time of follow-up evaluations. In each of the studies reviewed, the procedures for matching the two research groups on age will be described. Researchers have typically matched premature and full-term children on date of birth or chronological age at the time of assessment. In some studies, the age of the prematurely born child is then "corrected" for prematurity in calculating test scores by subtracting the number of weeks premature from the chronological age of the child. The reader should bear in mind, however, that the maturely born child has a "biological age advantage" on measures which are not age-norm referenced. Similarly, full-term children have a "biological age advantage" in studies which match groups on chronological age but fail to adjust for prematurity in calculating scores.

The Baltimore Study. A large scale prospective study of the growth and development of "premature" children born in Baltimore area hospitals in 1952 was conducted by researchers affiliated with the John Hopkins University School of Hygiene and Public Health (Knobloch et al., 1956; Harper et al., 1959; Wiener, 1968; Wiener et al., 1965, 1968). This study, referred to as the "Baltimore Study" in the research literature, is the most fully reported investigation of the sequelae of low birth weight in this country to date. As the Baltimore Study provides an important part of the research foundations for this investigation, the methodology and findings of the study will be discussed in some detail.

The research population was comprised of three groups of low-birth-weight infants, all singletons born in 1952. Sampling procedures were designed to include all infants born in Baltimore area hospitals with birth weights of 1,500 grams or less because of the relatively small number of survivors in this birth-weight category. Infants with slightly heavier birth weights (1,501 to 2,500 g) were selected on the basis of both birth weight and parental residence. A portion of eastern Baltimore with a socioeconomic composition similar to the composition of the city as a whole was identified, and infants with birth weights of 1,501 to 2,000 grams whose parents resided in this target area comprised the second low-birth-weight group. A third group included all infants born to parents residing in the target portion of the city with birth weights of 2,001 to 2,500 grams (Knobloch et al., 1956). These sampling procedures resulted in a study population of 500 low-birth-weight infants, 57 with very low birth weights (< 1,501 g) and 443 with birth weights of 1,501 to 2,500 grams. A control group of 492 full-term infants (singletons) was also included in the study. The control group was comprised of the next mature infant born in the same hospital in the same quarter year as the premature child matched for race, parity of mother, and socioeconomic status (based on census tract data). All socioeconomic groups were represented in the study.

The two research groups in the Baltimore Study were initially matched for season of birth rather than date of birth. Prematurely and maturely born children were then scheduled for each round of developmental assessments so as to equate chronological age at the time of follow-up, and the chronological ages of the prematurely born children were corrected for the number of weeks premature in calculating test scores (Knobloch et al., 1965, p. 582). This matching procedure consequently equated research groups on age at the time of testing when age-normed dependent measures were used.

The study children were seen for psychological evaluations and physical examinations at 40 weeks of age (Knobloch et al., 1956), 3 to 5 years of age (Harper et al., 1959), 6 to 7 (Wiener et al., 1965), and 8 to 10 years of age (Wiener et al., 1968). Academic achievement data were collected when the subjects were 12 to 13 years of age (Wiener, 1968). The research findings at each stage of the study will be summarized.

The first round of developmental evaluations was conducted when the study children were approximately 40 weeks of age, as mentioned above (Knobloch et al., 1956). Eighty-five percent (992) of the 1,170 infants selected for the study completed this first phase of the investigation, 3.5% refused to participate, and 11.5% could not be located. The follow-up measures at 40 weeks included the Gesell developmental examination (Gesell & Amatruda, 1941), a physical examination, and a history of health and adjustment as reported by the mother or guardian. A pediatrician rated the neurological status of each child based on the "absence or presence of impairment in neuromotor functioning" and an assessment of muscle tone and control (p. 582). The five neurological classification categories used were "normal," "indeterminate," "minimal damage," "possible cerebral palsy," and "overt abnormality." Estimates of intellectual potential based on performance on developmental tasks and clinical impressions were also made and eight classifications ranging from defective to superior were used. Evaluations were conducted by a pediatrician who had no prior knowledge of the birth histories of the children. Because of difficulties scheduling appointments, the age at examination ranged from 34 to 69 weeks, with 75% of the children seen between 39 and 41 weeks.

An analysis of the effectiveness of the sampling procedures and the impact of subject attrition showed that the low-birth-weight group did not differ from controls on indices of socioeconomic status ($\underline{p} > .05$). Non-white infants were found to be overrepresented in the low-birth-weight group. No differences in estimates of intellectual potential or incidence of neurological impairment were found between white and non-white infants when birth weight was statistically controlled, however. The data for blacks and whites were consequently pooled and only comparisons by birth weight were reported. The "expected incidence rates" of neurological and intellectual defects were adjusted to account for different sampling procedures used to select very light (< 1,501 g) and heavier (1,501 to 2,500 g) low-birth-weight children.

Knobloch et al. (1956) found that fewer low-birth-weight children were classified as neurologically "normal" (75.5%) than controls (88.4%), and this difference was significant at the .01 level. The lightest birth-weight group (< 1,501 g) had the highest proportion of children with all degrees of neurological impairment ($\underline{p} < .01$). Analysis of the estimates of intellectual potential showed a higher proportion of low-birth-weight children rated as dull-normal and defective and a lower proportion rated as above average when compared with controls. However, the "expected incidence rate" of mental deficiency (adjusting for differences in sampling procedures) for low-birth-weight children was found to be 2.6% which is not significantly higher than the incidence rate of 1.6% found for controls. Differences between the low-birth-weight children and controls on ratings of intellectual potential were most striking for the lowest birth-rate group.

About one-half (51%) of the infants with birth weights of 1,500 grams or less demonstrated intellectual or neurological abnormalities, and one-fourth (25%) of the infants with birth weights of 1,501 to 2,500 grams were classified as abnormal on one or both rating scales. Only 13% of the control children were found to have abnormalities, however. The "expected incidence rates" for some type of abnormality (neurological or intellectual) were 25.7% for low-birth-weight children and 12.8% for normal-birth-weight controls. These findings were independent of race and socioeconomic status.

Knobloch et al. (1956) concluded that their findings provide additional support for the body of research which suggests an association between premature birth and neurological and intellectual deficits in infancy. They also interpreted their results as suggesting an increase in the incidence of abnormalities as birth weight decreases.

A second round of evaluations was conducted during the preschool years (Harper et al., 1959). Nine hundred (91%) of the children seen at 40 weeks of age were available for the preschool follow-up evaluations (460 low-birth-weight subjects, 440 controls). Subject attrition was due to the following: 3.6% refused, 0.7% were deceased, 4.4% had moved away, and 0.5% could not be located. Slightly more white than non-white low-birth-weight children were lost to the second-round follow-up. Within each racial group, however, no differences were found between low-birth-weight children and controls on indices of socioeconomic status. Consequently, comparisons between the low-birth-weight group and their full-sized counterparts were reported separately for each racial group.

The preschoolers ranged in age from 29 to 62 months at the time of the second evaluation, with 92% age 3 or older. Information about the child's behavior and adjustment during the preschool years was obtained through a home interview. The Gesell Developmental Scales and the Revised Stanford-Binet, Form L (Terman & Merrill, 1937), were administered during the office visit, and about 65% of the children were seen for physical examinations. Neurological status was re-assessed through evaluation of neuromuscular functioning, muscle tone, and muscle control, and intellectual potential was again rated on the basis of test performance and clinical judgment.

Results of neurological evaluations during the preschool period were similar to those reported from the 40 week examinations. Normal-birth-weight children again fared better on assessments of neurological status than their low-birth-weight peers independent of race or examiner ($\underline{p} < .05$).

Assessments of intellectual potential also favored the normal birth-weight children at 3 to 5 years of age ($\underline{p} < .05$). Somewhat more discouraging, however, was the finding that the low-birth-weight children had "lost ground" in comparison to their full-sized peers between the first and second follow-up evaluations. Among white low-birth-weight children, 97% were judged to be at least average or low average at 40 weeks; only 84% were so classified at ages 3 to 5. In contrast, 98% of the maturely born children were judged to be low-average or above at 40 weeks and 94% continued to be rated similarly at ages 3 to 5. Children with birth weights between 2,001 and 2,500 grams were found to differ only slightly from controls on estimates of intellectual potential; those with birth weights of 2,000 grams or less were more seriously impaired. Very low-birth-weight children were also found to have the poorest prognosis for improvement. Similar results were reported for the black children in the study.

In summary, low-birth-weight children did not fare as well as their full-birth-weight counterparts on evaluations of neurological and intellectual status at 3 to 5 years of age, and very low-birth-weight children (< 2,000 g) continued to lag behind their slightly heavier age-mates (2,001 to 2,500 g). The IQ's of the majority of the low-birth-weight children (84%) fell in the normal range, however.

The third round of evaluations was conducted when the study children were 6 to 7 years of age (Wiener et al., 1965). The research at this stage of the study was designed to investigate performance differences between low-birth-weight children and controls on a variety of psychological and educational measures. Eight-hundred and fifty-seven of the children initially involved in the study were located for the third round of evaluations. The findings for 63 of these children (46 low-birth-weight, 17 controls) were excluded from the data analyses. In the low-birth-weight group, four excluded children were blind, four were bed patients, sixteen were retarded (IQ < 60), and thirteen emotionally disturbed. In the control group, one child was a bed patient, two were retarded, and eight emotionally disturbed. Follow-up results for nine other low-birth-weight children and six controls were not reported because of incomplete data.

Children seen for the third round of evaluations were administered the Revised Stanford-Binet Intelligence Test (Form L), the Lincoln-Oseretsky Test of Motor Development (Doll, 1946), the Goodenough Draw-A-Person Test (Goodenough, 1926), and the Bender-Gestalt Test of Visual-Motor Coordination (Bender, 1938).* Speech maturity (sound distortions, substitutions, or omissions) was rated by the psychologist. Ratings of perseveration-trends, concrete thinking, and the ability to comprehend test instructions were also made, and these three scores were combined into a single score called "thinking mode." A parent or guardian was interviewed by a social worker and information regarding socioeconomic status was obtained. A social class index based on parental occupation, income, and education, condition of the residence, crowding, availability of reading material, and presence of both biological parents in the home was calculated for each family. A modification of Schaefer and Bell's Parent Attitude Research Instrument (1958) was used to evaluate parental attitudes and child-rearing

---

*In this and subsequent evaluations, the Bender protocals were scored "blindly" according to a scheme devised by the researchers, variables scored included "instances of perseveration, separation of figures, inability to make acute angles or sine curves, crudeness of motor coordination and gross distortion of Gestalt perception" (Wiener et al., 1968, p. 112).

practices. The psychologist and social worker, except in a few cases, were uninformed of the child's birth history.

No differences were found between birth weight groups on social class or parental attitude variables. The researchers interpreted this finding as evidence of the success of their original sampling procedures in matching for socioeconomic variables.

Four of the six psychological measures were found to discriminate between the low-birth-weight children and their full-sized counterparts at the 0.01 level controlling for sex, race, and social class: IQ, the Bender Gestalt Test, "thinking mode," and motor development. Differences in speech maturity were significant at the .05 level. No differences were found between the two groups in performance on the Draw-A-Person task. Increasing impairment was again associated with decreasing birth weights. The results of psychological tests administered to low-birth-weight children at ages 6 to 7 thus suggested impaired visual-perceptual integration, immature speech patterns, delayed gross motor development, and less favorable estimates of school learning potential (a mean IQ difference of 3.4 points) when compared to their normal birth-weight peers. Perseveration and concrete thinking were also found to be more characteristic of low-birth-weight children than their maturely born counterparts.

Wiener et al. (1968) noted that the pattern of test performance characteristic of low-birth-weight children was suggestive of neurological involvement. To test this hypothesis, an "index of potential minimal neurological damage" was developed, and the data were re-analyzed statistically removing the variance in outcome measures accounted for by this index via analysis of covariance. The "index of potential minimal neurological damage" was based on the presence or absence of perinatal events which put the child at risk for neurological impairment and positive signs of minimal neurological dysfunction at 40 weeks. The perinatal history variables included pre-eclampsia during pregnancy, lues (syphilis) during pregnancy, mechanical trauma due to breech delivery, caesarean section or mid or high forceps birth, retraction and gasping during the first seven days of life, and jaundice and illness during the first seven days of life. Signs of possible neurological dysfunction noted at 40 weeks were abnormal arm and hand coordination, postural disturbances, abnormal reflexes, and abnormal muscle tone. It should be remembered that findings for children with severe retardation or sensory deficits were excluded from the data analysis during this phase of the study.

The researchers found that the "index of potential minimal neurological damage" accounted for differences between the two study groups on measures of IQ, motor development, and speech maturity. Measures of "thinking mode" and performance on the Bender Gestalt continued to differentiate the two birth weight groups at the .01 level with "statistical controls" for the "potential impairment" index.

The findings were summarized as follows:

> The data heretofore presented suggest that psychological performance is directly related to birth weight. This relationship is not dependent upon social class, maternal behavior, race, or sex, but a large part of this relationship seems to be a function of the indices of mild neurological impairment used in this study. (p. 438)

Weiner et al. then collected further data to determine if the relatively poorer performance of the low-birth-weight children on psychological tasks was due to behavior disturbances often associated with neurological dysfunction such as hyperactivity, impulsivity, distractibility, and anxiety. Ratings made by the psychologist at ages 6 to 7 and 8 to 10 along with ratings by teachers showed that the low-birth-weight children did not differ from controls on any of these dimensions except for impulsivity. Low-birth-weight children were found to be more impulsive than their normal birth-weight counterparts and this difference was significant at the .05 level. The data were then re-analyzed "statistically controlling" for impulsivity. The relatively impaired performance of the low-birth-weight children was not affected by removing the variance accounted for by the impulsivity ratings, however.

The researchers then calculated the optimal weighing of each of the psychological measures necessary to maximize the discrimination between the two birth weight groups. Results of the Bender Gestalt Test and the "thinking mode" variables contributed most to the discrimination, followed by IQ, speech maturity, and motor development. The independent contribution of each of the psychological tasks to the discrimination between the two birth weight groups was also calculated by controlling for the intercorrelations among the dependent measures. Birth weight was found to be significantly and independently associated with motor development ($p < .001$), Bender Gestalt test performance ($p < .001$) "thinking mode" ($p < .001$) and IQ ($p < .001$). IQ, however, was more strongly associated with social class ($p < .001$) than birth weight. When the variance accounted for by the "index of potential minimal neurological damage" was statistically removed, positive associations between birth weight and Bender Gestalt performance and birth weight and "thinking mode" were again found ($\underline{p} < .001$ and $\underline{p} < .02$, respectively), but the correlations between birth weight and motor development and IQ were no longer significant. The "index of potential minimal neurological damage" was found to be a potent independent correlate of motor development, Bender Gestalt performance, and "thinking mode" ($\underline{p} < .001$).

Data were also analyzed to determine if there was a significant interaction between socioeconomic status and birth weight as they effect the psychological dependent measures at ages 6 to 7. None of the interactions of social class, race, or sex with birth weight or the "index of potential neurological damage" were significant with regard to any of the six dependent measures.

In summary, low-birth-weight children again fared less well than their maturely born counterparts on tests of cognitive and perceptual development at ages 6 to 7. More specifically, findings from the third round of evaluations showed that low-birth-weight children demonstrated impaired visual-perceptual integration, "flaws in comprehension and abstract reasoning, perseveration trends, poor gross motor development, immature speech, and impaired IQ" when compared with their normal birth-weight age-mates, and these performance differences were indpendent of race, socioeconomic status, maternal attitudes, and impulsivity (p. 443). Wiener et al. interpreted the poorer performance of the low-birth-weight subjects as being due to minimal neurological impairment. In the discussion of their findings, the researchers also point out that global measures of IQ tended to obscure educationally important differences in the cognitive and perceptual skills of low-birth-weight children and their maturely born peers.

The study children were seen for a fourth round of evaluations at 8 to 10 years of age (Wiener et al., 1968). Eight hundred and forty-one of the initial study population children were located for the 8 to 10 year assessments. Of these, 822 (413 low-birth-weight subjects, 409 controls) participated in the evaluations and 19 were excluded because of retardation or severe neurological or sensory deficits.

The Wechsler Intelligence Scale for Children (Wechsler, 1949), the Bender Gestalt Test, and the Wide Range Reading and Spelling Tests (Jastak, Bijou, & Jastak, 1965) were administered to all study children along with measures of receptive language (comprehension aphasia), expressive language (complexity of grammar, use of tenses), speech maturity (distortions, substitutions, omissions), and perseveration. A parent or guardian of each child was again interviewed by a social worker and families were re-evaluated on social class and parent attitude variables. With the exception of a few cases, the psychologists and social workers were uninformed of the child's birth history.

The performance of the normal birth-weight children was found to be superior to the performance of the low-birth-weight children on 16 of the 20 dependent measures ($p < .05$). These findings were independent of sex, race, maternal attitudes, and socioeconomic variables. The WISC Full Scale, Verbal, and Performance Scale scores were significantly lower for both black and white low-birth-weight children when compared with controls (a mean IQ difference of 4.9 points, $\underline{p} < .0001$). Low-birth-weight children also fared less well on each of the following dependent measures: the 10 WISC subtests, assessments of abstract versus concrete reasoning, receptive language (comprehension aphasia), speech maturity, and the Wide Range Reading Test. Dependent measures which showed no relation to birth weight included measures of perseveration, sentence structure complexity, use of tenses, and spelling achievement (WRAT). Consistent with earlier findings, degree of impairment was found to increase with decreasing birth weight.

The researchers again used a modified version of the "index of potential minimal neurological damage" to determine whether this variable accounted for performance differences between the low-birth-weight group and controls on the fourth round measures. It was found that the scores of the low-birth-weight children differed significantly from normal birth-weight children on six of the 20 dependent variables after the data were re-analyzed "controlling statistically" for the index of possible neurological dysfunction. Performance differences between the two study groups on measures of language comprehension (comprehension aphasia) and the WISC Arithmetic Subtest were significant at the .01 level after the re-analysis; performance differences on the WISC Vocabulary and Information Subtests and measures of speech distortion and omissions were significant at the .05 level after the re-analysis.

Wiener et al. also hypothesized that low-birth-weight children might show more subtest scatter on the WISC than their maturely born peers. The standard deviation for each child's subtest scores was calculated as a measure of subtest variability. No differences between birth weight groups were found on this measure ($p > .05$).

In summary, results of psychological re-evaluation at ages 8 to 10 showed that the low-birth-weight children fared less well on assessments of IQ (all 10 WISC subtests), abstract reasoning, receptive language development, speech maturity, visual-perceptual integration, and arithmetic than their maturely born age-mates. Two educational achievement tests administered during the fourth round of evaluations suggested that low-birth-weight children had poorer reading skills than their normal birth-weight classmates but they did not differ appreciably in spelling achievement. These results were found to be independent of socioeconomic status and parental child-rearing attitudes. Furthermore, no statistical interaction effect was found between birth weight and social class or race on any of the dependent measures.

Results of the Metropolitan Achievement Test (Hildreth, Griffiths, & McGauvran, 1965) administered in third grade were collected from school records for low-birth-weight children and controls between the fourth and final rounds of the investigations (Wiener et al., 1968; Wiener, 1968). These test results replicated the finding of poorer WISC arithmetic test performance by low-birth-weight children when compared to controls ($p < .01$). The Metropolitan Achievement Test results did not show differences in reading achievement between the two study groups in third grade, however.

Academic achievement was the focus of the final round of the investigation (Wiener, 1968). The data were collected when the study participants were 12 to 13 years of age. At the time of the fifth round follow-up, 848 of the 1,170 children originally chosen for the study were attending private or public schools in the Baltimore area (excluding special schools). Twenty-six of the low-birth-weight children and four control children were enrolled in schools for the blind or severely retarded. Achievement test data were reported only for children in the regular school programs.

Follow-up data were obtained from school records. Grade placement, results of reading, arithmetic, and IQ tests, attendance records, and frequency of changes in school and home address were recorded for each child. The study children who resided in the Baltimore area at the time of the final follow-up attended school in one of three school systems. Unfortunately, each system differed in their selection and scheduling of achievement tests. All children were administered achievement tests by the sixth or seventh grade, however. Each child's arithmetic and reading achievement test score was divided by his age (achievement score/age) and grade placement (achievement score/grade) at the time of testing to control for the different test scheduling policies in the Baltimore area schools. The researchers reasoned that as the achievement tests used all correlated highly with IQ tests, there was likely to be a high correlation among the achievement tests themselves. No data were presented to support this assertion, however.

Two estimates of social class and the "index of potential minimal neurological damage" were used as control variables. Correlates of low birth weight were analyzed separately for each racial group.

Wiener et al. found that low-birth-weight children were more likely to have repeated school grades than normal birth-weight controls ($p < .025$). Differences between low-birth-weight children and controls in grade placement were most striking for the lightest birth weight groups. Contrary to the third grade findings, achievement test scores at ages 12 to 13 showed a positive correlation between birth weight and measures of both reading and arithmetic achievement ($p < .001$). These results remained significant when social class and neurological scores were covaried ($p < .01$). Interestingly, birth weight accounted for more of the variance in arithmetic achievement at ages 12 to 13 ($F = 11.91$) than reading achievement ($F = 5.01$). Wiener et al. suggest that the "effect of birth weight (and the neurologic deficit this implies) is apparently greater for arithmetic achievement than for reading achievement" (p. 246).

A stepwise regression analysis was conducted to determine the predictability of reading achievement from birth weight. It was found that, with social class and race partialed out, $r_p = .10$ ($p < .05$). When the neurological score was also partialed out, $r_p = .08$ ($p < .05$). Results of a stepwise regression analysis to determine the predictability of arithmetic achievement from birth weight was also reported. When social class and race were partialed out, $r_p = .15$ ($p < .001$); with the neurological score also partialed out, $r_p = .12$ ($p < .002$).

The overall predictability of reading achievement (R) based on social class, race, birth weight, and neurological score was .49. Social class, race, birth weight, and neurological score thus accounted for about 24% of the variance of the reading achievement test scores at ages 12 to 13. The overall predictability of arithmetic achievement (R) based on the same four predictor variables was .54. Social class, race, birth weight, and neurological score thus accounted for about 29% of the variance in arithmetic achievement test scores at ages 12 to 13.

In summary, normal birth-weight children demonstrated superior performance on reading and arithmetic achievement tests at ages 12 to 13 in comparison with low-birth-weight children, and low-birth-weight children were more likely to have repeated grades than their normal birth-weight counterparts. These findings were independent of socioeconomic status and race. In his discussion of the findings, Wiener points out that no differences in reading achievement were found between the low-birth-weight group and controls in third grade. At age 12 and 13, however, low-birth-weight children performed less well than controls on tests of reading achievement. He interprets these findings to suggest that deficits in reading skills associated with prematurity and perinatal complications may not be apparent until reading ability is fully developed, some time after age nine. Wiener also noted in his discussion that birth weight accounted for more of the variance in arithmetic achievement test scores than reading achievement test scores at ages 12 to 13. This is consistent with the earlier findings that the WISC arithmetic subtest discriminated effectively between the two study groups and that full-birth-weight subjects outperformed the low-birth-weight group in arithmetic achievement in third grade. He interprets these results to suggest that "measures of arithmetic achievement are more sensitive than measures of reading as a test of the impairment associated with low birth weight" (p. 247). Low-birth-weight children may be at greater risk for arithmetic disabilities than reading problems.

In his conclusions, Wiener reiterates that throughout his study "there was no evident statistical interaction between race or social class and birth weight as these affect achievement. Apparently a child of low birth weight is impaired regardless of this environment" (p. 248). Low-birth-weight thus places a child at risk for educational problems independent of social class and race.

The Educational Follow-Up Project. A second major prospective study of perinatal factors and developmental outcomes is currently under way in this country. In the early 1950's the National Institute of Neurological Diseases and Strokes (formerly the National Institute of Neurological Diseases and Blindness) together with fourteen medical centers planned and implemented the Collaborative Perinatal Project for the Study of Cerebral Palsy, Mental Retardation, and other Neurological and Sensory Disorders in Childhood. The purpose of the "Collaborative Project" was to investigate the antecedents of pregnancy, labor, and delivery complications, and to relate these variables to health and developmental outcomes during infancy and the preschool years. Data were collected over the seven-year period between January 1959 and

January 1966, from a sample population which included over 60,000 pregnant women.

In the early 1960's the Educational Follow-Up Project was initiated at the University of Minnesota with the cooperation of the Perinatal Research Branch of NINB and Collaborative Project researchers in Minnesota. The Educational Follow-Up Study was designed to "extend the investigation of subjects originally enrolled in the Minnesota branch of the Collaborative Project through their elementary and secondary school careers in order to determine possible influences of prenatal, perinatal, and early-childhood conditions and events on school learning and behavioral outcomes" (Rubin & Balow, 1977, p. 120). The pool of data collected by researchers with the Collaborative Project in Minnesota included records of prenatal and perinatal events, and results of early developmental assessments, for 1,612 children born between 1960 and 1963 in University of Minnesota hospitals. These children were registered with the Educational Follow-Up Project at age five.

One of the early studies conducted by the Educational Follow-Up Project researchers was designed to determine whether premature children "may appropriately be considered" at "high risk" for subsequent learning and behavior problems in school (Rubin et al., 1963, p. 352). A sample of 241 infants was drawn from the original study population of 1,612. The study children were classified by both gestational age and birth weight. "Preterm" birth was defined as gestation equal to or less than 37 weeks; "low-birth-weight" was defined as equal to or less than 2,500 grams. The sample selected included (1) 32 low-birth-weight preterm infants, (2) 46 low-birth-weight full-term infants, (3) 78 full-birth-weight preterm infants, and (4) 85 full-birth-weight full-term infants. Estimates of parental socioeconomic status were made based on parental education, occupation, and family income (a composite score). The study sample was predominantly white (96.5%) and the distribution of socioeconomic index scores was similar to that of the urban population of the North Central states. There were no differences between gestational age groups or birth weight groups on the measure of parental socioeconomic level. Children ranged in age from 7 to 11 years old at the time the follow-up data were collected.

Infancy and preschool outcome measures included results of neurological examinations at 60 hours, 4 months, and 12 months of age, IQ test scores at 8 months (Bayley Scales of Mental and Motor Development, research form) and 4 years (Stanford-Binet, LM, short form), and measures of school readiness (Metropolitan Readiness Test) and language development (Illinois Test of Psycholinguistic Abilities, McCarthy & Kirk, 1961) at age 5. School-age outcome measures included a neurological examination at age 7, IQ and academic achievement measures at age 7 (Wechsler Intelligence Scale for Children, Wide Range Achievement Test), and yearly information obtained from classroom teachers regarding special class placement, retention, and referral for support services (remedial reading, speech therapy, or psychological evaluation). Test scores were not "corrected" to adjust for prematurity. An index of socioeconomic status based on parental occupation, education, and family income was calculated for each study child.

Birth weight was found to be a stronger predictor of educational, psychological, and neurological sequelae than gestational age. The data gathered during the neonatal period showed an association between low birth-weight and an increased incidence of neurological abnormalities. IQ scores favored full-birth-weight subjects at all ages. Mean IQ scores for each study group at age 7 as measured by the Wechsler Intelligence Scales for Children were as follows: (1) low-birth-weight preterm, $\bar{X} = 97.0$, (2) low-birth-weight full-term, $\bar{X} = 97.5$, (3) full-birth-weight preterm, $\bar{X} = 101.1$, and (4) full-birth-weight full term, $\bar{X} = 103.3$. Measures of language development, school readiness, and academic achievement also favored full-birth-weight children. Low-birth-weight children fared less well than their full-birth-weight age-mates on measures of receptive and expressive language development (ITPA) administered at age 4 and on school readiness tests (MRT). Full-birth-weight children out-performed their low-birth-weight classmates on reading, spelling, and arithmetic achievement tests (WRAT) at age 7. No differences between the gestational age groups or between the sexes were found by the Minnesota researchers on measures of language development, school readiness, academic achievement, or IQ.

Low-birth-weight children were smaller in stature and demonstrated a higher incidence of neurological impairment than their full-birth-weight peers at age 7. A higher proportion of low-birth-weight children were placed in special classes, repeated grades, and received school support services than their full-birth-weight peers. Although there were no sex differences on objective measures of ability, low-birth-weight preterm males were more likely to receive special education services than their female counterparts. A higher incidence of educational problems was also found among low-birth-weight children born at term (small-for-dates) than among low-birth-weight preterm children (prematures). Two-thirds of the low-birth-weight preterm males and one-half of all low-birth-weight term children had been placed in special education classes or were receiving special educational services at the time of the follow-up investigation. Consistent with the Baltimore research team, Rubin et al. interpreted their findings to suggest that low-birth-weight children are "at risk" for subsequent school learning problems. Preterm males and small-for-dates of both sexes were identified as likely candidates for later academic failures.

The Wakoff Research Center Study. A third team of researchers have recently reported the results of a follow-up study of prematurely born children conducted at the Wakoff Research Center on Staten Island in New York (Caputo et al., 1978). Caputo et al. (1978) investigated the subsequent development of moderately premature infants from middle class homes at 12 months of age and in middle childhood.

The original study population included all low-birth-weight infants (1,400 to 2,500 g) born in one of three major Staten Island hospitals between July 1965 and January 1969. Infants born with birth weights less than 1,400 grams and those with major medical disorders such as cardiac dysfunction or a birth anomaly requiring surgery were excluded from the study. Children of unwed and divorced mothers were also excluded because of possible difficulties locating them for follow-up evaluations. A control group comprised of infants with birth weights over 2,500 grams and matched with the prematures on sex, hospital of birth, socioeconomic status (based on father's occupation), parity (first or later born), and date of birth was also selected.

Mothers of the study infants were contacted within the first 48 hours following birth. Sixty-four percent of the mothers of premature infants and 55% of the mothers of full-birth-weight babies agreed to participate in the study. The resulting sample included 233 infants, 137 prematures and 96 controls. No statistically significant differences were found between the two groups on the variables of hospital of birth, race, sex, socioeconomic status, type of birth, age of mother, or parity ($\underline{p} > .025$). Furthermore, no differences were found between families who participated in the study and non-participants on demographic variables within the premature or control group ($\underline{p} > .025$). All children were seen for neurological and physical examinations at birth and 72 hours after birth.

Thirty-eight low-birth-weight and 26 full-term children participated in the follow-up evaluations at one year of age and in middle childhood. Comparisons were made between the 64 children who participated in the follow-up assessments and the 99 children in the original study sample who did not participate in the follow-up assessments on a variety of background variables including sex, race, birthweight, parity, obstetric history, early developmental outcomes, and parental socioeconomic status. No differences were found between the participants and non-participants on any of the variables analyzed, and the researchers consequently concluded that the follow-up study group was representative of the original research sample.

The first round of evaluations was scheduled within two weeks of the first birthday. Caputo et al. found that the prematurely born children performed less well than their maturely born counterparts on the Cattell Infant Intelligence Scale (Cattell, 1960) at one year of age when scores were based on chronological age ($\underline{p} < .01$). The mean DQ for prematures was 97.3 (SD = 14.6) and the mean DQ for controls was 110.5 (SD = 15.7). The researchers also reported that correcting the DQ scores to adjust for prematurity raised the mean DQ of the low-birthweight children to 104.0 and decreased the mean DQ of the full-term children to 109.3. However, Caputo et al. did not report whether comparisons between the two research groups based on these adjusted scores reached statistical significance.

Caputo et al. stated that the purpose of the follow-up investigation in middle childhood was to determine whether the prematurely born children in their sample could be "differentiated from nonpremature children in terms of their cognitive functioning, visuo-motor functioning, personality, developmental data, and school functioning, at approximately 7 to 9½ years of age" (1978, p. 234). The study participants were administered the Wechsler Intelligence Scale for Children-Revised (Wechsler, 1974) and the Bender Visual Motor Gestalt

Test (Koppitz scoring) by psychometricians uninformed of the child's birth history. Test scores were not adjusted for prematurity. Mothers of the study children completed a questionnaire concerning social and emotional development and a social history form, and second grade report cards were obtained. The researchers chose $\underline{p} < .025$ as the level of statistical significance, more stringent than the .05 level chosen by the Baltimore research team and the Educational Follow-Up researchers.

