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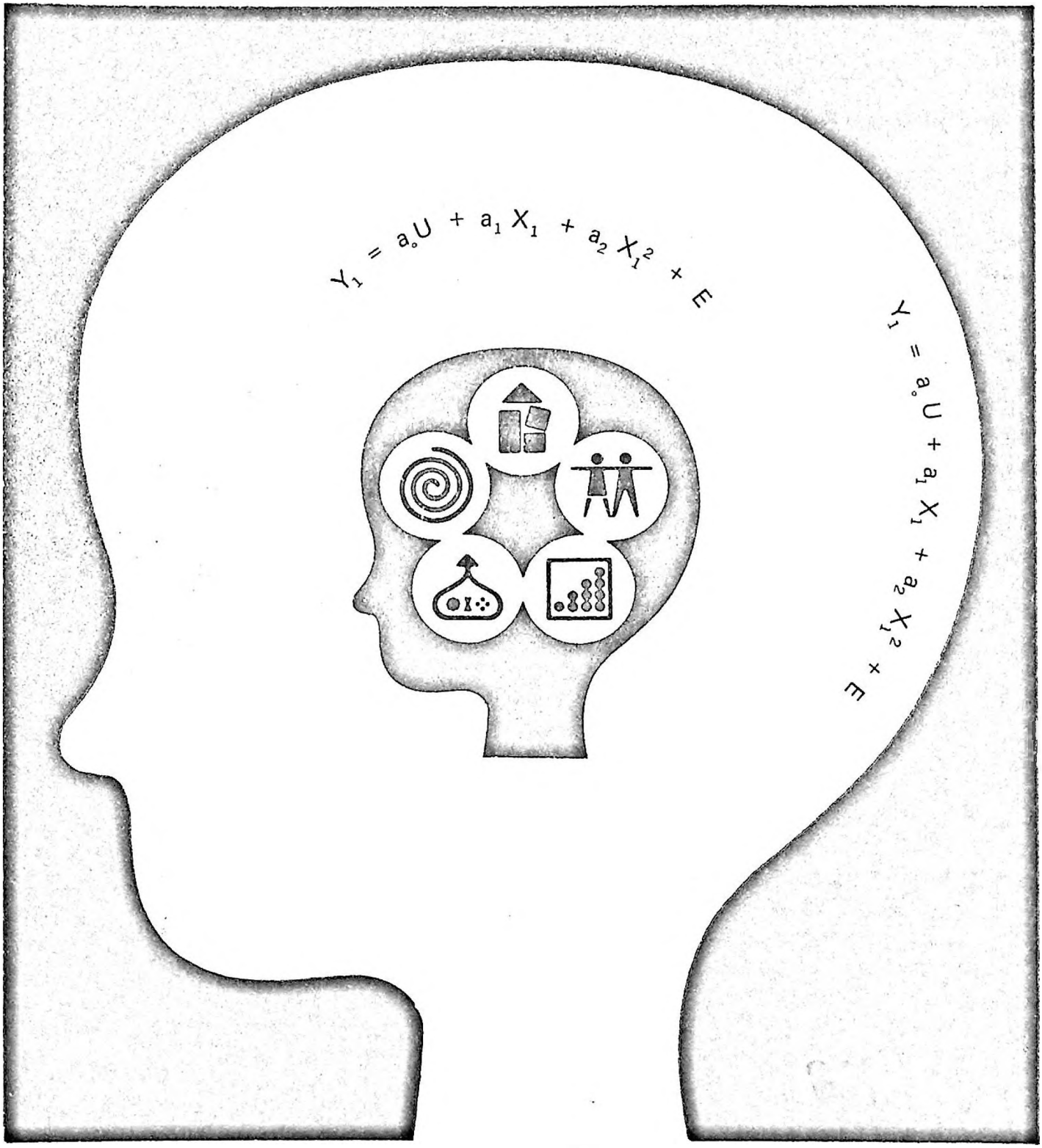

MONOGRAPH SERIES #1
INFLUENCES ON PRESCHOOL COGNITIVE ATTAINMENT

MULTIPLE LINEAR REGRESSION VIEWPOINTS

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INFLUENCES ON PRESCHOOL COGNITIVE ATTAINMENT

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ABSTRACT

An analysis of measures of cognitive attainment, two at two years, one measure at age three years, two at age four years, and three at age five years is reported. In part one a multiple linear regression analysis examined the contribution of twelve variables to prediction of the eight criteria. In the second part of the analysis the most influential variables were explicated by maximizing their interactions in a second regression analysis. Criteria were the same eight cognitive tests at child ages two to five years. All data were developed through prospective longitudinal case studies begun at birth.

CHAPTER I

INTRODUCTION

In recent years there has been a revival of interest in young children. To some the earliest years represent an opportunity to intervene in the cycle of deprivation; to others young children represent a vital stage in the cognitive development of the species. For both points of view, the common points of view, the common point of reference is the presence of a body of empirical knowledge on the course of early cognitive growth.

This report[1] is an attempt to study cognitive attainment from birth to school age with particular attention to the problem of low mental attainment at ages two to five years. The nexus of biological familial and social influences on growth presents some challenges to inquiry. A large number of variables requires a large number of subjects. The methodology of child study in the very young is invariably a process of individual case studies. Family cooperation requires that data collection be conducted under careful circumstances. The interrelation of these ideas required that studies be broadly conceived in the hope of shedding light on both focal and peripheral matters. The basic theme of the inquiry is acquisition of materials which will contribute to an understanding of cognitive style in middle childhood. As the next chapter indicates the appropriate information is quite diverse, with biological data being needed. This concern for the biological domain, in addition to seeing relevance in behavioral data, arises from a conservative position on the role of environment in early childhood and a critical

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position on the adequacy of current formulations of nature and nurture. Too often what is not clearly environment is rashly construed as heredity. More reasonably one can posit an external environment, man-made events impinging on the growing child, together with biological environments of prenatal and postnatal nutrition. The biological order in gestation is open to influence for good and ill by the external environment. Conversely, human environments are mediated in their effects by the presence of physiological realities.

The preceding remarks are little more than restatements of the obvious. Yet, they precipitate a series of unanswered questions about the relative influence of the several vectors of change. The extent to which human influences affect cognitive status in the presence of biological influences is a preoccupying question. A further elaboration, the extent to which such influence rise and fall in salience is equally unclear. Our age has based public planning for the welfare of the young on a predilection for environmentalism. It seems only reasonable to inquire into the magnitude of effects and the configuration through which they are expressed.

This report is an attempt to answer some of these questions using data from the St. Louis Baby Study (SLBS). It extends the picture developed in other studies of the pre-school period of child development in two ways. The first is by presenting data from birth to age five, and the second is by applying multivariate procedures to treatment of the data.

There is another observation which may be made at this point, one which touches on the continuity of normal and abnormal child development. In this study the data are drawn from a heterogeneous population of normal and slow children as an expression of the premise that normal and abnormal states of childhood are continuous rather than discrete. Study of abnormal states of development should, whenever possible, be conducted within the broad context

of human growth processes; that is, investigation of the phenomena of cognitive attainment should occur in a corpus of data on growth of all kinds of children, and not just retarded children. Obviously, there are occasions when this general observation should not obtain, but this study is organized on the premise that the prevailing concept should be the unity of child development processes.

I wish to express my thanks to a number of people for their assistance gathering data over a period of several years. For studies of children in their homes on repeated occasions, a situation requiring great tact, I wish to thank my friends and associates who gathered information at various occasions in the five years of data taking.

To Professor Claire Ernhart my thanks, and my special thanks to Professor Steven Spaner.

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CHAPTER II

EARLY DEVELOPMENT

The purpose of this chapter is to present a framework within which the intent of the investigation may be appreciated. The nature of child development and its study poses alternative ways to proceed, and the methodology of the investigation appears as a series of choices of direction at sequential points. The intent of the study and its methodology consist of a number of decisions arrived at by examining a number of significant variables and by appraising the range of methods of study available, modified by the presence of limiting considerations of available resources.

Introduction

The present investigation takes its place alongside a number of attempts to understand the characteristics of children by means of study over an extended period of time. It is also the case that the present study is one more example of the cyclic nature of interest in child study in natural time. In 1969, the Office of Economic Opportunity sponsored a study of growth in the preschool years. The goal of the study has been to understand how Head-start has contributed to cognitive attainment in elementary school children (Rhine, 1972). The study has gathered data in several settings, rural and urban, and in eastern, midwestern, and southern regions of the United States. In the United Kingdom Rutter, Tizard, & Whitmore (1970) reported study of a large population of children living on the Isle of Wight.

Both of the preceding studies have in common the fact that they are recent and are likely to produce significant educational and psychological data over a period of time. Two rather different studies had their origins over a decade ago. In the late 1950's the National Institute of Health began the Collaborative Perinatal Study (Berendes, 1966), an analysis of the

outcomes of 50,000 pregnancies. The study, conducted on a largely decentralized basis, has persisted in the face of many problems. It has produced a number of useful accounts of biological growth (Chung and Myrianthopoulos, 1968), and a few on cognitive growth (Balow, 1969). A British investigation with similar intentions was launched about the same time. The National Child Development Study began with identification of 17,000 deliveries. In 1967, Kellmer Pringle, Butler, and Davie reported the developmental status of 11,000 of the children at age seven.

It can be seen that there are several quite active studies of children using large populations and following them over time. In this regard, they are similar to studies begun in previous generations. Perhaps Terman's work (Oden, 1968) stands as the classic, following gifted children for several decades. Similarly, the Berkley Growth Study, now in its fourth decade (Jones et al., 1971) has studied several groups of individuals up to the present time. Such studies should not be confused with "follow-up" studies, investigations in which subjects of completed studies are investigated once more. In such studies cooperation of subjects is often fortuitous and the opportunity for distortions in results due to sampling problems is considerable, even though the findings are interesting (Oster and Van den Tempel, 1973). An exception to this rather pessimistic outcome is the classic followup of Dutch military conscripts by Stein et al. (1973). The investigators were able to trace a very large number of babies born in Western Holland during World War II, and to study the affects of communal starvation on pregnancy outcomes two decades later (1975).

In recent years studies of lesser magnitude than the U. S. and U. K. studies of very large populations have appeared. They are based on recognition of the value of developmental data in studies of cognitive development.

In Scotland, Drillien's program of study has examined the effects of prematurity on the growth of children from birth into the elementary school years (Drillien, 1963, 1964, 1969). The Washington University studies on anoxia (Graham, et al., 1962; Ernhart, Graham, & Thurston, 1960; Corah, 1965) have maintained a theme of concern for the effects of perinatal oxygen deprivation. The writer's St. Louis Baby Study (Jordan, 1971) has been an attempt to relate early social and biological data to sequential stages of development in the subsequent years (Jordan, 1976). At the time of writing the program is in its fourth phase of child study. A cohort of one thousand infants born in 1966 and the subject of this report, has been followed for several years. Finally, it is helpful to consider a fourth study of medium size. For the past several years a group of scientists in Baltimore (Hardy, 1966) have been studying the effects of an epidemic of rubella on a cohort. This work is interesting because of the cyclic nature of rubella and the probability of the problem recurring at fairly regular intervals, e.g. a reported rise in incidence in 1975.

In addition to programmatic inquiries there has been a growing series of studies directed at studying the connection between stages of development. Versacci's (1966) dissertation related a series of paranatal factors to reading skills of two hundred children in the fifth grade. Similarly, Balow's (1969) work has examined the educational outcomes of development in children originally enrolled in the Collaborative Perinatal Study. Phase I of the writer's work (Jordan, 1964) found an educationally significant relationship between paranatal data and educational data in elementary school children. Similarly, Edwards (1966) was able to relate birthweight and Apgar scores to mental and motor performance at age four.

An aspect of these and other studies is their explicit orientation to the value of data at the earliest stages of development. Further, there

emerges an interest in the study of characteristics without the kind of manipulation of events stereotyped as the only kind of worthwhile research. The relationship of this trend to naturalistic research is not clear. In part the machinery of Government interest in early child development provided an impetus to study of children in the preschool period. That progress has antecedents in the work of Pasamanick and Knobloch (1960) and others who had identified a number of illuminating elements in child development. In most cases findings emerged from non-manipulative inquiries, investigations in which nature rather than science assigned experiences to children.

A highly related aspect of the interest in correlating child development at various stages between infancy and adolescence has been the implicit use of large populations. Some of the more important influences on child development are quite rare, for example, the toxemias. Investigators have monitored large populations with two particular considerations in mind. First, the identification of rare conditions, and second, preservation of samples of adequate size over periods of time. From these two observations other insights into strategy may be elucidated. First, relatively little work exists to guide investigators in the selection of conceptual models for studying populations of children (Blum, 1962; Heirich, 1964; Schaie, 1965). Second, equally scarce have been statistical models for evaluating data in a fashion fully responsive to the passage of time as a critical dimension (Gottman, McFall, and Barnett, 1969; Werts and Linn, 1970). Third, few investigations have emerged to assist with crucial problems of manipulating phenomena in diverse realms, e.g., neurological data as predictors, and educational data as criteria. All too often rigorous data in the investigator's own domain is related to less than best data in another domain. Fourth, the procedural aspects of developing data in different realms and at different times

(Hoffman, 1969) has been rarely discussed (Huessy, 1967). A fifth aspect is the theoretical value of incorporating, both normal and abnormal development in the same design (Jordan, 1973).

From the preceding observations it can be seen that the context for connecting development of children at different stages consists of a varied assortment of procedures, ideas, and analyses. The alternatives tend to present themselves to investigators in the order of problems about (1) procedure and data gathering, (2) formal experimental design, and (3) statistical manipulation. In fact, this is an unfortunate arrangement; all three topics are reciprocal in their implications, and the nexus they form may be glimpsed in the commentaries of Kodlin & Thompson (1958); Thomas et al., (1960), and Schaie and Strother (1968). For the purposes of this discussion it is helpful to begin with (1) formal experimental design, considering next (2) statistical manipulation, and then (3) procedures and data gathering.