The Wakoff research team reported that Full Scale WISC-R IQ scores did not differentiate the prematurely born children from the control children at the .025 level of significance regardless of the definition of prematurity used. When birthweight was used as the criterion for defining prematurity, the mean Full Scale IQ for prematures was $\underline{\bar{X}} = 100.3$ and the mean IQ for full-birth-weight children was $\underline{\bar{X}} = 108.0$. However, this difference in IQ scores favoring the controls reaches statistical significance when $\underline{p} < .05$ is used as the criterion level ($.025 < \underline{p} < .05$). The results of the Wakoff study are thus consistent with results reported by the Baltimore study researchers (Wiener et al., 1968) and the Educational Follow-Up Project research team (Rubin et al., 1973). Furthermore, the mean IQ difference (WISC-R) between the low-birth-weight and full-birth-weight groups in the Wakoff study was about 7.7 points which is similar to the difference of 4.9 points at ages 8 to 10 reported by Wiener et al. (1968) and the difference of about 5.0 points at age 7 reported by Rubin et al. (1973).

A comparison of WISC-R test results at ages 7 to 9½ reported by Caputo et al. and WISC test results at ages 8 to 10 reported by Wiener et al. (1968) is shown in Table 2.1. Contrary to the results reported by Wiener and his colleagues (1968), Caputo et al. found no Verbal Scale IQ differences between the two study groups. Arithmetic was the only verbal subtest which differentiated premature and nonpremature children in the Wakoff study, with prematures performing less well than controls. Wiener et al. (1968), however, reported that five of the six verbal subtests administered, namely Information, Comprehension, Arithmetic, Digit Span, and Vocabulary differentiated the two groups in their study (using $\underline{p} < .025$); only the Similarities subtest did not.

Table 2.1

Comparison of WISC-R Test Results at Age 7 to 9½ Reported by Caputo, Goldstein, and Taub (1978) and WISC Test Results at Age 8 to 10 Reported by Wiener, Rider, Oppel, and Harper (1968)

WISC-R subtests	F[a]	WISC subtests	F
Information	N.S.	Information	6.36
Similarities	N.S.	Similarities	N.S.
Arithmetic	N.S.	Arithmetic	5.86
Vocabulary	N.S.	Vocabulary	4.74
Comprehension	N.S.	Comprehension	4.56
Picture Completion	4.19	Picture Completion	N.S.
Picture Arrangement	N.S.		
Block Design	9.51	Block Design	5.57
Object Assembly	5.17	Object Assembly	6.93
Coding	N.S.	Digit Symbol	5.97

[a] $\underline{p} < .025$. [a] $\underline{p} < .025$.

N = 64. N = 822.

These discrepant findings may be due to differences in sample size, differences in age at the time of testing, differences in the nature of the subject population, or differences in the psychometric properties of the WISC and the WISC-R. Wiener and his colleagues (1968), it will be recalled, located 822 children (413 low-birth-weight, 409 controls) for follow-up evaluations at ages 8 to 10. The findings of the Wakoff Center research team, in contrast, were based on a sample of 64 children (38 prematures, 26 controls). Small differences in performance on the WISC subtests between the two study groups would achieve statistical significance in the Baltimore Study because of the large sample population, similar differences might not achieve statistical significance in the Wakoff study because of the smaller sample size. A second possible explanation for the discrepant findings is that differences between prematures and controls in abilities tapped by the Wechsler verbal subtests are not measurable until the age of 9 or 10, the age of Wiener et al.'s subjects at the time of testing. A third possible explanation for the discrepancies noted is that the prematures in the study conducted by Caputo et al. are, in fact, less impaired in the verbal skill areas than the prematures in the Baltimore Study because of improvements in medical care for "at risk" newborns (subjects in the Wakoff Study were born in the mid-sixties; subjects in the Baltimore Study were born in the early fifties). A fourth possible explanation for the discrepant findings is that the WISC taps subtle differences in abilities associated with birth weight not tapped by the WISC-R. This explanation seems unlikely.

Prematures (as defined by birthweight or gestational age) followed by the Wakoff research group fared less well than their full-term counterparts on the WISC-R Performance Scale, and this difference was significant at the .025 level. Three performance subtests differentiated prematures and controls, with controls demonstrating superior scores: Block Design, Object Assembly, and Picture Completion ($p < .025$). No performance differences were found between the two study groups on the Picture Arrangement and Coding Subtests. In comparison, Wiener et al. (1968) also found that low-birth-weight children in their study fared less well on the Performance Scale of the WISC at ages 8 to 10 than controls. Three of four performance subtests differentiated low-birth-weight children from controls in their study ($p < .025$): Block Design, Object Assembly, and Digit Symbol (similar to Coding). The Picture Completion subtest did not differentiate the two groups.

Thus, Block Design and Object Assembly differentiated prematures and controls in both studies. Picture Completion differentiated the two groups in the Wakoff Study but not the Baltimore Study; Digit Symbol differentiated the two groups in the Baltimore Study but not in the Wakoff Study. As suggested above, these discrepancies may be due to differences in sample size, differences in age at the time of testing, differences in the nature of the subject populations, or differences in the psychometric properties of the WISC and the WISC-R.

Caputo et al. also found that maturely born children demonstrated superior visual-motor integration skills on the Bender Gestalt Test when compared with prematures ($p < .02$ or less) independent of the criteria used to define prematurity. This is consistent with the finding of superior Bender performance by maturely born children at ages 6 to 7 and 8 to 10 reported by Wiener and his colleagues (Wiener et al., 1968).

In studies reviewed previously, Rubin et al. (1973) reported that low-birth-weight children performed less well than controls on tests of reading, arithmetic, and spelling achievement (WRAT) at age 7, and Wiener et al. (1968) found that full-birth-weight subjects out-scored their low-birth-weight classmates on a test of reading but not spelling achievement at ages 8 to 10 (WRAT). Contrary to these findings, data gathered by Caputo et al. from school report cards at the end of second grade indicated no differences between the two study groups in grade average. This measure of academic progress used by the Wakoff research team is clearly less satisfactory than achievement test results, however. Report card data were missing from a large number of subjects, and the "averaging" of report card grades may have obscured discrepancies in progress in different subject areas.

No differences were found between the two Wakoff study groups on measures of personal-social development in middle childhood (based on mother's questionnaire responses), and the health history reports for the two groups were similar.

In the discussion of their findings, Caputo et al. pointed out that both Apgar scores and the sensorimotor development scores at 12 months showed little variability. The Apgar scores were almost uniformly high, suggesting most infants were relatively intact neurologically at birth, and almost no children evidenced signs of organic impairment at one year of age as measured by the sensorimotor score.

Caputo and his colleagues were of the opinion that, although no signs of organic impairment were seen among the prematurely born children at birth and at 12 months, their test performance on the WISC-R and Bender Gestalt Test at ages 7 to 9½ strongly suggested cognitive deficits when compared with their maturely born peers. Tasks which most clearly differentiated prematurely born children from their maturely born peers were those which tapped "visually mediated functions rather than functioning that is verbal or auditory in character" such as the Block Design, Object Assembly, and Picture Completion subtests of the WISC-R and the Bender Gestalt Test (1978, p. 238). The researchers concluded by suggesting that "the deficit associated with premature births in our sample is based on subtle, central dysfunction involving the visual system, rather than on more peripheral insult" (p. 239).

Wiener and his colleagues, as previously mentioned, interpreted the poorer performance of low-birth-weight children on psychological and educational tasks as being due to minimal neurological impairment associated with prematurity and perinatal complications (Wiener et al., 1965, 1968). Caputo et al.'s interpretation is similar but more specific as to the nature of the disability. The Wakoff researchers suggest that premature children are impaired by subtle deficits in the capacity to process visual-perceptual information, and that these deficits are associated with premature birth in the absence of signs of organic impairment.

Prematurity, cognitive organization, and family dynamics. A fourth follow-up study of prematurely and maturely born children was conducted by researchers affiliated with the psychiatric clinic at The Montreal Children's Hospital (Caplan et al., 1976). Their study was designed to investigate the psychological development of prematurely born children in comparison with maturely born age-mates.

The study sample was comprised of 50 "normal" prematurely born males selected from existing hospital records in the City of Montreal. "Prematurity" was defined by birthweight (between 1,500 and 2,250 g) and gestational age (one lunar month short of full term or ≤ 37 weeks). A control group of 50 males with birth weights above 2,600 grams matched for hospital of birth and birthdate (within a few days of the premature child) was also selected. All study children came from homes in which the dominant language was English, and, as a control for socioeconomic status, only infants born to mothers who received semiprivate or private hospital accommodations were included in the study. Children with medical problems or below average IQ's (< 90) as estimated from the WISC Vocabulary Subtest were excluded. The experimental and control groups included two age ranges, 7 to 8 and 11 to 12 years old. The refusal rates for each study group were high: 23% of the families of prematures and 37% of the families of maturely born children contacted refused to participate in the study. This high refusal rate was apparently due in part to the demands of the study which included 10 hospital visits and absence from school on those occasions.

Each child was first seen for a complete medical and neurological examination at which time a developmental history was obtained. The following psychological tests were administered over the course of the 10 hospital visits: WISC, the Lincoln-Oseretsky Test of Motor Development (Sloan, 1955); the Bender Visual Gestalt Test; the Durrell Analysis of Reading Difficulty (Durrell, 1955); the Marble Board Test (Werner & Crain, 1950); Werner's Test of the Perception of Verticality (Werner & Wapner, 1955); A Test of Size Constancy (Beyrl, 1926); and three groups of items from the University of Montreal Test of Mental Development including items related to the notions of space, time, and number (Laurendeau & Pinard, 1962). Test scores were not corrected to adjust for prematurity. Except for a few cases, research team members were uninformed of the birth history of the child at the time of the data collection.

Caplan et al. found that prematurely born children did not fare as well as maturely born children on the WISC ($\underline{p} < .02$). The mean Full Scale IQ for the prematures was $\underline{\bar{X}} = 108.24$; the mean Full Scale IQ for the controls was $\underline{\bar{X}} = 115.28$, a mean difference of about 7.3 IQ points ($\underline{p} < .02$). This difference was largely due to lower scores by prematures on the Performance Scale ($\underline{p} < .01$). Verbal Scale score differences slightly favored the controls, but this difference was not significant at the .05 level ($\underline{p} > .10$). A greater discrepancy in WISC scores between the two study groups was found in the 11 to 12 year old groups (50 subjects) than in the 7 to 8 year old's group (50 subjects). Prematurely born children also performed less well on the Durrell Analysis of

Reading Difficulty Test than their maturely born age-mates. This difference in test performance was statistically significant at the older ($p < .02$) but not the younger age level ($p < .10$).

Maturely born children also outperformed their prematurely born age-mates on most tests which tapped visual-motor integration and gross motor coordination in the study conducted by Caplan and his colleagues. The Bender protocols of the control group were superior to those of the premature group ($N = 100$, $p < .05$), and, in line with the Durrell and the WISC Performance Scale results, differences in Bender performance reached significance ($p < .05$) at the 11 to 12 year age range but not at the younger age level ($p > .10$). Prematures also fared less well on the Lincoln-Oseretsky Test of Motor Development at both age levels ($p < .05$). Interestingly, prematures were found to be more field-dependent on Werner's Test of the Perception of Verticality than their maturely born age-mates.

Consistent with previously reviewed studies (Caputo et al., 1978; Rubin et al., 1973; Wiener, 1968; Wiener et al., 1965, 1968). Caplan and his colleagues interpreted their findings to suggest that premature birth is associated with subsequent deficits in cognitive functioning and lags in school achievement. In line with the findings reported in the Baltimore and Wakoff studies, the Canadian researchers found little support for the notion that prematurely born children "catch up" developmentally with their maturely born age-mates in early childhood. Caplan et al.'s interpretation of the mechanisms underlying the relatively poorer performance of prematurely born children on psychological and educational tasks is similar to the neurological dysfunction explanation posited by the Baltimore researchers but phrased in different terminology. Consistent with the thinking of the ego psychologists (e.g., H. Hartmann, E. Kris, D. Rapaport), they hypothesized that there is a neurophysiological basis for certain "ego functions" including "the organization and control of motility, perception, and thought" (Caplan et al., 1978, p. 262). They then reasoned that the poorer performance of prematures may be the result of differences in the maturation of the apparatus which is the neurological basis for these autonomous ego functions (p. 262).

Prematurely and maturely born children at three age levels. A fifth study of intellectual functioning, perceptual development, and academic progress of prematurely and maturely born children was reported by De Hirsch et al. (1966). This investigation differs from the first four studies reviewed in several ways. First, the prematures and controls in the De Hirsch study were selected from two different study populations, and the sampling procedures are consequently less satisfactory than those used in the Baltimore Study, the Educational Follow-Up Project, or the Wakoff Research Center investigation. Second, the statistical analyses reported by De Hirsch and her colleagues are less sopisticated than analyses used in the four studies previously reviewed. It is consequently somewhat difficult to compare the results of the De Hirsch study with those of the other researchers. And, third, many of the dependent measures in the De Hirsch study were devised by the researchers. This also makes comparisons between studies somewhat difficult.

The De Hirsch study is important for several reasons, however, despite these methodological differences and shortcomings. First, none of the research groups reviewed previously evaluated their subjects at kindergarten age. Second, none of the studies reviewed thus far have used as wide a variety of measures as De Hirsch and her colleagues to compare the performance of prematurely and maturely born children. Third, while the De Hirsch study provides further support for some of the findings reported by Wiener, Rubin, Caputo, Caplan, and their colleagues, new areas of cognitive and perceptual functioning are also investigated.

De Hirsch et al. compared the performance of "premature" and maturely born children on measures of perceptual-motor maturation, language development, IQ, and academic achievement during their kindergarten year and at the end of first and second grade. The children studied were selected from the population of all infants born during 1955 and 1956 cared for at Babies Hospital, Columbia-Presbyterian Medical Center, New York City, with birth weights of 2,500 grams or less. The initial population included 158 infants, and on the basis of the following criteria, 53 low-birth-weight children were selected for the study: (1) the predominant language in the home was English, (2) the child had no known sensory deficits, (3) the child's IQ score on the Stanford-Binet (1937 Revision) fell within one standard deviation of the mean, and (4) results of clinical assessment showed no evidence of psychopathology. No differentiation was made between small-for-date infants and infants with birth weights appropriate for their gestational age.

A control group comprised of 53 full-sized infants was selected from the population of all children born between 1955 and 1956 inclusive who participated in the Fetal Life Study at Babies Hospital. These children were initially selected through a random sampling of admissions to a post-natal care clinic. The selection criteria used for the low-birth-weight group (outlined above) were also used in selecting the control group.

Sex and race differences were found between the low-birth-weight group and the control group, with the low-birth-weight group including more girls and white children than the control group. De Hirsch et al. reasoned that these differences favored the control group because girls are generally thought to be more mature than same-aged boys and white children are likely to experience more early educational stimulation than their non-white peers. Data on the family characteristics of the low-birth-weight children and controls showed few differences between the two groups. More mothers of the low-birth-weight children were found to have continued their education beyond high school than mothers of control children.

Forty-nine of the 53 low-birth-weight children were seen for psychological testing, neurological evaluation, and langauge development assessments at age three, and five were found to have signs of probable or definite neurological impairment. All children were seen for psychological and educational assessments during kindergarten and at the end of first and second grade. The kindergarten tests included measures of IQ, motor development, and motivation, among others. The Stanford-Binet (1937 Revision) was administered as a measure of IQ. Ratings of hyperactivity, distractibility, and disinhibition were made. Three tests of large motor coordination--hopping, throwing, and balance--were administered and motility was evaluated for the presence or absence of concomitant movements. Laterality and fine motor coordination were assessed by "pegboard speed, knot tying, and whittling and graphic activities" (1966, p. 618). The Bender Gestalt Test was administered to assess visual-motor performance. Fourteen language tests which included five receptive and nine expressive tests were given, and six tasks designed to measure reading readiness were administered. Children were also rated on "their ability to invest effort" (p. 619). There was apparently no adjustment for prematurity in calculating test scores.

At the end of the first grade, the study children were administered one writing test and three standardized reading tests (the Gray Oral and the Gates Primary Sentence and Paragraph Reading Tests). At the end of second grade, all children were administered two reading tests (the Gray Oral and the Gates Advanced Primary Reading Tests), the Metropolitan Spelling Tests, and a writing test devised by the researchers. Four of the kindergarten tests were also re-administered.

A "critical score level" was determined for each test or rating scale, and the number of children above and below the critical score level for each group (low-birth-weight children and controls) was reported. Within-group comparisons by sex and weight were made for the low-birth-weight group. It was found that significantly more low-birth-weight girls scored above the critical score level than low-birth-weight boys on tests of writing ($\underline{p} < .01$) and spelling ($\underline{p} < .05$) at the end of the second grade. Very low-birth-weight children (birth weights < 1,500 g) did not perform as well as heavier infants with birth weights between 1,500 and 2,500 grams on most achievement tests at the end of first and second grade; however, no statistical test results were reported for these differences.

Results from between-group comparisons showed that the low-birth-weight children fared less well on IQ tests administered during kindergarten (26 IQ's fell in the 84-94 range; 9 in the 113-116 range, scores for 19 cases were missing) than their normal birth weight peers (8 IQ's fell in the 84-94 range, 25 in the 113-116 range, 20 missing cases). IQ differences between the two groups were statistically significant at the .05 level. No group mean scores were given.

The performance of the low-birth-weight children was "almost uniformly poorer" on the kindergarten tasks (1966, p. 620). Differences favored normal birth weight children on 36 of 37 tests, and these differences reached statistical significance at the .05 level for 15 of the tests. Eleven of these were tests of language development or reading readiness. The remaining three were pegboard speed (fine motor coordination), the Bender Gestalt Test, and tapped patterns. At the end of first grade, the low-birth-weight children performed less well than controls in reading (composite score) and writing. These differences were significant at the .05 and .01 levels, respectively. The researchers summarized their impressions and findings as follows:

> The prematures' CNS functioning seemed more primitive, their behavioral controls less firmly established, their level of neurological integration lower than that of the maturely born subjects. They presented subtle difficulties in motor, perceptual, visuo-motor and linguistic patterning--difficulties that extended into the early academic years, and resulted in relatively inferior performance, especially with regard to tasks that required a high level of integration. (1966, p. 626)

Thus, in line with Wiener and his colleagues (Wiener, 1968; Wiener et al., 1965, 1968) and Caputo and his colleagues (Caputo et al., 1978), De Hirsch suggested that impaired neurological integration is "the link" between premature birth and later school failures. Consistent with the studies reviewed previously (Rubin et al., 1973; Wiener, 1968; Wiener et al., 1965, 1968), De Hirsch and her colleagues also concluded by suggesting that prematurely born children be regarded as an "academic high risk" group (1966, p. 626).

Summary of the Research Findings on the Psychological Sequelae of Premature Birth

The research findings pertaining to each of the following outcome variables will be summarized in this section of the literature review: general cognitive ability, academic progress, language, perceptual maturation, social development, and problem-solving competence. Studies which examine the interaction between socioeconomic variables and maturity at birth as they affect developmental outcomes will also be summarized.

General cognitive ability. Investigations of the psychological sequelae of premature birth in the elementary school years reviewed previously typically reported that prematurely born children fare less well on IQ tests than their maturely born classmates (Caplan et al., 1976; Caputo et al., 1978; De Hirsch et al., 1966; Harper et al., 1959; Rubin et al., 1973; Wiener, 1968; Wiener et al., 1965, 1968). These IQ differences found in middle childhood are small, however; researchers have generally reported a mean IQ difference of about five points between groups of prematurely and maturely born children in the elementary school years (Caplan et al., 1976; Caputo et al., 1978; Wiener et al., 1965, 1968).

Two studies not reviewed previously provide further support for these findings. Dann et al. (1964) reported an IQ difference of 12 points between prematures and full-term siblings (no correction for prematurity). Wright et al. (1972) conducted a follow-up study of 50 small prematures (birth weights of 1,500 g or less) and 50 controls born between 1952 and 1956 inclusive. Subjects were matched on sex, race, date of onset of pregnancy (78% within one month),* socioeconomic background, and obstetric variables. Consistent with the studies reviewed previously, an analysis of intra-pair differences showed that controls outperformed the small prematures on both Verbal

---

*Subject pairs were initially matched on date of onset of the pregnancy to control for variations in infectious disease in the community. Pairs were not matched on post-conceptual age at the time of follow-up, however.

($\underline{p} < .0001$) and Performance ($\underline{p} < .0005$) sections of the WISC at about ten years of age. No mean IQ scores were reported. The small prematures also fared less well on measures of visual perceptual development and reports of school progress.

Two additional studies conducted abroad also reported IQ differences between "prematurely" born children and controls. In both studies, however, socioeconomic status was confounded with birth weight which obscured the interpretation of the results reported. Douglas (1956, 1960) compared the performance of 407 low-birth-weight singletons (5½ pounds* or less) born in Britain the first week of March 1946, and matched controls (born the same week) on measures of mental ability and school achievement at 8 and 11 years of age. Paired comparisons showed that the low-birth-weight children performed less well than their full-birth-weight counterparts on reading, vocabulary, and picture intelligence tests at age 8. At age 11, low-birth-weight children performed less well on secondary selection examinations and they received less favorable rating by their teachers in the areas of attitudes towards work, power of concentration, and discipline in class. Although the pairs were originally matched on social class variables, additional family background information gathered during the primary school years showed that birth weight and family background variables were confounded; the prematurely born children generally came from relatively disadvantaged homes when compared with controls. In contrast to the researchers cited previously, Douglas (1960) interpreted the poorer performance of

---

*Approximately 2,495 grams or less.

the low-birth-weight children on psychological and educational tasks as being due to less adequate living conditions, low standards of maternal care, and lack of parental interest in education rather than central nervous system dysfunction.

Drillien (1964) followed the growth and development of 251 low-birth-weight infants born between 1953 and 1955 inclusive in two Edinburgh hospitals and 119 mature controls. Consistent with the findings reported by De Hirsch et al. (1966) and Wiener et al. (1965, 1968), she reported significantly lower Gesell DQ's at age four as a function of decreasing birth weight (test age was adjusted for prematurity). However, in contrast to other studies cited, Drillien did not exclude children with gross neurological and mental defects from her follow-up sample. Furthermore, like Douglas, the premature and control groups in her study differed in socioeconomic status and maternal parity, with significantly more controls from upper class homes with fewer previous children.

Three studies were located in the literature which reported no differences in IQ between prematurely and maturely born children. Abrams (1969) conducted an investigation of cognitive performance, perceptual integrity, and hyperactive behaviors of 21 upper birth weight "premature" children (3½ to 5½ pounds)* and 21 children born maturely between 1959 and 1962 in Portland, Oregon. When seen for follow-up evaluations at 6 to 9 years of age, no differences were found between the "prematures" and controls on any of the dependent measures (no adjustment for prematurity). Non-significant differences

---

*Approximately 1,588 to 2,495 grams.

favoring the maturely born children were noted on the Bender Gestalt Test, the WISC Performance Scale, and a test of mixed dominance. Abram's investigation suffered from several methodological shortcomings, however. First, his sample size was small, and consequently, large rather than subtle differences were needed between the two groups to achieve statistical significance. Second, the premature and maturely born children were selected from two different populations. The parents of the prematures were enrolled in a hospital group health plan that provided readily available prenatal care. The control children, however, were apparently not matched on hospital of birth and did not profit from the benefits of this health care plan. Third, Abrams selected his prematurely born children by birth weight only. It is likely that some of his "low-birth-weight" infants were children of small mothers born at term rather than "true prematures."

Robinson and Robinson (1965) compared the performance of three birth weight groups on measures of IQ, reading ability, and social behavior in the classroom. One group was comprised of 25 children with birth weights of 1,500 grams or less, the second group included 99 children with birth weights of 1,501 to 2,500 grams, and the third group was comprised of 90 children with birth weights equal to or greater than 2,500 grams. All of the study children were born in Wake County, North Carolina, between 1948 and 1951 inclusive. Although the researchers originally matched low-birth-weight and normal birth-weight groups on father's occupational status, significant differences were found between the birth weight groups on social class of the families and mother's education, with the lighter babies born to relatively disadvantaged families. The researchers consequently used analysis of covariance procedures to statistically remove the variance accounted for by social class differences. Using this procedure, Robinson and Robinson found no association between birth weight and IQ or birth weight and reading ability. Low-birth-weight children received less favorable teacher ratings on classroom behaviors than normal birth-weight children, and this difference was also interpreted as being due to social class differences. However, the confounding of social class and birth weight, and the smaller sample size makes this study somewhat less impressive than the others reviewed previously.

Additional support for the finding of no differences reported by Abrams and Robinson and Robinson is provided by McDonald (1964). McDonald conducted a follow-up study without controls of 1,066 children born between 1951 and 1953 in Great Britain who weighed four pounds or less at birth.* The children were 6 to 9 years old at the time of the follow-up. The mean IQ (Stanford-Binet, Form L) of the low-birth-weight children was 102.4 when children with cerebral palsy, sensory deficits, or mental retardation ($IQ < 50$) were excluded. Test scores were corrected for prematurity. McDonald did find an association between IQ and birth weight independent of social class among single born females but not males.

These three studies (Abrams, 1969; McDonald, 1964; Robinson & Robinson, 1965) which reported no differences in general cognitive ability between prematurely and maturely born children in middle

---

*Approximately 1,814 grams or less.

childhood are not as convincing as the investigations reviewed previously which suggests small subtle differences in IQ. Inadequate sampling procedures, the confounding of social class and birth weight, or the absence of controls makes each of these follow-up investigations methodologically "suspect."

Only two large-scale studies were located which investigated the developmental progress of prematures and their maturely born age-mates during the preschool years. One is the Baltimore Study, the second is the Educational Follow-Up Project. Harper et al. (1959), it will be recalled, evaluated the intellectual potential of the low-birth-weight children and controls in the Baltimore Study at ages 3 to 5. Consistent with findings from younger and older age groups, the Baltimore researchers found that the low-birth-weight preschoolers did not fare as well as their normal birth-weight counterparts on estimates of intellectual potential. The IQ's of the majority of the low-birth-weight children (84%) fell in the normal range, however. IQ tests administered to 4 year olds in the Educational Follow-Up Project yielded similar results.

Several researchers have suggested that the improvements in neonatal care and equipment introduced in the 1960's have resulted in better intellectual outcomes for children prematurely born in the 1960's and 1970's (Dweck, Saxon, Benton, & Cassady, 1973; Rawlings, Reynolds, Stewart, & Strange, 1971). Results of studies of prematures born since the middle 1960's are mixed, however. The study group followed by the Wakoff Research Center team (reviewed previously) was comprised of moderately low-birth-weight infants born between 1965 and 1969. Differences in IQ and visual-perceptual development favoring maturely born controls were found at age 7 to 9½ (Caputo et al., 1978).

Results of two other studies are more optimistic. Dweck et al., (1973) monitored the health, growth, and development of 14 tiny low-birth-weight infants (< 1,101 g) born between 1968 and 1970 and 14 full-birth-weight controls matched for hospital of birth, date of birth (within three days), sex, and race. No differences were found between the two groups in performance on the Cattell Infant Intelligence Scales at 11½ to 33½ months (age adjusted for prematurity). The mean for the low-birth-weight groups was 100; the mean for the full-birth-weight groups was 101. Similarly, Rawlings et al. (1971) reported that the distribution of IQ scores for 16 low-birth-weight children (< 1,501 g) tested at ages 3 to 4 was essentially the same as the distribution of IQ scores of their mothers (test scores were adjusted for prematurity).

Academic progress. Although the IQ scores of the majority of prematures fall in the normal range in middle childhood (Wiener et al., 1968), the literature suggests that prematures do not perform as well as their maturely born classmates on tests of reading achievement (Caplan et al., 1976; De Hirsch et al., 1966; Douglas, 1956, 1960; Rubin et al., 1973; Wiener, 1968; Wiener et al., 1968) and arithmetic achievement (Rubin et al., 1973; Wiener, 1968) in the elementary grades. Wiener (1968) has interpreted the findings from the Baltimore Study to suggest that prematurely born children are at greater risk for failure in arithmetic than reading. Prematures are also more likely to receive special education services (Rubin et al., 1973; Wright et al., 1972) or repeat grades (Rubin et al., 1973; Wiener, 1968) than their maturely born peers.

Further support for the finding that prematurely born children with normal range IQ's are "at risk" for school failures is provided by two non-comparative follow-up studies. Francis-Williams and Davies (1974) followed the growth and development of 95 very low-birth-weight infants (< 1,500 g) born or admitted into a London hospital between 1961 and 1968 inclusive (33 small-for-dates and 72 appropriate-for-dates). The children ranged from 4 to 12 years of age at the time of the follow-up evaluations. The mean IQ for the appropriate-for-dates was 99.2 (as measured by the WPPSI or WISC depending on age), and the mean IQ for the small-for-dates was 92.0. No correction was made for preterm birth. Forty-nine of the study children were 7 to 12 years of age at the time of the final round of testing, and these children were administered reading achievement tests. It was found that 14 children (19%) had made no progress in beginning to read and 5 others (10%) were three or more years retarded in reading. Thus, almost 40% of the very low-birth-weight study children were reading below their expected achievement levels at school age.

Lubchenco and her colleagues at Colorado General Hospital (1963) evaluated the progress of 63 very low-birth-weight infants (1,500 g or less) born between July 1, 1947 and July 1, 1950 at ten years of age. The researchers found that 25 of the 35 children (72%) with normal range IQ's (as measured by the WISC) were experiencing school learning difficulties. Eleven had repeated one or more of the primary grades and three were not enrolled in kindergarten until the age of 6 (1963, p. 110).

Results of a retrospective study (Harmeling & Jones, 1968) also suggest an association between low birth weight and educational outcomes in high school. Three study groups were selected with subjects (all black) matched for sex and measures of socioeconomic status: a group of high school drop-outs, a group of high school students placed in classes for slow learners, and a group of high school students placed in regular classes. High school drop-outs were found to have the lowest birth weights, followed by students placed in slow learning classes. Those placed in the regular classes had the highest birth weights.

Language. The findings pertaining to the language development of prematurely born children and their maturely born counterparts vary with the type of dependent measure used and the age of the children at follow-up. Rubin et al. (1973) reported that prematurely born 5 year olds did not fare as well as their maturely born age-mates on the Illinois Test of Psycholinguistic Abilities. De Hirsch and her colleagues (1966) found that maturely born kindergarteners out-performed prematures on 11 tests of language development. Wiener et al. (1965) reported that prematures in the Baltimore Study fared less well on assessments of language comprehension at age 6 to 7 than their maturely born peers.

However, all researchers reviewed, with the exception of Wiener and his colleagues (1968), reported no differences between prematures and controls on the Wechsler Verbal IQ Scale at ages 7 to 8 (Caplan et al., 1976), 7 to 9½ (Caputo et al., 1978), and 11 to 12 (Caplan et al., 1976). As previously discussed, Wiener et al.'s (1968) discrepant findings may be due to their large sample size. These results suggest that prematurely born children seem to lag behind their maturely born age-mates on assessments of early language development, but no meaningful differences are found in verbal ability in later childhood.

Two studies have also reported a higher incidence of speech immaturities among prematurely born children when compared with controls. Low-birth-weight children in the Baltimore Study demonstrated immature speech patterns (omissions, distortions, and substitutions) when compared with maturely born controls at ages 6 to 7 (Wiener et al., 1965) and 8 to 10 (Wiener et al., 1968). Fitzhardinge and Ramsey (1972) also reported a high incidence of speech immaturities and delayed language development in a follow-up study of small prematures (birth weights < 1,251 g) born in the early 1960's.