(1) Experimental Design: There are three general approaches to the study of children's development over a period of time. The first and most appealing is the retrospective study. In this approach, which has been analyzed elsewhere by the writer (Jordan, 1965) the basic strategy is identification of a group of individuals with a characteristic of particular salience, e.g., mongolism (Ingalls, Babbott, and Philbrook, 1957), behavior problems (Wolff, 1967), and cerebral palsy (Eastman et al., 1962). The previous histories of the probands are traced and the cause of their condition is thereby discovered. Procedurally, reconstruction of events from the early state ad hoc becomes a very uncertain enterprise. Neligan and Prudham (1969) have demonstrated that mothers' memories of early development are selective, and generally unreliable in cases of abnormal development. At a more basic level the retrospective inquiry starts with dependent vari-

ables and then searches for independent variables. The probability is high that a Type I error will occur. In that process a correct hypothesis of no difference will be rejected (Bailey, 1958). The work of Jordan (1967), and Klemmetti and Saxen (1967) has shown that outcomes of retrospective technique are not the same as those reached prospectively. Despite its problems the retrospective approach to studying human characteristics over time is attractive. The economics of money, time and energy it proffers are very appealing (Jones, 1967). Taulse and Headman (1969) have suggested that the use of multiple contrast groups can increase the probability of avoiding errors when making conclusions from retrospective data.

The second type of design is the prospective study. In such investigations probands are identified by means of the independent variable and followed, together with contrast cases through a period of natural time (Thomas et al., 1960). Drillien's studies of Scottish premature babies have yielded a picture of development from birth to school age (Drillien, 1964, 1969, 1970). Moore's (1967, 1968) investigation has reported development in a group of London boys and girls up to age eight years. The program from which this report emerges has examined three birth cohorts (Jordan, 1964, 1971). The second cohort, one thousand babies, has been examined at intervals of six and twelve months for several years. The advantages of the approach are considerable. Questions may be refined with the passage of time, and data of a sort not necessarily available in existing records or through testing on a single occasion may be generated. The hazards are formidable. Gross outlays of money, energy, and time are called for. The entire enterprise may be compromised before completion by a variety of events. Sample shirnkage may be uncontrollable as in Project Talent's loss of two-thirds of potential respondents to a five year mailed questionnaire (Flanagan et al., 1973). Berendes (1970) estimated the annual loss of cases in the Collaborative Perinatal Study of 55,000 pregnancies began

a decade before at 5 - 8% per annum. In the larger cohort from which the data of this investigation the attrition of the sample from birth to age six, and over seven major contacts with families and children was approximately twenty five percent. Fiscal crises are unavoidable; in Project Talent Tiedemann (1973) reported that the ten-year data-taking activity would have to be set back due to funding problems. Finally, the research policies of public and private agencies shift from time to time, leaving investigators high and dry.

Table 1 identifies the major prospective longitudinal studies of recent years giving an account of the sites and populations examined.

A third approach is to view the span of development, that is, time as a dimension manageable by simultaneous sampling at various ages or strata. The technique is appealing when contact with a population cannot be sustained through natural time. Cederblad's (1968) demonstration of intellectual decline in Sudanese children was possible because she studied children from ages seven to fifteen years simultaneously. Disadvantages lie in the need to have all questions formulated before data gathering. In addition, subjects born at different times may not have the same developmental baseline (Schaie and Strother, 1968). That is, they may have been exposed to highly dissimilar and transient experiences such as epidemics and social disturbances.

(2) Statistical Considerations: One of the realities of child behavior is that it is complex, arising from multiple causes, and occasionally, without cause or purpose. A description of behavioral status, accordingly, rests on a mass of information drawn from many sources. The basic information may, in turn, be manipulable in other forms as measures are segmented and combined, e.g., dichotomized and used to create cell contingencies. Anaylsis of variance has proved to be a powerful tool for analysis of data; however, a more flexible technique for studying large amounts of data in numerous independent categories is multiple linear regression. Introduced by Bottenberg and Ward

TABLE 1

SELECTED STUDIES OF DEVELOPMENT AND ACHIEVEMENT

Inquiry	Location	Principal Author	Year	Sample Size	Intervals	Technqiue
[1] The Home & the School	U.K.	Douglas	1946-1964	5,000	5-7 yrs.	cohort
[1] All Our Future	U.K.	Douglas	1946-1968	5,000	5-7 yrs.	cohort
[2] Plowden Report	U.K.	Peaker	1967	3,000	one shot	survey
[2] Plowden Children Four Years Later	U.K.	Peaker	1971	3,000	4 yrs.	cohort/follow up
[3] National Child Development Study	U.K.	Pringle	1958-1966	11,000	7 yrs.	cohort/follow up
[3] Born to Fail?	U.K.	Wedge & Prosser	1958-1969	10,000	11 yrs.	cohort/follow up
[3] National Child Development Study	U.K.	Davie	1972	11,000	7 yrs.	cohort/follow up
Equality of Educational Opportunity	U.S.	Coleman	1966	60,000	one shot	survey
Kauai Pregnancy Study	U.S.	Bierman	1971	1,000	10 yrs.	cohort/follow up
Educational Follow-Up Study	U.S.	Balow	1964	1,559	12 mos.	cohort/sequential
Edinburgh Studies	U.K.	Drillien	1950-1969	462	2 yrs.	*(Seriatim)* group
Mental Subnormality in the Community	U.K./U.S.	Birch	1970	104	one shot	pooled cohorts (3)-retrospective

[1,2,3] = common data bases

(1963) the technique has been elaborated by a series of commentaries (Cohen, 1968; Darlington, 1968; Kelly, Beggs, & McNeil, 1969). A statistical requirement met by the technique is the need to manipulate many variables simultaneously. A further advantage is that non-linear relationships among independent variables may be explored (Jordan, 1970). A basic justification for use of linear models to study developmental data has been presented by Werts and Linn (1970) while Cohen's (1968) commentary points to the wider applicability of the multilinear approach. The precise use of multiple linear regression is explained in a context of data analysis in Chapter III. Examples of applying multiple regression to developmental data may be found in Wilson, Parmelee and Huggins' (1963) analysis of low birth weight, and in Blatt and Garfunkel's (1969) analysis of intelligence test scores of poor children.

(3) Data Gathering: To some extent the options for considering data have been considered in the immediately preceding sections on design and statistics. However, those observations touched on information as formal data, and left unconsidered the strategies for gathering information and using it.

In research on development the process of gathering information often begins with searching clinical records. Two problems which immediately appear are first, the value of information in records. The expression "file drawer" research is invidious, and with reason. However good case records may be, they were generated for specific purposes and to answer specific questions. It is unlikely that they can help answer all inquiries. Second, an orientation to clinical records tends to modify questions into propositions which are answerable with the data on hand. The result is that information which is available may take priority over the intellectual substance of a question; the outcome is first-rate data for second-rate questions.

Virtually all styles of inquiry contain the option to gather data from subjects. Common to all is the need to gather the best data. With captive populations such as students continuous access to subjects is feasible. With non-captive populations, that is people who volunteer, or move to another city, acquisition of data is more difficult. Personal interviews and individual testing may be possible, but use of mailed questionnaires and telephone calls may also be needed. Hochstim's (1967) analysis suggests that the three methods are practically interchangeable in terms of validity and utility. Less manageable is the matter of public attitudes. Testing of all kinds is viewed with suspicion in some quarters. Entire segments of the population may decline to cooperate in periods of social unrest (Jordan, 1968). At a more sustained level a lack of interest on the part of parents and suspicions of possible interference are encountered (Moore, Hindley, & Faulkner, 1954). Finally, stigmatized parents, e.g. mothers of illegitimate children, may attempt to avoid being traced and interviewed (Spence, 1954).

Ecological Aspects of Development

To some extent consideration of child development in the contexts of nativism and the family can be considered traditional and tidy. While key concepts are related to other concepts they tend to be not unmanageable. On the other hand appreciation of child development tends to become more diffuse and uncertain when the matter is pursued in the larger context of society. To some extent the ambiguity is due to complexity; however, it is also due to haziness in some of the concepts. The matter is well illustrated in the matters of race, social class, and poverty, a nidus whose consideration while popular tends to be clouded.

There are a few subjects as likely to evoke a loss of objectivity in both the man in the street and the social scientist as the topics race, and ethnicity (Baratz and Baratz, 1970; Eysenck, 1971). At one end there arises

a perception that race is biology, pure and simple, while at the other a tendency to collapse all differences into "culture" is equally misleading. People can be markedly different in ways that are obvious, such as color, and in ways which are more clear to themselves, such as speaking a minority language. In such cases the differences, self-perceived and perceived by others, tend to be associated with differences in performance measured against a conventional standard (Dreger and Miller, 1960; Jensen, 1961; Rieber and Womack, 1968). In the United States, the most common form is the is commonly encountered. However, the earliest years of such children tend not to reveal basic differences (see Chapter IV). Cross cultural study indicates that children of wholly black ancestry, urban Bantu infants, tend to be ahead rather than behind urban white children (Griffiths, 1969; Liddicoats, 1969).

In Britain, Cypriot and Jamaican immigrant children are typically retarded in language development (Seidel, 1967), do poorly on standardized tests (Payne, 1969), and are poorly adjusted (Bhatnager, 1970). Oppé (1964) has shown that infants of Jamaican immigrants tend to have anemia and rickets. A wide range of health problems is encountered in this population, according to Pless and Hood (1967). The situation of Jamaican and that of Pakistani immigrants is the same. Their social and educational maladaptation in places such as the industrial city of Bradford, Yorkshire, is clear. In many respects, the condition of Pakistanis in Bradford is like that of Irish immigrants in the same city one hundred years earlier. Richardson (1968) has shown that among the Irish in England nineteenth century rates for illiteracy, infant mortality, tuberculosis, drunkenness, and crime were very high. Engels, in his classic, The Condition of the Working Class in England, (1845) gave a grim account of life of the poor in Bradford, Leeds, and other towns. Today, the same group shows these traits no longer, occupying essentially the same social strata as

the general population. A similar phenomenon of rising social competence has been reported by Taylor (1973) for Asian immigrants in Newcastle. In several aspects of educational attainment Asian children exceeded the native population. Heredity does not change, leaving social factors as the explanatory mechanism.

In the United States, it is the case that social factors operate to the detriment of blacks, primarily. Robinson (1967) has reported that Negro women account for 11.3 percent of live births, but 17.4 percent of fetal deaths. The preponderance of lower social class membership affects the health of black women and their babies. Hendricks (1967) has reported that reproductive accidents decline among black women as social class level rises. babies may be heavier than black babies for unknown reasons.

In recent years Jensen's (1969) remarks have raised once more perennial questions about the basis of observed differences between ethnic groups. The matter seems no better comprehended than in previous considerations. A basic flaw is the reductionist error of labeling all processes which are not responses elicited by environment as heredity. A more profitable alternative is to consider them native tendencies, vectors of developmental behavior which may or may not be completely autonomous. By the label the relatively obscure processes of prenatal growth may be treated with respect. That is, the early processes of growth involving genetic materials may be acknowledged; the environmental-hereditary basis of those processes then emerges as a question of substance rather than disappearing in the swift and erroneous conclusion that genetic mechanisms are immune to environmental influences. Prenatal growth retardation cannot be defined as genetic although it occurs in the absence of the normal range of environmental influences. The uterine environment provides hazards to development as well as constituting the optimal site. The placenta (Gruenwald, 1963) is a biological support to life, but it is also environmental. The effects of late-pregnancy growth

failure (Warkany, Monroe, & Sutherland, 1960; Dignam, 1967) are seen in mental retardation post-natally. Equally opaque are the effects of early pregnancy complications in the form of viruses (Monif, Hardy & Sever, 1966; Gitnick, Guccillo & Sever, 1968) although the effects are clear several years after delivery (N. Y. Times, 1969). An increasing body of information in the school years (Lytton, 1968; Denhoff, Hainsworth, and Hainsworth; Balow, Ruban, & Rosen, 1974; Jordan, 1976) points to the contribution of physical condition to learning disorders in children.

Biological Aspects of Development

To some extent learning problems are predictable in the preschool years. Neligan and Prudham (1969) have shown that ages for walking and talking in sentences are useful prediction of cognitive ability at school entry age. At an earlier age anoxia associated with delivery tends to produce lower cognitive attainment in subsequent years (Graham et al., 1962; Ernhart et al., 1963).

Measures of blood oxygenation are not good indices of trauma in the case of anoxia. A broader picture of early damage is available through use of Apgar's (Apgar, 1953; Apgar & James, 1962) system for evaluating the physiological state of infants. Five physiological signs rated in the first few minutes of life post partum yield a score of ten for babies in optimal condition. Scores of six or less are usually indicative of a clinically poor state (Colborn and Salzman, 1960; Gleiss & Holderburg, 1963; Klatskin, McGarry & Steward, 1966; Shipe, Vandenburg and Brooke Williams, 1968; Jekel, 1972). Apgar (1958) has reported a mortality rate of 15 percent in babies with scores of two or less. Chinn (1974) has observed a three-fold increase in neurological disorders at age one year in children with Apgar scores of three or less.

Low birth weight has emerged as a significant indicator of development

in children. Eaves (1970) identified depressed scores on the Griffiths scale of intelligence at eighteen months. At four years, however, the effects were less clear, a finding corroborated by Babson, and Kangas (1969). At seven and eight years of age normal intelligence was the rule for just over one thousand prematures studied by McDonald (1967); however, she found an abnormal incidence of low intelligence. At eight to ten years of age Wiener et al., (1968) found that intelligence test performance was generally satisfactory, although the Bender-Gestalt test revealed some differences. Lubchenco et al., (1963) analyzed development at age ten of a group of babies under 1500 gm. Two-thirds were found to have neuropsychiatric problems associated with their small birth weight. Drillien's (1969) prematures under 2,000 gm. showed tendencies to disturbed behavior and lowered academic competence. Of course prematurity does not operate in a vacuum (Jordan, 1968). A variety of studies (Drillien, 1963; Wortis, 1963; Wiener, Rider & Oppel, 1963) have related prematurity to development by means of social class. The effect is largely to depress levels of attainment. This is particularly the case among the smallest premature infants whose postnatal course is adversely affected by growing up in lower social class homes. In recent years birth weight above the optimum, which Rantakallio (1968) has put at 3200-4700 gm. for deliveries in the fortieth week of gestation, leads to adverse effects. Babson, Henderson, & Clark (1969) have found an above average incidence of low intelligence in children with birth weights above 4250 gm. Large babies were more like small babies than average size babies in the distribution of Binet IQ's at age four years. It seems likely that the relationship between birth weight and development is complex. Low birth weight leads to poor cognitive attainment in a disproportionate number of children, average birth weights having no effects, and high birth weights depressing performance once more.

It is probable that we will see an alternative to birth weight as a measure of neonatal development. In theory, gestational age is more accurate, but it is not always easy to calculate. French research (Pediatric Herald, 1970) has suggested that it may be possible to establish gestational age by studying reflexes and muscle tone. Weight has proved useful, however, and will probably continue to be employed on pragmatic grounds.

A broad picture of perinatal status and its meaning for subsequent growth has been provided by Jordan (1969b). A series of categorically defined abnormal states were related to growth in the first two years of life. Multiple complications proved most likely to affect physical and cognitive development.

Family Aspects of Development

A part of the complex of growth is the matter of nurture. Life style is altered by extreme income limitations; concern for the future and the corresponding broader notion of a rationally controlled way of life is not possible when the press of circumstances is felt immediately. The result is a life style oriented to the moment with the demands of the future being remote. Patterns of nutrition are radically altered by poverty, with poor food selection and unwise expenditure of money as the chief causes. The effects of malnutrition are particularly critical among the very young, where irreversible damage may be produced. Winick & Rosso (1969) have reported significant brain weight reduction and protein supply in Chilean children succumbing to malnourishment. Rosenbaum et al., (1969) have reported that proteinuria among pregnant women produced lowered intelligence at age four years in fifty-three children. At a less critical level poor eating patterns such as missing breakfast have an obvious effect on the responsiveness of children; their powers of concentration are reduced and they are less capable of sustained interest. Another of poverty's effects on children is the

simple matter of inadequate clothing. Wet, cold feet, together with a degree of malnourishment can lead to poor school work among even the brightest children. Still another byproduct of poverty is its effects on the structure of the family. Poor black and Puerto Rican families have been characterized as matriarchies. Their instability and poor nurturance compound the effects of other problems. Bandler (Pavenstedt, 1967) has drawn a picture of families in which children's needs are less important than parents' needs, and in which parents' roles have not become stabilized. Maternal health is often not good in poor families. Children suffer in two ways. First, they are born to mothers who as a group have a higher incidence of pregnancy complications and premature births (Baird and Illsley, 1953; Fairweather and Illsley, 1960). As issue of lower class mothers, their biological adversity is compounded by social adversity (Wortis et al., 1963). Klaus and Gray (1968) have shown that there is no shortage of stimulation in poor homes; the difficulty is that it is on the order of noise rather than signal, i.e., it is not constructive stimulation. Finally, poverty's heritage of disorganization leads to patterns of neglect. It is clear from a large amount of research (Aserlind, 1963; Bing, 1963; Marge, 1967; Honzik, 1967) that a home which is child-centered and stimulating plays a vital role in helping young children reach their potentials for cognitive attainment and language skills.

Social class differences in levels of child development are well known. The term itself is not without ambiguities, but it tends to consistency. Most techniques for measuring SES level incorporate the level of education and the occupation of the breadwinner. In some contexts, particularly those where social class is unusually significant, an old name and family connections may lead to underassessment of social status. The reverse can occur, and there are families known to social agencies as multiproblem families. For such groups, for example the North Point families described by Pavenstedt

(1967), social mobility often means a downward drift, to the detriment of the children. It seems to be the case that the social class level of families influences young children largely in the negative, (see Chapter IV), producing inhibitions in attainment. Such overt influences are not always present in the first year of life (Jordan & Spaner, 1970), but they seem to be clearly established by the end of the preschool years. To some extent social class influences operate more powerfully than ethnic group. Stodolsky & Lesser's (1967) research shows that differences in social class level persist within a variety of ethnic groups, Chinese, Negro, etc. Freeberg and Payne (1967) believe that social class differences tend to express themselves through parental language stimulation. In addition to parental language behavior social class differences are exhibited in styles of control exerted over children. Authoritarian patterns of interaction with children tend to be inhibiting. Jordan's (1970) research and that of Ernhart and Loevinger (1969) shows that authoritarianism is quite related to social class; as social class level rises authoritarianism declines, providing a less inhibiting atmosphere for children's cognitive growth.

From the preceding discussion it can be seen that study of child development in the preschool years suggests that answers may be available to questions about the course of growth. There are alternative ways to proceed, and there are many problems to pursue. The following chapters describe an attempt to shed light on antecedents to cognitive growth from birth to the fifth birthday with particular attention to the phenomenon of low performance on criterion measures at each age.

CHAPTER III

PROBLEM AND METHODOLOGY

Concepts

The investigation reported here is a product of a longitudinal prospective inquiry into the processes of physical and cognitive growth in children from birth until they are in elementary school. A goal of this and other investigations (Jordan, 1971) is to describe patterns of development and to identify the factors which influence attainment at various ages.

The problem pursued in this investigation may be expressed broadly as an inquiry into the relevance of a series of child-, mother-, and society-oriented factors to cognitive attainment at ages two to five years. More analytically, the problem has been to identify the comparative value of various aggregates of developmental data in the study of preschool children. The types of developmental data are described in Table 2. The predictors are grouped in the form of discrete variables and also in three aggregates under the Headings, Child, Mother, and Ecology.

The first set of predictors consisted of birthweight, Apgar score, sex, biological risk status at birth, development at twelve months on the writer's Ad Hoc Scale of Development (Jordan, 1967), and weight at twelve months of age. The second set consisted of maternal characteristics, age at delivery, marital status, authoritarianism score, and an anxiety score six months post partum. The third set of predictors consisted of race and SES.

The criteria of cognitive attainment employed were, at age two, (1) the Intellectual domain of the Preschool Attainment Record (Doll, 1966); (2) the Verbal Language Development Test (Mecham, 1959). At age three,

TABLE 2

MULR-05 PREDICTOR AND CRITERION SERIES

PREDICTORS	CRITERION
Child Data	Twenty Four Months
Birth weight	1. Preschool Attainment Record, Intellectual score (Doll, 1966)
Apgar score	2. Verbal Language Development Scale (Mecham, 1959)
Sex	
Risk status	Thirty Six Months
12 month development	3. Peabody Picture Vocabulary Scale (Dunn, 1965)
12 month weight	
Maternal Data	Forty Eight Months
Anxiety score	4. Boehm Test of Basic Concepts (1967)
Delivery age	5. Preschool Inventory (Caldwell, 1970)
AFI_{65}	
Marital status	Sixty Months
Ecological Data	6. Illinois Test of Psycholinguistic Abilities (1969) Auditory Association and Auditory Sequential Memory (digit span) subtests
Race	7. Wechsler Preschool and Primary Scale of Intelligence (1968) Vocabulary subtest
SES	

(3) the Peabody Picture Vocabulary Test, form A. At age four, (4) the Boehm Test of Basic Concepts, and (5) the Preschool Inventory. At age five, (6) the WPPSI Vocabulary Subtest, (7) the ITPA Auditory Association subtest, and (8) the ITPA Digit Span Subtest, which was scored for the number of test items reproduced correctly.

The general hypothesis of the investigation was that there is a statistically significant relationship between the variables listed in Table I as predictors and criteria.

Mathematically stated, the hypotheses are in the form of the proposition that a given variable in the presence of other variables contributes in a statistically significant way to the prediction of criterion variance. The statistical expression of the hypotheses is discussed more extensively in the chapter on methodology. The hypotheses of the investigation sequentially relate fifteen predictors to each of eight criteria in a multivariate design.

In some respects this report has antecedents and parallels in other studies. The technique of studying children through periods of time was pioneered in Terman's studies of gifted children. The Berkeley growth studies (Eichorn, 1969) have yielded a great deal of information on the processes of growth in children, and indeed adults, as children under study mature and pursue the middle years of life are seen in the work of Balow and Isom (1970), who have been studying children previously identified as high risk cases. Drillien's premature babies have been studied in a manner similar to that of the present investigation (Drillien, 1969). Scottish prematures have been followed into the school years in a rigorous way. The outcomes have been described in Chapter II.

The St. Louis Baby Study of early development may be described along other dimensions. It is naturalistic in the sense that processes of change

in children are observed, and descriptions are obtained. Like the ecologist's pond, changes occur in the subjects, and they are pursued in the context of interdependence of lives. For these studies interdependence is not expressed between species, but between children and families. However, like the pond, interdependence is examined in the context of gross material circumstances of life; social class and ethnic group generally impose environmental influences, as do family ideology. The naturalism of observing life in the pond is matched in the St. Louis studies by relating the growth of groups of children to the environmental qualities of their lives.

The dimension of time is an important aspect of studying development in the early years of life. It presents a series of conceptual problems in the choice of methodology. In particular there arises the matter of repeating measures in a given aspect of development on children. Data may be gathered at points in time which are too close, leading to undiscriminable changes in traits. Conversely, data may be gathered at intervals which are too wide, clouding critical periods of change. Not the least problem posed by the matter of time is the scarcity of instruments for use over broad spans of time in the first years of life. The choice of data gathering techniques and their yield in the form of data is less than edifying. The best measures are probably gross and physiological. That is, reflex elicitation and gross anthropomorphic measures have a good deal of utility, but their reliability may be less than optimal. The length of infants is an example of an apparently uncomplicated quantifiable measure. However, the reliability of babies' lengths turns out to be disappointing. A further consideration is that only one gross anthropomorphic measure, weight, tells much about babies' future development; like measures of neurological status it can be meaningful in a negative sense; that is, low birth weights like impaired reflexes are more meaningful than normal status for understanding the growth of infants in the first several

years of life. In a positive sense weight at a later date - in this investigation age one year - expresses the extent of subsequent physical development.

Procedurally, time presents problems. The act of gathering data on infants requires either bringing children to study centers or conducting examinations in home. Both approaches are burdensome to families, and the repetition of the measurement process in longitudinal study requires considerable forthought in planning and delicacy in execution. Conversely, successful contacts with families over a period of time can increase the probability of success as parents and children become familiar with the routines for child study.

The data of this investigation are drawn from an array of biological, behavioral and social information on the development of one thousand children from delivery ad hoc. The data bank has expanded with development of the children and with the opportunity to gather additional information on families. The population is non-captive; that is, their cooperation is in no way maintained by an institutional bond connecting investigator and subjects. A captive population is exemplified by college students, bored inmates of penal institutions, and children enrolled in schools. The 1966 cohort consists of children and parents whose cooperation is consistent across all social class, ethnic, and income levels. Some variation in accessibility arises as lower class families migrate in ways designed to cloud rather than reveal their locations. Other families particularly middle class families, are vulnerable to transfer at the direction of the father's employer. However, in both instances cooperation is not impaired when the families are found.

The process of developing information on the 1966 cohort has been that of individual case study. Caseworkers made appointments with families and visits them at scheduled times. Since many families have been visited by

the same caseworker several times the relationships tend to facilitate data gathering. Not all families provide full information. The result is that omissions in data exist; they are rarely fatal to inquiry since several hundred families provide an ample supply of information for any given inquiry. Families in this inquiry are a portion of a much larger group studied at ages two, through nine years. The particular sample sizes were produced by the desire to facilitate computer processing through a uniform number of subjects for all variables. A second influence was the intent to have a suitable subject/variable ratio to avoid overfitting regression lines. A third factor was the procedural decision at cohort age three years to split the sample into two half-year groups in order to facilitate tracing highly mobile cases. This report is based on one of the two groups, the children studied close to birthdays.

An additional aspect of the methodology is that developmental data have been gathered prospectively. That is, a choice was made, by means of pilot studies several years before this investigation, among the various styles of inquiry over time. Stratified sampling by age, retrospective inquiry, and prospective study were all considered.

Stratified sampling is a process by which an age range is studied by means of samples at given ages. For example, one hundred children at each age from birth to age ten yields eleven hundred children simultaneously. The economy of time in gathering data is clear and is illustrated in Quereshi's (1973) treatment of mental growth in children between age 5 and 18 years in one sample of 514 youngsters. The drawback is that the technique absolutely requires that data be obtainable at one time. That premise flows, in turn, from a decision to conduct a closed-ended inquiry in which basic questions are completely clear. Emerging questions suggested by data may not be pursuable, however.

Retrospective inquiry is considerably more common, and intellectually less sturdy. However, it may be practical; for example, study of influences on engineering students' vocational choices (Kuhlberg & Owens, 1960), or the previous history of battered children (Skinner & Castle, 1969) requires emergence of the trait in question. In the technique a cohort is identified at a criterion or dependent variable level, e.g. having developed a disease, or being at a particular state of attainment or age. The history of the individual is reconstructed ad hoc by interview and, commonly, by searching records. Since the salience of questions is modulated by availability of data, and indeed by generation of data, as in questionnaires, some questions are more feasible than others. Answers to even feasible questions may be biased by the subjects' perception of topics. Asking women if their pregnancies were unusual may embark them on phantasy, as imagination and desire to cooperate influence power of recall. Analysis of retrospective technique (Jordan, 1967) indicates that retrospective inquiries produce biased answers to questions.

Prospective technique consists of identifying a group of subjects or probands, using independent variables and co-variables as the basis of selection. Usually a large number of cases is desirable in order to cope with loss of cooperation, migration, and other forms of sample attrition. However, that need tends to run counter to the value of using small population which can be studied intensively. In the study reported here a large number of children were selected at birth and studied at intervals of a year. The problem of sample attrition has been countered by means of vigorous pursuit of cooperation; efforts have been successful, and prospective technique has yielded increasing information on mothers and children. The data bank has been extended beyond the variables studied here and beyond the developmental age of eight years, although on a greatly reduced basis due to fiscal problems.

Data gathering began with simultaneous analysis of deliveries in five St. Louis metropolitan hospitals. The hospitals were selected as optimal sites for developing a cohort over a period of four months. Further criteria for selection of given hospitals were the potential for administrative cooperation and the probability of identifying particular sub-populations born at risk. The latter process was, on balance, successful; e.g. middle class negro neonates were not found in desirable numbers, while juvenile pregnancies were found beyond expectations. Deliveries were scrutinized for suitability by social class, race, and biological states. In particular, high risk babies were selected in several categories reflecting disorders of pregnancy, delivery, and infancy. Cases were generated by means of daily consultations in obstetric and pediatric units rather than by reviewing hospital records. Selection criteria and diagnoses were standardized by use of the International Classification of Diseases as a descriptive lexicon.

It can be seen that the cohort from which the subjects of this investigation emerged is a contrived group of infants. In particular, it is a cohort generated in order to reflect the existence of risk and low risk neonates. Requirements in the form of social class levels and race dictated that specific cells be deliberately filled. Negatively expressed, the 1966 cohort was not a random sample of babies. In order to fill randomly all the cells specified in programmatic design a group of perhaps a quarter of a million subjects would have been required. The subjects selected for this study are members of a cohort of one thousand cases so chosen as to include enough subjects to test the wide range of variables hypothesized as influencing cognitive growth.