Perceptual maturation. Relatively impaired performance by prematures on tests of visual-perceptual development was the most consistently reported finding in the literature on premature children at school age. In the studies reviewed previously, maturely born children outperformed their premature classmates on the Bender Gestalt Test at age 5 (De Hirsch et al., 1966), 6 to 7 (Wiener et al., 1965), 7 to 8 (Caplan et al., 1976), 7 to 9½ (Caputo et al., 1978), 8 to 10

(Wiener et al., 1968), and 11 to 12 (Caplan et al., 1976) regardless of the scoring system used. Furthermore, studies which examined Wechsler Verbal and Performance Scale scores consistently reported that prematures fare less well on the Performance Scale than maturely born age-mates in the middle childhood years (Caplan et al., 1976; Caputo et al., 1978; Wiener et al., 1968; Wright et al., 1972). The Block Design and Object Assembly subtests were found to discriminate prematures and controls in two major studies, with controls demonstrating superior scores (Caputo et al., 1978; Wiener et al., 1968). Additional support for the notion that prematures demonstrate relatively impaired visual-perceptual development is provided by Wright et al.'s (1972) finding that prematures fared less well than controls on the Halstead Battery form board tests at age 10.

Personal-social development. Only one of the studies reviewed examined the early personal-social development of prematurely born children. Caputo et al. (1978) found no differences between the premature and control groups in their study on parental reports of personal-social development.

Problem-solving competence. Caplan et al. (1976) reported that prematurely born 7 to 8 year olds and 11 to 12 year olds were more field dependent than their maturely born age-mates as assessed by Werner's Test of the Perception of Verticality (1950). De Hirsch and her colleagues (1966) observed that prematures in their study were more "disorganized" than maturely born children in their task approach in kindergarten and first and second grades. Wiener et al. (1965) found that prematurely born children were rated as more impulsive than their maturely born age-mates at 6 to 7 years of age by psychologists and teachers. These findings suggest that prematurely born children may be less competent in their problem-solving approach than their maturely born peers. More specifically, prematurely born children may have more difficulty quickly grasping the goal of the problem presented, devising orderly problem-solving schemes, and persisting in self-directed efforts until mastery is achieved than their maturely born age-mates.

Socioeconomic variables and maturity of birth. As previously mentioned, most of the early studies of prematurely born children were based on the main effects model. Performance differences observed were interpreted as being due to a single causal factor, typically central nervous system dysfunction (e.g., De Hirsch et al., 1966; Lubchenco et al., 1963). Douglas (1960), in contrast, interpreted the relatively poorer performance of the prematures in his study as being due to a poorer home environment. Studies based on the main effects model did not investigate the possible interaction of socioeconomic variables and maturity at birth as they affect developmental outcomes.

The Baltimore Study and the Wakoff Study were both based on an interactional model. The Baltimore Study was the only large scale investigation located, however, which specifically attempted to evaluate the interaction of socioeconomic variables and maturity at birth as they affect developmental outcomes at several ages. In his concluding comments, Wiener (1968) stated that throughout the Baltimore Study "there was no evident statistical interaction between race or social class and birth weight as these affect achievement" (p. 248). Results of the Baltimore Study thus suggest that low birth weight places the child at risk for educational problems independent of social class. In line with research based on the main effects model, Wiener and his colleagues also concluded that central nervous system dysfunction was the primary "link" between prematurity and later academic failures. More research is needed to investigate the interaction of family background characteristics and maturity at birth in shaping the developmental patterns of these "at risk" children.

Rationale

One goal of the study was to investigate whether there are differences between prematurely and maturely born 3 and 4 year olds in general cognitive ability, perceptual maturation, and personal-social development which may foreshadow later school learning problems. Two methodological departures from the previous research studies were made. Consistent with the literature which suggests both birth weight and gestational age be used as criteria in selecting prematures, only preterm children with birth weights appropriate for their gestational age were included in the research sample. This inclusion of small-for-dates helps to clarify the population to which the findings may be generalized. Furthermore, unlike previous investigations of the sequelae of prematurity, research groups were matched on post-conceptual age rather than chronological age at the time of testing. There were three reasons for this second methodological departure from previous studies. First, if differences in the performances of prematurely and maturely born children are interpreted as being due to immaturities or deficits in the central nervous system, it seems most reasonable to equate research groups on "biological" or post-conceptual age at the time of follow-up evaluation rather than matching groups on chronological age and then correcting scores for prematurity. Second, by re-scoring the McCarthy protocols for the prematurely born children using chronological age, it was possible to evaluate whether prematurely born preschoolers are developmentally more similar to children of the same chronological or post-conceptual age. This comparison clearly has bearing on the question of "catch up" growth. Third, because groups were matched on post-conceptual age at testing, comparisons between the two study groups using raw scores rather than age-normed scores was appropriate. Unlike most previous studies, observation coding systems and behavioral rating scales did not afford an age advantage to the control group children in this study.

It was anticipated that the finding of differences in general cognitive ability and perceptual maturation between prematurely born children and their full-term counterparts would be replicated in this study. Consequently, a second goal of the study was to investigate mechanisms underlying the relatively poorer performance of prematurely born children on psychological and educational tasks. Most researchers cited "impaired neurological integration" as "the link" between premature birth and later school failures in the studies reviewed above. However, as previously suggested, the notion that prematurely born children may suffer central nervous system dysfunction does little to explain what it is that they fail to do in the testing situation or the classroom which results in their relatively inferior performance. The importance of gathering information about the problem-solving process as well as recording success or failure on particular tasks has been noted by critics of traditional tests (Estes, 1974; Furth, 1973; Inhelder, 1966; Inhelder & Matalon, 1960; Pinard & Sharp, 1972; Vygotsky, 1962). Systematic observation of the child's problem-solving efforts can lead to a genuine understanding of learning problems and provide direction for instruction and remediation.

The decision to focus specifically on the child's problem-solving efforts for the purposes of this study rather than other aspects of the testing situation (e.g., anxiety, motivation, characteristics of the examiner) was based on two considerations. First, problem-solving skills are clearly important for test performance and learning tasks in the classroom, and second, the literature on prematurely born children reviewed previously suggests differences in problem-solving styles and abilities favoring maturely born children at school age.

Identification of developmental differences between prematurely and maturely born preschoolers was seen as particularly important because the preschool period is thought to be an optimal time for educational intervention. The studies examined above strongly suggest that the prematurely born child is appropriately considered "at risk" for later academic failure. Few studies of the early development of prematurely born children, particularly at ages 3 and 4, were found in the research literature, however.

Hypotheses and Research Questions

The following research hypotheses were tested in the study:

1. Prematurely born preschoolers will not perform as well as their maturely born age-mates on measures of (a) general cognitive ability, (b) verbal ability, and (c) perceptual performance when scores are based on chronological age.

2. Prematurely born children will not perform as well as their maturely born peers on measures of (a) general cognitive ability, (b) verbal ability, and (c) perceptual performance when scores are based on post-conceptual age.

3. Prematurely born children will not perform as well as their maturely born counterparts on measures of visual-perceptual development: the McCarthy Scales (a) Block Building, (b) Puzzle Solving, and (c) Draw-A-Design tests.

4. Prematurely born preschoolers will not perform as well as their maturely born peers on measures of problem-solving competence: prematures will not perform as well as their maturely born counterparts on measures of (a) self-direction and (b) planfulness. Prematures (c) will be rated as more impulsive in their task approach than their maturely born counterparts, and (d) they will demonstrate less task persistence than their maturely born peers.

5. A higher incidence of children with speech articulation difficulties will be found among prematurely born 3 and 4 year olds than among the maturely born controls.

6. No differences will be found between the two groups of preschoolers on parental reports of personal-social development.

Four supplementary analyses of the data were also conducted. The strength of the relationship between parental socioeconomic status and performance on the McCarthy GCI scale was examined for each research group and the interaction of socioeconomic status and birth history (premature or mature birth) as they affect performance on the GCI scale was evaluated. The relationship between birth weight and GCI scores, and gestational age and GCI scores, was examined for the premature research group.

Additionally, data were gathered to determine the incidence and types of special education referrals for all prematurely born 3 and 4 year olds in the "at risk" research population.

Definitions

Prematurity and Mature Birth

The criteria for defining "prematurity" in this study included: (1) birth weight less than or equal to 2,500 grams; (2) "preterm" birth, i.e., before 38 weeks completed gestation (Lubchenco, 1976, p. 128); and (3) birth weight appropriate for gestational age, i.e., between the 10th and 90th percentiles on the Colorado Intrauterine Growth Curves (Lubchenco, Hansman, & Boyd, 1966). The resulting sample population is shown graphically in Figure 2.1. The criteria for defining "mature"

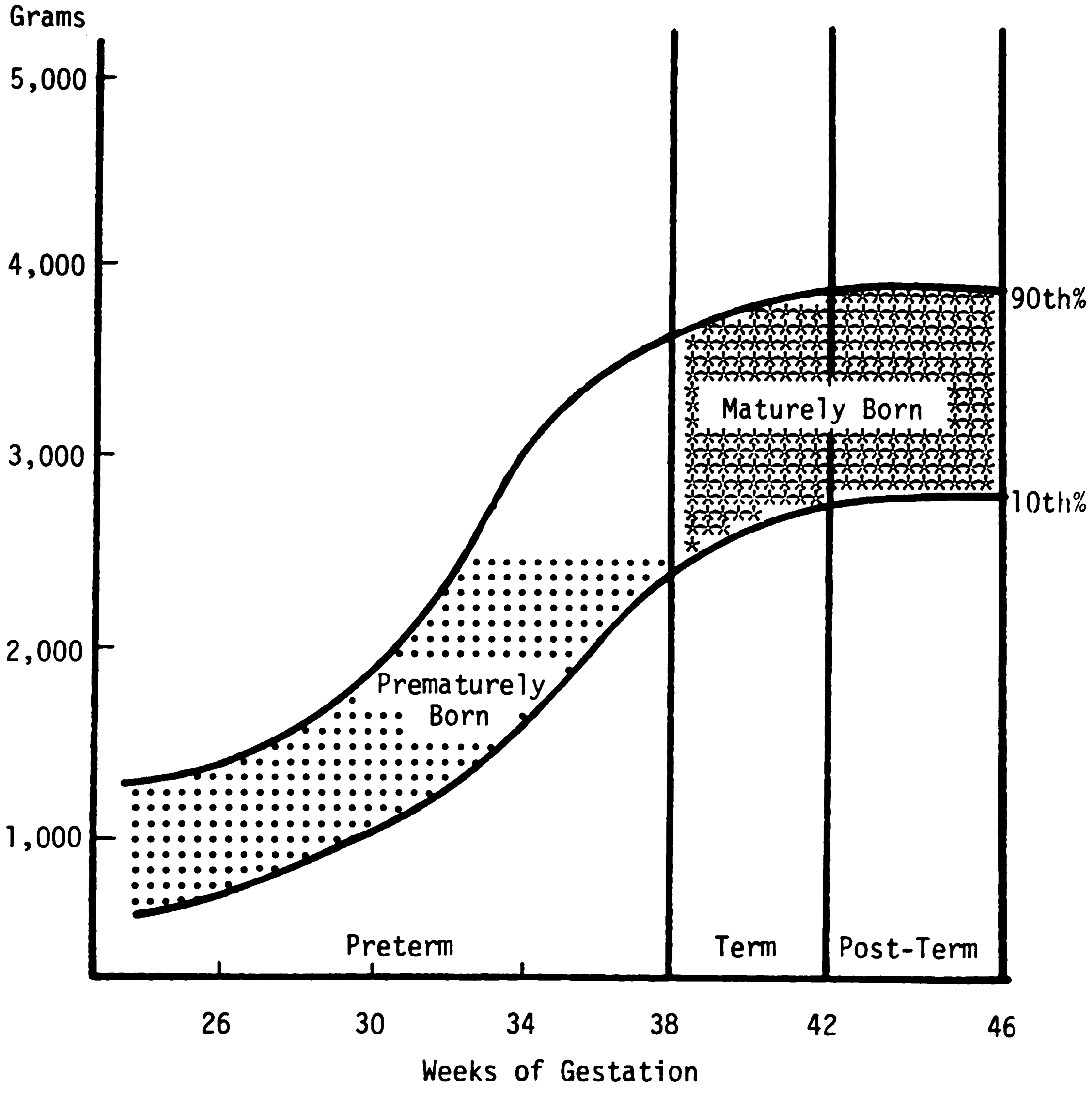


Figure 2.1 Birth weight and gestational age of the prematurely and maturely born sample populations shown graphically. Adapted from the Colorado Intrauterine Growth Curves (Lubchenco, Hansman, and Boyd, 1966).

birth in this study thus included: (1) birth weight over 2,500 grams; (2) "term" birth, i.e., after 38 weeks completed gestation; and (3) birth weight appropriate for gestational age on the Colorado Intrauterine Growth Curves (Lubchenco et al., 1966).

The definitions of "prematurity" and "mature" birth outlined above were selected for three reasons. First, these definitions resulted in two mutually exclusive categories. This can be seen graphically in Figure 2.1. Second, these definitions resulted in the exclusion of "small-for-date" infants which helps to clarify the population to which the findings may be generalized. Third, these definitions are consistent with recommendations in the research literature that both birth weight and gestational age be used as criteria in selecting "prematures" (Caputo et al., 1978).

Post-Conceptual Age

For the purposes of this study, "post-conceptual age" was operationally defined as chronological age minus the number of weeks premature. (Number of weeks premature was determined by recording the physician's estimate of gestational age at birth from hospital records and subtracting estimated gestational age from 40 weeks). For example, a child with a chronological age of 3 years 6 months at the time of assessment who was born eight weeks premature would have a post-conceptual age of 3 years 4 months at testing. (Thus, for full-term subjects, post-conceptual age equals chronological age.) Subject pairs were matched on post-conceptual age at the time of testing.

General Cognitive Ability

"General cognitive ability" was operationally defined as a child's score on the General Cognitive Scale (called the "General Cognitive Index") of the McCarthy Scales of Children's Abilities (McCarthy, 1972).

Verbal Ability

"Verbal ability" was operationally defined as the child's score on the Verbal Scale of the McCarthy Scales.

Perceptual Maturation

"Perceptual maturation" was operationally defined as the child's score on the Perceptual-Performance Scale of the McCarthy Scales.

Visual-Perceptual Development

"Visual-perceptual maturation" was operationally defined as the child's scores on the Block Building, Puzzle Solving, and Draw-A-Design tests of the McCarthy Scales. Kaufman and Kaufman's analysis of the McCarthy Scales suggests that Block Building, Puzzle Solving, and Draw-A-Design are the tests on the Performance Scale which best measure visual perception, spatial relations, and visual-motor coordination (1977, p. 88). These scores were analyzed separately (rather than as a composite score) because of recent research literature which suggests that the McCarthy Block Building and Puzzle Solving tasks tap right hemisphere parietal lobe information processing while drawing tasks such as the Draw-A-Design test are sensitive to right hemisphere frontal lobe functioning among 3 year olds (Hartlage & Telzrow, 1981b).

Problem-Solving Competence: Self-Direction, Planfulness, Impulsivity, and Task Persistence

The "Preschool Problem-Solving Competence Test" devised by the researcher yields four scores which were analyzed separately (see Appendix C). "Self-direction," "planfulness," "impulsivity," and "task persistence" were operationally defined as the child's score on each of the respective scales.

Speech Maturity

"Speech maturity" was defined as the rating the child received (normal or abnormal) on the Denver Articulation Screening Exam (University of Colorado Medical Center, 1971).

Social Development

"Social development" was defined as a child's score on the "Personal-Social Development Questionnaire" (Appendix D) completed by a parent or guardian. The Personal-Social Development Questionnaire is comprised of items from the "Personal-Social Development" section of the Yale Child Study Center Revised Developmental Schedules (1971) and items from the Vineland Social Maturity Scale (1965).

Socioeconomic Status

Father's occupation (or mother's occupation in father-absent homes) was used as the index of family socioeconomic status. Occupation was coded according to the Duncan Socioeconomic Scale (Duncan, 1961). This scale was devised from the 1950 census on the basis of average income and educational level of persons in each census occupational category. Families supported by public assistance were assigned a code of zero.

Special Education Referral

"Special education referral" included all referrals for special education services.

CHAPTER III

METHOD

Subjects

The "At Risk" Research Population

The "at risk" research population included all children referred to the Developmental Assessment Clinic for evaluation with birthdates between March 1, 1976 and August 15, 1977. The Developmental Assessment Clinic, funded in part by Project Find, monitors the health and developmental progress of babies who required placement in E. W. Sparrow Hospital's Regional Neonatal Intensive Care Unit (RNICU) during the first days or weeks of life. All graduates of Sparrow's RNICU are referred to the Developmental Assessment Clinic for follow-up evaluations* These high risk children are seen by the medical-educational team at 6, 12, 18, and 24 months, and 3, 4, and 5 years of age. The clinic also monitors the progress of children with suspected delays in development who are referred by area physicians.

---

*A name and address card for each neonatal intensive care graduate is routinely prepared by the ward secretary at the time the child is discharged from the intensive care unit. These cards are forwarded to the Developmental Assessment Clinic, and parents are then contacted by the DAC receptionist to schedule a clinic visit. Children are thus automatically referred to the DAC from RNICU unless there is a specific request by the family pediatrician that no referral be made, and this occurs very infrequently (M. Meade, RNICU ward secretary, personal communication, June 1981).

A search of the Developmental Assessment Clinic records showed that 202 children with birthdates during the target period had been referred for developmental evaluations. One hundred eighty-two (90%) of the 202 children with target birthdates were graduates of the RNICU at Sparrow Hospital while 20 (10%) were referred to the clinic for developmental assessment by area physicians. As of September 1980, 115 (57%) of the 202 children referred to the DAC were listed as active cases (i.e., parents scheduled and kept follow-up appointments).

Prematurely and Maturely Born Subjects

Eighty-eight children who met the following subject selection criteria were identified through a search of the Developmental Assessment Clinic records for the target period:

1. birthdate between March 1, 1976 and August 15, 1977, inclusive
2. child was referred to the Developmental Assessment Clinic from RNICU (physician referrals excluded)
3. singleton birth (twins, triplets excluded)
4. no mention of moderate-to-severe neurological damage, sensory loss (i.e., deaf, blind) or mental retardation (IQ estimates < 60) in clinic records*
5. birth weight less than 2,500 grams
6. "preterm" birth, i.e., before 38 weeks completed gestation

---

*Children seen for physical therapy because mid-to-moderate motor delays were not excluded from the research sample.

7. birth weight appropriate for gestational age, i.e., between the 10th and 90th percentile of the Colorado Intrauterine Growth Curves (small-for-dates excluded)*

8. English is the dominant language in the home.

Children with moderate-to-severe neurological damage, sensory loss, and those identified as mentally retarded were excluded from the study sample for two reasons. First, exclusion of children with moderate-to-severe neurological or intellectual impairment is consistent with the subject selection procedures used in most of the comprehensive studies reviewed previously (Caplan et al., 1976; Caputo et al., 1978; De Hirsch et al., 1966; Wiener, 1968; Wiener et al., 1965, 1968). The specific criteria used to exclude children with neurological or intellectual impairments is different for each of the studies reviewed, however. Second, the McCarthy Scales do not have sufficient "easy" items to obtain reliable IQ's for 3 to 4 year olds with IQ's below 50 (see Kaufman & Kaufman, 1977), and the use of infant scales would have resulted in an undesired change in the focus of the study.

Letters were mailed to 68 families with prematurely born preschoolers who met all subject selection criteria asking whether or not parents were interested in participating in the study (hospital records showed no known address for 20 families). To encourage parents to volunteer, the names of all study volunteers (prematures and controls) were entered in a drawing. The prize was a $50 gift certificate for

---

*Consideration was given to including a group of small-for-date children in the research study. This notion was rejected because of limitations of time and money available for the study and the relatively low incidence of small-for-date births.

Sears Roebuck & Company donated by an area physician. Forty-two families (62%) consented to participate in the study, 14 families refused, and 11 letters were returned stamped "Moved--No Forwarding Address" or "Addressee Unknown." Two of the prematurely born volunteers were excluded from the study because the child was found eligible for special education placement during the months between the subject selection and initial contact with the parents (one child showed marked delays in motor and language development; the second child was found to be hearing impaired).

One hundred seventy-two families with maturely born preschoolers were located with the help of 16 mid-Michigan pediatricians and three day care centers, and through a search of birth announcements which appeared in <u>The State Journal</u> in 1976 and 1977. Research assistants attempted to match each prematurely born subject ($N = 40$) with a maturely born control on the following variables: race, sex, singleton birth, parity (first or later born), post-conceptual age at testing, and parental socioeconomic status.

The research sample which resulted was comprised of 38 white subject-pairs, one Black subject-pair, and one racially-mixed prematurely born child paired with a white maturely born preschooler. There were 22 male subject-pairs and 18 female subject-pairs. All study children were singletons. Research assistants were not able to match pairs on parity (first or later born) because of the small number of control group volunteers. The research sample consequently included 26 pairs matched on parity and 14 mis-matched pairs (i.e., first borns matched with later born children). Parity was matched on group level, however, with 19 first borns and 21 later borns in each study group.

The post-conceptual age of the subject-pairs ranged from 36 to 51 months at the time of testing. Matches on post-conceptual age were achieved by scheduling appointments to adjust for age differences. For example, a child 4 years 0 months tested in September 1980 (D.O.B. 9-76) might be matched with a child born 12-76 by scheduling the second child for testing in December. Thirty-eight subject-pairs were tested within one week of the same post-conceptual age; two subject-pairs were tested within ten days of the same post-conceptual age. The mean post-conceptual age at testing for each group was 44.5 months (SD = 3.9 for each group).

The study sample included children from low-income, blue collar, semi-professional, and professional family backgrounds. Figure 3.1 shows the occupational groups for fathers of prematurely born study participants. Comparisons between the study groups on the Duncan Scale indices showed no differences in socioeconomic status (see Appendix A). The mean Duncan Scale Index for the prematures was 44.5 (SD = 24.8); the mean Duncan Scale Index for the controls was 43.8 (SD = 25.1) [$\underline{t}$ (39) = .89, $\underline{p} > .05$]. A summary of family background variables for the prematurely and maturely born study groups is shown in Table 3.1. There were no differences between the two groups on parental education. The average educational attainment for mothers and fathers in each research group was "some college but less than a B.A. or B.S." The prematurely born preschoolers in the research study had fewer siblings

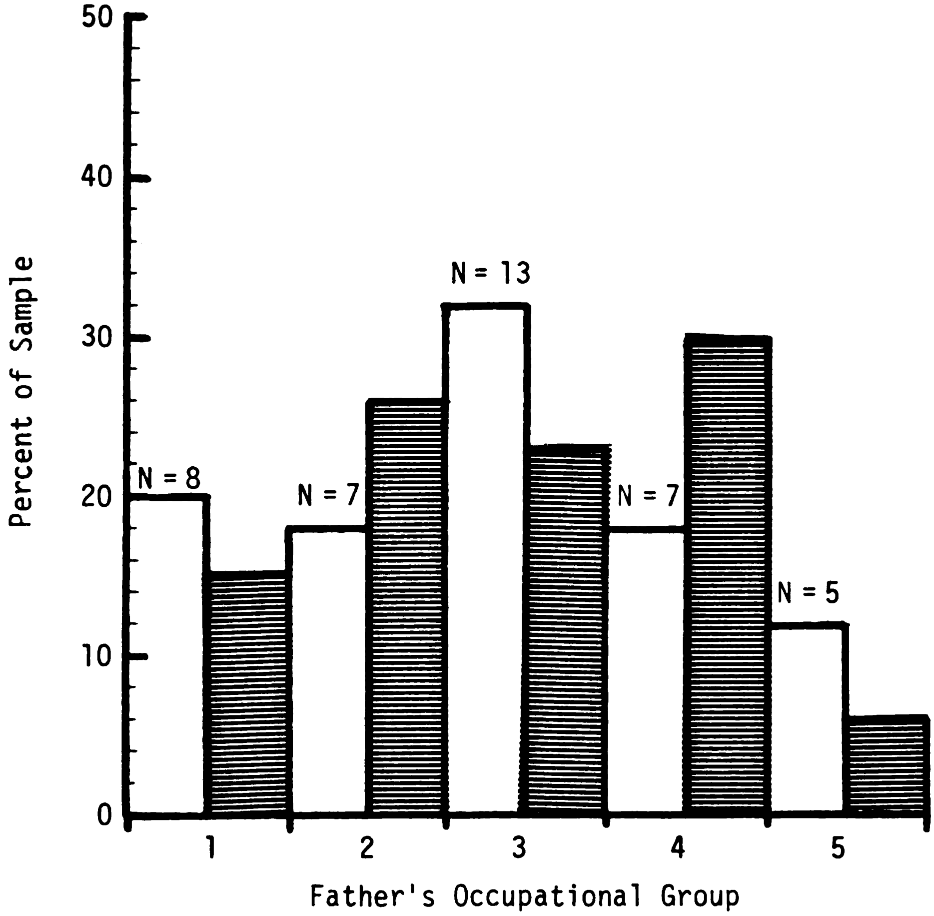


Figure 3.1 Occupational groups for fathers of prematurely born preschoolers. The unshaded bars show occupational groups for fathers of prematurely born study participants; shaded bars show occupational groups for fathers of the 3½ year olds in the McCarthy Scales standardization sample. Occupational groups were defined as follows: 1 = professional and technical workers; 2 = managers, officials, proprietors, clerical workers, and sales workers; 3 = craftsmen and foremen; 4 = operatives, sales workers, farmers, and farm managers; 5 = laborers, farm laborers, and farm foremen.

Table 3.1

Comparison of Family Background Variables for Prematurely and Maturely Born Preschoolers

	Prematures[a]		Controls[a]		
Background Variable	Mean	S.D.	Mean	S.D.	t^b
Father's education[c]	3.0	1.3	3.2	1.0	-1.82
Mother's education[c]	2.6	1.0	3.0	0.9	-1.27
Siblings	1.0	0.8	1.4	0.8	-2.54*
Mother's age[d]	26.5	5.1	25.9	4.5	0.97

[a] $N = 40$.

[b] With *df* = 39, a *t* value greater than 2.326 or less than -2.326 is significant at the (.05/4) or .0125 level (two-tailed).

[c] Based on a 6-point scale: 1 = less than high school; 2 = high school graduate; 3 = some college, but less than a B.A. or B.S.; 4 = B.A. or B.S.; 5 = 5-year degree, Master's degree; 6 = Ph.D., M.D., or other advanced degree(s).

[d] Mother's age at the time of the birth of the study child.

*$p < .05$.

than their maturely born age-mates. Several research studies have shown an association between giving birth to a low-birth-weight infant and a history of perinatal or infant loss (see Bakketeig, 1977; and Niswander, 1977). Consequently, this difference in family size may be a result of difficulties in childbearing experienced by mothers of preterm infants. There were no differences between the two study groups in maternal age at the time of the birth of the study child.

Matching subject-pairs on rural or urban households was not feasible because of the limited number of control group children. Research assistants attempted to locate maturely born preschoolers in rural as well as metropolitan areas, however. The U.S. Bureau of Census defines "urban" as (1) places with 2,500 inhabitants or more incorporated as a city, borough, or village, or (2) incorporated or unincorporated places which comprise the urban fringe of a city with a population of 50,000 or more. "Rural" is defined as those places which do not meet the criteria for the definition of "urban" (Verway, 1978, p. 3). The households of prematurely and maturely born study participants were designated as "rural" or "urban" based on postal address using these definitions and population estimates for places in Michigan from the Michigan Statistical Abstract (Verway, 1978). Sixteen of the prematurely born children (40%) came from rural homes; 24 (60%) came from homes in an urban setting. Ten control group preschoolers (25%) came from rural homes; 30 (75%) came from homes in an urban setting. Results of the chi square test of two correlated proportions being equal indicated that a higher proportion of prematurely born children than controls came from homes in rural areas [$\chi^2(1) = 4.26$, $p < .05$], and a higher proportion of maturely born children than prematures came from homes in urban settings [$\chi^2(1) = 5.76$, $p < .05$]. The geographical distribution of households of the study participants is shown in Figure 3.2.

The birth weights of the prematurely born children ranged from 855 grams to 2,495 grams, with a mean of 1,727 grams (SD = 481 g). The gestational age at birth of the prematurely born children ranged from 27 to 36 weeks, with a mean gestational age of 32 weeks at birth. The birth weight of each prematurely born child was within normal limits for gestational age. Twenty-three (58%) of the prematurely born children were born at E. W. Sparrow Hospital while 17 (42%) were transported from area hospitals during the neonatal period. Thirty-nine of the study participants were active Developmental Assessment Clinic cases; one was inactive. Information describing pregnancy and delivery complications and the hospital course for each of the prematurely born subjects is shown in Appendix B. Birth weights of maturely born children ranged from 2,835 grams to 4,252 grams, with a mean of 3,544 grams (SD = 313 g). All maturely born children were from 38 to 42 weeks gestation at birth. The birth weights of 35 of the full-term children were within normal limits for their gestational age; birth weights were above the 90th percentile for five of the maturely born children.

Twenty-five of the study children (31%) had attended day care or preschool full or part time prior to September 1980. There were no

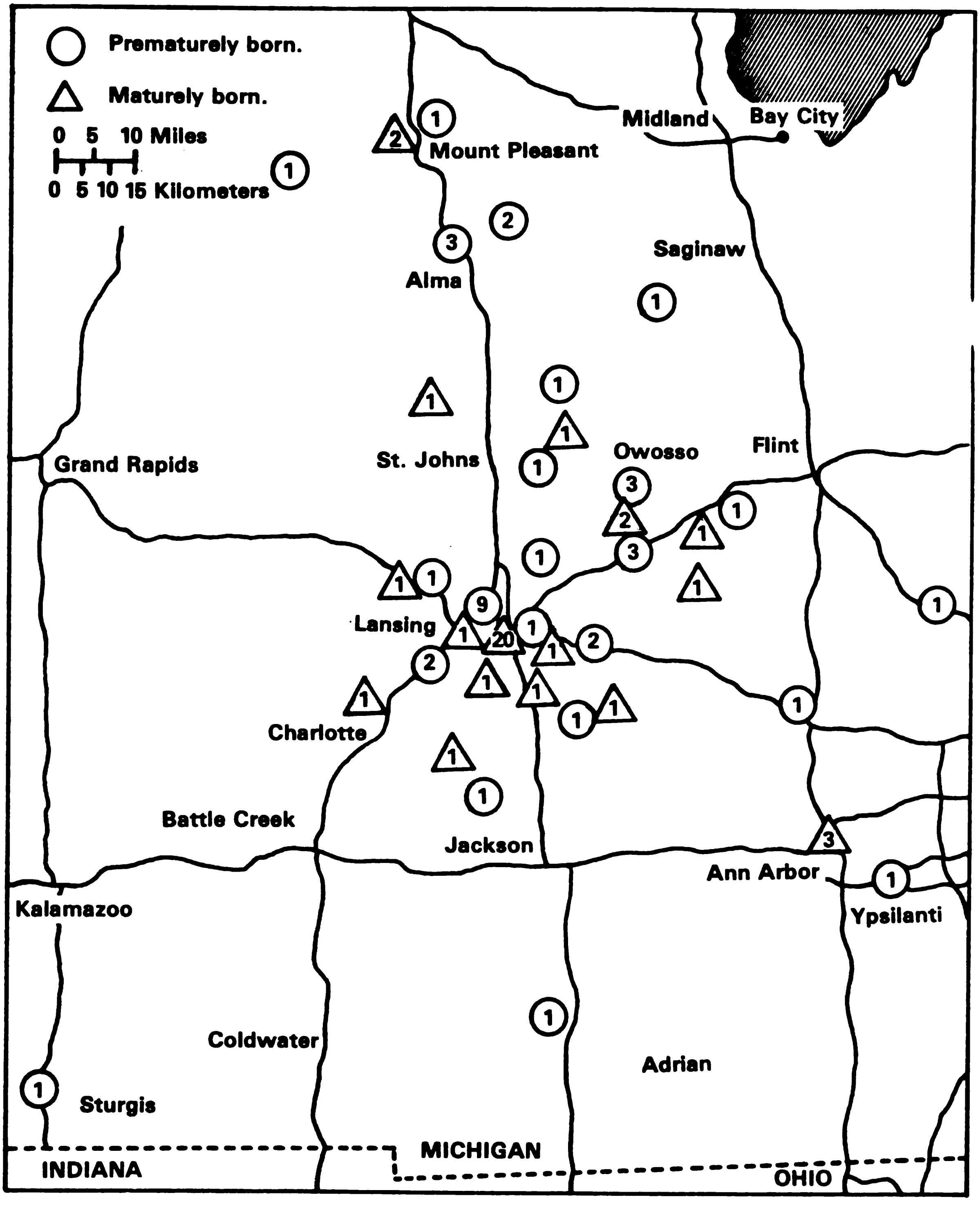


Figure 3.2: Geographical distribution of households of the study participants.

differences between the research groups in the number of years of preschool experience [t (39) = -.51, p >.05]. The mean number of years of day care or preschool (full or part time) for prematures was .35 (SD = .62) and the mean number of years of day care or preschool for controls was .45 (SD = .68). Two premature and one maturely born subject received physical therapy during the preschool years because of mild-to-moderate delays in motor development. The control child was seen for physical therapy for several months during the first year of life; similarly, one premature child was seen for therapy for several months beginning at one year of age. A second prematurely born child was seen for physical therapy following surgery at three years of age.