Statistical Models

Prospective longitudinal study results in the acquisition of significant

amounts of information. Optimal use of such developmental data posits a system for maximizing its use. Ideally, all pieces of information should be used in explanations of how children grow. Some information is basic to the inquiry process i.e., the independent variables of a prospective study, while other pieces of information are supplemental, playing the role of covariates and modulating the primary factors.

It is a matter of fact that statistical solutions to problems impose at least some procedural and conceptual limitations on the use of data. Some impose less influence than others. In this category arises the multiple linear regression model developed by Bottenberg and Ward (1963) and known as MULR-05. In perhaps the most relevant commentary Cohen (1968) has pointed out the wide utility of multiple linear regression. He had discussed the utility of using the multi-linear approach to deal with problems of curvillinearity, interaction, missing data and covariables. Complementary sources of information on the practical use of multiple linear regression may be found in Kelly, Beggs, and McNeil (1969), Ward and Jennings (1973), and Kerlinger and Pedhazur (1973).

In multiple linear regression a regression model of selected variables or vectors is generated in order to predict a criterion. Both the predictor and criterion variables may be in continuous or discrete form. The number of predictor variables, i.e., independent variables and covariates, which can be handled in the Bottenberg and Ward program is quite large, a feature obviously useful when the purpose of an investigation is simultaneous consideration of many variables. The process of hypothesis testing consists of creating an alternative to the original regression model. This is accomplished by deleting or collapsing critical variables. The resulting <u>restricted</u> model, as it is termed, is compared for effectiveness with the original or <u>full</u> model as a predictor of the criterion. Prediction is expressed as the proportion

of criterion variance, R^2, and hypothetical value of a given predictor variable is seen in the putative reduction in the size of R^2 produced by its omission in the restricted regression model. The difference between the full regression model and the restricted regression model is tested by means of an F-value which can be expressed in terms of the level of probability. The basic or full model may be illustrated as follows:

$$Y = a_o u + a_1 x_1 + a_2 x_2 + \ldots a_n x_n + e$$

where Y = a criterion of continued or discrete data

u = a unit vector which when multiplied by the weight a_o yields the regression constant

$a_1 \ldots a_n$ = partial regression weights arrived at by multiple linear regression techniques and calculated to minimize the error sum of square of prediction (Ee^2)

$x_1 \ldots x_n$ = variables in continuous or discrete form

In the present investigation the basic or full model consisted of the twelve vectors listed in Table I, together with three vectors representing the three groupings of information (i.e. all child data, all maternal data, and all ecological data).

A second variety of regression analysis employed Koplyay's (1972) Automatic Interaction Detector program (AID-4). This is a multivariate technique which tests for significant patterns of interaction by splitting predictors into subsets. The technique maximizes the proportions of variance accounted for, by dichotomizing variables and also by generating squared and polynomial exponential forms.

The two regression analyses, MULR-05 and AID-4 were applied to the data in the same way. All cases were treated as single criterion groups for the MULR-05 analysis, and for the AID-4 analysis. However, the predictor set used for the original linear regression analysis

was culled to create a parsimonious predictor set. Predictors were retained for the interaction analysis using the AID-4 program when they met the criterion of contributing substantially to an accounting of criterion variance in the MULR-05 linear regression models.

Predictors

The following child-centered measures were used as predictor elements in the regression models:

Sex, a discrete vector in which male=1, and female=0.

Weight expressed in pounds at birth and at twelve months of age. There is a voluminous literature on the role of birthweight as a determinant of cognitive attainment, and there is an emerging body of research on the effects of overweight at birth on the subsequent course of development (Erhardt, et al., 1964; Babson, Henderson & Clark, 1969).

Apgar Score. The use of quantified descriptions of neonates' condition in the first few moments of life has been found useful in the study of infancy (Apgar & James, 1962; Colburn & Salzman, 1960: Klatskin, McGarry, and Steward, 1966). Apgar scores are ratings in the first few minutes post partum of infants' respiration, muscle tone, color, reflex irritability, and pulse. Gleiss & Holdenburg (1963) considered scores of 9-10 normal (i.e., optimal scores of 7-8 slightly disturbed, and applied the term "highly disturbed" to scores below that.

Ad Hoc Development Scale. This instrument was developed by the investigator (Jordan, 1967b) in order to obtain information quickly and easily when interviewing mothers. Its particular utility has arisen in the case of lower class, unsophisticated mothers whose ability to participate in substantively oriented interviews is not great. The validity of the 12 month Ad Hoc scores is indicated by statistically significant correla-

tions with 24 month Binet mental age.

Biological Risk. This predictor was the presence or absence of any of four generic factors placing the child at risk during gestation and early infancy. The elements of the selection criteria were:

Disorders of Pregnancy and Gestation

Anemia of pregnancy, toxemia, pyelonephritis, diabetes, miscarriages, eclampsia, pre-eclampsia, serious infections, over- and under-age, developmental anomalies, hypertension, hemorrhages.

Disorders of Delivery

Cord complications, delivery complications, presentation complications.

Neonatal Disorders

Low birth weight, immaturity, hemolytic disease, low Apgar, anoxia, multiple birth (not twins), traumatic defect.

Multiple Complications

These elements were combined into a predictor unit referred to in Tables 3-7 as Child Data.

The following pieces of information about mothers were employed in the linear regression analyses:

Anxiety. Bendig's (1955) version of the Taylor Anxiety Scale was administered at child age six months. While some maternal data was taken during confinement the anxiety measure was delayed in order to suppress increments in scores associated with the delivery.

Delivery Age. This relatively simple measure was obtained from mothers and validated against hospital records whenever possible. The range of delivery ages was broad, ranging from thirteen for the youngest mothers to forty two years for the oldest.

Marital Status was also obtained by interview and validated whenever possible.

Authoritarianism. This variable, the authoritarian family ideology subtest (AFI_{65}) of Ernhart and Loevinger's (1969) Family Problems Scale, was administered before mothers left the hospital with the newborn infant. These four measures were also combined into the predictor Maternal Data.

Data on the broad ecological matrix for development were also taken. Social Class status at birth (SES) was measured by assigning weights provided by McGuire and White (1955) to three characteristics of the head of the household at the time of delivery of the study child, the proband. The three pieces of information used were the breadwinner's occupation, level of education, and some of income (not amount of income). McGuire and White SES scores range from high scores (low SES) of 84 to low scores of 14 (high SES).

Race consisted of self-identification as black or white, the minority and majority ethnic groups in the metropolitan community.

Social class and race were also combined to form the predictor set Ecological Data. The twelve discrete predictors plus the three data sets they were combined into were used in multiple linear regression analyses of the criterion measures at ages one to five years.

Criteria. The criterion measures employed at ages two to five years totalled eight. At age two years information was gathered on the children by means of two structured interviews, the Verbal Language Development Scale by Mecham (1959) referred to in the text as the VLDS, and the Preschool Attainment Record by Doll (1966). In the case of the last test, three subtests were employed. In the case of the Preschool Attainment Record (PAR) some of the items of inquiry

were operationalized. At the remaining ages, beginning with the third birthday, the children were tested directly using largely verbal measures. In some instances the same examiner saw the family at all testing sessions from birth to age five.

Preschool Attainment Record (PAR). Doll (1966) has extended the Vineland scale in the form of the PAR. The scale has subtests in several domains and one domain was used in the present investigation. The summed scores on three subtests, labelled Information, Ideation, and Creativity, were used to provide a score for what Doll refers to as the Intellectual domain.

Verbal Language Development Scale (VLDS). Mecham's (1959) scale is a measure of attainment in the use of language. Like the PAR it is an interview instrument; an informant, usually the biological mothers in this investigation, provide data on the attainment of children. Both the PAR and VLDS were used at age two.

Peabody Picture Vocabulary Scale (PPVT). Dunn's (1966) instrument consisting of a series of pictural stimuli which elicit recognition vocabulary in children. Form A of the test was used at age three.

The Boehm Test of Basic Concepts (1967) was used at age four. It is a test composed of pictures which represent a range of common concepts, up, near, big, etc., which children ordinarily acquire by indirect as well as direct means. In view of the age of the subjects only the first half of the test was administered.

The Preschool Inventory (Caldwell, 1970) was also administered at age four. This test consists of items of functional behavior and concepts which children can be expected to show at the end of the preschool period.

The Wechsler Preschool and Primary Scale of Intelligence (1969). The WPPSI Vocabulary subtest was administered at age five years.

The Illinois Test of Psycholinguistic Abilities (Kirk and McCarthy, 1969)

was partially administered at age five. Two subtests, Auditory Association and Digit Span, were administered. These two measures are stated by Bereiter and Engelmann (1966) to be particularly useful in educational planning for children of low cognitive development. Jensen (1969) has asserted that the digit span task is an excellent measure of associative learning, the process in which there is little transformation of the input within the mental processes (Pezzullo, Thorsen, Madsen, 1972).

In the case of the PAR and VLDS measures used as criteria of cognitive attainment a few observations may be made. One test deals narrowly with language, the VLDS scale, while the other, the PAR, deals with a broader range of behaviors. It is important to note that the criterion series at two years represents a choice of indirect observations of children, as well as indirect observations by means of an informed person. In its original form the PAR uses an informed person, usually the mother, to develop a description of child development. In this investigation the three PAR subtests in the Intellectual domain were operationalized whenever possible. For example, items of motor behavior can be translated into child behavior. It is sometimes possible to obtain information about (e.g.) hopping by asking the child to imitate the interviewer, who hops. Binet's were administered to a number of subjects, but the resulting number of really satisfactory scores was not sufficient to be included in this investigation. In practice the choice of indirect measures of attainment has the advantage of being based on mothers' extensive and intensive observations of behavior. It does not depend, as Binet performance does, on the happy or fortuitous conjunction of a two year old's temperament, the examiner, and a series of uncontrollable influences on child performance. In all cases children and examiners were matched by race.

CHAPTER IV

RESULTS

Linear Regression Analyses

Three hundred and sixty-four children were studied on the basis on completeness of information at birth and at age two years in the categories chosen for investigation. Three quarters of the children were white (77%), one-half were males (53%), and a fraction (7%) were illegitimate. The proportion of "risk" perinatal histories (49%) was in balance with the proportion of "low risk" (51%) perinatnal histories. Risk was defined as the presence of three perinatal conditions. First, clinical evidence of gestation problems or having a mother with characteristics such as age (16<>40 years) generally considered threatening. Second, clinical evidence of abnormal status post partum. The risk series was categorical in nature, with the degree of risk ranging from very mild to extreme. An example of very mild was a birth weight of eighty-seven ounces in the presence of a classification standard of eighty-eight ounces for non-risk weight. High risk was illustrated by the presence of several categories of disturbance, i.e., multiple complications. The risk group was heterogeneous, and drawn from a population used to study the putative role of biological adversity in the presence and absence of social adversity (Jordan, 1971).

At birth the average child weighed seven pounds three and a half ounces (115.53 oz.), which is similar to the value reported by the writer elsewhere (Jordan, 1969a) for 497 neonates with normal perinatal status (115.86 oz.).

Apgar scores, ratings of physiological processes in the first few minutes post partum, ranged from ten to one, with the mean close to a perfect

TABLE 3

CHARACTERISTICS OF THE MULR-05 GROUPS

VARIABLE	RANGE	MEAN	STANDARD DEVIATION
Two Year Group, N = 364			
Birth Weight (lbs)	2.56-12.00	7.22	1.22
Apgar score	1-10	8.56	1.52
One Year Weight (lbs.)	17.00-27.12	21.27	2.64
One Year Development	7-19	14.80	2.11
Delivery Age	13-42	26.60	6.34
Maternal Anxiety	0-17	5.15	4.27
Social Class	16-84	49.89	15.84
AFI	6-46	27.51	9.28
Married Mothers		93%	
Sex		53% Male	
Race		77% White	
Two Year PAR Intellectual	9-29	18.15	3.71
Two Year Mechan Language	2-36	19.83	5.10
Three Year Group, N = 176			
Birth Weight (lbs.)	2.30-12.00	7.16	1.21
Apgar Score	2-10	8.72	1.33
One Year Weight (lbs.)	15.90-30.10	22.14	2.56
One Year Development	10-19	14.77	2.07
Delivery Age	15-43	26.14	6.44
Maternal Anxiety	0-17	5.42	4.39
Social Class	16-81	50.17	16.83
AFI	7-46	28.62	8.84
Married Mothers		92%	
Sex		55% Male	
Race		76% White	
Peabody Picture Vocabulary Test	5-54	27.04	11.09
Four Year Group, N = 181			
Birth Weight (lbs.)	2.50-12.00	7.21	1.19
Apgar Score	4-10	8.83	1.14
One Year Weight (lbs.)	15.90-30.10	22.20	2.59
One Year Development	10-19	14.79	2.14
Delivery Age	15-43	25.85	6.36
Maternal Anxiety	0-17	5.37	4.44
Social Class	16-81	49.96	17.04
AFI	7-46	28.88	8.84
Married Mothers		91%	
Sex		54% Male	
Race		75% White	
Boelm Test of Basic Concepts	0-24	14.59	5.04
Preschool Inventory	0-58	34.66	12.42
Five Year Group, N = 180			
Birth Weight (lbs.)	2.50-12.00	7.22	1.18
Apgar Score	2-10	8.79	1.25
One Year Weight (lbs.)	15.90-30.00	22.19	2.51
One Year Development	10-19	14.82	2.13
Delivery Age	15-43	25.74	6.23
Maternal Anxiety	0-17	5.42	4.48
Social Class	16-81	49.49	16.85
AFI	7-46	28.75	8.79
Married Mothers		92%	
Sex		54% Male	
Race		75% White	
WPPSI Vocabulary	2-36	14.52	5.21
ITPA Auditory Association	4-25	10.58	4.02
ITPA Digit Span Items	4-30	14.82	2.13

condition. An Apgar score of ten means an excellent condition in the neonate on five physiological characteristics. A score of two, one, or zero is assigned to describe five physiological states from the optimal (two) to the highly abnormal (zero). The mean value for the subjects of this investigation (8.56) represents a depression of the mean level to a condition which is less than perfect but not really abnormal. Apgar scores are not really psychometric tools but positively skewed quantitative descriptions. Most babies receive perfect scores, and a few receive scores below seven (Gleiss & Holdenberg, 1963).