Instruments

Two standardized assessment instruments and two researcher devised instruments were used to evaluate the developmental progress of the preschoolers in the study.

The McCarthy Scales of Children's Abilities

The McCarthy Scales of Children's Abilities (MSCA) was administered to all children in the study. The MSCA was designed to evaluate general intellectual ability as well as specific strengths and weaknesses in cognitive and perceptual performance. The MSCA were developed for use with children 2½ through 8½ years of age and the test items are "gamelike and nonthreatening" and "enjoyable" (McCarthy, 1972, p. 1).

The MSCA is comprised of six sub-scales and performance on five of these sub-scales was evaluated for the purposes of the study: (1) performance on the General Cognitive Scale was assessed as the measure of general cognitive ability, (2) performance on the Verbal Scale was assessed as a measure of verbal ability, and (3) performance on the Perceptual-Performance Scale was assessed as a measure of perceptual maturation. Scores on the Memory and Quantitative Scales were also reported. Results of factor analytic studies of the MSCA, however, have shown that Quantitative factors do not emerge until the age of five (Kaufman & Kaufman, 1977). Kaufman and Kaufman have found that numerical tasks load most heavily on the General Cognitive and Verbal factors during the preschool years (1977, p. 93). Motor Scale items were not administered because of the problem of inadequate space in many homes. Total testing time for the MSCA is estimated to be 45 to 50 minutes for children under age 5 (McCarthy, 1972, p. 47).

The standardization of the MSCA was based on a national sample stratified on the variables of age, sex, color, geographic region, and father's occupation. The total sample was comprised of 1,032 cases (McCarthy, 1977, p. 13) and this included 104 3 year olds, 100 3½ year olds, and 102 4 year olds (p. 23). The split-half reliability coefficients of the General Cognitive Index (corrected by the Spearman-Brown formula) for the 3 to 4 year olds are as follows: (1) for 3 year olds, $\underline{r} = .94$; (2) for 3½ year olds, $\underline{r} = .96$; and (3) for 4 year olds, $\underline{r} = .91$ (p. 31). The reliabilities reported were clearly acceptable for the purposes of the research.

Thirty-five first graders participated in a study of the validity of the MSCA. Each child was administered the Wechsler Preschool and Primary Scale of Intelligence, the Stanford-Binet (Form L-M), and the MSCA within 20 days. The order of test administration was counterbalanced. The correlation between the MSCA General Cognitive Index and the WPPSI Full Scale IQ was .71, and the correlation between the MSCA General Cognitive Index and the Stanford-Binet IQ was .80 (McCarthy, 1977, p. 40). The 35 first graders were re-tested four months later with the Metropolitan Achievement Test. The predictive validity coefficient for the MSCA General Cognitive Index with the MAT overall score as the criterion was .49 (p. 42).

Denver Articulation Screening Exam

The second standardized research instrument selected for the study was the Denver Articulation Screening Exam (DASE) published by the University of Colorado Medical Center (1971). The DASE was designed to detect articulation disorders among children 2½ to 6 years of age. The test is based on evaluation of the child's ability to articulate 34 sound elements. Unlike other articulation instruments reviewed, the DASE was developed to be administered and interpreted by persons without training in speech pathology (Darley, 1979). Test results are based on a composite articulation score and an intelligibility rating. The total score results in classification as "normal" or "abnormal." An "abnormal" rating is equivalent to performance below the 15th percentile for age.

The DASE was standardized on a sample of 1,450 preschoolers in Denver, Colorado. These children ranged in age from 2 years 4 months to 6 years 3 months, and they were equally divided by sex.

The test re-test reliability of the DASE is reported to be .95 based on a study sample of 110 children screened and re-screened by the same speech pathologist within 4 to 8 days. The Henja Developmental Articulation Test was used as a criterion measure in a study of the concurrent validity of the DASE. Comparisons of scores on the DASE and the Henja for 89 preschoolers yielded co-positivity scores of .88 and co-negatively score of .91 and .97 (Frankenburg & Drumwright, 1973).

The Preschool Problem-Solving Competence Test

Consideration was given to two different strategies for observing differences in problem-solving styles and behaviors. One approach is to modify the administration of portions of the McCarthy Scales to highlight differences in problem-solving behaviors (such as a testing-the-limits approach), and a second strategy is to develop supplementary tasks to study these differences.

Systematic modification of standardized testing procedures has been used by researchers in the past to pinpoint and alter test behaviors and conditions which inhibit optimal performance (see Budoff & Hamilton, 1966; Carlson & Wiedl, 1978; Jackson, Farley, Zimet, & Gottman, 1979; Palkes, Stewart, & Kahana, 1968; Zigler, Abelson, & Seitz, 1973; Zigler & Butterfield, 1968; among others). The strategy of modifying the testing procedures of the McCarthy Scales was rejected, however, for two reasons. First, it was found that the McCarthy Scales could not easily be adapted to the needs of the study. Items included on the McCarthy Scales are generally examiner-structured, and seem to minimize the assessment of differences in task approach styles. This may be due, in part, to the fact that the McCarthy Scales were developed specifically for preschool and primary grade children. Second, a means of observing process variables without compromising the standardized administration of the McCarthy Scales seemed desirable as the power of the test to predict learning problems is one of the questions which will be addressed in a follow-up study. Development of a supplementary measure, on the other hand, offered the advantage of an observation system tailored to the needs of the study without altering the standard McCarthy administration procedures.

The "Preschool Problem-Solving Competence Test" was therefore devised as a measure of (1) self-direction, (2) planfulness, (3) impulsivity, and (4) task persistence. The "test" is, simply, a systematic way of observing a child's problem-solving approach, schemes, and skills, under varying degrees of examiner-imposed structure. It is comprised of three parts: (1) a Test of Self-Direction and Planfulness, (2) an Impulsivity-Reflectivity Rating, and (3) a Task Persistence Rating.

Self-Direction and Planfulness. Materials for the Test of Self-Direction and Planfulness include three wooden form-boards, a search strategy task, and two sorting tasks. The form boards are similar to the one included in the Bayley Scales of Infant Development, and each form board represents a different level of difficulty. The search strategy task is conceptually similar to the Plan of Search test item on the Stanford-Binet. The task requires that the child devise a scheme to find a frog painted on the underside of one of twelve and then eighteen blocks. One sorting task requires sorting by shape, the second sorting by color. Tasks of this type are found on the Stanford-Binet and Piagetian scales. (See Appendix C for more detailed information.)

The administration of the Test of Self-Direction and Planfulness is consistent with Vygotsky's (1962) testing strategy of giving a child a problem more difficult than he can handle alone and observing his problem-solving efforts when examiner-provided hints are given. A modified version of Feldhusen et al.'s (1972) list of problem-solving component skills provided the guidelines for the hints offered by the examiner. Depending on the child's performance, the examiner (1) helped the child define the problem (i.e., identify the goal of the task); (2) helped the child identify salient features of the task; (3) suggested a problem-solving scheme; (4) helped the child evaluate the correctness of his/her solutions; or (5) directed the child to the correct solution. The measure of "self-direction" was based on a tally of the number of examiner-provided hints a child needed to successfully complete the test tasks. Scores were obtained by subtracting the number of hints given from the total number of possible hints (max = 29). Consequently, high scores are associated with self-direction; low scores are associated with examiner-direction.

The measure of "planfulness" (see Flavell, 1976) is based primarily on the child's ability to spontaneously generate an orderly, "non-redundant" search pattern on the search strategy task described above. Search patterns were categorized as follows:

- Non-Goal Directed: child does not appear to understand the goal of the task
- Random: appears to use a guessing game approach; no discernible pattern
- Partial Scheme; Forgets: appears to have an orderly scheme to begin with but then "forgets" and becomes unsystematic: defined as a sequence of 4 or more blocks in a row or column pattern followed by 1 or more non-row (or non-column) selections.
- Partial Scheme; Develops: begins with no discernible scheme but develops one: defined as a non-orderly pattern ending with a sequence of 4 or more blocks in a row or column.
- Partial Scheme; Ignores: has an orderly scheme but ignores part of the field of search: defined as a row or column pattern which begins in the middle of a row or column, i.e., a non-conventional starting point.
- True Scheme; Rows: searches across rows.
- True Scheme; Columns: searches up/down columns.
- Re-Groups: spontaneously re-groups the blocks before beginning search
- Sets Aside: spontaneously sets aside blocks examined.

"Planfulness" scores range from 0 to 8, with higher scores associated with orderly search schemes and lower scores associated with trial-and-error search patterns. Inter-coder agreement of 94% in categorizing the search patterns was reached using the pilot study data for 24 preschoolers (two trials for each child). Pilot study subjects ranged from 3 to 5 years of age. The correlation between age at testing and "maturity" of the search plan was $\underline{r} = .63$ ($p < .001$)

for the pilot study data. The correlation between age at testing and maturity of the search plan was also significant at the .001 level for the study sample ($\underline{r}$ = .33). The higher correlation between age at testing and maturity of search plan for the pilot study data was most likely due to the wider age-range sampled.

Impulsivity. The second section of the Preschool Problem-Solving Competence Test, the Impulsivity-Reflectivity Rating, focused on one aspect of problem-solving style. Consideration was given to administering the Matching Familiar Figures Test (Kagan, 1965) which is a measure of conceptual tempo; however, many items on this instrument seemed too difficult for 3 and 4 year olds. The Impulsivity-Reflectivity Rating subtest is comprised of eleven descriptive statements scored "often," "sometimes," or "never." The eleven statements were based on descriptions of impulsive children which have appeared in the literature (Schleifer, Weiss, Cohen, Elman, Cvejic, & Kruger, 1975; Stewart, 1970) and the examiner's clinical impressions of the test-taking behaviors of impulsive children.

High scores on the Impulsivity-Reflectivity Rating scale are associated with reflectivity (max = 33); low scores are associated with impulsivity. Analysis of the pilot study data indicated that the inter-rater reliability of the most acceptable version of the rating scale was $\underline{r}$ = .82 (two independent observers, N = 10). Independent observations were also made during the collection of the study data by the principal researcher and a research assistant during 26 home visits. These data yielded an inter-rater reliability coefficient of .95 (two independent observers, N = 26). The stability of the rating scale was estimated by correlating the ratings made by the examiner during the first and second home visits, which were scheduled within an 8-day period. This yielded a correlation coefficient of .80 (N = 80).

Task Persistence. The third section of the test was a measure of Task Persistence. This measure is comprised of a frequency count of the number of times the child is encouraged or verbally re-directed to the task at hand by the examiner during the administration of the Preschool Problem-Solving Competence Test. High scores on the task persistence measure are associated with low persistence; low scores are associated with high persistence. The original version of the measure included three categories of child-focused examiner verbalizations: praise, encouragement, and re-direction to the task at hand. Inter-coder agreement levels for the three categories based on the pilot study data were not acceptable, however. Consequently, the categories were collapsed and all three types of child-focused verbalizations were included in the Task Persistence frequency count. The average inter-coder agreement on the number of child-focused verbalizations (combining praise, encouragement, and re-direction) was 96% based on two independent frequency counts of 10 PPSCT test administrations recorded on audiocassette tapes (percentage agreement was calculated by dividing the low tally by the high tally and multiplying by 100).

Personal-Social Development Questionnaire

The fourth instrument used to assess the developmental progress of the preschoolers who participated in the study was the "Personal-Social Development Questionnaire" which was completed by a parent or guardian. This questionnaire is comprised of items from the "Personal-Social Development" section of the Yale Child Study Center Revised Developmental Schedules (1971) and items from the Vineland Social Maturity Scale (1965) (see Appendix D). The maximum score on the questionnaire is 68, with high scores associated with personal-social maturity and mastery of self-help skills. No reliability or validity data were gathered for this instrument.

Family Background Information

Parents were also asked about family size and composition, and parental occupation(s) and education (see Appendix E). Father's occupation was used as the index of family socioeconomic status (mother's occupation in father-absent homes). Occupational status was coded by two independent coders using the Duncan Socioeconomic Scale (Duncan, 1961). This scale was devised from the 1950 census on the basis of average income and educational level of persons in each census occupational category. Coder disagreements were resolved by averaging the two codes assigned (see Appendix A).

Procedures

Approximately 88 preschoolers who met the subject selection criteria for the prematurely born research group were identified from the records of the Development Assessment Clinic. (This search was conducted under the supervision of a Developmental Assessment Clinic staff member.) Location of 88 potential study participants (68 with known addresses) required a search of approximately 200 clinic cases with birthdates extending from March 1976 through August 15, 1977 (i.e., 17 months of clinic referrals). The incidence and types of special education referrals for all children with birthdates between March 1, 1976 and August 15, 1977, were tallied from the clinic records at that time.

A letter was mailed to the parents of each potential study child in the prematurely born research group by the Developmental Assessment Clinic team explaining the research project and asking parents to volunteer to participate. Parents were asked to return a postcard to the research team indicating whether or not they were willing to volunteer for the study (see Appendix F). A follow-up phone call was made by a Developmental Assessment Clinic staff member when parents failed to return the postcard.

Families who consented to participate in the study were then contacted by phone to schedule two home visits. Scheduling was done by research assistants to assure that the principal investigator was unfamiliar with the birth history of the child at the time of the developmental assessment. Older children were scheduled first to reduce the variability in ages of the study participants at the time of follow-up.

The control group study children were located with the help of 16 mid-Michigan pediatricians, three day care centers, and through a search of birth announcements which appeared in The State Journal in 1976 and 1977. Information describing the research study was mailed to potential volunteers or made available to parents by teachers and nurses. This information packet included a prestamped envelope addressed to the research team. Study volunteers were asked to provide background information needed for matching subject-pairs along with their name, address, and telephone number (Appendix F). A letter explaining the scope and purpose of the study was also mailed to non-participating area pediatricians.

Data were collected over an eight month period between July 1980 and February 1981. Each preschooler was seen at home for two evaluation sessions of approximately 50 minutes each. The first and second home visits were scheduled within an eight-day period. The examiner spent the first 10 to 15 minutes of the initial evaluation session talking with the parent at home. Questions about the research project were answered, consent forms were discussed and signed (see Appendix G), and the parent was asked to complete the Family Background Information form and the Personal-Social Development Questionnaire. The researcher explained that the child's individual scores on assessment instruments would not be shared with parents; however, a summary of the findings from the study based on all of the participants would be available at the conclusion of the project.

The first few minutes with the child were spent setting up a child-sized folding table to work on and arranging materials for the session. Hand puppets were used to establish positive rapport with the child and capture his/her interest in the testing materials. The examiner explained to the child that she wanted to talk and play some games together because she was interested in learning about 3 (or 4) year olds. Although some children failed to respond to individual test items, no child refused to be tested. Each child was administered the Preschool Problem-Solving Competence Test and the first portion of the McCarthy Scales of Children's Abilities (Tests 1-7) during the initial home visit. The remaining McCarthy tests (Tests 12-18) and the Denver Articulation Screening Examination were administered during the second home visit. All developmental testing was done by the principal researcher.

It was originally planned that an undergraduate research assistant would accompany the principal researcher on each initial home visit, but this was not feasible because of the transportation problems involved. An undergraduate assistant did accompany the principal researcher on 26 randomly selected first home visits. On these visits, the assistant recorded the examiner's verbalizations during the administration of the Preschool Problem-Solving Competence Test and these protocols were used to tally encouragement and verbal re-directions for the Task Persistence measure. The assistant also completed an Impulsivity-Reflectivity Rating, and these ratings were used to evaluate the inter-observer reliability of the scale. Tape recordings were made of the first evaluation session when a research assistant was not available and Task Persistence tallies were made from the recordings in those instances. The tape recorder failed in five instances, and Task Persistence tallies were then made by the examiner.

Birth and developmental information for the 40 prematurely born study participants was gathered from the Developmental Assessment Clinic records. This information was used to describe pregnancy and delivery complications and the hospital course for the prematurely born subjects (see Appendix B).

Analysis of the Data

The statistical hypothesis tested in most instances was H_o: $u_p \geq u_c$; H_1: $u_p < u_c$ where p = prematures and c = controls (exceptions are noted in the results section). Four considerations were involved in selecting the significance level: the subject pool and practical limits on sample size, the need to detect a medium effect size, statistical power, and the consequences of a Type I error.

Increase in the sample size (N = 40 pairs) was not feasible, first of all, because of the limited size of the initial sample pool. Through a search of the Developmental Assessment Clinic records, research assistants identified only 68 potential prematurely born study participants who would be 3 to 4 years of age during the months of the data collection. Consequently, with subject refusals, testing children younger than 3 or older than 4 years of age would have been necessary to increase the sample size, resulting in an undesired change in the focus of the research study. Second, the practical considerations of time and travel money also imposed limits on the size of the study sample.

It was decided that detection of a .5 SD between the two research groups in performance on the developmental tasks was statistically feasible and practically important (i.e., an 8-point difference between groups on the McCarthy General Cognitive Index and a 5-point difference on the Scale Indexes). Detection of a .5 SD difference was seen as practically significant because it would be consistent with the differences in test performance found by previous researchers. The majority of the research hypotheses were directional because of the substantial body of research suggesting prematures fare less well than maturely born children on assessments of cognitive and perceptual growth. It was assumed that there would be a weak positive correlation ($\underline{r}$ approximately .20) between subject pairs on the dependent measures because of the matching on sex, race, post-conceptual age, and parental socioeconomic status, and consequently, it was estimated power would be approximately .80 at the .05 significance level and .88 at the .10 significance level (see Cohen, 1969, pp. 46-47). The .05 level of significance was chosen because the consequences of making a Type I error (i.e., reporting prematures performed less well than maturely born preschoolers when in fact there were no differences) seemed particularly undesirable in this research situation. Results of a post hoc power analysis are reported in the Discussion section.

The design used in the analysis of differences between prematurely born subjects and matched controls was a one factor-repeated measures analysis of variance (Myers, 1979). This design treats the scores of matched pairs as if they were produced by the same subject. The power of this statistic is directly related to the effectiveness of the matching of experimental and control subjects on the specified criteria. Both multivariate and univariate analysis were used in the analysis of data. Multivariate analysis of variance was used to determine whether there were differences between the two research groups on the Verbal, Perceptual-Performance, and Quantitative Indexes* of the McCarthy Scales when scores were based on chronological age (Hypotheses 1b, 1c) and post-conceptual age (Hypotheses 2b, 2c), and to determine if there were differences between the research groups on the 14 McCarthy Weighted Raw Test Scores (Hypotheses 3a, 3b, 3c). Multivariate analysis of variance was also used to determine whether the research groups differed in their performance on the Preschool Problem-Solving Competence Test of Self-Direction and Planfulness (Hypotheses 4a, 4b). A disadvantage of the multivariate analysis is that it is non-directional. Comparisons which comprised a significant multivariate $\underline{F}$ were consequently evaluated using a one-tailed $\underline{t}$ test. All remaining hypotheses (Hypotheses 1a, 2a, 4c, 4d, 5, and 6) were tested using univariate analysis of variance and the chi square statistic.

---

*The Verbal, Perceptual-Performance, and Quantitative Scale Indexes of the McCarthy are comprised of non-overlapping items; the General Cognitive Index is based on a composite raw score earned on the Verbal, Perceptual-Performance, and Quantitative Scales; and the Memory Scale is comprised of items selected from the three scales. Consequently, MANOVA was done using only three of the five McCarthy Scale Indexes.

Comparisons of performance on the McCarthy Scales based on chronological age (Hypotheses 1a, 1b, 1c) and post-conceptual age (Hypotheses 2a, 2b, 2c) were each considered to be a family of contrasts. A third family of contrasts was comprised of comparisons between the two groups on the fourteen McCarthy weighted raw test scores, and a fourth family of comparisons was comprised of scores on the Preschool Problem-Solving Test of Self-Direction and Planfulness. The remaining six comparisons were grouped as a fifth set of planned contrasts. The overall error rate was controlled by evaluating $\underline{t}$ at the EF/k level, where EF equals the error rate per family or set of contrasts and k equals the number of contrasts per family (see the Bonferroni $\underline{t}$ statistic, Myers, 1979, p. 298).

The chi square statistic, scatterplots, and linear regression statistics were used in supplementary analyses of the data. Frequencies and percentages were used to report the incidence and types of special education referrals for the "at risk" research population. All analyses were conducted at the Michigan State University Computer Center using the Statistical Package for the Social Sciences (Nie, Hull, Jenkins, Steinbrenner, & Brent, 1975).

CHAPTER IV

RESULTS

In this section, information gathered on the incidence and types of special education referrals for the prematurely born research population will be summarized first. The findings from the tests of the formally stated hypotheses will then be presented followed by results of the supplementary analyses of the data.

Special Education Referrals

Special education referrals for premature RNICU graduates are shown in Table 4.1. Approximately 114 premature RNICU graduates with birth dates during the target period were referred to the Developmental Assessment Clinic from the Regional Neonatal Intensive Care Unit at Sparrow. As of September 1980, 19 (17%) of the 114 premature graduates with birth dates during the target period had been referred for special education services. For the purposes of this table, "prematurely" born children includes singletons and twins born (1) prior to 38 weeks completed gestation, (2) with birth weights of 2,500 grams or less, and (3) with birth weights appropriate for their gestational age. Small-for-dates are thus excluded.

Table 4.1

Special Education Referrals for Prematurely Born RNICU Graduates with Birthdates Between March 1, 1976 and August 15, 1977

Reason for referral	(f)[a]	Incidence[b] (%)	% of referrals (N = 19) (%)
Motor delays	17	15	89
Language delays	0	0	0
Cognitive delays/mild/ moderate	2	2	10
Cognitive delays/severe	2	2	10
Blind/visually impaired	4	4	21
Deaf/hearing impaired	1	0.9	4

[a] Data gathered from the Developmental Assessment Clinic records show that 19 prematurely born RNICU graduates (less than 38 weeks gestation, 2,500 g or less, weight appropriate for gestational age) with birthdates between March 1, 1976 and August 15, 1977, had been referred for special education services as of September 1980. Twins (N = 3) and singletons (N = 16) are included. The frequencies (f) for each of the six reasons for referral are shown. Seven children were referred for more than one reason.

[b] Approximately 114 premature RNICU graduates born during the 17 month target period were referred to the Developmental Assessment Clinic from RNICU; incidence figures are based on N = 114 (26 twins and 88 singletons). Physician referrals to the clinic were excluded.

Cognitive, Perceptual, and Personal-Social Development of Prematurely and Maturely Born Preschoolers

Hypothesis 1: Prematurely born preschoolers will not perform as well as their maturely born age-mates on measures of (a) general cognitive ability, (b) verbal ability, and (c) perceptual performance when scores are based on chronological age.

Hypotheses 1a and 1b were not supported; hypothesis 1c was confirmed. Multivariate analysis of the performance of prematurely and maturely born preschoolers on the McCarthy Verbal, Perceptual-Performance, and Quantitative Scales yielded an overall F (3, 37) of 3.37, $p < .05$. Differences favoring maturely born preschoolers were found on the Perceptual-Performance Scale (see Table 4.2). No differences were found between the two research groups on the remaining four McCarthy Scale Indexes.

Hypothesis 2: Prematurely born children will not perform as well as their maturely born peers on measures of (a) general cognitive ability, (b) verbal ability, and (c) perceptual performance when scores are based on post-conceptual age.

Hypothesis 2a, 2b, and 2c were not supported (see Table 4.3). Multivariate analysis of the performance of prematurely and maturely born preschoolers on the Verbal, Perceptual-Performance, and Quantitative scales when scores are based on post-conceptual age yielded an overall F (3, 37) of 1.93, $p > .05$. No differences were found between prematurely and maturely born preschoolers on any of the five McCarthy Scale Indexes when scores are based on post-conceptual age.

Table 4.2

Comparison of McCarthy Scale Indexes for Prematurely and Maturely Born Preschoolers Based on Chronological Age

	Prematures[a]		Controls[a]		
Scale index	Mean	SD	Mean	SD	_t_[c]
Verbal[b]	50.8	9.4	54.0	8.1	-1.72
Perceptual-performance[b]	48.4	8.9	53.6	8.9	-2.55*
Quantitative[b]	48.4	10.1	48.8	8.1	-0.18
General cognitive	99.7	14.5	106.0	12.3	-2.16
Memory	49.3	9.5	51.6	8.1	-1.16

[a] $N = 40$.

[b] Scales included in multivariate analysis of variance; $F\ (3, 37) = 3.37$, $p < .05$.

[c] To control the overall error rate for this family of five comparisons, _t_ was evaluated at the .05/5 or .01 level. With _df_ = 39, a _t_ value less than -2.426 is significant at the .05 level where .05 is the error rate/family (one-tailed); a _t_ value less than -2.157 is significant at the .10 level where .10 is the error rate/family (one-tailed).

*$p < .05$.

Table 4.3

Comparison of McCarthy Scale Indexes for Prematurely and Maturely Born Preschoolers Based on Post-Conceptual Age

Scale index	Prematures[a]		Controls[a]		
	Mean	SD	Mean	SD	*t*[c]
Verbal[b]	53.2	9.0	54.0	8.1	-0.47
Perceptual-performance[b]	51.0	9.1	53.6	8.9	-1.22
Quantitative[b]	50.8	9.7	48.8	8.1	1.04
General cognitive	103.8	14.1	106.0	12.3	-0.78
Memory	51.4	9.3	51.6	8.1	-0.14

[a] $N = 40$.

[b] Scales included in multivariate analysis of variance; $F(3, 37) = 1.93$, $p > .05$.

[c] To control the overall error rate for this family of five comparisons, *t* was evaluated at the .05/5 or .01 level. With *df* = 39, a *t* value less than -2.426 is significant at the .05 level where .05 is the error rate/family (one-tailed); a *t* value less than -2.157 is significant at the .10 level where .10 is the error rate/family (one-tailed).

Hypothesis 3: Prematurely born preschoolers will not perform as well as their maturely born counterparts on three measures of visual-perceptual development: the McCarthy Scales (a) Block Building, (b) Puzzle Solving, and (c) Draw-A-Design tests.

Hypothesis 3c was confirmed; hypotheses 3a and 3b were not supported. Multivariate analysis of the performance of prematurely and maturely born preschoolers on the 14 McCarthy Weighted Raw Test Scores yielded an overall F (3, 37) of 2.55, $p < .05$ (see Table 4.4). No significant differences were found between the two study groups for 13 of the 14 weighted raw scores. As predicted, however, prematures did not perform as well as controls on the Draw-A-Design test, and this difference was significant at the .05 level.

Hypothesis 4: Prematurely born preschoolers will not perform as well as their maturely born peers on measures of problem-solving competence: prematures will not perform as well as their maturely born counterparts on measures of (a) self-direction and (b) planfulness. Prematures (c) will be rated as more impulsive in their task approach than their maturely born counterparts, and (d) they will demonstrate less task persistence than their maturely born peers.

Hypotheses 4a, 4b, 4c, and 4d were not supported. Multivariate analysis of the performance of the two research groups on measures of self-direction, planfulness, and solutions achieved on the Preschool Problem-Solving Competence Test yielded an overall F of 1.17, $p > .05$ see Table 4.5). "Self-direction" scores were obtained by subtracting the number of hints given from the total number of possible hints

Table 4.4

Comparison of McCarthy Weighted Raw Test Scores for Prematurely and Maturely Born Preschoolers

	Prematures[a]		Controls[a]		
Test	Mean	SD	Mean	SD	*t*[b]
<u>Verbal</u>:					
Pictorial Memory[c]	3.3	1.3	3.3	1.4	0
Word Knowledge	12.0	3.1	13.1	3.0	-1.86
Verbal Memory[c]	10.5	5.8	10.2	5.8	0.27
Verbal Fluency	8.9	4.6	8.4	3.5	0.50
Opposite Analogies	6.9	3.3	7.9	3.1	-1.82
<u>Perceptual-performance</u>:					
Block Building	7.0	2.2	6.9	2.1	0.27
Puzzle Solving	2.3	1.3	2.8	1.7	-1.33
Tapping Sequence[c]	1.9	1.2	2.1	1.1	-0.98
Draw-A-Design	2.7	1.5	3.7	1.8	-3.02*
Draw-A-Child	4.9	3.0	5.2	4.2	-0.41
Conceptual Grouping	5.0	2.1	5.6	2.4	-1.48
<u>Quantitative</u>:					
Number Questions	6.1	2.5	5.2	2.6	1.77
Numerical Memory[c]	4.8	1.6	4.6	1.7	0.62
Counting and Sorting	2.4	1.9	2.5	1.9	-0.32

[a] N = 40.

[b] All fourteen tests were included in the multivariate analysis of variance; *F* (3, 37) = 2.55, $p < .05$. To control the overall error rate for this family of fourteen comparisons, *t* was evaluated at the .05/14 or .004 level. With *df* = 39, a *t* value less than -2.892 is significant at the .05 level where .05 is the error rate/family (one-tailed); a *t* value less than -2.632 is significant at the .10 level where .10 is the error rate/family (one-tailed).

[c] Tests included in the Memory Scale.

*$p < .05$.

Table 4.5

Comparison of Mean Scores for Prematures and Controls on PPSCT Measures of Self-Direction, Planfulness, and Solutions Achieved

	Prematures[a]		Controls[a]		
PPSCT measure	Mean	SD	Mean	SD	*t*[b]
Self-direction	25.7	3.4	26.9	2.2	-1.90
Planfulness	2.7	2.0	2.9	2.2	-0.48
Solutions achieved	32.6	3.0	33.4	2.0	-1.37

[a] N = 40.

[b] All three scores were included in the multivariate analysis of variance; *F* (3, 37) = 1.17, *p* > .05. To control the overall error rate for this family of three comparisons, *t* was evaluated at the .05/3 or .016 level. With *df* = 39, a *t* value less than -2.323 is significant at the .05 level where .05 is the error rate/family (one-tailed); a *t* value less than -2.236 is significant at the .10 level where .10 is the error rate/family (one-tailed).

(max = 29). Consequently, high scores are associated with self-direction; low scores are associated with examiner-direction. "Planfulness" scores ranged from 0 to 8, with higher scores associated with orderly search schemes and lower scores associated with trial-and-error search patterns. Prematurely and maturely born preschoolers did not differ in their ability to devise planful schemes and master the Preschool Problem-Solving Competence tasks through self-directed efforts.