At twelve months the babies varied in weight (17-21.25 lbs.). The average baby weighed twenty-one pounds (340.46 oz.). The mean weight is nineteen ounces less than that reported elsewhere (Jordan, 1968) for 281 low risk children at twelve months of age. Low birth weight children in the present study group accounts for the difference.

Development at twelve months was measured by means of the investigator's Ad Hoc Development Scale (Jordan, 1967b). The scores given in Table 3 were similar to those reported elsewhere (Jordan, 1968).

The criterion measures at twenty-four months were the intellectual domain of the Preschool Attainment Record (Doll, 1966), and the Verbal Language Development Scale (Mecham, 1959). Examination of the raw scores in Table 3 show a mean PAR score of 18.15, with a broad range, 9-29 points. The mean level for all subjects is the equivalent of a normative age of 3.1 years; this attainment level is an approximate statement, being derived from three subtests. Scores on the Mecham VLDS were a mean of 19.83, a range of 2-36, and a standard deviation of 5.10. The mean score of 19.83 may be expressed, according to Mecham as an "equivalent language age" of 2.4 years. Neither the Mecham nor the Doll manuals provide detailed normative data, e.g., sample size at age two years. The 364 subjects at age two years

are representative of the general population and so the attainment ages derived probably need not be interpreted narrowly.

The 364 mothers had an average age of delivery of 26.60 years. The range was broad; some of the mothers were as young as thirteen years while others were as old as forty-two. The juvenile pregnancies were unmarried Black girls. There were no special characteristics of the over-age mothers. In delivery age the mothers deviated slightly from 497 mothers of low risk babies; the study group mothers' mean age at delivery was 26.60 years, which is just a year and four months younger than the mean for the 1966 SLBS cohort mothers ($\bar{M}$ = 25.29).

The anxiety score, the Bendig (1955) version of the Taylor Manifest Anxiety Scale, was administered six months after delivery. Chovanec (1968) has shown that anxiety scores of SLBS mothers together with delivery age influence several test scores of children. The mean anxiety scores at six months post partum given in Table 2 is virtually identical to the mean of 5.80 identified in 653 mothers by the writer.

The social class level of the families was wide; in fact, it covered the range of differences quantified by the McGuire and White (1955) technique. The mean and standard deviation values given in Table 2 are similar to those describing one thousand SLBS families (Jordan, 1969). The mean score of 49.89 is exemplified by a family with a score of 49. Their daughter weighed seven pounds and twelve ounces at birth, and was thirty-three and one-half inches high, and weighed twenty-four pounds and eight ounces at two years. She had a Stanford-Binet mental age of twenty-six months and a PAR Intellectual score of 18 ($\bar{M}$ = 17.99) at age two. At age three and a half the PPVT IQ was 109; height was thirty-five and one-half inches and she weighed thirty-one pounds. Four and a half year Boehm score was eighteen, which was above the group mean in Table II of 14.59. The four and a half year Preschool

Inventory score obtained by the little girl was forty-four ($\bar{M}$ = 34.66). Height was forty-one inches, and weight was thirty-seven pounds. There are two other children. The father was twenty-five years of age, his wife was twenty-three, when the proband was delivered. The family live in an area occupied solely by white families; the homes are generally brick bungalows built in the 1920's. The father has two years of college and he works as a cable splicer for the phone company. He earned $7,000 per annum in the early 1970's.

A measure of maternal child rearing ideology, Ernhart & Loevinger's (1969) Authoritarian Family Ideology measure (AFI 65) was obtained towards the end of confinement. The mean score given in Table 2, 27.51, is virtually identical with that given as normative by Ernhart & Loevinger (1969).

This set of descriptive characteristics of the two year group of 364 cases, as Table 3 shows, also applies to the groups of children and their families studied at ages three to five. Some of the characteristics of the later age groups are virtually identical. Mean twelve month development scores for the four criterion groups are 14.80, 14.77, 14.79 and 14.82. Mean birth weights for the four groups are 7.22 lb., 7.16 lb., 7.21, lb., and 7.22 lb. The standard deviations are equally consistent. The explanation is that the children analyzed at four ages were selected on the basis of completeness of data at any given age. The three to five year criterion groups are drawn from the two year group and represent splitting the two year group into two subgroups for study six months apart. They are filial cohorts, sub-units, of the two year cohort. It is important to note that sub-cohorts do not automatically retain identity in selected traits. It would be easy to accept a false hypothesis of similarity of groups by default. Table 3 shows that the groups, described as separate criterion/age groups are indeed comparable to each other.

The 176 children studied at age three years were given Form A of the Peabody Picture Vocabulary Test. The mean raw score at age three was 27.04. The PPVT manual gives a mental age of two years and eleven months for this means. At life age thirty-six months this combination of mental age and chronological age yields a mean IQ for the subjects of 97. The range is from IQ 73 to IQ 138. The ± one standard deviation IQ's of the three year group are IQ 79 and IQ 114. The standard deviation for the three-year olds used in this study is 11.09, which is slightly larger than Dunn's value of 9.66, indicating slightly wider scatter.

At age four years data were gathered on the mean delay between the fourth anniversary of delivery and actual administration of tests. Obviously, the actual anniversary of birth, the fourth birthday, is not a very practical date for giving tests. The delay in administrating the criterion series was .32 weeks, which is between two or three days. The four year criterion series consisted of two tests, the Boehm Test of Basic Concepts (1967) and Caldwell's (1970) Preschool Inventory. Table 3 records the descriptive statistics of the test results. The Boehm score was based on administration of the first twenty-five items. No ceiling effect was encountered, with the top end of the range being a score of twenty-four. The mean was 14.59, and the standard deviation was 5.04. The second test given in its entirety was the Preschool Inventory. The range of scores was 0 - 58, and the mean was 34.66; the standard deviation was 12.43.

At age five years the mean WPPSI Vocabulary score of 180 children was 14.52. A score of fifteen is expected at age sixty months, according to ITPA norms. The ITPA Auditory Association mean, the number of items passed rather than number of digits, was 10.58. The ITPA Digit Span test, a test of auditory sequential memory, was scored for number of items passed, rather than number of digits repeated. The mean was 14.82. Mean test delay at age

four years was only a few days on the average.

Two Year Results

The inferential analysis of factors contributing to cognitive development is based on regression models composed of fifteen predictors and two criteria at age two.

PAR Intellectual Scores (Doll, 1966)

The full regression model of (N=364) PAR Intellectual scores, produced a highly significant R^2 value, .12. Deletion of Specific variables from the full regression model (models 3(a) - 15(a)) produced slight drops in the actual R^2 values. The majority of restricted models produced R^2's in the general area of .08 - .12. However, one restricted model (model 2(a)) reduced the R^2 value by one-half, from .12 to .06.

The first hypothesis tested was the contribution of all the biological data to prediction of the PAR Intellectual scores. As Table 4 shows the six pieces of child development data contributed greatly to prediction of the criteria. Their absence (model 2(a)) reduced the significance of the regression model from $<$ .00004 to .001. The R^2 value of model two was .06, and the drop was statistically significant ($F = 2.79$, $p = .003$). Model three tested the contribution of knowledge of the child's sex to prediction of the criterion. A slight reduction in the R^2 value was produced, but it was a statistically significant difference ($F = 4.17$, $p = .04$). Model four examined the contribution of birth weight; the results were insignificant ($F = 1.20$, $p = .27$). Model five represented deletion of Apgar scores and was also insignificant ($F = .40$, $p = .52$). Models six, seven, and eight, examined the contribution of vectors representing weight and development scores at twelve months, and the presence of factors indicative of "at risk" perinatal status. Only one vector, twelve month development, was insignificantly related to the criterion.

TABLE 4

COMPARISON OF MODELS IN REGRESSION OF CRITERION (a): PAR INTELLECTUAL SCORES AND (b) MECHAM VLDS SCALE AT AGE TWO YEARS

Variables	Models Compared	R^2	F	P		R^2	F	P
Child Data	Full Model (a)	.12	2.79	<.00004*	(b)	.20	6.97	<.00001*
				.003				<.00001
	Model 2 (a)	.06		<.001*	(b)	.06		<.0006*
Sex	Full Model (a)	.12	4.17	<.00004*	(b)	.20	12.18	<.00001*
				.04				<.0005
	Model 3 (a)	.11		<.00001*	(b)	.17		<.00001*
Birthweight	Full Model (a)	.12	1.20	<.00004*	(b)	.20	.45	<.00001*
				.27				.50
	Model 4 (a)	.12		<.00002*	(b)	.20		<.00001*
Apgar	Full Model (a)	.12	.40	<.00004*	(b)	.20	.00	<.00001*
				.52				.99
	Model 5 (a)	.12		<.00003*	(b)	.20		<.00001*
Twelve Month Weight	Full Model (a)	.12	.25	<.00004*	(b)	.20	.02	<.00001*
				.61				.87
	Model 6 (a)	.12		<.00002*	(b)	.20		<.00001*
Twelve Month Development	Full Model (a)	.12	15.51	<.00004*	(b)	.20	42.62	<.00001*
				.0001				<.00001
	Model 7 (a)	.08		<.005*	(b)	.10		<.00001*
Risk Factor	Full Model (a)	.12	.31	<.00004*	(b)	.20	.56	<.00001*
				.86				.68
	Model 8 (a)	.12		<.0005*	(b)	.10		<.00001*
Maternal Data	Full Model (a)	.12	3.76	<.00004*	(b)	.20	2.16	<.00001*
				.005				.07
	Model 9 (a)	.08		<.0008*	(b)	.18		<.00001*
Anxiety	Full Model (a)	.12	3.73	<.00004*	(b)	.20	.04	<.00001*
				.05				.84
	Model 10 (a)	.11		<.00001*	(b)	.20		<.00001*
Delivery Age	Full Model	.12	6.66	<.00004*	(b)	.20	5.59	<.00001*
				.01				.01
	Model 11 (a)	.10		<.00002*	(b)	.19		<.00001*
AFI_{65}	Full Model (a)	.12	3.45	<.00004*	(b)	.20	3.06	<.00001*
				.06				.08
	Model 12 (a)	.11		<.00008*	(b)	.19		<.00001*
Marital Status	Full Model (a)	.12	.44	<.00004*	(b)	.20	.36	<.00001*
				.50				.54
	Model 13 (a)	.12		<.00003*	(b)	.20		<.00001*
Ecological Data	Full Model (a)	.12	3.25	<.00004*	(b)	.20	6.27	<.00001*
				.03				.002
	Model 14 (a)	.10		<.00001*	(b)	.17		<.00001*
Social Class	Full Model	.12	5.40	<.00004*	(b)	.20	9.89	<.00001*
				.02				.001
	Model 15 (a)	.10		<.00001*	(b)	.18		<.00001*
Race	Full Model (a)	.12	2.52	<.00004*	(b)	.20	.61	<.00001*
				.11				.43
	Model 16 (a)	.11		<.00005*	(b)	.20		<.00001*

*Significance of the difference from zero.

as Table 4 shows.

Model nine represented the deletion of four pieces of information about the mothers from the full model. The result of comparing model nine with model one, the full model, was statistically significant, ($F = 3.76$, $p = .005$), and it produced a comparatively substantial drop to an R^2 of .08. Models ten through thirteen examined the value of specific pieces of maternal information. Anxiety scores ($F = 3.73$, $p = .05$), and delivery age ($F = 6.66$, $p = .01$), were significantly related to prediction of the criterion. AFI_{65} scores were very close to statistical significance, although the reduction in R^2 value was slight; marital status was not associated with the criterion.

The last three models, fourteen, fifteen, and sixteen, examined the contribution, jointly and separately, of social class score (SES) and race (Negro). Race was not significantly associated with the criterion, but social class was significantly associated ($F = 5.40$, $p = .02$.).

Verbal Language Development Scale (Mecham 1959)

The second criterion of cognitive development at twenty-four months of age used in this investigation was Mecham's measure of verbal attainment. It is similar to the PAR in its derivation from the Vineland Social Maturity Scale.

The full model of prediction in Table 4, based on 364 cases ($N = 364$), was highly significant ($p = <.00001$) and had an R^2 value of .20. Deletion of all biological data, affected through model two, reduced the R^2 value to .06, which is statistically significant ($F = 6.97$, $p = <.00001$). Of the six elements in the biological aggregate of data only two were significant. They were the twelve month development score ($F = 42.62$, $p = .00001$), and the sex factor ($F = 12.18$, $p = <.00005$). Only one of four maternal traits, age at delivery, was significantly associated with the criterion ($F = 5.59$, $p = .01$). One ecological factor, social class score, altered prediction of the criterion significantly. When omitted from the full model of prediction, in model

fifteen, the resulting restriction reduced prediction materially ($F = 9.89$, $p = < .001$). The combination of race and social class was also significant ($F = 6.27$, $p = .002$). Race was not significant as a factor within the combination. On the other hand social class as represented by McGuire & White scores was. Deletion of the social class scores reduced the Model R^2 value to a significant degree ($F = 9.89$, $p = .001$).

Three Year Results

176 records were selected on the basis of complete information at birth, one year, and three years in the thirteen categories used as predictor and criterion variables. This number is approximately one-half the number retrieved at child age twenty-four months. The reason is a procedural decision, taken at thirty-six months, to split the sample in order to permit concentrated search for some members of the cohort. Three-quarters of the thirty-six month study group were white (76%), slightly more than half were male (55%), and a small group (7%) were illegitimate. The proportion of perinatal status at risk was 49%. The latter two categories were virtually identical with those in the group studied at twenty-four months. Consideration of the data in Table 3 shows that the thirty-six month group resembled the twenty-four month group in other ways. Birth weight and Apgar values are very close, as are weight and development scores at twelve months. Maternal age at delivery and anxiety score at six months are also similar for both groups. The similarity between study groups holds for social class levels and AFI_{65} scores.