Similarly, comparisons between the two research groups using univariate analysis of variance showed no differences between the groups on examiner ratings of impulsivity made during the first and second assessment session and no differences between the two groups on the measure of task persistence. High scores on the rating scale are associated with reflectivity (max = 33); low scores are associated with impulsivity. Based on the first assessment session, the mean score for prematures was 28.4 (SD = 4.3) and the mean score for controls was 28.0 (SD = 5.1) [$\underline{t}$ (39) = .41, $\underline{p} > .05$].* Based on the second assessment session, the mean score for prematures was 27.8 (SD = 4.7); the mean score for controls was 28.5 (SD = 4.4) [$\underline{t}$ (39) = -.41, $\underline{p} > .05$].* High scores on the task persistence measure are associated with low persistence; low scores are associated with high persistence (consequently, H_0: $u_p \leq u_c$; H_1: $u_p > u_c$). The mean score for the prematures on task

---

*This was one of six planned comparisons. To control the overall error rate for the set of six comparisons, $\underline{t}$ was evaluated at the .05/6 or .008 level. With $\underline{df}$ = 39, a $\underline{t}$ value less than -2.776 is significant at the .05 level where .05 is the error rate/family (one-tailed); a $\underline{t}$ value less than -2.323 is significant at the .10 level where .10 is the error rate/family (one-tailed).

persistence was 22.8 (SD = 10.9); the mean score for the controls was 25.4 (SD = 13.2) [$\underline{t}$ (39) = -1.03, $\underline{p} < .05$].*

Hypothesis 5: A higher incidence of children with speech articulation difficulties will be found among prematurely born 3 and 4 year olds than among the maturely born controls.

Hypothesis 5 was not supported [χ^2 (1) = .08, $\underline{p} > .05$]. Thirty-two of the prematurely born preschoolers received normal ratings on the Denver Articulation Screening Exam and eight prematures received abnormal ratings. Similarly, thirty-three control group preschoolers received normal ratings; seven received abnormal ratings.

The finding of no difference between the two research groups in the incidence of children with speech articulation difficulties was confirmed by comparison of the Denver raw scores for each group. The mean number of correct sound imitations for prematures was 25.8 (SD = 4.5) and the mean raw score for controls was 26.4 (SD = 3.6) [$\underline{t}$ (39) = -.66, $\underline{p} > .05$].*

Hypothesis 6: No differences will be found between the two groups of preschoolers on parental reports of personal-social development.

Hypothesis 6 was supported. No differences were found between prematurely born preschoolers ($\underline{\bar{X}}$ = 61.3, SD = 4.3) and their maturely

---

*This was one of six planned comparisons. To control the overall error rate for the set of six comparisons, $\underline{t}$ was evaluated at the .05/6 or .008 level. With $\underline{df}$ = 39, a $\underline{t}$ value less than -2.776 is significant at the .05 level where .05 is the error rate/family (one-tailed); a $\underline{t}$ value less than -2.323 is significant at the .10 level where .10 is the error rate/family (one-tailed).

born age-mates ($\underline{\bar{X}} = 60.5$, SD = 4.1) on parental reports of personal-social development [$\underline{t}$ (39) = 1.01, $\underline{p} > .05$].*

Supplementary Analyses

In addition to testing the formally stated hypotheses, four supplementary analyses of the data were done to further clarify the nature and meaning of the findings.

Parental Socioeconomic Status and Birth History as They Affect Performance on the GCI Scale

A comparison of the regression lines for predicting performance on the GCI scale from the parental socioeconomic status index for prematures and controls is shown in Figure 4.1. As previously stated, socioeconomic status was operationally defined as father's occupational level (or mother's occupational level in father-absent homes) according to the Duncan Socioeconomic Scale (Duncan, 1961).

The correlation between socioeconomic status and scores on the McCarthy GCI scale at ages 3 or 4 was .42 for prematures ($\underline{p} = .003$) while the correlation between socioeconomic status and GCI scores was .31 for controls ($\underline{p} = .02$). Socioeconomic status thus accounted for approximately 18% of the variance in GCI scores among prematures and approximately 10% of the variance in GCI scores among controls. These correlations between SES and GCI ($\underline{r} = .42$ for prematures and $\underline{r} = .31$ for controls) are not significantly different at the .05 level (see Stanley,

---

*This was one of six planned comparisons. With $\underline{df} = 39$, a $\underline{t}$ value less than -2.816 is significant at the .05 level where .05 is the error rate/family (two-tailed).

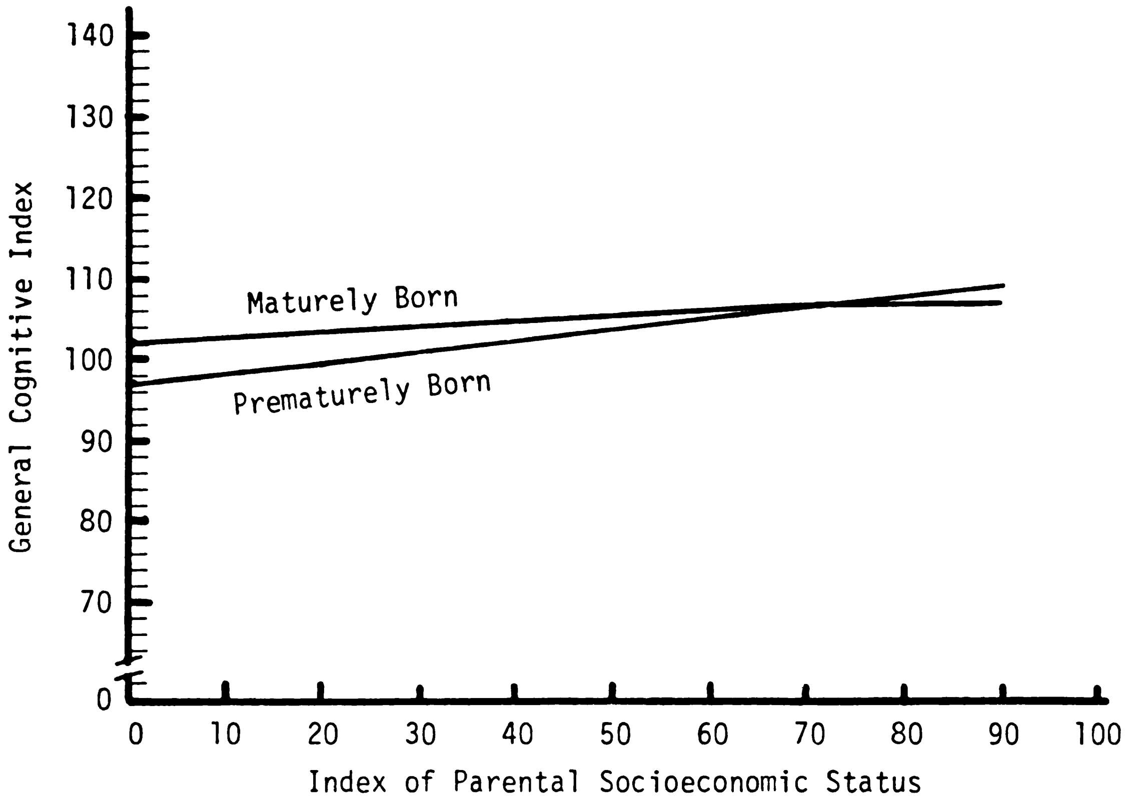


Figure 4.1 A comparison of the regression lines for predicting performance on the McCarthy GCI scale from SES for prematures and controls.

1967, p. 114). If it is assumed that there are no differences between the research groups in the variances of SES and GCI (i.e., $\sigma^2_{GCI}/\sigma^2_{SES}$ for prematures is not different from $\sigma^2_{GCI}/\sigma^2_{SES}$ for controls), then the slopes of the two lines in Figure 4.1 are not significantly different at the .05 level ($\beta_{GCI \times SES} = \rho \, \sigma^2_{GCI}/\sigma^2_{SES}$). This analysis suggests there was no interaction between birth history (premature or mature birth) and socioeconomic status as they affect GCI at ages 3 or 4.*

A chi square test of goodness of fit was done to determine whether the distribution of two categories of GCI scores (low/high) across two categories of socioeconomic status (low/high) was the same for the two research groups. As shown in Figure 4.2, a 2 x 2 frequency table was created for each research group showing the number of children who received low or high GCI scores (defined as < 105 and ≥ 105, respectively) from each SES category (low SES defined as < 42.5 on the Duncan Scale; high SES defined as > 42.5 on the Duncan Scale). Expected frequencies were defined by the control group distribution; observed frequencies were those found for the premature study group. The critical value for χ^2 with $\underline{df} = 3$ is 7.81 at the .05 level of significance. The analysis yielded a chi square of 11.76 indicating that the observed frequencies for the premature study group did not fit the distribution predicted by the control group.

---

*It was not appropriate to test for an interaction between birth history and SES category (low/high) as they affect GCI using ANOVA because the assumption of independence of observations between and within low/high SES groups is violated by the matched pairs-design.

Observed Frequencies
(Prematures)

HIGH[a] GCI	5	12	17
LOW GCI	14	9	23
	19	21	40
	LOW SES	HIGH SES[b]	

Expected Frequencies
(Controls)

HIGH[a] GCI	14	12	26
LOW GCI	9	5	14
	23	17	40
	LOW SES	HIGH SES[b]	

[a] High GCI = score ≥ 105; low GCI = score < 105.

[b] High SES = index score > 42.5; low SES = index score < 42.5

Figure 4.2 Frequency tables for prematures and controls showing the number of children who received low/high GCI scores from low/high SES categories.

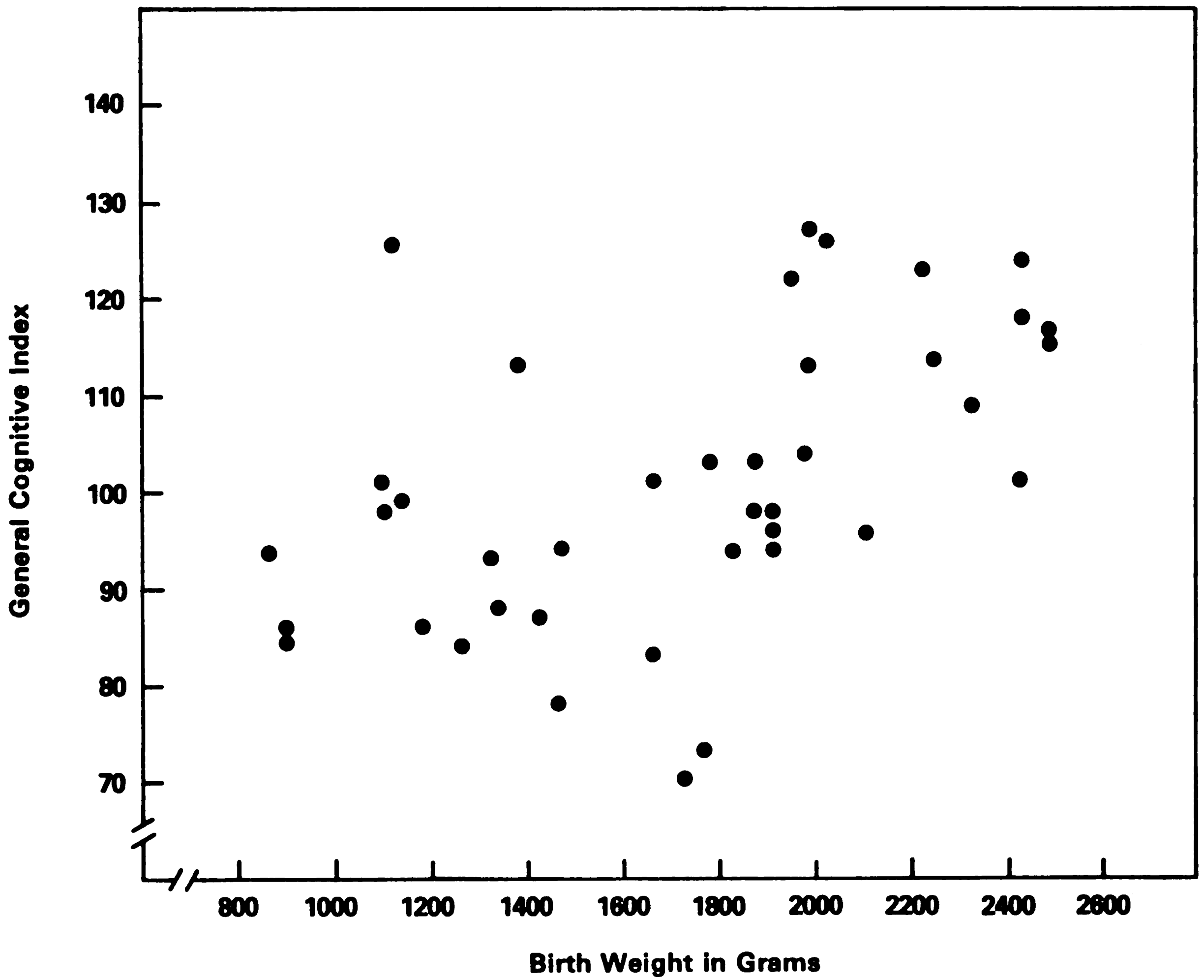


Figure 4.3 Birth weight and performance on the McCarthy GCI scale for prematurely born preschoolers. The GCI scores are based on chronological age.

Birth Weight of Prematures and Performance on the McCarthy GCI Scale

A scattergram of birth weight (in grams) and performance on the McCarthy GCI scale for prematurely born preschoolers is shown in Figure 4.3. The correlation between birth weight and GCI scores based on chronological age was .52 ($\underline{p} = .0002$). Heavier birth weights are associated with higher scores on the McCarthy GCI scale and low birth weights are associated with lower GCI scores. Birth weight accounts for approximately 27% of the variance in GCI scores among prematures in this research sample.

Gestational Age of Prematures and Performance on the GCI Scale

The correlation between gestational age at birth and McCarthy GCI scores based on chronological age was .33 ($\underline{p} = .02$). Gestational age thus accounts for only 11% of the variance in GCI scores among prematures in this research sample.

CHAPTER V

DISCUSSION

Findings

Special Education Referrals

Data gathered from the records of the Developmental Assessment Clinic at Sparrow Hospital indicated that 17% (N = 19) of the 114 premature RNICU graduates with birth dates between March 1, 1976 and August 15, 1977, had been referred for special education services as of September 1980. The practical importance of this 17% incidence figure can be evaluated by comparing it with statistics from the general population. Data gathered by Dingman and Tarjan (1960), Kushlick and Blunden (1974), and Mercer (1973) indicate that moderate to severe developmental problems are found among less than 1% of the population in the preschool years. Thus, the finding of a 17% incidence of referrals to special education among prematurely born graduates of neonatal intensive care is interpreted as providing support for the notion that these children comprise a developmentally "at risk" population.

The "incidence of special education referrals" clearly comprises only a rough estimate of the number of children with neurological and intellectual impairments. Nevertheless, the 17% figure for special education referrals for prematurely born children is not inconsistent with previous investigations which report that from 10% to 40% of prematurely born children show neurological or intellectual impairments (Kopp & Parmelee, 1979). The "reason for referral" figures shown in Tables 4.1 should also be interpreted with caution as they are only a rough estimate of the number of children with various developmental problems in the at risk population. Furthermore, motor dysfunction can often be identified in the first two years of life whereas delays in language and cognitive development are often not apparent until after the age of three. Thus, the "reason for referral" does not reflect the scope or severity of the developmental problems. (Difficulties in intellectual and neurological functioning may not be apparent for some children until school age.) However, the high incidence of referrals for motor delays found among prematurely born neonatal intensive care graduates is consistent with medical literature which has long recognized that prematurely born children are at high risk for cerebral palsy and associated impairments in motor development (see Towbin, 1978, p. 629).

The incidence of referrals for cognitive delays found among prematurely born children is similar to findings reported by Harper et al. (1959) and Drillien (1964) for the same age group. Harper et al. found that approximately 5% of the white low-birth-weight children and 10% of the non-white low-birth-weight children (< 2,500 g) in the Baltimore Study tested in the borderline defective or defective range on intellectual assessments at age 3 to 5 ($N = 460$). Drillien found that approximately 5% of the children with birth weights less than

2,496 grams in her study achieved Developmental Quotients below 69 on items from the Terman-Merrill "L" Form Scale at age four (N = 241). Results of these two studies are not directly comparable with findings from this investigation because of differences in the criteria for prematurely and impairment, however. Both Harper et al. and Drillien used results of individual assessments as the basis for their incidence figures (rather than referrals for special education) and both studies failed to exclude small-for-dates from their research sample.

Developmental Progress of Prematurely and Maturely Born Preschoolers

Contrary to the previous literature on the sequelae of prematurity, no differences were found between prematurely and maturely born preschoolers in this study on measures of general cognitive ability, verbal ability, problem solving, and speech articulation. As predicted, differences were found between the two research groups on measures of perceptual performance. A first step in exploring the discrepant findings was to investigate whether the failure to replicate previous results was due to inadequate statistical power to detect differences between the research groups on the dependent measures. Results of a *post hoc* power analysis are shown in Table 5.1. The power to detect a .5 SD difference in performance on the dependent measures fell short of the anticipated .80 value. This was due to the fact that matching subjects on race, sex, post-conceptual age, and socioeconomic status did not result in as high a correlation between pairs on measures of cognitive ability as expected ($r = .05$ for GCI; $r = .10$ for the Verbal Scale index).

Table 5.1

Post Hoc Power Analysis: Probability of Detecting a Small, Medium, and Large Effect Size

Effect size	GCI scale points	Scale index points[a]	$\alpha = .05$[b]	$\alpha = .10$[b]
Small [.3 SD]	5	3	43	57
Medium [.5 SD]	8	5	76	86
Large [.75 SD]	12	7.5	97	99

[a] Verbal, Perceptual-Performance, and Memory Scales.

[b] Significance level, one-tailed *t* test.

Note: power values estimated from Cohen's power tables using linear interpolation (1969, pp. 26-29).

The low positive correlation between pairs on measures of general cognitive ability despite apparently successful matching on socioeconomic indicators (no differences were found between the two groups on father's occupational status, father's education, or mother's education) was seemingly due to the low correlations between SES and GCI ($r = .31$ for controls; $r = .42$ for prematures). Socioeconomic status accounted for only ±15% of the variance in GCI scores. It is suspected that the weak correlation of GCI scores between pairs despite matching on SES indicators is due to differences in the procedures used to locate volunteers for each research group and differences between the research groups in reasons for volunteering for the study. The parents of the prematurely born children were initially contacted by a letter from the Developmental Assessment Clinic team requesting that they consent to participate in the study (see Appendix F). The participation rate for prematures was high; 42 (75%) of the 56 families who received the letter agreed to participate in the study. Parents of the prematurely born preschoolers all shared a history of parenting a preterm infant cared for in the neonatal intensive care unit at Sparrow Hospital and most had a continuing involvement with the RNICU and DAC staffs through follow-up visits. All parents of prematurely born children also had access to a team of professionals who kept them abreast of the health and developmental progress of their prematurely born child. It is believed that many of the parents of premature children volunteered for the study because of their history of personal involvement with the RNICU and DAC staff and because of an interest in knowledge about the developmental progress of preterm infants.

In contrast, parents of maturely born preschoolers were contacted through a variety of sources and it proved quite difficult for research assistants to locate an adequate control group sample. It is suggested that procedures for locating control group volunteers may have attracted a disproportionate number of mothers who volunteered for the study because they felt confident their child was developing well (i.e., a "proud mother" syndrome). The procedure for locating maturely born children thus perhaps tended to exclude mothers who were uninterested in their child's developmental progress and those who perceived problems they did not wish acknowledged to a research team. Some support for this interpretation of the low correlation between SES and GCI scores for control group children is provided by the 2 X 2 frequency tables in Figure 4.2 showing the distribution of low/high GCI scores for children from low/high SES categories for each research group. Inspection of this figure suggests a disproportionate number of low/low middle SES control group preschoolers performed above the median GCI score.

Although the power to detect a .5 SD difference between the research groups on the dependent measures fell short of the desired level, failure to replicate studies which reported differences in cognitive abilities between prematurely and maturely born children did not seem to be due to inadequate statistical power. Inspection of the results tables (see Tables 4.2, 4.3, and 4.4, in particular) suggests that the findings would not have differed meaningfully had the .10 significance level been chosen (power = .86). The only comparison between the two research groups which reaches statistical significance at the .10 level but not the .05 level was the GCI score based on chronological age. This difference was due to poorer performance by prematures on the Perceptual-Performance Scale (which was significantly different at the .05 level) rather than differences in performance on the Verbal or Quantitative Scales, so the pattern of findings would remain essentially unchanged if the .10 level had been selected.

Each of the findings from the study will be reviewed briefly in the paragraphs which follow. The biological deficits associated with premature birth will then be summarized (i.e., the "continuum of reproductive casualty") and literature on caregiver response to the premature child which may help to explain the age-appropriate developmental patterns of the prematures who participated in this study will be summarized (i.e., the "continuum of caretaking casualty"). Limitations of the study, practical implications, and implications for future research will then be discussed.

General cognitive ability. Contrary to the research hypotheses, no differences were found between prematurely and maturely born preschoolers on the McCarthy General Cognitive Index scale whether scores were based on chronological or post-conceptual age. These findings are not consistent with the results of earlier studies which typically reported that prematures fare less well on IQ tests than their maturely born counterparts in the preschool years (Harper et al., 1959; Rubin et al., 1973) and at school age (Caplan et al., 1976; Caputo et al., 1978; De Hirsch et al., 1966; Wiener, 1968; Wiener et al., 1965). One possible explanation for the failure to replicate previous findings is based on differences in subject selection criteria used in this study and earlier investigations. As previously mentioned, the present study differs from most of the earlier studies on the sequelae of prematurity because of the exclusion of small-for-date children. In five of the major studies reviewed, low birth weight was the sole criterion used for selecting "premature" subjects [Knobloch et al., 1956 (the Baltimore Study); Caputo et al., 1978 (the Wakoff Research Center study); De Hirsch et al., 1966; Dann et al., 1964; Wright et al., 1972]. While Rubin et al. (1973) differentiated low-birth-weight-preterm and low-birth-weight-full-term children in reporting their findings, they did not exclude preterm small-for-dates from their low-birth-weight-preterm study group. As previously mentioned, research conducted in the 1960's and 1970's has shown that small-for-date infants perform less well than appropriate-for-date prematures on follow-up assessments of intellectual development (see Caputo & Mandell, 1970; Kopp & Parmelee, 1979). Furthermore, results of recent studies reported by researchers affiliated with the Collaborative Perinatal Project (Towbin, 1978) have shown that small-for-dates born at term or near term may be more at risk for damage to the cerebral cortex and subsequent impairment in the higher mental processes than appropriate-for-date prematures. (These findings will be reviewed in more detail in the following section). Consequently, the small mean IQ differences between low birth weight subjects and controls (about 5 points) reported by six of the studies reviewed may be due in part to a failure to exclude small-for-dates from the study sample.

A second possible explanation for failure to replicate the finding of superior performance by maturely born children on a test of general cognitive ability is based on differences in the measurement instruments selected. It may be that differences in IQ reported by previous researchers were due primarily to poorer performance by prematures on perceptual performance tasks. Both Caputo et al. (1978) and Caplan et al. (1976) found that differences in IQ between research groups in middle childhood were due to superior performance by the control group on the WISC-R and WISC Performance Scale; no differences were found between research groups on the Verbal Scale. [Wiener et al. (1968) did report differences in WISC Verbal IQ at 8 to 10 years of age, but his large sample size (N = 822) and statistical analyses make it difficult to interpret whether or not this difference was practically meaningful.] Factor analytic studies of the WISC and WISC-R have shown that five of the ten subtests routinely administered load on the Perceptual Organization factor (Kaufman, 1979). Similarly, the Stanford-Binet, administered to study children at ages 3 to 5 by the Baltimore researchers (Harper et al., 1959) and at age 4 by the Educational Follow-Up researchers (Rubin et al., 1973) is heavily loaded with perceptual performance tasks at year-levels II through V (Sattler, 1974). In contrast, Kaufman and Kaufman (1977) report that the six best measures of general cognitive ability on the McCarthy Scales (factor loading > 60) all involve verbal ability (p. 103), and only four of the fourteen McCarthy tests administered in this study load more heavily on the Perceptual-Performance Scale than the Verbal Scale. Thus, perceptual performance tasks weighed more heavily in the IQ tests used by previous researchers in comparison with the McCarthy Scales, and it is perceptual performance tasks which seem to be the most difficult for prematurely born children.

A third possible explanation for the failure to replicate previous research which reported IQ differences between prematurely and maturely born children is that advances in medical care have resulted in improved outcomes for preterm infants. Medical procedures and equipment introduced in the late 1960's and 1970's have decreased infant mortality and reduced the risk of brain damage among premature survivors ("Infants in Isolation," undated; Rawlings et al., 1971). Two of the most recent studies which have appeared in the literature found no differences between low-birth-weight children born in the late 1960's and controls. As reported previously, Dweck et al. (1973) found no differences in Cattell DQ scores between 14 low-birth-weight infants (< 1,101 g) born between 1968 and 1970 and matched controls when seen for follow-up at 11½ to 33½ months of age (scores adjusted for prematurity). Similarly, Rawlings et al. (1971) found that the distribution of IQ scores for 16 low-birth-weight children born between 1966 and 1969 (< 1,501 g) and tested at ages 3 to 4 was essentially the same as the distribution of IQ scores of their mothers (test scores were adjusted for prematurity).

Additional support for the findings of no differences in general cognitive ability between prematurely and maturely born preschoolers is provided by comparisons between the two research groups on rural or urban background. Research studies have shown that urban children typically outperform rural children on IQ tests (Lehmann, 1959), and a higher proportion of maturely born children than premature came from homes in urban settings. No significant differences were found between prematurely and maturely born research groups in general cognitive ability, however, despite the control group advantage of a higher proportion of children from urban homes.

Language. No differences were found in this study between the two research groups on the McCarthy Verbal Scale whether scores were based on chronological or post-conceptual age. This finding is not consistent with De Hirsch et al.'s finding that maturely born kindergarteners outperformed their premature classmates on eleven tests of language development and differences in ITPA performance at age five favoring full-term children reported by Rubin et al. (1973). The finding that prematures and controls did not differ in verbal ability is consistent with results of follow-up studies in middle childhood which showed no differences in Verbal IQ on the WISC-R (Caputo et al., 1978) and the WISC (Caplan et al., 1976). The discrepant findings from the preschool period may be due, again, to differences in subject selection criteria, assessment instruments, or improved outcomes for prematures in this study population. De Hirsch et al. did not exclude small-for-dates from their study sample and little is known about their language assessment tests. Similarly, Rubin et al. did not exclude small-for-dates from their low-birth-weight study sample. It is difficult to evaluate why low-birth-weight subjects fared less well on the ITPA because subtest scores were not reported.

The finding of no differences between prematurely and maturely born preschoolers in this study on the McCarthy Quantitative Scale provides further support for the notion that the groups did not differ in verbal ability or general cognitive ability. As previously mentioned, Kaufman and Kaufman (1977) found that the Quantitative factor does not emerge in analyses of the McCarthy Scales until age five, and items on the Quantitative Scale have their highest loadings on the GCI and Verbal factors at ages 3 to 4.

Perceptual maturation. Prematurely born preschoolers did not fare as well as their maturely born counterparts on the McCarthy Perceptual-Performance Scale when scores were based on chronological age. No difference was found between the two research groups on the Perceptual-Performance Scale Index when scores were based on post-conceptual age. As stated previously, relatively impaired performance by prematures on tests of visual-perceptual development was the most consistently reported finding in the literature on premature children. Results of previous studies have shown that maturely born children outperform their prematurely born counterparts on the Bender Gestalt Test at age five (De Hirsch et al., 1966) and throughout the middle childhood years (Caplan et al., 1976; Caputo et al., 1978; Wiener et al., 1968; Wright et al., 1972). The Block Design and Object Assembly Subtests discriminated between prematures and controls in two earlier studies, with controls achieving superior scores (Caputo et al., 1978; Wiener et al., 1968).

No differences were found between the two research groups in this study in performance on the McCarthy Block Building and Puzzle Solving tests. Significant differences favoring maturely born preschoolers were found on the McCarthy Draw-A-Design test.* Both the Draw-A-Design test and the Bender Gestalt Test require the child to copy a series of

---

*Differences favoring maturely born preschoolers on the Draw-A-Design test were not due to poor performance by the two premature study children seen for physical therapy. Based on the test age equivalents of weighted raw scores on the McCarthy reported by Kaufman and Kaufman (1977, p. 128), both children seen for physical therapy achieved age-appropriate Draw-A-Design test scores.

printed designs; the task demands of the two tests are thus highly similar. According to Kaufman and Kaufman (1977), the McCarthy Block Building, Puzzle Solving, and Draw-A-Design tests measure visual-perception, visual-motor coordination, and spatial relations (p. 88). The question which arises is whether the poorer performance of prematures on drawing tasks is due to difficulties with visual-perception and spatial relations or poor visual-motor coordination. [Wiener (1966) also recognized this problem in the studies of the Bender performance of low-birth-weight children.] Kaufman and Kaufman (1977) suggest that the unique contribution of the Draw-A-Design task to variance in performance on the McCarthy perceptual-performance factor is most likely due to its sensitive measure of visual-motor coordination (see also Kaufman, 1979, pp. 36-37). The notion that the poorer performance of prematures on perceptual performance tasks may be due to relatively impaired visual-motor coordination is consistent with the finding of a high incidence of special education referrals for motor delays among prematurely born RNICU graduates, and the finding of differences favoring maturely born children on motor tasks reported in earlier studies. As previously mentioned, De Hirsch et al. (1966) found that maturely born kindergarteners outperformed low-birth-weight classmates on tests of pegboard speed and tapped patterns. Maturely born children also outperformed their premature age-mates on the Lincoln-Oseretsky Test of Motor Development at ages 6 to 7 (Wiener et al., 1965), and ages 7 to 8 and 11 to 12 (Caplan et al., 1976).

Problem-solving competence. No differences were found between the two research groups on the four measures of problem-solving competence, namely, self-direction, planfulness, impulsivity, and task persistence. These findings are not consistent with the observations of previous researchers who described prematurely born children as more disorganized (De Hirsch et al., 1966) and impulsive (Wiener et al., 1965) in their task approach than their maturely born peers. Unlike these previous studies which matched subjects on chronological age at the time of follow-up, however, subject-pairs in the present study were matched on post-conceptual age at the time of testing. Differences in problem-solving approach reported in earlier studies may have been due to the fact that maturely born study participants had a "biological age advantage" in the testing situation and the dependent measures (i.e., rating scales) were not age-norm referenced. Also, as previously mentioned, subject selection procedures used in earlier studies resulted in the inclusion of small-for-date children who may be at higher risk than appropriate-for-date prematures for impairment in cerebral cortex functions including planning and impulse control.

Speech articulation. No differences were found between the two research groups in the incidence of speech articulation difficulties. This finding was contrary to results reported by the Baltimore Study researchers (Wiener et al., 1965, 1968) and Fitzhardinge and Ramsay's (1972) finding of a high incidence of speech immaturities among prematurely born children. Speech ratings made by the psychologist (not an age-norm referenced measure) were used to evaluate speech maturity in the Baltimore Study. Consequently, the discrepancy in findings between this investigation and the Baltimore Study may be due to differences in criteria for selecting prematures, differences in procedures for matching research groups on age at the time of follow-up, differences in the assessment instruments used, and improved outcomes for prematurely born children in this study population. Fitzhardinge and Ramsay's (1972) non-comparative study followed the developmental progress of very low birth weight (< 1,500 g) appropriate-for-date prematures (N = 32). Low IQ and neurologically impaired children were not excluded in their follow-up sample. Differences in sampling procedures, assessment instruments, and the lack of controls in the Fitzhardinge and Ramsay study make it difficult to compare the findings with this investigation.

Personal-social development. As predicted, no differences were found between the two groups on parental reports of personal-social development. This is consistent with previous findings reported by Caputo et al. (1978).

Socioeconomic variables and maturity at birth. A comparison of the regression lines for predicting GCI from SES for prematures and controls (Figure 4.1) was interpreted as indicating there was no interaction between birth history and parental socioeconomic status as they affect McCarthy GCI scores at age 3 or 4. This finding of no interaction effect is consistent with results reported from the Baltimore Study (Wiener, 1968).

The statistically significant chi square test of goodness of fit done to determine whether the distribution of two categories of

GCI scores (low/high) across two categories of socioeconomic status (low/high) was the same for both research groups was not interpreted as evidence of an interaction effect between SES and birth history. The significant chi square test was seemingly due to an irregular control group distribution which included a disproportionate number of low/low middle SES control group children who scored above the median on the McCarthy GCI scale (see the previous discussion of the volunteer control group).

Birth weight and gestational age of prematures and performance on the McCarthy GCI Scale. A correlation of .52 between birth weight and GCI scores based on chronological age was found for the premature study group. This is similar to the .44 correlation between birthweight and Cattell DQ scores at one year of age reported by Caputo et al. (1978). Francis-Williams and Davies (1974), however, did not find a significant correlation between birthweight and IQ in their study of very low-birth-weight infants (< 1,500 g) and later intelligence. Children in their study ranged from 4 to 12 years of age at the time of follow-up (72 appropriate-for-dates, 33 small-for-dates). The lack of a significant correlation between birth weight and IQ in their study may be due to the restricted range of birthweights and the age of the children at follow-up. The correlation between gestational age and GCI scores (based on chronological age) for prematures in this study was .33 ($p = .02$). This is lower than the .49 correlation between gestational age and DQ at age one reported by Caputo et al. (1978). Studies of high risk children and subsequent development generally suggest that the relationship between neonatal factors and IQ becomes less significant over time while socioeconomic variables take on increasing importance in determining developmental outcomes (see Hartlage & Telzow, 1981a).

Summary. In summary, the developmental picture of the prematurely born preschooler which emerges from this study and a critical re-evaluation of the previous research literature is as follows: appropriate-for-date prematures do not differ from their maturely born age-mates in performance on tests of higher mental processes including reasoning, verbal ability, memory, problem solving, planning, and impulse control. Prematurely born 3 and 4 year olds do not perform as well as maturely born peers on perceptual performance tasks, particularly items which are sensitive measures of visual-motor coordination such as copying a design. The notion that the poorer performance of prematures on perceptual performance tasks may be due to relatively impaired visual-motor coordination is consistent with the finding of a high incidence of special education referrals for motor impairment among prematurely born children.

As stated previously, the transactional model of child development outlined by Sameroff and Chandler (1975) provided the conceptual framework for this study. One important premise of this model is that non-adaptive patterns of development set in motion by biological insult may be offset or minimized by factors in the caretaking environment. The biological deficits often associated with premature birth (i.e., the "biological risk continuum") will be described followed by aspects of the caretaking environment which may help to explain the age-appropriate developmental patterns found for the prematures in this study.

Biological Risk Factors Associated with Premature Birth

Research conducted by neuropathologists affiliated with the Collaborative Perinatal Project (Towbin, 1978) helps to clarify the biological risk continuum for appropriate-for-date prematures and the possible causal factors underlying motor impairment frequently observed among appropriate-for-date preterm infants. Neuropathologic studies (based on autopsies and animal studies) have identified two forms of chronic lesions which may occur in the developing brain and place the child at risk for mental retardation, cerebral palsy, epilepsy, and psychopathy: one type of brain injury involves "deep cerebral lesions, scars, and cavitations affecting the basal ganglia and neighboring structures at the core of the forebrain"; the second form involves "cortical cerebral damage, affecting mainly surface structures of the convolutions" (Towbin, 1978, p. 618). This research suggests there is a relationship between gestational age at birth and vulnerability to a particular form of cerebral damage. The premature fetus and newborn is at risk for deep cerebral lesions affecting the basal ganglia and structures at the core of the forebrain; the term infant is primarily at risk for cortical damage (p. 619).

The notion that brain injury is a result of damage which occurs during delivery, i.e., "birth injury" is for the most part a misconception, according to Towbin (p. 619). Brain damage in the newborn is typically a result of intrauterine disturbances which occur "silently" for a period of time prior to birth. The most common cause of brain injury is "hypoxia" or "anoxia" (p. 619). "Hypoxia" is the abnormal reduction of oxygen in the body tissues. "Inadequate oxygenation of the fetus or newborn . . . is the process which underlies the bulk of neonatal neuropathic case material" (1978, p. 619).

The process which leads to the deep cerebral lesions in the premature infant evolves through three stages. The process begins with a "hypoxia-producing complication" which may be due to a variety of disturbances in the fetal-placental balance including maternal illness, faulty placenta, premature detachment of the placenta, or a compressed umbilical cord. Prolonged hypoxia leads to the second stage in the process, namely weakening of the heart followed by systemic circulatory failure. "Failure of the heart to adequately pump out the blood from the venous side of the circulatory system leads to venous engorgement, a stagnant backlog of blood in the veins of the body--congestive circulatory failure" (1978, p. 624). The third stage which results from interference of circulation is "venous infarctional damage" (p. 624). This means that the slow down in circulation results in blood clots, a breakdown of the blood vessels, bleeding, and tissue damage (necrosis). Of all the developing organs, the brain seems to be most vulnerable to "hemorrhagic venous infarction" and damage.

The factors which determine the locus of cerebral lesions due to bleeding in the brain are related to gestational age: (1) the presence or absence of germinal matrix tissue,* (2) the developmental stage of the portion of the brain insulted, and (3) the maturity of the intracranial blood vessels. During early fetal life, the organ structures in the forebrain are developing most rapidly. The deep structures of the brain "which are undergoing rapid differentiation are immediately susceptible to hypoxic infarctional injury" (p. 625). As the fetus nears term, however, the germinal matrix tissue is "used up" and the thrust of brain growth and elaboration "shifts to the cerebral surface, where the cortex, maturing rapidly at term, becomes the main target of hypoxic injury" (p. 626).

Thus, the premature infant is especially vulnerable to damage to the germinal matrix and deep structures of the brain. As Towbin points out, however, "the hypoxic state initiated prior to birth is extended postnatally with the development of hyaline membrane disease, pneumonia, or other pulmonary complication" (p. 624). Respiratory distress, which occurs frequently among prematures, may consequently create additional risk for intracranial hemorrhage. The range of outcomes for preterm infants who suffer intracranial bleeding include total neurologic collapse and death, hydrocephaly, cerebral palsy, and other sensorimotor dysfunctions, and minor cerebral dysfunctions including awkwardness. Minimal hypoxic lesions in the deep structures of the brains of premature infants (i.e., small, focal blot clots) occur with high frequency, sometimes in the absence of clinical signs. Autopsies

---

*The germinal matrix is "the depot of building tissue for the future formation of the basal ganglia and neighboring structures and the cerebral cortex" (Towbin, 1978, p. 625).

of 140 premature infants 22 to 35 weeks gestation showed that 52% suffered minimal hypoxic lesions in the deep structures (1978, p. 629). As a result of recent studies, researchers affiliated with Georgetown University report that 75% of the prematures born with birth weights less than 1,700 grams may suffer unsuspected bleeding in the germinal matrix ("Doctors Discover Many Premature Babies Suffer Bleeding in Brain," 1980).

In contrast, infants born near term may be more vulnerable to cortical cerebral lesions. The term infant who suffers damage from hypoxia is at risk for mental retardation, convulsive disorders, and behavior disorders including hyperactivity, aggressiveness, and psychosis (Towbin, 1978, p. 632). Thus, small-for-date infants may be more vulnerable to cortical damage than appropriate-for-date prematures.

The continuum of biological risk for appropriate-for-date prematures outlined in the research of Towbin and others "fits well" with the findings from this study and underscores the importance of distinguishing appropriate-for-date prematures from low-birth-weight full-term children in future research.

The Caretaking Continuum

No differences were found in this study between the prematurely born preschoolers and their maturely born counterparts on measures of general cognitive ability, verbal ability, problem-solving competence, and parental reports of personal-social development. While there is a continuum of potential caretaker responses to the premature infant, there is a small but growing body of literature on preterm-infant/ caregiver interaction which may help to explain the age-appropriate developmental patterns found among the prematurely born children in this study.

First, it is important to note that there can be no doubt that parents of a premature infant perceive their child as "different" (Dubois, 1975; Hawkins-Walsh, 1980) and that preterm infants both look and behave differently than their full-term peers. Several studies have found that premature infants are initially less alert and responsive than full-term babies (Field, 1977a, 1977b; Divitto & Goldberg, 1978); and there is research evidence which suggests they are less competent "social partners" than their full-term counterparts (Field, 1977a; Divitto & Goldberg, 1978), and more vulnerable to frequent minor medical problems (ear infections, colds, allergies) than infants born at term (Beckwith & Cohen, 1978). Furthermore, as Goldberg points out, parents of prematurely born children must "wait longer" before developmental milestones such as rolling, sitting, and walking are achieved (1978, p. 143).

It is perhaps not surprising that parental response to caretaking of a premature infant may arouse a sense of "worrisomeness" which motivates many parents to "work harder" (Goldberg, 1978). Field (1977a, 1977b), Divitto and Goldberg (1978), and Beckwith and Cohen (1978) have found that mother's of preterm infants are more active and intrusive in interaction with their children than mother's of full-term infants. Goldberg summarizes her review of this literature as follows:

> Perhaps in response to these early difficulties, perhaps because they perceive their parental task as more important and challenging than that of average parents, perhaps because their infants remain less responsive, parents of preterm infants seem to adopt a strategy in which they invest more time and energy in interactions than is usual in full-term dyads. (1978, p. 142)

Few of the studies of caregiver-infant interaction have investigated the effects of these interaction patterns observed among preterm dyads on development. Thus, the links between parent-infant interaction patterns and subsequent development of the prematurely born child are tenuous. However, in her analysis of longitudinal data from the Berkeley Guidance Study, Honzik found that a tense, concerned, energetic, worrying mother had an accelerating effect on the mental growth of her children (1967, p. 348). Similarly, Beckwith, Cohen, Kopp, Parmelee, and Marcy (1976) found that active patterns of caregiving were associated with more advanced cognitive development in a sample of premature 8 month olds and their parents.

The notion that age-appropriate developmental patterns observed for prematures in this study may be due to parent "push" is especially plausible because of parental educational attainment (mothers averaged some college) and the continued involvement by most parents of premature children with the Developmental Assessment Clinic (39 of the 40 premature volunteers were active clinic cases).

Limitations of the Study

The study reported here has numerous limitations. Three shortcomings of the research which cloud interpretation of the findings require special discussion, however. The procedures used to obtain a sample of prematurely born preschoolers is one source of difficulty in interpreting results from the study. More specifically, it is not known whether or not prematurely born study participants are representative of the population of all children born prematurely at Sparrow Hospital during the target period. As previously mentioned, 88 families with preschoolers who met all subject selection criteria were identified through a search of the records of the Developmental Assessment Clinic. The records showed no known address for 20 families, 42 families consented to participate, 11 letters were returned undeliverable, and 14 families refused to participate in the study. In compliance with a request from the hospital research committee, parents who refused to participate in the study were not asked about their reasons for refusal. Thus, of the 88 families with prematurely born children, 35 (37%) had re-located and 14 (16%) refused to participate. The possibility that the prematurely born children who did not participate in the study differed from the volunteer children cannot be ruled out.

The lack of reliability and validity statistics for two research instruments is a second source of difficulty in interpreting the findings. Interobserver agreement statistics were reported for the Preschool Problem-Solving Competence Test based on pilot study data; however, no validity studies of the instrument have been conducted. Similarly, no reliability or validity data are available for the Personal-Social Development Questionnaire. Consequently, the finding that the two research groups did not differ in problem-solving competence or personal-social development must be interpreted with caution.

Failure to include measures of motor development is seen as a third shortcoming of the study. The McCarthy Scales Motor Scale items were not administered because of the limited space in many homes. Consequently, there is little test data to support the interpretation that the poorer performance by prematures on copying tasks is due to motor difficulties, and this interpretation must consequently be viewed with caution.

Practical Implications

As previously stated, analysis of the incidence of special education referrals for premature graduates of Sparrow Hospital's neonatal intensive care units confirms the notion that they comprise a group of infants at risk for later developmental difficulties. The Developmental Assessment Clinic at Sparrow thus plays an important role in the early identification of children with special education needs by monitoring the health and progress of RNICU graduates. Results of the comparative study of the developmental progress of 40 prematurely born RNICU graduates and maturely born controls are more optimistic than outcomes reported for the preschool years by previous researchers. While the discrepancy in findings may be due in part to differences in methodology (i.e., excluding small-for-dates and matching groups on post-conceptual age), it seems likely that they are also due to advance in neonatal medical care (see "Infants in Isolation," undated; Rawlings et al., 1971).

The age-appropriate developmental patterns which were found for prematurely born preschoolers in the areas of verbal ability, problem solving, and personal-social development were interpreted as being due in part to "parental push" as well as neurological integrity of the portions of the brain responsible for higher mental processes. Dr. Eugene A. Dolanski, Director of Newborn Services at Sparrow Hospital, has suggested that parent involvement in follow-up visits to the Developmental Assessment Clinic should be recognized as a type of "intervention" whether or not the child is referred to an outside agency for educational or supportive services, and this writer concurs (Dolanski, personal communication, March 1980). Involvement in the DAC may be a factor which heightens parent awareness of the at risk status of their prematurely born child and encourages them to "work harder." (A similar "Hawthorne effect" may occur in longitudinal studies of infant-parent interaction and the sequelae of prematurity). Thus, encouraging parent participation in the DAC may itself contribute to improved developmental outcomes. Although parent education is not the primary goal of the DAC, it is suspected that concrete suggestions for enhancing a child's developmental progress help parents translate their concerns into appropriate action patterns.

The results of this study also have implications for the screening procedures used to monitor the developmental progress of prematurely born neonatal intensive care graduates. Results of this investigation argue in favor of adjusting scores for prematurity on tests of development during the preschool years. Comparisons were made between prematurely and maturely born preschoolers on the McCarthy Scale indexes with scores based on chronological and post-conceptual age.

No differences were found between the two groups on the Verbal, Quantitative, Memory, or General Cognitive Scale indexes whether scores were based on chronological or post-conceptual age, it will be recalled. However, prematures fared less well than maturely born preschoolers on the Perceptual-Performance Scale when scores were based on chronological age. These findings are interpreted as suggesting that maturely born children of the same post-conceptual age are the appropriate reference group for evaluating the developmental progress of prematurely born children in the preschool years, particularly in the area of perceptual-motor maturation.

This same finding has implications for the notion of "catch up" growth. It seems likely that prematures administered infant scales during the first two years of life fare less well than their maturely born counterparts because infant tests are comprised primarily of motor items. Prematures appear to "catch up" in the preschool years when the measurement focus shifts from motor items to language items. Thus, it is likely that prematures do not "catch up" developmentally as is sometimes reported in the literature (see Benton, 1940); rather what is measured shifts from motor to verbal skills which results in a "narrowing of the gap" between scores of prematurely and maturely born children on developmental assessment instruments.

Future Research

As stated in the introductory chapter, one objective of this study was to provide developmental data for a target group of preschoolers for follow-up in second grade. The focus of the follow-up study will be to determine if there are differences between the two research groups in general cognitive ability and achievement in second grade and to determine whether measures from the preschool period predict performance in second grade. This data may provide information about the early identification of children at risk for school failures and the developmental course of learning problems.

Results of this study coupled with findings from previous investigations suggest some interesting research directions for the follow-up study. Wiener (1968) interpreted findings from the Baltimore Study to suggest that low-birth-weight children are at greater risk for poor arithmetic achievement than reading achievement. The Bender Gestalt Test, it will be recalled, differentiated low-birth-weight and maturely born children in his study throughout the elementary grades. In a study of first ($N = 215$) and second graders ($N = 219$), Rosner (1973) found a .50 correlation between performance on a test of copying skills (the "Visual Analysis Test") and performance on the Stanford Achievement Test Arithmetic Computations subtest ($\underline{p} < .001$) while performance on a test of auditory perception correlated with each of four SAT reading achievement subtests at the .001 level. Analysis of the power of the McCarthy Draw-A-Design test at age 3 or 4 to predict second grade arithmetic computation skills for prematurely and maturely born second graders certainly warrants investigation. It is also interesting to note the similarities between Wiener's findings from the Baltimore Study of low-birth-weight children and the clinical features of the "developmental Gerstmann syndrome" described by Kinsbourne and Warrington (1963). The characteristics of the "developmental Gerstmann syndrome" include normal verbal ability, poor constructional ability as evidenced by low scores on the WISC performance subtests, particularly Block Design and Object Assembly, difficulty in copying and writing neatly, difficulties with "mechanical arithmetic," i.e., addition and subtraction, poor performance on tests of finger differentiation and order ("finger agnosia"), left-right confusion, and a history of perinatal trauma. If possible, Kinsbourne and Warrington's (1963) test of finger differentiation and order (appropriate for seven year olds) will be administered to children in the follow-up study along with tests of copying skills and left-right differentiation to rule out the possibility that prematurely born children are at risk for developmental Gerstmann syndrome.

The findings from this study also suggest some interesting areas for future research on caregiver-infant interaction and the developmental progress of the prematurely born child. Studies were cited which suggest that the premature infant may arouse a sense of "worrisomeness" which motivates parents to "work harder" (see Goldberg, 1978). Research is needed which investigates whether the anxiety level of mothers of premature children is related to "parent push" and favorable developmental outcomes. More specifically, some of the research questions which need to be explored include: Are mothers of premature infants more "worrisome" than mothers of maturely born infants? In what ways do the child rearing practices of "worrisome" parents differ from other parents? In what ways is parental concern beneficial and under what circumstances might heightened parental anxiety interfere with healthy caregiver-infant interactions? What support from a health care team might help parents translate "worrisomeness" into beneficial child-rearing patterns?

The results of this study have implications for future research on the sequelae of prematurity in general. The findings of this investigation underscore the importance of carefully delineating the premature study population (i.e., excluding small-for-dates) and the appropriateness of matching subject pairs on post-conceptual rather than chronological age. Additional studies are needed to determine if the findings reported here are replicated with other premature research samples. Studies of prematurely born children are particularly needed to determine whether the poorer performance by the preterm child on perceptual performance tasks is in fact due to difficulties in visual-motor coordination. As the medical technology for identifying infants who suffer minimal hypoxic lesions becomes more "fine tuned" and available, follow-up studies of the sequelae of germinal matrix bleeding will be feasible, and these will also be a valuable research contribution.

APPENDICES

APPENDIX A

DUNCAN SCALE SCORES BASED ON FATHER'S OCCUPATIONAL STATUS

APPENDIX A

DUNCAN SCALE SCORES BASED ON FATHER'S OCCUPATION STATUS

Duncan Scale Codes: Group I

		A[a]	B[b]	$\overline{A + B}$[c]
1.	computer programmer	68	62	65
2.	factory line worker (auto)	21	21	21
3.	land surveyor	48	48	48
4.	draftsman	67	67	67
5.	chemical processing lab worker	53	48	50
6.	state level administrator	66	66	66
7.	state level administrator	66	66	66
8.	electrician	44	44	44
9.	auto/fleet supervisor	47	47	47
10.	unemployed	0	0	0
11.	mechanic	25	27	26
12.	amusement park manager	39	39	39
13.	telephone switching technician	49	49	49
14.	telephone lineman	49	49	49
15.	unemployed	0	0	0
16.	beverage plant manager	70	70	70
17.	production control (auto)	46	46	46
18.	state level administrator	66	66	66
19.	minister	52	52	52
20.	factory line worker (auto)	21	21	21

		A[a]	B[b]	$\overline{A+B}$[c]
21.	doctoral level graduate student	75	75	75
22.	carpenter	19	19	19
23.	farm owner and manager	36	36	36
24.	electrician	44	44	44
25.	foreman (auto)	41	41	41
26.	college professor	84	84	84
27.	construction foreman	40	40	40
28.	attorney	93	93	93
29.	factory line worker (auto)	21	21	21
30.	auto repair (self-employed)	36	36	36
31.	college administration	66	66	66
32.	accountant	78	78	78
33.	farm owner and manager	36	36	36
34.	ADC	0	0	0
35.	school counselor	72	72	72
36.	unemployed	0	0	0
37.	farm equipment repairman	19	19	19
38.	accountant	78	78	78
39.	construction worker	18	7	12
40.	construction foreman	40	40	40

---

[a] A = Duncan Scale codes assigned by coder A.

[b] B = Duncan Scale codes assigned by coder B.

[c] $\overline{A+B}$ = Average of two codes; used when intercoder agreement not reached.

Duncan Scale Codes: Group II

		A^a	B^b	$\overline{A + B}^c$
1.	teacher	72	72	72
2.	factory line worker (auto)	21	21	21
3.	heating and cooling (self-employed)	49	34	42
4.	state level administrator	66	66	66
5.	service manager (auto, salaried)	47	47	47
6.	business manager--wholesale (salaried)	70	70	70
7.	teacher	72	72	72
8.	assembly line inspection (auto)	41	41	41
9.	T.V. repairman	36	36	36
10.	unemployed	0	0	0
11.	heating and cooling installer	27	27	27
12.	farmer and mail carrier	44	44	44
13.	mortgage appraiser	52	39	46
14.	plumber	34	34	34
15.	unemployed	0	0	0
16.	teacher	72	72	72
17.	police officer	39	39	39
18.	technician and instructor	68	68	68
19.	salesman--farm equipment	50	50	50
20.	factory line worker (auto)	21	21	21
21.	doctoral level graduate student	75	75	75
22.	auto repairman (salaried)	19	19	19
23.	police rescue	39	39	39

	A[a]	B[b]	$\overline{A+B}$[c]
24. farm owner and manager	36	36	36
25. policeman	39	39	39
26. manufacturing official (salaried)	79	79	79
27. foreman (auto)	41	41	41
28. college professor	84	84	84
29. millwright	31	31	31
30. security officer	36	36	36
31. customer relations--retail trade	68	68	68
32. accountant	78	78	78
33. fire protection installer	32	32	32
34. ADC	0	0	0
35. draftsman	67	67	67
36. unemployed	0	0	0
37. mover	8	8	8
38. engineer	87	87	87
39. truck driver	15	15	15
40. telephone lineman	49	49	49

---

[a] A = Duncan Scale codes assigned by coder A.

[b] B = Duncan Scale codes assigned by coder B.

[c] $\overline{A+B}$ = Average of two codes; used when intercoder agreement not reached.

APPENDIX B

BIRTH HISTORY INFORMATION FOR PREMATURELY BORN PRESCHOOLERS

APPENDIX B

Birth History Information for Prematurely Born Preschoolers

Maternal Health Characteristics and Delivery Variables

Subject	Diabetes	Chronic Pulmonary Disease	Hypertension	Heart Disease	Toxemia	Premature Rupture Membranes	Placenta Previa	Abruptio Placenta	Vaginal Bleeding	Incompetent Cervix	Prolonged Labor			Vaginal Delivery	Forceps	Breech	C-Section
1								●						●			
2						●										●	
3						●					●			●			
4														●			
5														●			
6						●	●										●
7														●			
8														●			
9						●			●								●
10					●												●
11	●	●												●			
12														●			
13																	
14														●		●	
15				●												●	
16														●			
17														●			
18						●								●			
19											●					●	●
20						●											●

Birth History Information for Prematurely Born Preschoolers

Maternal Health Characteristics and Delivery Variables

Subject	Diabetes	Chronic Pulmonary Disease	Hypertension	Heart Disease	Toxemia	Premature Rupture Membranes	Placenta Previa	Abruptio Placenta	Vaginal Bleeding	Incompetent Cervix	Prolonged Labor			Vaginal Delivery	Forceps	Breech	C-Section
21														●			
22																●	●
23														●			
24						●					●			●	●		
25									●					●		●	
26						●									●		
27														●			
28										●				?			
29						●			●								
30														?			
31							●		●								
32														●		●	
33							●	●	●					●			
34						●	●	●	●					?			
35														?			
36																●	●
37						●			●								
38						●				●							●
39														●			
40						●	●										●

Birth History Information for Prematurely Born Preschoolers

Infant Health Characteristics

Subject	RDS	Hyaline Membrane Disease	Birth Asphxia	Apnea	Hyperbilirubinemia	Sepsis	Anemia	Bradycardia	Jaundice	Hypothermia	Hypocalcemia	Hypvolemia	Hypoalbuminemia	Hypoglycemia	Hyponatremia	Pneumothorax	Necrotizing Entercolitis	Congestive Heart Failure	Patent Ductus Arteriosus	Pneumonia	Meningitis	CNS Bleed	Birth Defects
1	●	●			●	?													●				
2	●		●	●	●	●							●										
3	●	●		●	●	?	●												●				
4	●																						
5	●	●	●	●		?	●	●					●										
6	●			●	●																		
7					●	?																	
8	●			●			●	●	●		●		●										
9	●					?			●		●					●							
10	●	●			●	?					●												●
11	●						●		●			●	●						●				●
12	●			●												●		●					
13	●	?		●	●																		
14	●		●	●	●	●	●	●			●		●		●					●			
15	●	●		●	●		●	●			●	●	●	●	●		?						
16	●			●	●				●														
17						?			●														
18	●		●		●	●						●											
19	●	●				●	●	●	●		●		●			●				●			
20	●			●	●	●	●	●	●						●					●			

Birth History Information for Prematurely Born Preschoolers

Infant Health Characteristics

Subject	RDS	Hyaline Membrane Disease	Birth Asphxia	Apnea	Hyperbilirubinemia	Sepsis	Anemia	Bradycardia	Jaundice	Hypothermia	Hypocalcemia	Hypvolemia	Hypoalbuminemia	Hypoglycemia	Hyponatremia	Pneumothorax	Necrotizing Entercolitis	Congestive Heart Failure	Patent Ductus Arteriosus	Pneumonia	Meningitis	CNS Bleed	Birth Defects
21	●	●			●	?																	
22	●	●					●					●											
23	●			●	●	?			●		●				●								●
24	●		●		●	?		●	●		●												
25	●			●	●		●				●						?		●			●	
26	●				●	?																	
27	●					?																	
28	●			●	●	?	●				●										●	●	
29				●	●	?		●						●									●
30	●										●		●	●		●						●	
31						?																	
32			●	●	●	●		●															
33	●					●	●					●											
34	●				●		●				●												
35	●				●	?	●																
36	●		●		●						●												
37	●					?		●				●	●	●	●	●	?	●					
38	●				●	●			●										●	●			
39	●					?																	
40	●			●	●	●																	

APPENDIX C

PRESCHOOL PROBLEM-SOLVING COMPETENCE TEST

APPENDIX C

PRESCHOOL PROBLEM-SOLVING COMPETENCE TEST

The Preschool Problem Solving Competence Test includes the following materials:

1. Directions for Administration
2. Observation Coding Form
3. Scoring and Coding Key
4. Test Kit.

The test will be administered according to the procedures outlined in the Directions for Administration. Each child's testing behaviors will be recorded on an Observation Coding Form (not included here) during the test administration. These observations will be used to complete the Scoring and Coding Key for each child to summarize and describe problem solving skills and processes (i.e., self-direction, planfulness, impulsivity, and task-persistence).

Directions for Administration

Part I: Test of Self-Direction and Planfulness

FORM BOARDS

Subtest 1: Level A Form Board (Blue)

Materials: Two shape form board (9 pieces) and forms.

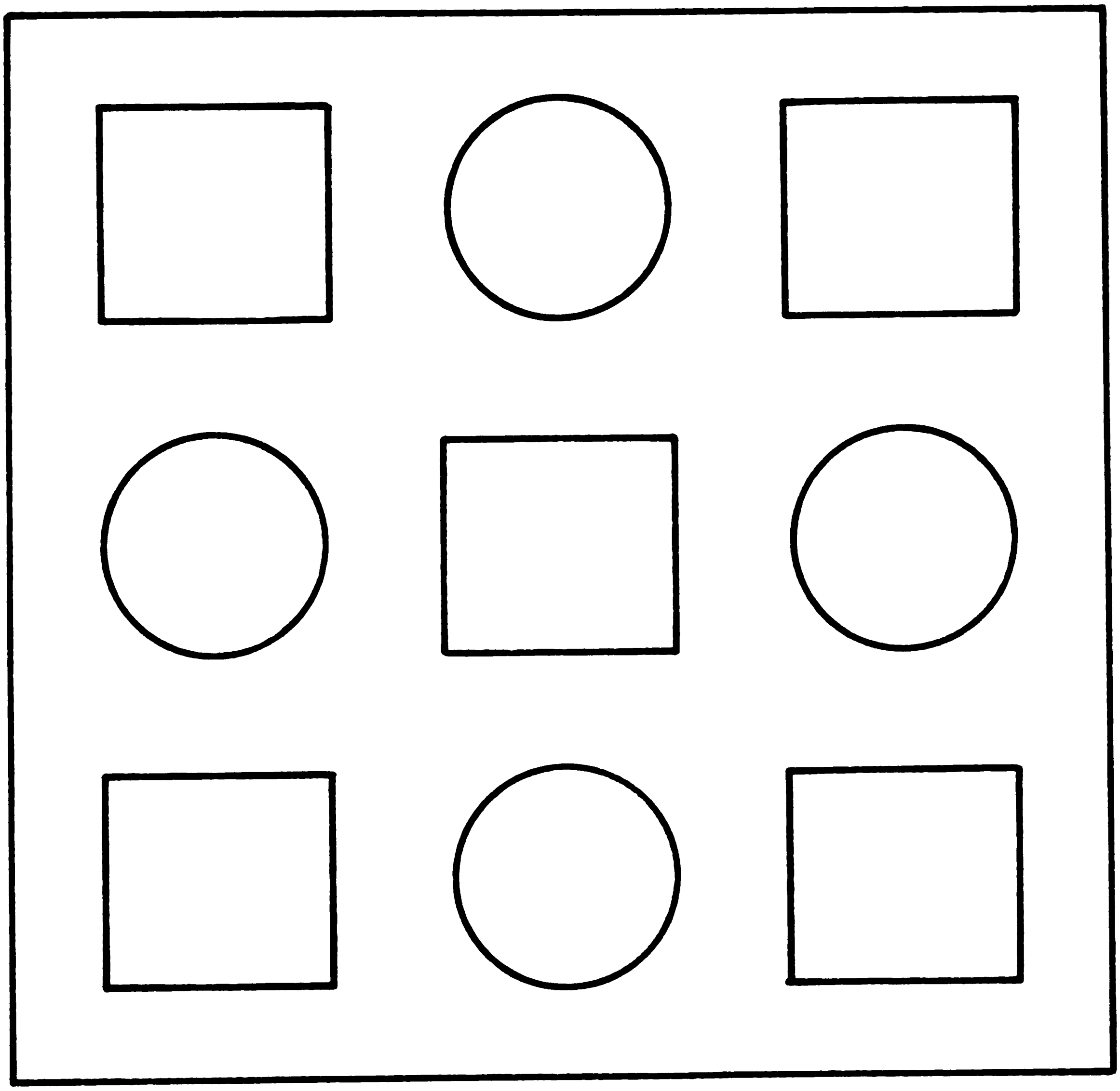
Definitions:

No Success: The child does not make an attempt to begin the task within 45"; the child begins the task but places and replaces the same form one or more times before making and leaving three successful placements.
Three or More Errors: The child begins the task but makes (and appears satisfied with) three or more incorrect placements.
Two Errors: The child completes the task with two incorrect placements.

Procedure: Trial 1. No hints.

The examiner says: "I'm going to show you a puzzle. Let's see if you know what to do" The examiner presents the form board and all form pieces (in three piles) to the child.

No success--go to Trial 2
Three or more errors--go to Trial 3
Two errors--go to Trial 5.



Level A Form Board (Blue)

True size is 9" by 9"

Trial 2. Hint: Defining the Problem

The examiner says: "Show me how you can put each piece in the puzzle for me." The examiner demonstrates the placement of one piece and then removes it and says: "Put all the pieces in the puzzle" (points from the pieces to the puzzle board).

No success--go to Trial 3.
Three or more errors--got to Trial 3.
Two errors--go to Trial 5.

Trial 3. Hint: Identifying Salient Features

The examiner says: "See, this one (round) is the same shape as this hole, so it goes in here." The examiner highlights the shape of the form by tracing it with his/her finger (as the child watches). "And this one (square) is the same shape as this hole, so it goes here" (traces shape with finger). The examiner demonstrates the placement of 4 shapes in this manner and then removes all forms and says: "Now you put each block in the hole where it belongs."

No success--go to Trial 4.
Three or more errors--go to Trial 4.
Two errors--go to Trial 5.