Peabody Picture Vocabulary Scale, Form A Raw Scores (Dunn, 1965)

The full regression model used to study antecedents to PPVT scores at thirty-six months of age was based on twelve pieces of information in three domains. Consideration of Table 5 shows that the full regression model had

TABLE 5

COMPARISON OF MODELS IN REGRESSION ANALYSES OF CRITERION (c): PEABODY PICTURE VOCABULARY TEST AT AGE THREE YEARS

Variables	Models Compared	R^2	F	P
	Full Model (c)	.20		.0001*
Child Data			.67	.66
	Model 2 (c)	.18		<.00001*
	Full Model (c)	.20		.0001*
Sex			.00	.93
	Model 3 (c)	.20		.00006*
	Full Model (c)	.20		.0001*
Birthweight			.67	.66
	Model 4 (c)	.20		.00006*
	Full Model (c)	.20		.0001*
Apgar			.00	1.0
	Model 5 (c)	.20		.0001*
	Full Model (c)	.20		.0001*
Twelve Month Weight			.007	.93
	Model 6 (c)	.20		.00005*
	Full Model (c)	.20		.0001*
Twelve Month Development			2.87	.09
	Model 7 (c)	19		.0001*
	Full Model (c)	.20		.0001*
Risk Factor			.18	.67
	Model 8 (c)	.20		.00006*
	Full Model (c)	.20		.0001*
Maternal Data			2.69	.03
	Model 9 (c)	.15		.0004*
	Full Model (c)	.20		.0001*
Anxiety			3.19	.07
	Model 10 (c)	.19		.0001*
	Full Model (c)	.20		.0001*
Delivery Age			2.04	.15
	Model 11 (c)	.19		.0001*
	Full Model (c)	.20		.0001*
AFI_{65}			3.44	.06
	Model 12 (c)	.18		.0002*
	Full Model (c)	.20		.0001*
Marital Status			1.98	.16
	Model 13 (c)	.19		.0001*
	Full Model (c)	.20		.0001*
Ecological Data			1.73	.17
	Model 14 (c)	.18		.0001*
	Full Model (c)	.20		.0001*
Social Class			2.33	.12
	Model 15 (c)	.19		.0001*
	Full Model (c)	.20		.0001*
Race			.28	.59
	Model 16 (c)	.20		.00006*

*Significance of the difference from zero.

an R^2 value of .20, and was statistically significant ($p = < .0001$). The value of aggregates of data was generally slightly lower. Only deletion of the aggregate, Maternal data produced a statistically significant drop in R^2 values. The value of the model was .15 ($F = 2.69$, $p = .03$). Three of the four elements in the maternal data model contributed .01 of the criterion variance, while one, AFI_{65}, contributed .02. The aggregate of early child data, six elements, contributed only .02 of the criterion variance when deleted; it was statistically insignificant, however ($F = .67$, $p = .66$). The third aggregate, Ecological data, made an insignificant contribution, .02 of the criterion variance. Neither social class nor race materially contributed. Social class, however, was similar to maternal data, contributing one percent of the variance.

Four Year Results

At four years the number of cases employed was 181. They were drawn from the pool established at age three years by splitting the full birth group in order to facilitate case tracing. The number of cases was higher than that used at age three years. It illustrates a difference in the cases cooperating at age four years, and also illustrates the tendency for the number of cases in the birth cohort employed at subsequent testing dates to rise. This is in contrast to the stereotype of a decline in the number of cases available in longitudinal study. The four year data represent the ninth study period for the 1966-67 birth cohort; the phenomenon of increasing as well as decreasing sample size in longitudinal study has been observed since birth.

Preschool Inventory

The full regression model of raw scores on the Preschool Inventory (Caldwell, 1970) produced an R^2 value of .37. The aggregate of six elements of child data up to the first birthday was deleted in model 2(d) in order to test its significance. The result was a drop in R^2 value from .37 to .34.

The drop in R^2 value was statistically significant ($F = 3.11$, $p = .02$), as Table 6 shows. Within the aggregate of child data none of the individual predictors was insignificant; sex and twelve month weight produced the largest F-values, but without a decrement from the R^2 value of the full regression model. Maternal data in the aggregate (model 9(d)) significantly affected prediction of the criterion. When deleted from the full model the maternal data group lowered the R^2 value to .32 and was statistically significant ($F = 3.74$, $p = .006$). Within the aggregate the individual predictors marital status (i.e. married) anxiety score at six months post partum, and age at delivery were not significant. On the other hand, the AFI_{65} authoritarianism score was quite significant (reducing the R^2 value from .37 to .33 ($F = 12.58$, $p = .0005$). The ecological aggregate of race and social class, model 14(d), was more significant than the other two aggregates, dropping the R^2 value from .37 to .31. Race was not significant, but social class scores were reducing the R^2 to .33 ($F = 11.06$, $p = .001$).

Boehm Test of Basic Concepts

The full regression model of the Boehm Test yielded an R^2 value of .30. The aggregate of child data contributed to this proportion of criterion variance to a significant degree when tested in model 2(e). When the child data aggregate was deleted from the full model the R^2 value dropped from .30 to .24 ($F = 5.30$, $p = .02$). Within the aggregate of six factors four were insignificant, birthweight, Apgar score, twelve month development and risk factor. Two were significant, sex ($F = 7.77$, $p = .005$) and twelve month weight ($F = 6.56$, $p = .01$). Maternal data in the aggregate were significant ($F = 2.44$, $p = .04$). Within the aggregate of four predictors, anxiety score, age at delivery, and marital status were not significant. Only one factor, the AFI_{65} authoritarianism score, was significant ($F = 7.29$, $p = .007$). The aggregate of ecological data, composed of race and social class score, was

TABLE 6

COMPARISON OF MODELS IN REGRESSION ANALYSES OF CRITERION (d): PRESCHOOL INVENTORY AND (e): BOEHM TEST OF BASIC CONCEPTS AT FOUR YEARS

Variables	Models Compared	R^2	F	P		R^2	F	P
Child Data	Full Model (d)	.37	3.11	<.000001*	(e)	.30	5.30	<.000001*
				.02				.02
	Model 2 (d)	.34		<.000001*	(e)	.24		<.000001*
Sex	Full Model (d)	.37	2.51	<.000001*	(e)	.30	7.77	<.000001*
				.11				.005
	Model 3 (d)	.37		<.000001*	(e)	.27		<.000001*
Birthweight	Full Model (d)	.37	.01	<.000001*	(e)	.30	.13	<.000001*
				.91				.71
	Model 4 (d)	.37		<.000001*	(e)	.30		<.000001*
Apgar	Full Model (d)	.37	.51	<.000001*	(e)	.30	.29	<.000001*
				.47				.58
	Model 5 (d)	.37		<.000001*	(e)	.30		<.000001*
Twelve Month Weight	Full Model (d)	.37	2.40	<.000001*	(e)	.30	6.56	<.000001*
				.12				.01
	Model 6 (d)	.37		<.000001*	(e)	.27		<.000001*
Twelve Month Development	Full Model (d)	.37	.37	<.000001*	(e)	.30	1.11	<.000001*
				.54				.29
	Model 7 (d)	.37		<.000001*	(e)	.30		<.000001*
Risk Factor	Full Model (d)	.37	2.11	<.000001*	(e)	.30	.31	<.000001*
				.14				.57
	Model 8 (d)	.37		<.000001*	(e)	.30		<.000001*
Maternal Data	Full Model (d)	.37	3.74	<.000001*	(e)	.30	2.44	<.000001*
				.006				.04
	Model 9 (d)	.32		<.000001*	(e)	.26		<.000001*
Anxiety	Full Model (d)	.37	.11	<.000001*	(e)	.30	1.56	<.000001*
				.73				.21
	Model 10 (d)	.37		<.000001*	(e)	.29		<.000001*
Delivery Age	Full Model (d)	.37	3.07	<.000001*	(e)	.30	1.51	<.000001*
				.08				.21
	Model 11 (d)	.36		<.000001*	(e)	.29		<.000001*
AFI_{65}	Full Model (d)	.37	12.58	<.000001*	(e)	.30	7.29	<.000001*
				.0005				.007
	Model 12 (d)	.33		<.000001*	(e)	.27		<.000001*
Marital Status	Full Model	.37	.59	<.000001*	(e)	.30	.90	<.000001*
				.44				.34
	Model 13 (d)	.37		<.000001*	(e)	.30		<.000001*
Ecological Data	Full Model	.37	9.43	<.000001*	(e)	.30	6.71	<.000001*
				.0001				.001
	Model 14 (d)	.31		<.000001*	(e)	.24		<.000001*
Social Class	Full Model	.37	11.06	<.000001*	(e)	.30	4.62	<.000001*
				.001				.03
	Model 15 (d)	.33		<.000001*	(e)	.28		<.000001*
Race	Full Model	.37	2.59	<.000001*	(e)	.30	4.58	<.000001*
				.10				.03
	Model 16 (d)	.37		<.000001*	(e)	.28		<.000001*

*Significance of the difference from zero.

significant ($F = 6.71$, $p = .001$). Both elements were significant, race ($F = 4.50$, $p = .03$), and social class ($F = 4.62$, $p = .03$).

Five Year Results

The number of children studied at age five years was 180, a decrease of one from the number studied at age four. Inspection of Table 3 indicates the continued similarity of the five year subjects to the total sample of children.

WPPSI Vocabulary

The full regression model for this criterion shown in Table 7 produced an R^2 value of .17. The first comparison, that with model 2 deleting all child data was insignificant. The restricted model R^2 declined from .17 to .15. All of the elements of this group of predictors contributed very small amounts within the two percent discrepancy, which was statistically insignificant ($F = .61$, $p = .71$). The maternal data aggregate of four elements produced a drop in R^2 value from .17 to .14. It was not, statistically significant, however, ($F = 1.75$, $p = .13$). Within the aggregate delivery age was statistically significant, with a decline in R^2 to .15 ($F = 5.32$, $p = .02$). The discrepancy between a decline of .03 for the aggregate which was statistically insignificant and this .02 decline which was significant, is probably due to the difference in the degrees of freedom. The third aggregate, ecological data, produced a four percent decline to $R^2 = .13$ ($F = 4.63$, $p = .01$). Social class accounted for the criterion variance ($F = 8.64$, $p = .003$) rather than ethnic group.

Auditory Association

A slightly lower R^2 value for this criterion, .14, was generated by the full model in Table 7. The drop to R^2 .10 generated by restricted model 2 was not statistically significant, nor were any of the six items in the child

TABLE 7

COMPARISON OF MODELS IN REGRESSION ANALYSES OF CRITERION (f): WPPSI VOCABULARY AND (g): ITPA AUDITORY ASSOCIATION AT FIVE YEARS

Variable	Models Compared	R^2	F	P		R^2	F	P
Child Data	Full Model (f)	.17	.61	.0008*	(g)	.14	1.34	.008*
				.71				.24
	Model 2 (f)	.15		.0001*	(g)	.10		.004*
Sex	Full Model (f)	.17	.22	.0008*	(g)	.14	.76	.008*
				.63				.38
	Model 3 (f)	.17		.0001*	(g)	.14		.006*
Birthweight	Full Model (f)	.17	.89	.0008*	(g)	.14	1.59	.008*
				.34				.20
	Model 4 (f)	.17		.0006*	(g)	.13		.008*
Apgar	Full Model (f)	.17	.01	.0008*	(g)	.14	3.38	.008*
				.89				.06
	Model 5 (f)	.17		.0004*	(g)	.12		.01*
Twelve Month Weight	Full Model (f)	.17	.04	.0008*	(g)	.14	.92	.008*
				.83				.33
	Model 6 (f)	.17		.0004*	(g)	.14		.006*
Twelve Month Development	Full Model (f)	.17	.63	.0008*	(g)	.14	1.44	.008*
				.42				.23
	Model 7 (f)	.17		.0005*	(g)	.13		.008*
Risk Factor	Full Model (f)	.17	.97	.0008*	(g)	.14	1.34	.008*
				.32				.24
	Model 8 (f)	.17		.0006*	(g)	.13		.007*
Maternal Data	Full Model (f)	.17	1.75	.0008*	(g)	.14	2.02	.008*
				.13				.09
	Model 9 (f)	.14		.0008*	(g)	.10		.01*
Anxiety	Full Model (f)	.17	.13	.0008*	(g)	.14	.006	.008*
				.71				.93
	Model 10 (f)	.17		.0004*	(g)	.14		.004*
Delivery Age	Full Model (f)	.17	5.32	.0008*	(g)	.14	6.04	.008*
				.02				.01
	Model 11 (f)	.15		.003*	(g)	.11		.03*
AFI_{65}	Full Model (f)	.17	2.91	.0008*	(g)	.14	3.66	.008*
				.08				.05
	Model 12 (f)	.16		.001*	(g)	.12		.01*
Marital Status	Full Model (f)	.17	.60	.0008*	(g)	.14	1.25	.008*
				.43				.26
	Model 13 (f)	.17		.0005*	(g)	.13		.007*
Ecological Data	Full Model (f)	.17	4.63	.0008*	(g)	.14	5.42	.008*
				.01				.005
	Model 14 (f)	.13		.0009*	(g)	.08		.005*
Social Class	Full Model (f)	.17	8.64	.0008*	(g)	.14	2.04	.008*
				.003				.15
	Model 15 (f)	.13		.005*	(g)	.13		.01*
Race	Full Model (f)	.17	.00	.0008*	(g)	.14	10.52	.008*
				.99				.001
	Model 16 (f)	.17		.0004*	(g)	.08		.13*

*Significance of the difference from zero.

data aggregate. Maternal data was not a statistically significant contribution to the prediction of the criterion, although the R^2 value declined to .10. Delivery age contributed .03 of the variance ($F = 6.04$, $p = .01$), and authoritarianism score AFI_{65}, was also statistically significant ($F = 3.66$, $p = .05$). The ecological aggregate was significant, dropping the R^2 from .14 to .08 ($F = 5.42$, $p = .005$). In contrast to the previous criterion, the WPPSI Vocabulary ethnic identity was the contributing element reducing the R^2 from .14 to .08 ($F = 10.52$, $p = .001$).

Digit Span

The full model of twelve predictors plus three groupings of predictors produced an R^2 value of .30, which is approximately twice that for the other two sixty month criteria. Neither the aggregate child data nor its constituent elements contributed significantly to the R^2 value in Table 8. In contrast, deleting the maternal data produced a decline of about twenty percent in the full model R^2, from .30 to .25. A statistically significant but functionally trivial decline in R^2 was associated with maternal age at delivery; $R^2 = .01$, ($F = 3.65$, $p = .05$). The most significant element within the maternal data was the authoritarianism score. Deletion of this element from the full model dropped the R^2 value from .30 to .26 ($F = 10.12$, $p = .001$). The ecological data group was the most significant predictor in the series. Deletion of the two elements dropped the R^2 from .30 to .23. Social class rather than ethnic group did the work, accounting for twenty percent of the full model variance ($F = 16.08$, $p = .00009$).

AID-4 Analyses

The preceding results indicate that the variables which influence mental test performance in a population including normal, superior and abnormal children are particular. There is a shift over the early years of child

TABLE 8

COMPARISON OF MODELS IN REGRESSION ANALYSES OF CRITERION (h): DIGIT SPAN AT AGE FIVE YEARS

Variable	Model Compared	R^2	F	P
Child Data	Full Model (h)	.30	1.01	<.00001*
	Model 2 (h)	.28		.41
				<.00001*
Sex	Full Model (h)	.30	1.40	<.00001*
	Model 3 (h)	.30		.23
				<.00001*
Birthweight	Full Model (h)	.30	.01	<.00001*
	Model 4 (h)	.30		.89
				<.00001*
Apgar	Full Model (h)	.30	.68	<.00001*
	Model 5 (h)	.30		.40
				<.00001*
Twelve Month Weight	Full Model (h)	.30	1.64	<.00001*
	Model 6 (h)	.30		.20
				<.00001*
Twelve Month Development	Full Model (h)	.30	.61	<.00001*
	Model 7 (h)	.30		.43
				<.00001*
Risk Factor	Full Model (h)	.30	2.31	<.00001*
	Model 8 (h)	.30		.12
				<.00001*
Maternal Data	Full Model (h)	.30	3.42	<.00001*
	Model 9 (h)	.25		.01
				<.00001*
Anxiety	Full Model (h)	.30	.67	<.00001*
	Model 10 (h)	.30		.41
				<.00001*
Delivery Age	Full Model (h)	.30	3.65	<.00001*
	Model 11 (h)	.29		.05
				<.00001*
AFI_{65}	Full Model (h)	.30	10.12	<.00001*
	Model 12 (h)	.26		.001
				<.00001*
Marital Status	Full Model (h)	.30	.01	<.00001*
	Model 13 (h)	.30		.89
				<.00001*
Ecological Data	Full Model (h)	.30	8.73	<.00001*
	Model 14 (h)	.23		.0002
				<.00001*
Social Class	Full Model (h)	.30	16.08	<.00001*
	Model 15 (h)	.24		.00009
				<.00001*
Race	Full Model (h)	.30	.00	<.00001*
	Model 16 (h)	.30		1.00
				<.00001*

*Significance of the difference from zero

development in the relative influence of predictor variables. At age two years there is a broad range of influential variables. While numerous, their contributions to the full model linear R^2 values at age two years are not great. This pattern persists to age four years on the Boehm concepts test but begins to change with the four year Preschool Inventory test. With these results the pattern shifts in two ways. The first change is to emphasis on maternal and ecological data, and the second is to larger R^2 contributions within those two predictor domains.

The picture emerging from these data is that of an abbreviated set of predictors influencing mental attainment. The analyses from which this observation emerges share in common the linearity of the models used in the MULR-05 analyses. What remains to be considered is the probability that predictor sets can be related to each other in more complex ways which produce larger accounts of criterion variance (R^2). That is, it is hypothetically possible that predictors can be related to each other optimally in regression models which include exponential values of predictors and interactions of various order. The problem which this observation precipitates is that we need to explore the potentially endless combinations of these elements so that we can combine parsimony of predictors with maximum clarity of their interrelations. Resolution of this challenge is aided greatly by the AID-4 regression program developed by Koplyay (1972) and previously applied by the writer to study of mental retardation (Jordan, 1973a). In this program a series of predictors is dichotomized with a view to maximizing the R^2 to be achieved through various successive levels of splits and combinations. Prior judgments are called for in predetermining criterion levels of R^2 to be reached before ending dichotomies and in selecting the minimum number of cases to be used in the various groups considered for inclusion. The results of these analyses are reported with their splits or branches in the form of

trees, examples of which are Figures 1-8.

Predictors. From review of the results at the end of the preschool years it was decided to select the predictors identified as salient for AID-4 analysis, and shown in Table 9. For the criterion 24 month PAR Intellectual score they were sex, 12 month development score, maternal anxiety, delivery age, SES score, and race. For the 24 month Mecham language criterion sex, 12 month development, maternal anxiety, and SES score. The predictors employed for the 36 month PPVT criterion were maternal anxiety, delivery age, AFI_{65}, and marital status (M). For the AID-4 analysis of Boehm Concepts scores the predictors were sex, 12 month weight, AFI_{65}, SES, and race. For the second 48 month criterion, the Preschool Inventory scores, the selected predictors were AFI_{65} and sex. The first of the three 60 months criteria WPPSI Vocabulary, used as predictors AFI_{65}, marital status, and SES. Race, delivery age, and AFI_{65} were used as predictors of ITPA Auditory Association scores at 60 months. The third 60 month criterion, ITPA digit span items, used three predictors, delivery age, AFI_{65}, and SES (see Table 9). The predictors were chosen by the criterion of contributing three percent of the variance for the eight criteria at each of four ages from two to five years in the linear models.

Criteria. It is with consideration of the criteria used in the AID-4 analysis that the topic of low cognitive attainment moves into focus. It will be recalled that a major premise of the study expressed earlier is that study of exceptional development should be conducted in a broad context of development-normal and exceptional. Other elements may not be incorporated. First, there is the observation that the majority of cases of cognitive delay are mild rather than severe. That is, the major subpopulation of school children who require study are in the range of retardation which the American Association on Mental Deficiency formerly described as Levels V, Borderline, and IV, Mild, retardation of measured intelligence (Jordan, 1972).

A second observation is that it is such cases which provide the maximum possibility for intervention based on manipulation of elements in their life contexts. Both of these observations are relevant since they constituted the premises on which the AID-4 study group was formed. Examination of the data in Table 10 shows that the children used for the AID-4 analyses were generally around the twentieth percentile in mental ability, and, conversely, were exceeded in test performance by about eighty percent of all the children originally tested at any given age between two and five years. The highest mean raw scores in Table 12, the two 24 month criteria and the 48 month Preschool Inventory, were at the 22nd percentile: the lowest, the mean number of items passed on the 60 month ITPA digit span items, was at the fifteenth percentile.

The subjects of the AID-4 analysis were defined as the children for whom requisite data were on hand, and who had criterion scores which reached normality. More precisely, the AID-4 study group was formed by automatic selection from the SLBS data file of all probands tested near their birthdays who had scores on the predictor variables and whose criterion scores did not exceed the average value for all children tested at a given age. This last point needs further consideration. By specifying an upper criterion value close to or at the 50th percentile the resulting study population contains individuals from the normal range down to the lowest levels of performance. An additional value is that it permits generation of samples of a reasonable size for multivariate analysis. This is seen in Table 10's entry for age-sample sizes which tend to be in the range of 150-250 children, with the exception of the 48 month Preschool Inventory sample (N=98).

Two Year Results

Two hundred and forty children met the specifications for data at age two, having the appropriate predictor scores and scores on the PAR Intellec-

TABLE 9

PREDICTOR AND CRITERION SERIES FOR AID-4 ANALYSES

PREDICTORS	CRITERIA
Sex, 12 mos. devpm. score, anxiety delivery age, SES, & race	Twenty Four Months
	Preschool Attainment Record, Intellectual Domain
Sex, 12 mos. devpm. score, anxiety & race	Verbal Language Development Scale
	Thirty Six Months
Anxiety, delivery age, AFI_{65}, & marital status	Peabody Picture Vocabulary Test (Form A)
	Forty Eight Months
Sex, 12 mos. wt., AFI_{65}, SES & race	Boehm Test of Basic Concepts
AFI_{65}, & race	Preschool Inventory
	Sixty Months
Marital status, AFI_{65}, & SES	Wechsler Preschool and Primary Scale of Intelligence, Vocabulary subtest
Delivery age, AFI_{65}, & race	Illinois Test of Psycholinguistic Abilities Auditory Association subtest
Delivery age, AFI_{65}, & social class	Illinois Test of Psycholinguistic Abilities, Auditory Sequential Memory (digit span) subtest

TABLE 10

AID-4 ANALYSIS SELECTION CRITERIA

Criteria			SLBS Cohort				AID-4 Group		
			$\bar{M}$	σ	Cohort Percentile	Cut-off	$\bar{M}$	Cohort Percentile	N
24	Month	PAR(I)	18.03	3.69	44	17	15.21	22	240
24	Month	VLDS	19.61	5.01	47	19	15.82	22	241
36	Month	PPVT	24.88	10.72	47	23	16.62	20	148
48	Month	PI	32.97	11.68	49	33	23.92	22	98
48	Month	Boehm	14.01	4.76	50	14	10.78	21	167
60	Month	WPPSI (V)	14.01	5.13	46	13	10.27	20	168
60	Month	ITPA (AA)	15.41	5.23	46	15	11.42	19	163
60	Month	ITPA Digits	10.82	3.99	50	10	7.26	15	274

tual criterion. An additional case was available for the other 24 month criterion, the Verbal Language Development Scale, giving a study group of two hundred and forty one children.

The AID-4 analysis begins by splitting the predictors in order of magnitude of the increment in R^2 value. The most important effect which may be seen in Figure 1 is that due to splitting the predictor 12 month development. The R^2 value of this step was .03, a highly significant dichotomy ($p = .001$). Beyond that point most of the subsequent branching occurs for high scores. Groups 4 and 5 were splits on SES, raising the R^2 value quite substantially to $R^2 = .07$, a statistically significant increment ($p = .002$). Delivery age constituted the next split on the highest side of the AID-4 tree, groups 6, 7. SES appeared once more as a squared value indicated in groups 8 and 9, raising the R^2 value of the predictor set in a statistically significant way ($R^2 = .11$, $p = .04$). Twelve month development and SES also reappear as predictors in groups 14 and 15, and 16 and 17. The last increment is that due to the sex of the children and is seen in groups 21 and 22. Like the increment associated with the immediately preceding dichotomy, groups 17, 16, the final split was not a statistically significant increment ($p = .07$). The lowest side of the tree was that generated from group 2 by delivery age. The lowest group generated was number 13, a set representing older mothers at time of delivery. The mean for this group of eleven children was 13.27, which is between one and two standard deviations below the cohort mean of 18.03 (see Table 10). A fairly close group mean, 14.43, was generated in group 11 which represents high maternal anxiety six months post-partum, as a split from low SES status in group 5.

In the case of the second 24 month criterion, score on Mecham's Verbal Language Development Scale, a schematic tree was generated which is the opposite of that for the PAR Intellectual score. Figure 2 shows that the

Figure 1

AID-4 TREE FOR 24 MONTHS PAR INTELLECTUAL SCORES

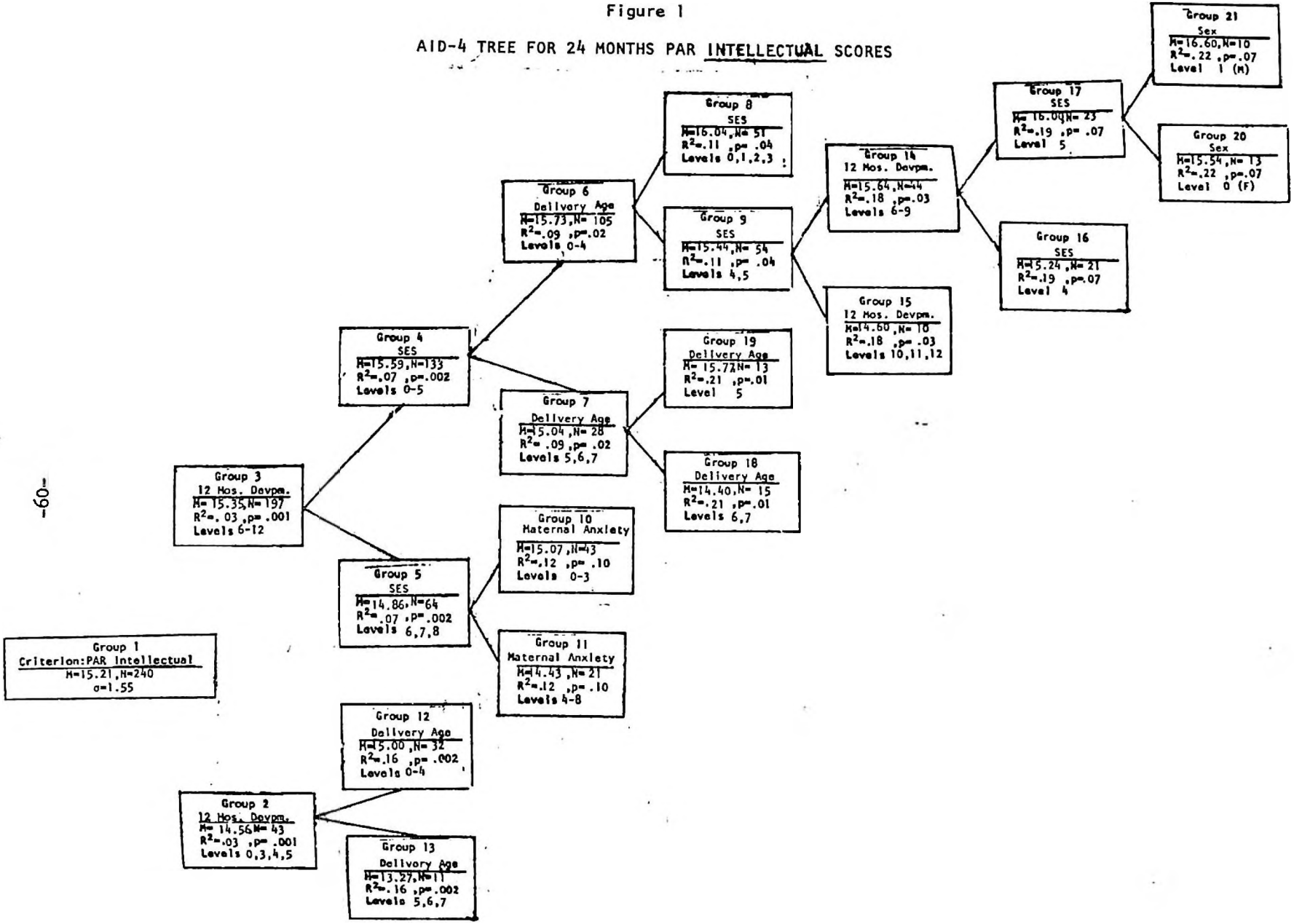


TABLE 11

AID-4 GENERATED REGRESSION MODELS

Model	R^2	Criterion
1. Y=12 mos.devpm. + SES + delivery age + maternal anxiety + sex + (devpm.*SES) + (devpm.*SES *d.age) + (devpm.*SES^2*age) + (devpm.^{2}*SES^2*age) + (devpm.^{2}*SES^3*age) + (devpm.^{2}+SES^3*age *sex) + (devpm.*SES*age^2) + (devpm.*SES*anx.) + (devpm.*age)	.22	24 Mos. PAR Intellectual
2. Y=Anxiety + 12 mos.devpm + SES + (anx.*devpm.) + (anx.*devpm.*SES) + (anx.^{3}*devpm.^{2}*SES^2)	.14	24 Mos. Mecham VLDS
3. Y=Marital status + d.age + anxiety + (marital*d.age) + (marital*d.age*anx.) + (marital*anx.)	.10	36 Mos. PPVT(A)
4. Y=SES + 12 mos.weight + AFI_{65} + (SES*wt.) + (SES*wt.*AFI_{65}) + (wt.*AFI_{65})	.19	48 Mos. Boehm T.
5. Y=SES	.09	48 Mos. Preschl.Inventory
6. Y=SES + AFI_{65} = (SES*AFI_{65})	.04	60 Mos. WPPSI Vocabulary
7. Y=AFI_{65}	.04	60 Mos. ITPA Aud.Assoc.
8. Y=AFI_{65} + SES + (AFI_{65}*SES) + (AFI_{65}^2*SES)	.07	60 Mos. ITPA Digits

dichotomization of predictors was more simple on the high side of the first split, low maternal anxiety in group 2. In contrast, the splits which began with group 3 were extensive. A similarity to the PAR tree in Figure 1 is the brief dichotomization leading to the lowest group score in group 4. Its mean of 13.25 is at the seventh percentile, and occurs as a split for low 12 month development (group 4) generated from the primary source of an increment in R^2, maternal anxiety (group 3). The range in R^2 created by the combination of interaction terms and squared vectors for this regression model (see Table 12) is from $R^2 = .04$ in groups 4, 5 to $R^2 = .14$ in groups 14, 15. It is interesting to note that the variable accounting for the first and last increments is the same, maternal anxiety 6 months post partum.