Trial 4. Hint: Suggesting a One-by-One Scheme

The examiner says: "Let's begin again, and this time I'll give you the pieces one by one." The examiner then takes all form pieces and hands them to the child one by one (alternating squares and circles on subtest 1, varying shapes on subtests 2 and 3).

No success--go to Trial 6.
Three or more errors--go to Trial 6.
Two errors--go to Trial 5.

Trial 5. Hint: Helping to Evaluate Correctness of Solution

(Only children who have completed the puzzle with two errors are administered to Trial 5.)

The examiner says: "Are you done?" If the child does not attempt to correct the error, the examiner asks: "Are all the pieces in the right place?" If the child again does not attempt to correct the errors, the examiner asks: "What about this piece?" and points to the incorrectly placed piece.

If the child does not correct the misplacements--go to Trial 6.

Trial 6. Examiner Directed Solution

The examiner says: "Let's try that block in this hole" (points to correct placement). The examiner continues to guide the child (as necessary) until all forms are correctly placed. (All spontaneous correct placements made by the child are noted on the Observation Record Form).

Scoring: See Scoring and Coding Key.

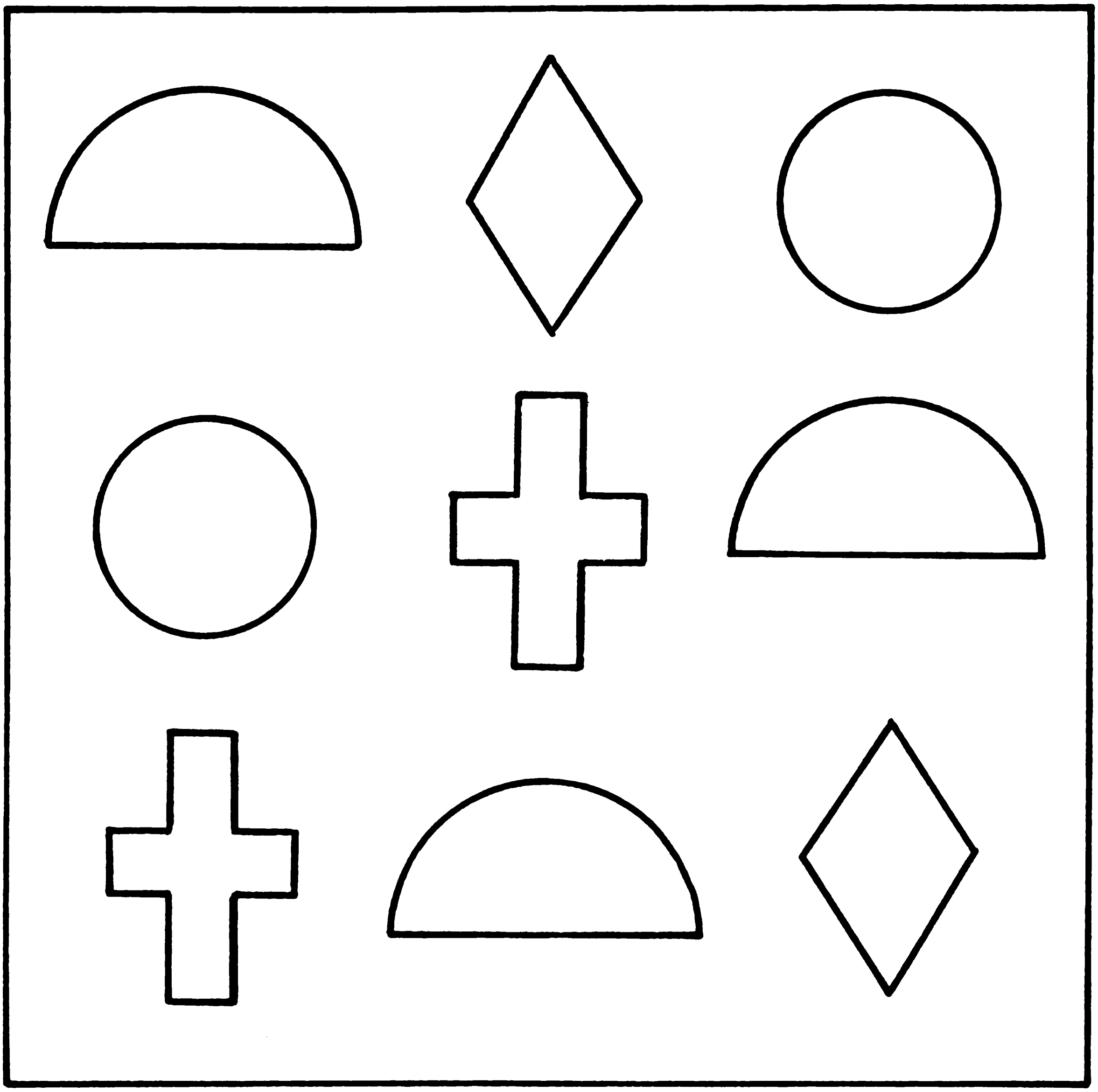
Subtest 2. Level B Form Board (the green form board is administered only if the child successfully completed the puzzle on Trials 1-5 of the level A form board).

Materials: Four-shape form board (9 pieces) and forms.

Procedure:

The procedure for level B is the same as for the level A form board.

Scoring: See Scoring and Coding Key.



Level B Form Board (Green)

True size is 9" by 9"

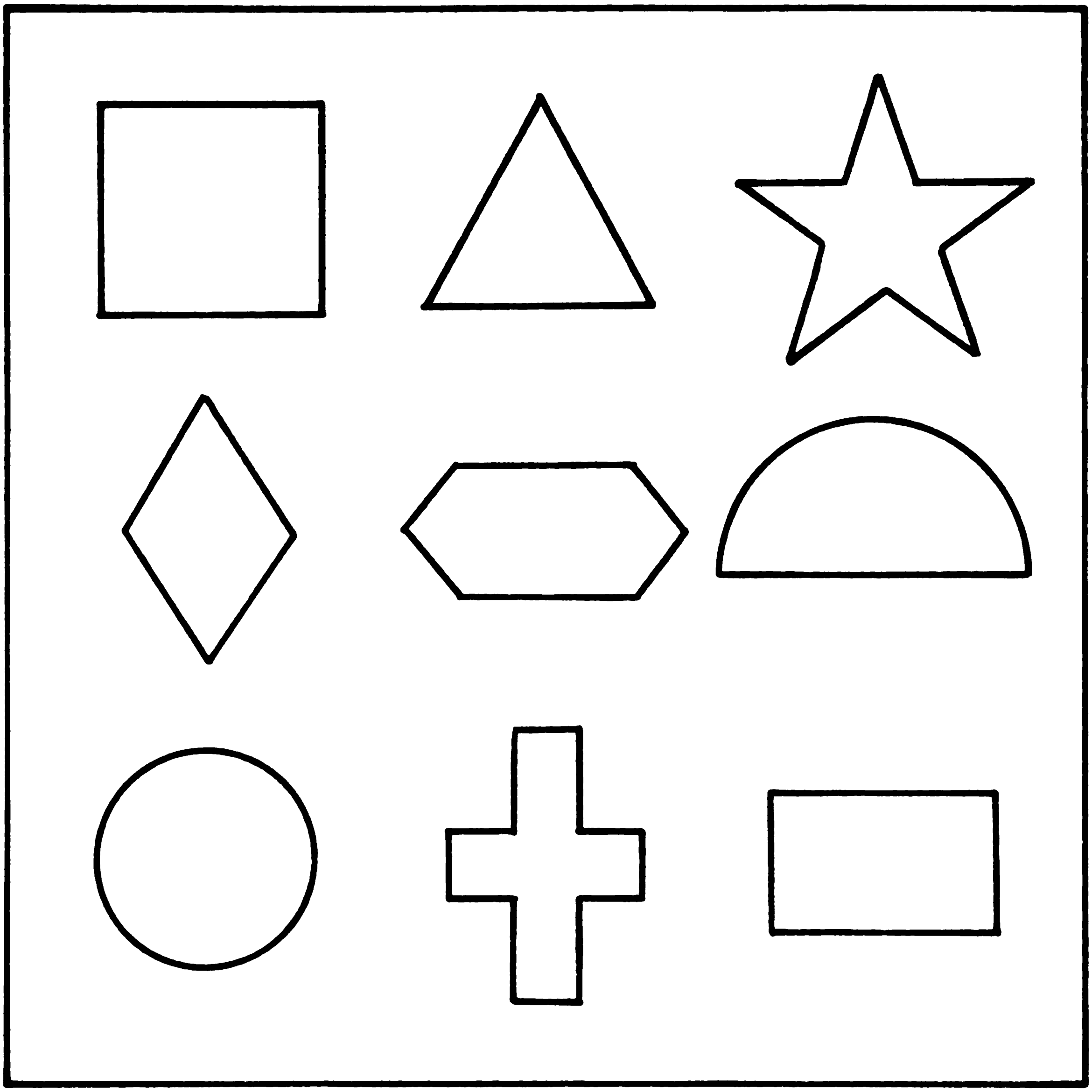
Subtest 3. Level C Form Board (the yellow form board is administered only if the child successfully completed the level B form board on Trials 1-5).

Materials: Four-shape form board (9 pieces) and forms.

Procedure:

The procedure for level C form board is the same as for the level A form board.

Scoring: See Scoring and Coding Key.



Level C Form Board (Yellow)

True size is 9" by 9"

SEARCH STRATEGY TASK

Subtest 4. Frog Search Task.

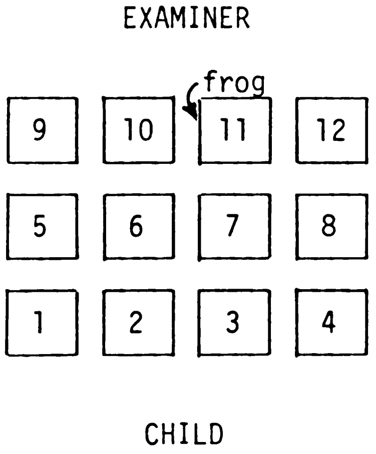
Materials: Seventeen cubical white blocks. Two blocks have a frog painted on one side.

Definitions:

No Success: Child does not solve the problem (find the frog) within 90".

Procedure:

The examiner places 12 blocks in three rows of four each in front of the child, and one of these (see diagram) has a frog painted on it facing down so it cannot be seen.



Trial 1. Problem presented; no hints.

The examiner shows the child the second painted block and says: "See the nice little frog who lives on this block? See how he can hide on the bottom?" (Examiner demonstrates by putting the frog side down on the table and tilting the block up so the child can see the frog on the bottom.) "This frog has a friend who is hiding on one of these blocks (gestures to blocks). Show me how you can find his friend who is hiding here."

No success--go to Trial 2.

Trial 2. Hint: Scheme of Removing the Blocks Examined.

The examiner re-directs the child to the task at hand and encourages him/her to continue the search. The examiner takes away the blocks one by one as the child finishes examining them saying, "Well, we know the frog isn't on this one" until the frog is found.

The task is then repeated with 16 blocks.

Scoring: See Scoring and Coding Key.

SORTING TASKS

Subtest 5. Level A Sorting (By Shape).

Materials: Three boxes, one with a triangle on the cover, one with a square, and one with a circle. Eighteen thin wooden forms, six triangles, six squares, and six circles, all orange.

Definitions:

No Success: The child does not make an attempt to begin the task within 45".
Four or More Errors--The child begins the task but makes (and appears satisfied with) four or more errors.
Three Errors--The child completes the task with three or less errors.

Procedure: Trial 1. No hints.

The examiner says: "I'm going to show you another game. Let's see if you know what to do." The examiner empties each of the three boxes (each containing the appropriate shapes) on the table and mixes them up in a pile. The three boxes are lined up in front of the child.

No success--go to Trial 2.
Four or more errors--go to Trial 2.
Three errors--go to Trial 5.

Trial 2. Hint: Defining the Problem.

The examiner says: "Each of these shapes belongs in a different box." The examiner demonstrates the placement of one shape and then removes it and says: "Put each shape in the box where it belongs for me" (gesturing to the boxes).

No success--go to Trial 3.
Four or more errors--go to Trial 3.
Three errors--go to Trial 5.

Trial 3. Hint: Identifying Salient Features.

The examiner says: "Now, watch. This round block goes in this box (points to circle on box) because the shapes are the same." The examiner highlights the shape of the form by tracing it with his/her finger. "And this one (square) goes in this box (points to square on box) because these shapes are the same" (traces shape with finger). The placement of the triangle is demonstrated in the same manner. The examiner then removes all shapes and says: "Now you put each shape in the box where it belongs."

No success--go to Trial 4.
Four or more errors--go to Trial 4.
Three errors--go to Trial 5.

Trial 4. Hint: Suggesting a One-by-One Scheme.

The examiner says: "Let's begin again, and this time I'll give you pieces one by one." The examiner then takes all pieces and hands them to the child one by one (alternating shapes on subtest 5, varying colors on subtest 6).

No success--go to Trial 6.
Four or more errors--go to Trial 6.
Three errors--go to Trial 5.

Trial 5. Hint: Helping to Evaluate Correctness of Solution.

(Only children who completed the sorting with three or less errors are administered Trial 5.)

The examiner says: "Are you done?" If the child does not attempt to correct the errors, the examiner asks: "Are all the pieces in the right box?" If the child again does not attempt to correct the errors, the examiner asks: "What about this piece?" and points to an incorrectly placed piece.

If the child does not correct the errors--go to Trial 6.

Trial 6. Examiner Directed Solution.

The examiner says: "Let's try that shape in this box" (points to correct placement). The examiner continues to guide the child (as necessary) until all forms are correctly placed. (All spontaneous correct placements made by the child are noted on the Observation Record Form.)

Scoring. See Scoring and Coding Key.

Subtest 6. Level B Sorting (By Color)

Materials: Four boxes, on red, one blue, one green, one white; and 24 chips, 6 red, 6 blue, 6 green, and 6 white.

Procedure:

The procedure for level B sorting is the same as that outlined in level A sorting, substituting color for shape.

Scoring: See Scoring and Coding Key.

Part II. Impulsivity-Reflectivity Rating

Procedure:

The examiner rates the child's performance on the behaviors outlined on the following page at the end of the first and second testing session. The examiner does not review the first ratings until the second are completed.

Scoring: See Scoring and Coding Key.

Part III. Task Persistence Rating

Procedure:

The number of times the child is encouraged, praised, or re-directed to the task at hand by the examiner during the administration of the Preschool Problem Solving Competence Tests is tallied from a tape recording.

Scoring: See Scoring and Coding Key.

Observer: ____________________ I.D. __________

IMPULSIVITY

	Rarely	Sometimes	Usually
1. Waits for instructions before beginning tasks when appropriate, e.g., search strategy task.			
2. Makes "careless" mistakes.			
3. Hesitates when unsure of self; asks questions when unsure of self.			
4. Short work span; jumps to something else before completing task-at-hand.			
5. Picks up and manipulates small test materials (e.g., color chips) patiently.			
6. "Rushes" through tasks; seems to be stuck in "fast gear."			
7. Attempts to correct unsatisfactory solutions to tasks, i.e., "tries again" if not satisfied with outcome.			
8. Daydreams, inattentive to surroundings.			

9. Which of the following best describes this child's response style?

___ fast - accurate
___ fast - inaccurate
___ slow - accurate
___ slow - inaccurate

DISTRACTIBILITY/ACTIVITY

10. Easily distracted by noises or objects in testing environment.			
11. Rough or "aggressive" with test materials, i.e., throws, bangs together.			
12. Unable to sit still.			

*** When in doubt, score conservatively, that is, give the child the benefit of the doubt.

Preschool Problem Solving Competence Test

Scoring and Coding Key

Information	Value Labels	Column
I.D.		1-2-3 ☐☐☐
Card Number	06	4-5 ☐☐
FORM BOARDS: BLUE		
Approach (check one)		
___ trial & error	trial & error = 1	
___ transitional	transitional = 2	
___ visually guided	visually guided = 3	6 ☐
Hints Needed (check all that apply)		
___ defining the problem	yes = 1, No = 0	7 ☐
___ identifying salient features	yes = 1	8 ☐
___ suggestion of one-by-one scheme	yes = 1	9 ☐
___ evaluating correctness of solutions	yes = 1	10 ☐
___ examiner-directed solution (trial 6)	yes = 1	11 ☐
Scoring - Self-Direction and Planning		
___ number of hints needed (above)	no hints = 5 1 hint = 4 2 hints = 3 3 hints = 2 4 hints = 1 examiner-directed = 0	12 ☐
Scoring - Independent Solutions		
___ number of correct solutions child spontaneously achieves on any trial (1-6)	9 correct = 5 7 correct = 4 5 correct = 3 3 correct = 2 1 correct = 1	13 ☐

Information	Value Labels	Column
FORM BOARDS: GREEN		
Approach (check one)		
___ trial & error	trial & error = 1 transitional = 2 visually-guided = 3	
___ transitional		
___ visually-guided		14 ☐
Hints Needed (check all that apply)		
___ defining the problem	yes = 1, no = 0	15 ☐
___ identifying salient features	yes = 1	16 ☐
___ suggestion of one-by-one scheme	yes = 1	17 ☐
___ evaluating correctness of solutions	yes = 1	18 ☐
___ examiner-directed solution (trial 6)	yes = 1	19 ☐
Scoring - Self-Direction and Planning		
___ number of hints needed (above)	no hints = 5 1 hint = 4 2 hints = 3 3 hints = 2 4 hints = 1 examiner-directed = 0	20 ☐
Scoring - Independent Solutions		
___ number of correct solutions child spontaneously achieves on any trial (1-6)	9 correct = 5 7 correct = 4 5 correct = 3 3 correct = 2 1 correct = 1	21 ☐
FORM BOARDS: YELLOW		
Approach (check one)		
___ trial & error	trial & error = 1 transitional = 2 visually-guided = 3	
___ transitional		
___ visually-guided		22 ☐

Information	Value Labels	Column
(YELLOW FORM BOARD CONTINUED)		
Hints Needed (check all that apply)		
___ defining the problem	yes = 1, no = 0	23 ☐
___ identifying salient features	yes = 1	24 ☐
___ suggestion of one-by-one scheme	yes = 1	25 ☐
___ evaluating correctness of solutions	yes = 1	26 ☐
___ examiner-directed solution (trial 6)	yes = 1	27 ☐
Scoring - Self-Direction and Planning		
___ number of hints needed (above)	no hints = 5 1 hint = 4 2 hints = 3 3 hints = 2 4 hints = 1 examiner directed = 0	28 ☐
Scoring - Independent Solutions		
___ number correct solutions child spontaneously achieves on any trial (1-6)	9 correct = 5 7 correct = 4 5 correct = 3 3 correct = 2 1 correct = 1	29 ☐
SEARCH STRATEGY TASK: FROG 1		
Scheme		
___ uses guessing game approach, no discernible pattern	no pattern = 1 partial: forgets = 2 partial: develops = 3 partial: ignores = 4 rows = 5 columns = 6 re-groups = 7 sets aside = 8	
___ partial scheme: forgets		
___ partial scheme: develops		
___ partial scheme: ignores		
___ true scheme: rows		
___ true scheme: columns		
___ spontaneously re-groups		
___ spontaneously sets aside		30 ☐

Information	Value Labels	Column
(FROG 1 CONTINUED)		
Scheme Level		
	no pattern = 1 partial: forgets = 2 partial: develops = 3 partial: ignores = 3 rows = 4 columns = 4 re-groups = 5 sets aside = 5	31 ☐
Hints Needed		
____ scheme of elimination	yes = 1, no = 0	32 ☐
____ examiner-directed	yes = 1	33 ☐
Scoring - Self-Direction and Planning		
____ number of hints (above)	no hints = 2 1 hint = 1 examiner-directed = 0	34 ☐
Scoring - Independent Efficient Solution		
____ number of times the child re-examined the same block twice	no repeats = 5 1-2 repeats = 4 3-4 = 3 5-6 = 2 more than 6 = 1	35 ☐
SEARCH STRATEGY TASK: FROG 2		
Scheme (check one)		
____ uses guessing game approach, no discernible pattern ____ partial scheme: forgets ____ partial scheme: develops ____ partial scheme: ignores ____ true scheme: rows ____ true scheme: columns ____ spontaneously re-groups ____ spontaneously sets aside	no pattern = 1 partial: forgets = 2 partial: develops = 3 partial: ignores = 4 rows = 5 columns = 6 re-groups = 7 sets aside = 8	36 ☐

Information	Value Labels	Column
(FROG 2 CONTINUED)		
Scheme Level	no pattern = 1 partial: forgets = 2 partial: develops = 3 partial: ignores = 3 rows = 4 columns = 4 re-groups = 5 sets aside = 5	37 ☐
Hints Needed		
___ scheme of elimination	yes = 1, no = 0	38
___ examiner-directed solution	yes = 1, no = 0	39 ☐
Scoring - Self-Direction and Planning		
___ number of hints (above)	no hints = 2 1 hint = 1 examiner-directed = 0	40 ☐
Scoring - Independent Efficient Solution		
___ number of times the child re-examines the same block twice	no repeats = 5 1-2 repeats = 4 3-4 = 3 5-6 = 2 more than 6 = 1	41 ☐
SORTING: BY SHAPE		
Scheme (check one)		
___ no spontaneous scheme (trial 5)	no scheme = 1 one shape = 2	
___ one shape at a time	alternating = 3 any shape = 4	
___ alternating shapes		
___ any shape, no pattern		42 ☐
Scheme Level	no scheme = 1 one shape = 2 alternating = 2 any shape = 3	43 ☐

Information	**Value Labels**	**Column**
(SORTLING BY SHAPE CONTINUED)		
Hints Needed (check all that apply)		
____ defining the problem	yes = 1, no = 0	44 ☐
____ identifying salient features	yes = 1	45 ☐
____ suggestion of one-by-one scheme	yes = 1	46 ☐
____ evaluating correctness of solutions	yes = 1	47 ☐
____ examiner-directed solution	yes = 1	48 ☐
Scoring - Self-Direction and Planning		
____ number of hints (above)	no hints = 5 1 hint = 4 2 hints = 3 3 hints = 2 4 hints = 1 examiner-directed = 0	49 ☐
Scoring - Independent Solutions		
____ number of correct solutions child spontaneously achieves on any trial (1-6)	18 correct = 5 17 correct = 4 16 correct = 3 15 correct = 2 14 correct = 1	50 ☐
SORTING: BY COLOR		
Scheme (check one)		
____ no spontaneous scheme (trial 4)	no scheme = 1	
____ one color at a time	one color = 2	
____ alternating colors	alternating = 3	
____ any color, no pattern	any color = 4	51 ☐
Scheme Level		
	no scheme = 1 one color = 2 alternating = 2 any color = 3	52 ☐

Information	Value Labels	Column
(SORTING BY COLOR CONTINUED)		
Hints Needed (check all that apply)		
____ defining the problem	yes = 1, no = 0	53 ☐
____ identifying salient features	yes = 1	54 ☐
____ suggestion of one-by-one scheme	yes = 1	55 ☐
____ evaluating correctness of solutions	yes = 1	56 ☐
____ examiner-directed solution	yes = 1	57 ☐
Scoring - Self-Direction and Planning		
____ number of hints (above)	no hints = 5 1 hint = 4 2 hints = 3 3 hints = 2 2 hints = 1 examiner-directed = 0	58 ☐
Scoring - Independent Solutions		
____ number of correct solutions child spontaneously achieves on any trial (1-6)	24 correct = 5 23 correct = 4 22 correct = 3 21 correct = 2 20 correct = 1	59 ☐

IMPULSIVITY/DISTRACTIBILITY/ACTIVITY

Examiner - First Session	Rarely/ Never	Sometimes	Often/ Usually	
(1) Waits for instructions.	1	2	3	114 ☐
(2) Careless mistakes.	3	2	1	115 ☐
(3) Hesitates when unsure.	1	2	3	116 ☐
(4) Short work span.	3	2	1	117 ☐
(5) Manipulates easily.	1	2	3	118 ☐
(6) Rushes.	3	2	1	119 ☐
(7) Corrects self.	1	2	3	120 ☐
(8) Daydreams.	3	2	1	121 ☐

Information	Value Labels			Column	
IMPULSIVITY CONTINUED)					
	Rarely/ Never	Sometimes	Often/ Usually		
(10) Easily distracted.	3	2	1	123	☐
(11) Rough or aggressive.	3	2	1	124	☐
(12) Unable to sit still.	3	2	1	125	☐
	Enter total..................			126-127	☐☐
Observer - First Session					
(1) Waits for instructions.	1	2	3	128	☐
(2) Careless mistakes.	3	2	1	129	☐
(3) Hesitates when unsure.	1	2	3	130	☐
(4) Short work span.	3	2	1	131	☐
(5) Manipulates easily.	1	2	3	132	☐
(6) Rushes.	3	2	1	133	☐
(7) Corrects self.	1	2	3	134	☐
(8) Daydreams.	3	2	1	135	☐
(9) Response style:					
	fast - accurate = 4 fast - inaccurate = 1 slow - accurate = 3 slow - inaccurate = 2			136	☐
(10) Easily distracted.	3	2	1	137	☐
(11) Rough or aggressive.	3	2	1	138	☐
(12) Unable to sit still.	3	2	1	139	☐
	Enter total..................			140-141	☐☐
Examiner - Second Session					
(1) Waits for instructions.	1	2	3	142	☐
(2) Careless mistakes.	3	2	1	143	☐

Information	Value Labels			Column	
	Rarely/ Never	Sometimes	Often/ Usually		
(IMPULSIVITY CONTINUED)					
(3) Hesitates when unsure.	1	2	3	144	☐
(4) Short work span.	3	2	1	145	☐
(5) Manipulates easily.	1	2	3	146	☐
(6) Rushes.	3	2	1	147	☐
(7) Corrects self.	1	2	3	148	☐
(8) Daydreams.	3	2	1	149	☐
(9) Response style:	fast - accurate = 4 fast - inaccurate = 1 slow - accurate = 3 slow - inaccurate = 2			150	☐
(10) Easily distracted.	3	2	1	151	☐
(11) Rough or aggressive.	3	2	1	152	☐
(12) Unable to sit still.	3	2	1	153	☐
	Enter total....................			154-155	☐☐
CARD NUMBER	00001-99999			156-157-158-159-160	

APPENDIX D

PERSONAL-SOCIAL DEVELOPMENT QUESTIONNAIRE

PERSONAL-SOCIAL DEVELOPMENT QUESTIONNAIRE

The following is a list of items describing children's personal-social growth...the things children learn to do as they grow and become more and more capable of looking after themselves and getting along with family members and friends. Your responses to the checklist below will help us learn more about your child's personal-social development. The items include descriptions of things children learn between the ages of two and six years old, so some of the items may not apply to your child. Please circle the number at the right which best describes your preschooler now.

	NEVER	SOMETIMES	ALMOST ALWAYS
1. Overcomes simple obstacles; opens doors, climbs up on chairs; uses a stool for reaching.	1	2	3
2. Uses "I" or "me" to refer to himself.	1	2	3
3. Eats with a spoon.	1	2	3
4. Helps put his own toys away.	1	2	3
5. Puts on his own shoes except for tying.	1	2	3
6. Unbuttons clothing by working the button through the buttonhole rather than simply pulling the two sides of the garmet apart.	1	2	3
7. Asks to go to the toilet (by actions, gestures, or speech).	1	2	3
8. Can pour from a small pitcher into a cup without spilling.	1	2	3
9. Has learned to take turns with another person and will wait for his turn.	1	2	3
10. Washes and dries has own face and hands.	1	2	3
11. Plays cooperatively with other children.	1	2	3
12. Does simple errands or chores around the house such as helping to set the table, dusting, feeding pets, picking up things.	1	2	3
13. Laces his shoes.	1	2	3

	NEVER	SOMETIMES	ALMOST ALWAYS
14. Dresses and undresses himself with supervision.	1	2	3
15. Can feed himself a complete meal, without help, using a spoon or fork, with little spilling (except for cutting meat).	1	2	3
16. Plays a chosen role such as mother, father, or baby when playing with other children.	1	2	3
17. Is usually dry during the day; no accidents.	1	2	3
18. Walks down stairs unassisted, one step per tread.	1	2	3
19. Goes to the toilet alone, without help.	1	2	3
20. Gives a simple account of experiences or tells stories with a beginning and an end.	1	2	3

21. "Performs" for others; does little stunts imaginatively or for the entertainment of others, such as singing dancing, or reciting.	YES	NO
22. Knows a few nursery rhymes or songs.	YES	NO
23. Prints simple words of 3 or 4 letters from memory (not using a copy).	YES	NO
24. Goes about the neighborhood unsupervised.	YES	NO

Thank you.

APPENDIX E

FAMILY BACKGROUND INFORMATION FORM

FAMILY BACKGROUND INFORMATION

(1) Who are the child's caretakers? Please check two:

_____ natural mother	_____ natural father
_____ adopted or foster mother	_____ adopted or foster father
_____ step-mother	_____ step-father
_____ other female, please specify	_____ other male, please specify
_____ no adult female in home	_____ no adult male in home

(2) Please describe your occupation and that of your spouse:

(a) Mother's occupation:

(b) Father's occupation:

(3) Which of the following best describes your educational attainment and that of your spouse:

Mother	Father	
_____	_____	less than high school
_____	_____	high school graduate
_____	_____	some college, but less than B.A. or B.S.
_____	_____	B.A., B.S.
_____	_____	5-year degree, Master's degree
_____	_____	Ph.D., M.D., other advanced degree(s)

(4) Please list below the birth dates of the children in the family under the appropriate columns.

	Males	Females
EXAMPLE	1-13-56	3-26-63

(5) Who currently cares for your child during the week days?

_____ family member, please specify:

_____ babysitter

_____ day care center

_____ nursery school

(6) Please indicate during which of the following school years your child attended a day care center or nursery school.

_____ 1976-1977 Part time _____ or full time _____

_____ 1977-1978 Part time _____ or full time _____

_____ 1978-1979 Part time _____ or full time _____

_____ 1979-1980 Part time _____ or full time _____

(7) Has your child ever been referred for special education services?

_____ yes _____ no

If yes, what was the reason for referral?

(8) Has your child ever received special education services?

_____ yes _____ no

If yes, what types of services did he or she receive?

Thank you very much for your help.

APPENDIX F

LETTERS TO PARENTS

EDWARD W. SPARROW HOSPITAL
ASSOCIATION

1215 EAST MICHIGAN AVENUE · P. O. BOX 30480 · LANSING, MICHIGAN 48909 · TELEPHONE 517 487-6111

Dear Mr. and Mrs.

We would like to invite you and your 3 year old to participate in a study of the developmental progress of children born prematurely in 1976 and 1977. The study is being conducted by Susan Jacob, a child development specialist who is experienced in working with preschool children. Miss Jacob was a member of the Developmental Assessment Clinic staff last year, and she is familiar with our goals, objectives, and procedures.

As you may know, reports in the medical literature suggest that approximately 80-95% of the children born prematurely will show normal patterns of growth and development. Miss Jacob's study is designed to gather up-to-date information about the developmental progress of pre-term children who received special care here at Sparrow Hospital. Your participation in this project is important to us for two reasons. First, the information gathered will allow us to speak more confidently to future parents about the early development of prematurely born children. Not long ago you experienced some of the uncertainties associated with parenting a pre-term infant, so you know how helpful this up-to-date information might be to new mothers and fathers of pre-term babies. Your participation in the study will also provide us with some feedback about how well we help premature children through difficult times in the intensive care unit.

If you choose to participate in the study, arrangements will be made for Miss Jacob to visit you and your child at home. The developmental assessment tasks selected for the study are game-like and fun for the children. An information sheet prepared by the researchers is enclosed.

As your involvement with the Developmental Assessment Clinic is a confidential matter, we will not release your name to Miss Jacob without your permission. If you are interested in participating in the study, please return the postcard enclosed.

We feel that research of this nature is needed if we hope to find ways of helping all children reach their full potential in life. We know you share this belief, and we hope you will help us with this project.

Thank you for your thoughtful consideration of this matter.

Sincerely,

Eugene A. Dolanski md

P. Karna

Eugene A. Dolanski, M.D.
Director of Newborn Services

Padmani Karna, M.D.
Neonatologist

M Mennesson

Michel Mennesson, M.D.
Neonatologist

Was your preschooler born between March 1, 1976 and November 1, 1977?

We would like to invite you and your preschooler to participate in a study of the developmental progress of children born prematurely and maturely in 1976 and 1977. The primary purpose of the study is to gather up-to-date information about the developmental progress of pre-term children who received special care at Sparrow Hospital in Lansing. We feel this study is important for two reasons. First, results of the study will provide the staff at Sparrow Hospital with some feedback about how well they help premature children through difficult times in the neonatal intensive care unit. Second, the information gathered will allow physicians to speak more confidently to new parents about the early development of prematurely born children.

In order to understand the developmental patterns of the pre-term children in our study, however, **we must also gather information about the early development of maturely born children. We are currently seeking families with preschoolers born full-term (approximately 40 weeks gestation) with birth dates between March 1, 1976 and November 1, 1977 to help us with our project.** If you choose to participate in the study, a child development specialist will visit you and your preschooler at home. The developmental assessment tasks selected for the study are game-like and fun for the children. All information gathered by the researchers will be held in strictest confidence. (Additional information appears on the following pages).

We feel that research of this nature is needed if we hope to find ways of helping all children reach their full potential in life. We know you share this belief as parents, and we hope you will help us with this project.

Susan Jacob, Principal Researcher
Kelly, Sandy, Lori, Cathy, and Louise,
Research Assistants

What does participation in the study involve?

We anticipate the study will require two home visits of about 50 minutes each. These visits will be scheduled at your convenience during the summer months or in the early fall (depending on your child's date of birth). Saturday and Sunday appointments will be available. During the home visits the principal researcher will work with your preschooler on a variety of tasks designed to measure speech and language development, mental growth, and perceptual maturation. These tasks are game-like and fun for the children.

What will be done with the information gathered?

A summary report will be prepared describing the early development of children born prematurely and maturely based on the findings from all of the children who participate in the study. No information will ever be released in a way in which you or your child could be identified. Area pediatricians and study volunteers will receive a copy of the summary report.

What happens next?

If you are interested in participating in the study, please complete the enclosed volunteer form. Children from both single-parent and two-parent families are needed.

One requirement of good research is that children in each of the groups being studied come from similar backgrounds. Because it is important to match the two study groups (prematurely and maturely born children) on certain background variables, most but not all volunteers will be needed for the study. However, all families who volunteer will receive a copy of the summary report whether or not they participate. **In addition, the names of all volunteer families will be entered in a drawing. The prize is a $50.00 Sears Roebuck and Company gift certificate donated by an area physician to encourage families to volunteer for the study.**

Please be advised that you may withdraw your consent to participate at any time.

Project Support and Approval

This study was designed by the principal researcher in partial fulfillment of the requirements for a Doctorate in Education. The project has been approved by the Michigan State University Committee on Research Involving Human Subjects and the Institutional Research Review Committee at Sparrow Hospital. At this time the cost of the study is being born solely by the research team members.

A Study of the Developmental Progress of Prematurely and Maturely Born Preschoolers

Study Volunteer Form

The information requested below will help us match our two study groups on background variables. All information will be held in strictest confidence.

Child's Name: ______________________________ Sex: Male Female

Parents' Names: ______________________________

Address: ______________________________

____

Telephone: ____________________

Child's Date of Birth: ____________ Birth Weight: ____________________

First Born Child: Yes No Single Birth (not twins): Yes No

Race: Black White Oriental Mother's Age: __________

Mother's Occupation: ______________________________

Father's Occupation: ______________________________

Pediatrician or Family Doctor: ______________________________

Was this child a full term baby? Yes No Unsure

....

Please forward this form to the principal researcher via the pre-stamped envelope provided. A member of the research team will contact you during the summer months, and we will be happy to answer any questions you may have at that time. Thank you very much for your cooperation.

Susan Jacob, Principal Researcher
Kelly, Sandy, Lori, Cathy, and Louise,
Research Assistants

Return Address: Developmental Assessment Clinic - 7th Foster, E.W. Sparrow Hospital, 1215 E. Michigan Ave., Lansing, Michigan 48909 or Susan Jacob, 3227 Holiday Dr., Apt. 10, Lansing, Michigan 48912

APPENDIX G

CONSENT TO PARTICIPATE FORMS

Susan Jacob

Consent to Participate

A Study of Early Developmental Outcomes
For Children Born Prematurely in
the Mid-Seventies

I ________________________________ agree to participate, along with my child, in the above mentioned study. The nature of the study and the processes involved have been adequately explained to me, and even though I give my consent at this time, I understand that I may, at any time, withdraw without penalty from the study and retract my permission to use any information obtained.

I have been assured that all information will be held in the strictest confidence, and I have been offered an explanation of the findings at the conclusion of the project.

____

Signature of Parent or Legal Guardian   Date

Susan Jacob
Jeff Roach

Permission to Maintain Records For Follow-Up Research

A Study of School-Age Outcomes For Children Born Prematurely in the Mid-Seventies

I ________________________________ consent to having the research information for my child kept on file with the Developmental Assessment Clinic at Sparrow Hospital for a follow-up study in 1984-85. The nature of the planned follow-up study has been explained to me, and even though I give my consent at this time, I understand I may, at any time, withdraw my permission, without penalty, and the records on file pertaining to my child will be removed and destroyed.

I have been informed that the research information will be stored separately from other clinic records, and only the principal researchers involved with the follow-up project will have access to these records. I have been assured that all information will be held in strictest confidence. I have also been informed that, if the researchers are unable to locate me at the time of the follow-up study, any information pertaining to my child will be removed and destroyed at that time.

____

Signature of Parent or Legal Guardian Date

REFERENCES

REFERENCES

Abrams, S. The upper weight level premature child. Diseases of the Nervous System, 1969, 30, 414-417.

Avery, G. B. (Ed.). Neonatology. Philadelphia: J. B. Lippincott Co., 1975.

Bacola, E., Behrle, F. C., de Schweinitz, L., Miller, H. C., & Mira, M. Perinatal and environmental factors in late neurogenic sequaelae. 1. Infants having birthweights under 1,500 grams. American Journal of Diseases of Children, 1966, 112, 359.

Balow, B., Rubin, R., & Rosen, M. Perinatal events as precursors of reading disability. Reading Research Quarterly, 1975-76, 11(1), 36-71.

Bakketeig, L. S. The risk of repeated preterm or low birth weight delivery. In D. M. Reed & F. J. Stanley (Eds.), The epidemiology of prematurity. Baltimore: Urban & Schwarzenberg, 1977.

Bayley, N. Manual for the Bayley scales of infant development. New York: The Psychological Corporation, 1969.

Beckwith, L., & Cohen, S. Preterm birth: Hazardous obstetrical and postnatal events as related to caregiver-infant behavior. Infant Behavior and Development, 1978, 1, 403-411.

Beckwith, L., Cohen, S. E., Kopp, C. B., Parmelee, A. J., & Marcy, T. Caregiver-infant interaction and early cognitive development in preterm infants. Child Development, 1976, 47, 579-587.

Bell, D. A., Taylor, W. C., & Dockrell, W. B. A ten year follow-up of low birthweight infants: Intellectual functioning. Alberta Journal of Educational Research, 1965, 11, 220-225.

Bell, R. Q. A reinterpretation of the direction of effects in studies of socialization. Psychological Review, 1968, 75(2), 81-95.

Bender, L. A visual motor gestalt test and its clinical use. Research Monograph No. 3. New York: The American Orthopsychiatric Association, 1938.

Benton, A. L. Mental development of prematurely born children. A critical review of the literature. American Journal of Orthopsychiatry, 1940, 10, 719.

Beyrl, F. Uber die Grussenauffassung bei Kindern. Zeitshrift für Psychologic, 1926, 100, 344-371.

Brady, M. L. An examination of the team process in a regional neonatal developmental assessment clinic. Unpublished doctoral dissertation, Midwest Union for Experimenting Colleges and Universities, 1979.

Brooks, J., & Wienraub, M. A history of intelligence testing. In M. Lewis (Ed.), Origins of intelligence: Infancy and early childhood. New York: Plenum Press, 1976.

Budoff, M., & Hamilton, J. L. Optimizing test performance of moderately and severely mentally retarded adolescents and adults. American Journal of Mental Deficiency, 1976, 81, 49-57.

Caplan, H., Bibace, R., & Rabinovitch, M. S. Paranatal stress, cognitive organization and ego functions: A controlled follow-up study of children born prematurely. In E. N. Rexford, L. W. Sander, & T. Shapiro (Eds.), Infant psychiatry. New Haven: Yale University Press, 1976.

Caputo, D. V., Goldstein, K. M., & Taub, H. B. The development of prematurely born children through middle childhood. In T. Field, A. Sostek, S. Goldberg, & H. H. Shuman (Eds.), Infants born at risk. New York: Spectrum, 1978.

Caputo, D., & Mandell, W. Consequences of low birth weight. Developmental Psychology, 1970, 3, 363-383.

Caputo, D., Taub, H. B., Goldstein, K. M., Smith, N., Dalack, J. D., Pursner, J. P., & Silverstein, R. M. An evaluation of various parameters of maturity at birth as predictors of development at one year. Perceptual and Motor Skills, 1974, 39, 631-652.

Carlson, J. S., & Wiedl, K. H. Use of testing-the-limits procedures in the assessment of intellectual capabilities of children with learning difficulties. American Journal of Mental Deficiency, 1978, 82, 559-564.

Cattell, P. Cattell infant intelligence scale. New York: The Psychological Corporation, 1960.

Cohen, J. The factorial structure of the WISC at ages 7-6, 10-6, and 13-6. Journal of Consulting Psychology, 1959, 23, 285-299.

Cohen, J. Statistical power analysis for the behavioral sciences. New York: Academic Press, 1969.

Colligan, R. C. Psychometric deficits related to perinatal stress. Journal of Learning Disabilities, 1974, 7, 154-160.

Corrigan, F. V., Berger, S. T., Dienstbier, R. A., & Srok, E. S. The influence of prematurity on school performance. American Journal of Mental Deficiency, 1967, 71, 533.

Dann, M., Levine, S. Z., & New, E. V. The development of prematurely born children with birth weights or minimal postnatal weights of 1,000 grams or less. Pediatrics, 1958, 22, 1037.

Dann, M., Levine, S. Z., & New, E. V. A long-term follow-up study of small, premature infants. Pediatrics, 1964, 33, 945-955.

Darley, F. L. Evaluation of appraisal techniques in speech and language pathology. Reading, Mass.: Addison-Wesley Publishing Co., 1979.

Davies, P., & Stewart, A. L. Low birth-weight infants: Neurological sequelae and later intelligence. British Medical Bulletin, 1975, 31, 85-91.

De Hirsch, K., Jansky, J., & Langford, W. S. Comparisons between prematurely and maturely born children at three age levels. American Journal of Orthopsychiatry, 1966, 36, 616-628.

De Hirsch, K., Janskey, J., & Langford, W. S. Predicting reading failure. New York: Harper & Row, 1966.

Dingman, H., & Tarjan, G. Mental retardation and the normal distribution curve. American Journal of Mental Deficiency, 1960, 64, 991-994.

DiVitto, B., & Goldberg, S. The development of early parent-infant interaction as a function of newborn medical status. In T. Field, A. Sostek, S. Goldberg, & H. H. Shuman (Eds.), Infants born at risk. Holliswood, N.Y.: Spectrum, 1978.

Doll, E. A. (Ed.). The Oseretsky test of motor proficiency. Minneapolis: Educational Test Bureau, 1946.

Doll, E. A. Vineland social maturity scale: Condensed manual of directions (Rev. ed.). Circle Pines, Minn.: American Guidance Service, 1965.

Douglas, J. W. B. Mental ability and school achievement of premature children at 8 years of age. British Medical Journal, 1956, 1, 1210-1214.

Douglas, J. W. B. "Premature" children at primary schools. British Medical Journal, 1960, 1, 1008-1013.

Drillien, C. M. The growth and development of the prematurely born infant. Baltimore: Williams & Wilkins, 1964.

Drillien, C. M. Growth and development in a group of children of very low birth weight. Archives of Disease in Childhood, 1958, 33, 10.

Drillien, C. M. School disposal and performance for children of different birthweight born 1953-1960. Archives of Disease in Childhood, 1969, 44, 562-570.

Drillien, C. M. The incidence of mental and physical handicaps in school-age children of very low birth weight. Pediatrics, 1961, 27, 452.

Drillien, C. M. Aetiology and outcome in low-birth-weight infants. Developmental Medicine and Child Neurology, 1972, 14, 563-574.

Dubois, D. R. Indications of an unhealthy relationship between parents and premature infant. Journal of General Nursing, 1975, 4(3), 21-24.

Duncan, O. D. A socioeconomic index for all occupations. In J. Reiss, Jr. (Ed.), Occupations and social status. New York: Free Press of Glencoe, 1961.

Durost, W. M. (Ed.). Metropolitan achievement tests. New York: Harcourt, Brace, & World, Inc., 1961.

Durrell, D. The Durrell analysis of reading difficulty. New York: World Book Co., 1955.

Dweck, H. S., Saxon, S. A., Benton, J. W., & Cassady, G. Early development of the tiny premature infant. American Journal of Diseases of Childhood, 1973, 126, 28-34.

Estes, W. K. Learning theory and intelligence. American Psychologist, 1974, 29, 740-749.

Feldhusen, J. F. Problem solving and the concrete-abstract dimension. Gifted Child Quarterly, 1975, 19, 122-129.

Feldhusen, J. F., Houtz, J. C., & Ringenbach, S. The Purdue Elementary Problem-Solving Inventory. Psychological Reports, 1972, 31, 891-901.

Field, T. M. Effects of early separation, interactive deficits, and experimental manipulations on infant-mother face-to-face interaction. Child Development, 1977, 48(3), 763-771. (a)

Field, T. M. Maternal stimulation during infant feeding. Developmental Psychology, 1977, 13, 539-540. (b)

Fitzhardinge, P. M., & Ramsay, M. The improving outlook for the prematurely born infant. Developmental Medicine and Child Neurology, 1973, 15(4), 447-459.

Flavell, J. H. Cognitive development. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1977.

Francis-Williams, J., & Davies, P. A. Very low birth weight and later intelligence. Developmental Medicine and Child Neurology, 1974, 16, 709-728.

Frankenburg, W. K., & Drumwright, M. A. Denver articulation screening exam. Colorado: University of Colorado Medical Center, 1971.

Furth, H. G. Piaget, IQ, and the nature-nuture controversy. Human Development, 1973, 16, 61-73.

Gesell, A. L., & Amatruda, C. S. Developmental diagnosis: Normal and abnormal child development. New York: Paul B. Hoeber, Inc., 1941.

Gesell, A. L., & Amatruda, C. S. Developmental diagnosis. New York: Paul B. Hoeber, 1945.

Goldberg, S. Prematurity: Effects on parent-infant interaction. Journal of Pediatric Psychology, 1978, 3(3), 137-144.

Goldstein, K. M., Caputo, D. V., & Taub, H. B. The effects of prenatal and perinatal complications on development at one year of age. Child Development, 1976, 47(3), 613-621.

Goodenough, F. L. Measurement of intelligence by drawings. Yonkers, N.Y.: World Book Co., 1926.

Gray, W. S. Gray oral reading test. New York: Bobbs-Merrill Co., Inc., 1963.

Halstead, W. C. Brain and intelligence. Chicago: University of Chicago Press, 1947.

Hartlage, L. C., & Telzrow, C. F. Specific preschool medical findings which predict specific learning outcomes. Paper presented to the Association for Children with Learning Disabilities International Conference, Atlanta, February 1981. (a)

Hartlage, L. C., & Telzrow, C. F. Using familiar tests for preschool neuropsychological assessment. Paper presented to the Annual Meeting of the National Association of School Psychologists, Houston, April 1981. (b)

Harmeling, J. D., & Jones, M. B. Birthweights of high school dropouts. American Journal of Orthopsychiatry, 1968, 38, 63-65.

Harper, P. A., Fischer, L. K., & Rider, J. V. Neurological and intellectual status of prematures at three to five years of age. Journal of Pediatrics, 1959, 55, 679-690.

Harper, P. A., & Wiener, G. Sequelae of low birth weight. Annual Review of Medicine, 1965, 16, 405-420.

Hawkins-Walsh, E. Diminishing anxiety in parents of sick newborns. Maternal-Child Nursing Journal, 1980, 5, 30-34.

Hildredth, G., Griffiths, N., & McGauvran, M. Metropolitan readiness tests: Manual of directions. New York: Harcourt, Brace, & World, 1965.

Honzik, M. P. Environmental correlates of mental growth: Prediction from the family setting at 21 months. Child Development, 1967, 38, 337-364.

Honzik, M. P. Value and limitations of infant tests: An overview. In M. Lewis (Ed.), Origins of intelligence: Infancy and early childhood. New York: Plenum Press, 1974.

"Infants in isolation." Michigan's Health, undated, 63(2).

Inhelder, B. The diagnosis of reasoning in the mentally retarded. New York: John Day Co., 1968.

Inhelder, B., & Matalon, B. The study of problem solving and thinking. In P. H. Mussen (Ed.), Handbook of research methods in child development. New York: Wiley, 1960.

Jackson, A. M., Farley, G. K., Zimet, S. G., & Gottman, J. M. Optimizing the WISC-R test performance of low- and high-impulsive emotionally disturbed children. Journal of Learning Disabilities, 1979, 12(9), 622-625.

Jastak, J., Bijou, S., & Sastak, S. Wide range achievement test: Reading, spelling, arithmetic from pre-school to college. Wilmington, Del.: Guidance Associates, 1965.

Kagan, J. Matching familiar figures test. Cambridge, Mass.: Harvard University, 1965.

Kaufman, A. S. Factor analysis of the WISC-R at 11 age levels between 6½ and 16½ years. *Journal of Consulting and Clinical Psychology*, 1975, *43*, 135-147.

Kaufman, A. S. *Intelligent testing with the WISC-R*. New York: John Wiley & Sons, 1979.

Kaufman, A. S., & Hollenback, G. P. Factor analysis of the standardization edition of the McCarthy Scales. *Journal of Clinical Psychology*, 1973, *29*(3), 358-362.

Kaufman, A. S., & Kaufman, N. L. *Clinical evaluation of young children with the McCarthy scales of children's abilities*. New York: Grune & Stratton, 1977.

Kearsley, R. B., & Sigel, I. E. (Eds.). *Infants at risk: Assessment of cognitive functioning*. New York: John Wiley & Sons, 1979.

Knehr, C. A., & Sobol, A. Mental ability of prematurely born children at early school age. *Journal of Psychology*, 1949, *27*, 355-361.

Knobloch, H., & Pasamanick, B. Prospective studies on the epidemiology of reproductive causalty. *Merrill-Palmer Quarterly of Behavior and Development*, 1966, *12*, 27-43.

Knobloch, H., Rider, R., Harper, P., & Pasamanick, B. Neuropsychiatric sequelae of prematurity. *Journal of the American Medical Association*, 1956, *161*, 581-585.

Kopp, C. B., & Parmelee, A. H. Prenatal and perinatal influences on infant behavior. In J. D. Osofsky (Ed.), *Handbook of infant development*. New York: John Wiley & Sons, 1979.

Koppitz, E. M. *The Bender gestalt test for young children*. New York: Grune & Stratton, 1963.

Koppitz, E. M. *The Bender gestalt test for young children* (Vol. 2). New York: Grune & Stratton, 1975.

Kushlick, A., & Blunden, R. The epidemiology of mental subnormality. In A. M. Clarke and A. D. B. Clarke (Eds.), *Mental deficiency: The changing outlook* (3rd ed.). New York: Free Press, 1974.

Laurendeau, M., & Pinard, A. *Causal thinking in the child*. New York: International Universities Press, 1962.

Laurendeau, M., & Pinard, A. *The development of the concept of space in the child*. New York: International Universities Press, 1970.

Lehmann, I. J. Rural-urban differences in intelligence. *Journal of Educational Research*, 1959, *53*, 62-68.

Lubchenco, L. O. Assessment of gestational age and development at birth. Pediatric clinics of North America, 1970, 17, 124-145.

Lubchenco, L. O. The high risk infant. Philadelphia: Sanders, 1976.

Lubchenco, L. O., Delivoria-Papadopoulos, M., & Searls, D. Long-term follow-up studies of prematurely born infants: 2. Influence of birth weight and gestational age on sequelae. Journal of Pediatrics, 1972, 80, 509-512.

Lubchenco, L. O., Hansman, D., & Boyd, E. Intrauterine growth in length and head circumference as estimated from live birth at gestational ages from 26 to 42 weeks. Pediatrics, 1966, 37, 403.

Lubchenco, L. O., Hausman, C., Dressler, M., & Boyd, E. Intrauterine growth as estimated from live born birth weight data at 24 to 42 weeks gestation. Pediatrics, 1963, 32, 793-799.

Lubchenco, L. O., Horner, F. A., Reed, L. H., Hix, I. E., Metcalf, D., Cohig, R., Elliott, H. C., & Bourg, M. Sequelae of premature birth: Evaluation of premature infants of low birth weight at ten years of age. American Journal of Diseases of Childhood, 1963, 106, 101-115.

McCarthy, D. Manual for the McCarthy scales of children's abilities. New York: The Psychological Corporation, 1972.

McCarthy, J., & Kirk, S. Illinois test of psycholinguistic abilities: Experimental edition. Urbana, Ill.: Institute for Research on Exceptional Children, University of Illinois, 1961.

McDonald, A. D. Children of very low birthweight. M.E.I.U. Research Monograph no. 1. London: S.I.M.P. with Heinemann Medical, 1967.

McDonald, A. D. Intelligence in children of very low birth weight. British Journal of Preventive and Social Medicine, 1964, 18, 59-74.

Mercer, J. Labeling the mentally retarded. Berkeley: University of California, 1973.

Moreau, T. Neonatal prematurity and subsequent development: Discussion. In N. Solkoff (Chair.), Symposium on neonatal prematurity and subsequent development. Presented at the 48th Annual Meeting of the Eastern Psychological Association, Boston, April 1977.

Nie, N., Hull, C. H., Jenkins, J. G., Steinbrenner, K., & Brent, D. H. Statistical package for the social sciences. New York: McGraw-Hill, 1975.

Nieswander, K. R. Obstretic factors related to prematurity. In D. M. Reed & F. J. Stanley (Eds.), The epidemiology of prematurity. Baltimore: Urban & Schwarzenberg, 1977.

Owen, F. W., Adams, P. A., Forrest, T., Stolz, L. M., & Fischer, S. Learning disorders in children: Sibling studies. Monographs of the Society for Research in Child Development, 1971, 36(4) (serial number 144).

Palkes, H., Stewart, M., & Kahana, B. Porteus Maze performance of hyperactive boys after training in self-directed verbal commands. Child Development, 1968, 39, 817-826.

Parmelee, A. H., & Haber, A. Who is the risk infant? Clinical Obstetrics and Gynecology, 1973, 16, 376-387.

Parmelee, A. H., Kopp, C. B., & Sigman, M. Selection of developmental assessment techniques for infants at risk. Merrill-Palmer Quarterly of Development and Behavior, 1976, 22, 177-199.

Parmelee, A. H., & Schulte, F. Developmental testing of pre-term and small-for-dates infants. Pediatrics, 1970, 45, 21-28.

Pasamanick, B., & Knobloch, H. Retrospective studies on the epidemiology of reproductive causality: Old and new. Merrill-Palmer Quarterly, 1966, 12, 7-26.

Pasamanick, B., & Lillienfeld, A. M. Association of maternal and fetal factors with the development of mental deficiency. 1. Abnormalities in the prenatal and paranatal periods. Journal of the American Medical Association, 1955, 159, 155-160.

Pinard, A., & Sharp, E. IQ & point of view. Psychology Today, 1972, 6(1), 65-80, 90.

Rawlings, G., Reynolds, E. O. R., Stewart, A., & Strang, L. B. Changing prognosis for infants of very low birthweight. Lancet, 1971, 1, 516-519.

Ringenbach, S. E., Houtz, J. C., & Feldhusen, J. F. Development of a new measure of problem solving abilities of disadvantaged children. Proceedings of the American Psychological Association, 1972, 7, 55-56.

Robinson, N., & Robinson, H. A follow-up study of children of low birth weight and control children at school age. Pediatrics, 1965, 35, 425-433.

Rosner, J. Language arts and arithmetic achievement, and specifically related perceptual skills. American Educational Research Journal, 1973, 10, 59-68.

Rosner, J. Helping children overcome learning difficulties. New York: Walker & Co., 1975.

Rubin, R. A., & Balow, B. Learning and behavior disorders: A longitudinal study. Exceptional Children, 1971, 37, 293-299.

Rubin, R. A., & Balow, B. Perinatal influences on the behavior and learning problems of children. In B. B. Lahey and A. E. Kazdin (Eds.), Advances in clinical child psychology. New York: Plenum Press, 1977.

Rubin, R. A., Rosenblatt, C., & Balow, B. Psychological and educational sequelae of prematurity. Pediatrics, 1973, 52, 352-363.

Saltzman, G. B. A study of the relationship between infants temperament variables in biological risk and average populations and the self-concept of the mother. Ph.D. dissertation, Michigan State University, 1978.

Sameroff, A. J. The etiology of cognitive competence: A systems perspective. In R. B. Kearsley and I. E. Siegel (Eds.), Infants at risk: Assessment of cognitive functioning. New York: John Wiley & Sons, 1979.

Sameroff, A. J., & Chandler, M. J. Reproductive risk and the continuum of caretaking causality. In F. D. Horowitz (Ed.), Review of child development research (Vol. lV). Chicago: University of Chicago Press, 1975.

Sattler, J. M. Assessment of children's intelligence (Rev. reprint). Philadelphia: W. B. Saunders Company, 1974.

Schaefer, E. S., & Bell, R. Q. Development of a parent attitude research instrument. Child Development, 1958, 29, 339-361.

Schleifer, M., Weiss, G., Cohen, N. Elman, M., Cvejic, H., & Kruger, E. Hyperactivity in preschoolers and the effect of methylphenidate. American Journal of Orthopsychiatry, 1975, 45, 38-50.

Sibinga, M. S., & Friedman, C. J. Diet therapy and other sources of influence on the outcome of children with phenylketonuria. Developmental Medicine & Child Neurology, 1972, 14, 445-446.

Sloan, E. The Lincoln-Oseretsky scale of motor development. Genetic Psychology Monographs, 1955, 51, 183-252.

Smith, A. C., Glick, G. L., Ferris, G., & Sellman, A. Prediction of developmental outcomes at seven years from prenatal, perinatal and postnatal events. Child Development, 1972, 43, 495-507.

Speedie, S. M., Houtz, J. C., Rigenbach, S., & Feldhusen, J. F. Abilities measured by the Purdue Elementary Problem-Solving Inventory. Psychological Reports, 1973, 33, 959-963.

Stanley, J. C. (Ed.). Improving experimental design and statistical analysis. Chicago: Rand McNally & Co., 1967.

Stedman, D. J., & Eichorn, D. H. A comparison of the growth and development of infants and young children with Down's syndrome (mongolism). American Journal of Mental Deficiency, 1964, 69, 391-401.

Stewart, M. A. Hyperactive children. Scientific American, 1970, 222 (4), 94-99.

Stewart, A. L., & Reynolds, E. O. R. Improved prognosis for infants of very low birth weight. Pediatrics, 1974, 54, 724-735.

Taub, H. B., Goldstein, K. M., & Caputo, D. V. Indices of neonatal prematurity as discriminators of development in middle childhood. Child Development, 1977, 48(3), 797-805.

Terman, L. M., & Merrill, M. A. Measuring intelligence. Cambridge: Mass.: Houghton Mifflin Co., 1937.

Terman, L. M., & Merrill, M. A. Stanford-Binet intelligence scale: Manual for the third revision, Form L-M. Boston: Houghton Mifflin Co., 1960.

Thomas, A., & Chess, S. Temperament and development. New York: Brunner/Mazel, 1977.

Thomas, A., Chess, S., & Birch, H. Temperament and behavior disorders in children. New York: New York University Press, 1968.

Thomas, A., Chess, S., Birch, H. C., Hertzig, M., & Korn, S. Behavioral individuality in early childhood. London: University of London, 1963.

Towbin, A. Cerebral dysfunctions related to perinatal organic damage: Clinical-neuropathologic correlations. Journal of Abnormal Psychology, 1978, 87(6), 617-635.

Verway, D. I. (Ed.). Michigan statistical abstract. East Lansing: Michigan State University, Graduate School of Business Administration, 1978.

Vygotsky, L. S. Thought and language. Cambridge, Mass.: M.I.T. Press, 1962.

Wechsler, D. Manual for the Wechsler intelligence scale for children. New York: The Psychological Corporation, 1949.

Wechsler, D. Manual for the Wechsler preschool and primary scale of intelligence. New York: The Psychological Corporation, 1967.

Wechsler, D. Wechsler intelligence scale for children--revised. New York: The Psychological Corporation, 1974.

Wender, P. H. Minimal brain dysfunction in children. New York: Wiley-Interscience, 1971.

Werner, E., Bierman, J., & French, F. The children of Kauai: A longitudinal study from the prenatal period to age ten. Honolulu: University of Hawaii Press, 1971.

Werner, E., Honzik, M. P., & Smith, R. S. Prediction of intelligence and achievement at 10 years from 20 months pediatric and psychologic examination. Child Development, 1968, 39, 1063-1075.

Werner, E. E., & Smith, R. S. Kauai's children come of age. Honolulu: University of Hawaii Press, 1977.

Werner, H., & Crain, L. Marbleboard test performance in normal children. Journal of Genetic Psychology, 1950, 77, 217-229.

Werner, H., & Wapner, S. Developmental study on the perception of verticality. Paper presented at the Eastern Psychological Association Meeting, Philadelphia, 1955.

Wiener, G. Psychologic correlates of premature birth. Journal of Nervous and Mental Disease, 1962, 134, 129-144.

Wiener, G. The Bender-Gestalt Test as a predictor of minimal brain damage in children eight to ten years of age. Journal of Nervous and Mental Disease, 1966, 143, 275.

Wiener, G. Scholastic achievement at age 12-13 of prematurely born infants. The Journal of Special Education, 1968, 2, 237-250.

Wiener, G. The relationship of birth weight and length of gestation to intellectual development at ages 8 and 10 years. The Journal of Pediatrics, 1970, 76, 694-699.

Wiener, G., Rider, R. V., Oppel, W. C., Fischer, L. K., & Harper, P. A. Correlates of low birth weight: Psychological status at six to seven years of age. Pediatrics, 1965, 35, 434-444.

Wiener, G., Rider, R. V., Oppel, W. C., & Harper, P. A. Correlates of low birth weight. Psychological status at eight to ten years of age. Pediatric Research, 1968, 2, 110-118.

World Health Organization. Manual of the international statistical classification of diseases, injuries, and causes of death, 1975 revision. Geneva: World Health Organization, 1977.

Wright, F. H., Blough, R. R., Chamberline, A., Ernest, T., Halstead, W. C., Meier, P., Moore, R. Y., Naunton, R. F., & Newell, F. W. A controlled follow-up study of small prematures born 1952 through 1956. American Journal of Diseases of Children, 1972, 124, 506-521.

Yale child study revised developmental schedules. New Haven: Yale University, 1971.

Zigler, E., Abelson, W. D., & Seitz, V. Motivational factors in the performance of economically disadvantaged children on the Peabody Picture Vocabulary Test. Child Development, 1973, 43, 294-303.

Zigler, E., & Butterfield, E. C. Motivational aspects of changes in IQ test performance of culturally deprived nursery school children. Child Development, 1968, 39, 1-14.

Zitrin, A., Ferber, P., & Cohen, D. Pre- and paranatal factors in mental disorders of children. Journal of Nervous and Mental Diseases, 1964, 139, 357-361.