Three Year Results

One hundred and forty eight children were used for the AID-4 analysis of PPVT form A raw scores. The predictor set was first dichotomized through marital status, with unmarried mothers forming the low side of the tree. This side formed only one more branch, maternal anxiety, and the increment in R^2 was insignificant ($p = .21$). The lowest group mean in Figure 3 is that formed by group 9. It is the third predictor variable on the high side of the tree and was preceded by delivery age at the higher levels 5,6,7 in group 5. The group 8 mean of 13.25 is at the twelfth percentile of the 1966-7 cohort values.

Four Year Results

The smallest group of children used in the AID-4 phase of analysis was the set of 98 children whose scores on the Boehm Test of Basic Concepts were a four-year criterion. Of the five predictors chosen for further analysis two were dropped, race and delivery age. The most significant of the remaining three was the SES score ($R^2 = .08$, $p = .004$) followed by 12 month weight and AFI_{65}. The full model R^2 generated by the three predictors was .19, and is seen in the group 8, 9 dichotomy. The lowest Preschool Inventory mean score

Figure 2

AID-4 TREE FOR 24 MONTH VLDS SCORES

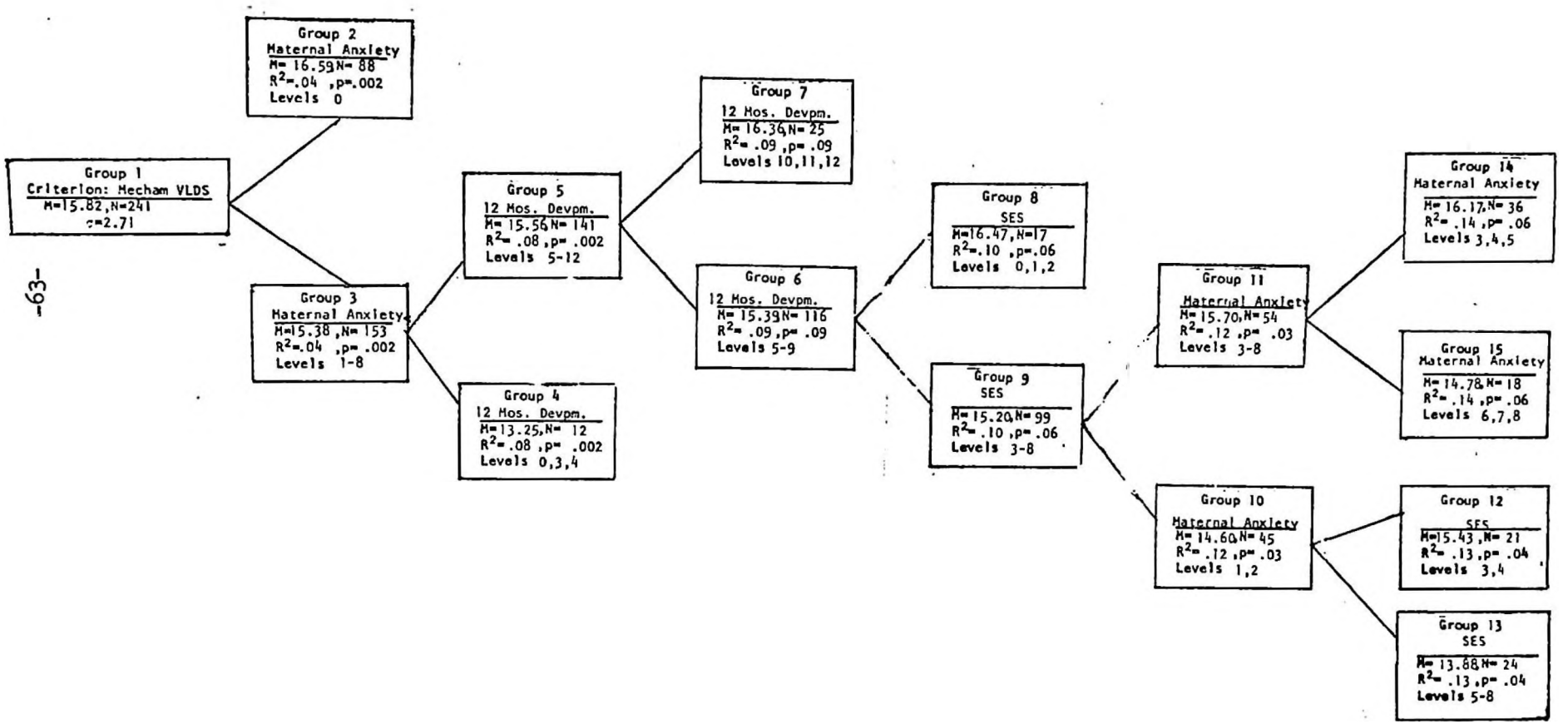


Figure 3

AID-4 TREE FOR 36 MONTHS PPVT (A) SCORES

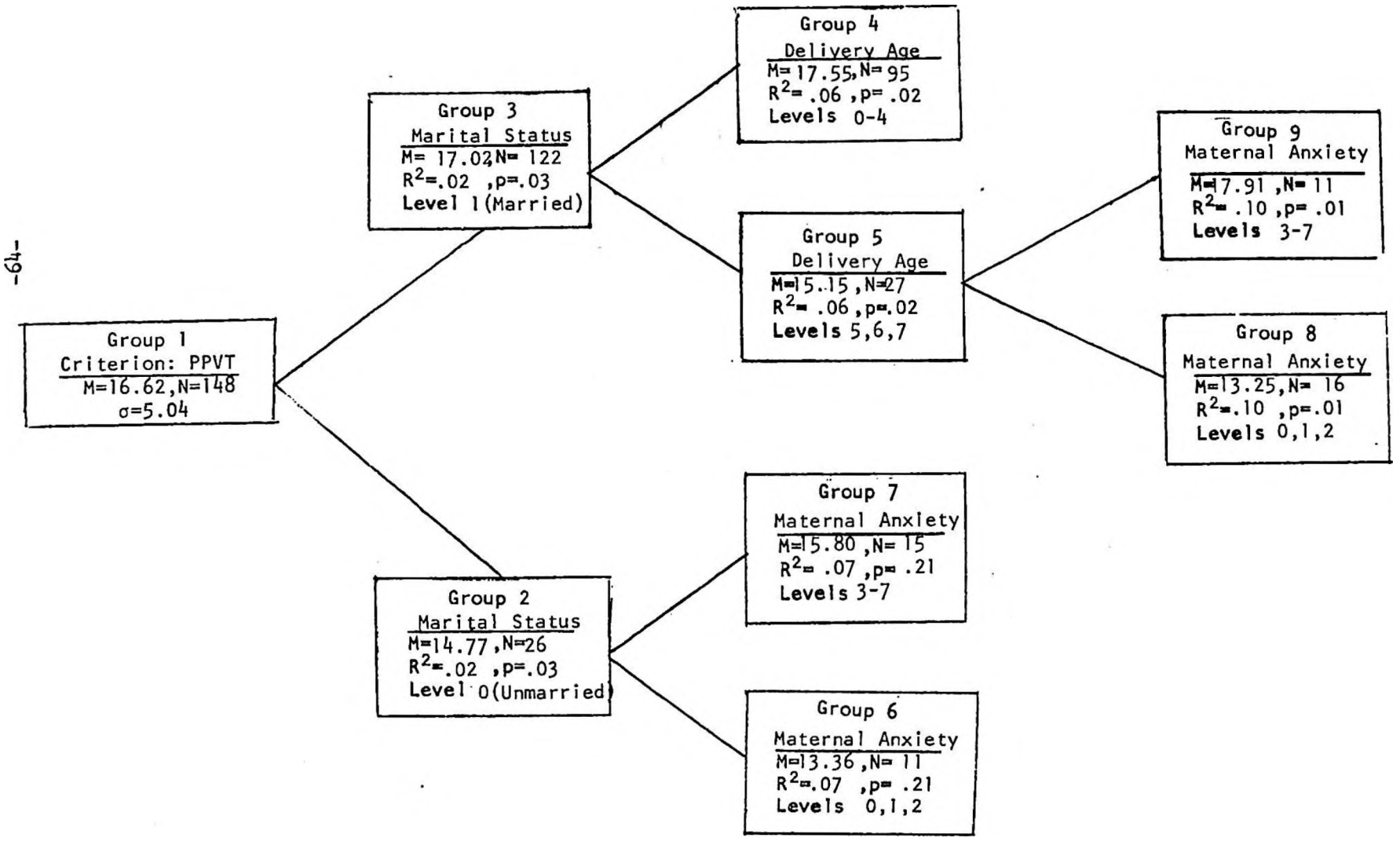


Figure 4

AID-4 TREE FOR 48 MONTHS BOEHM CONCEPTS TEST SCORES

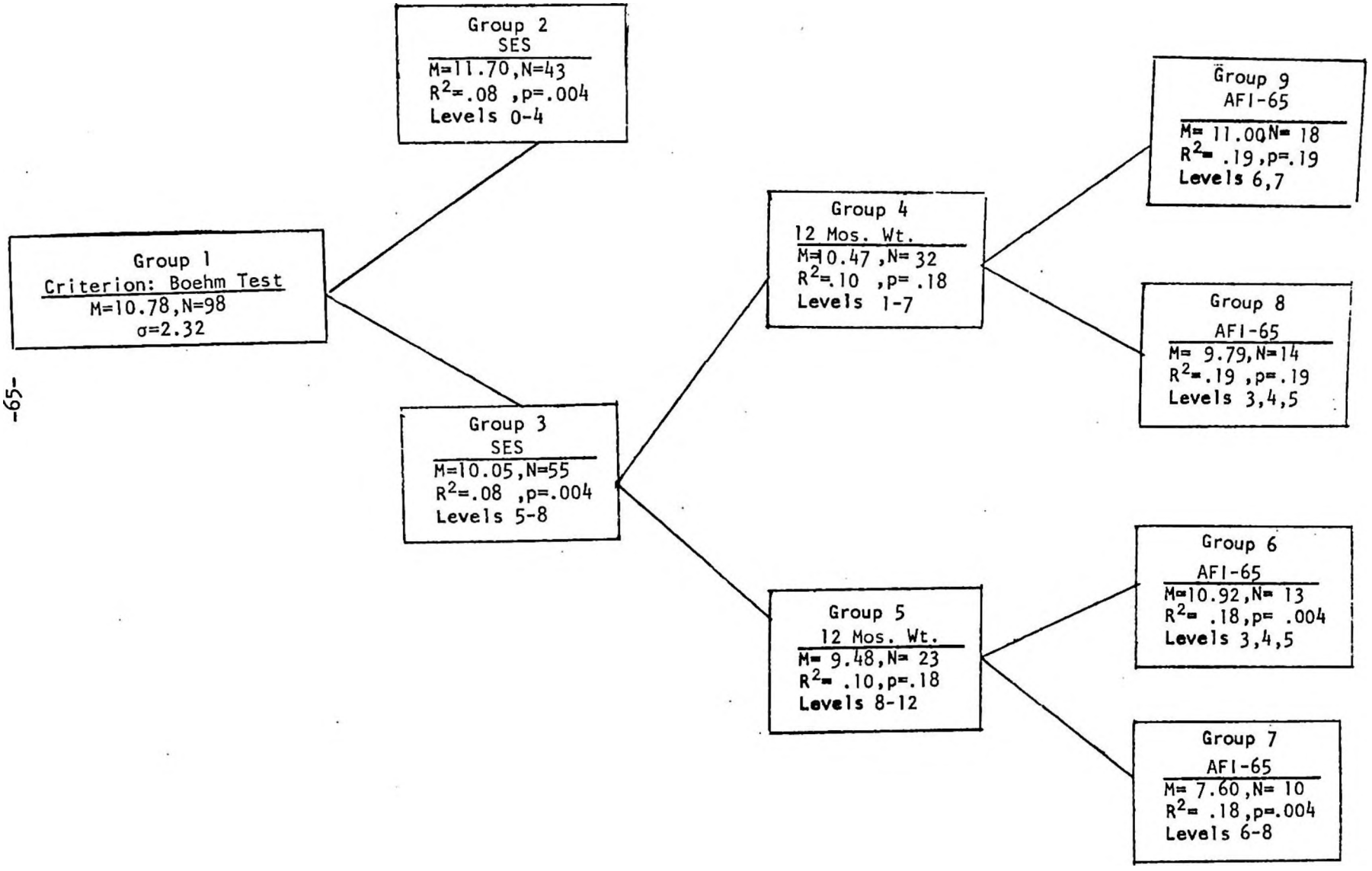
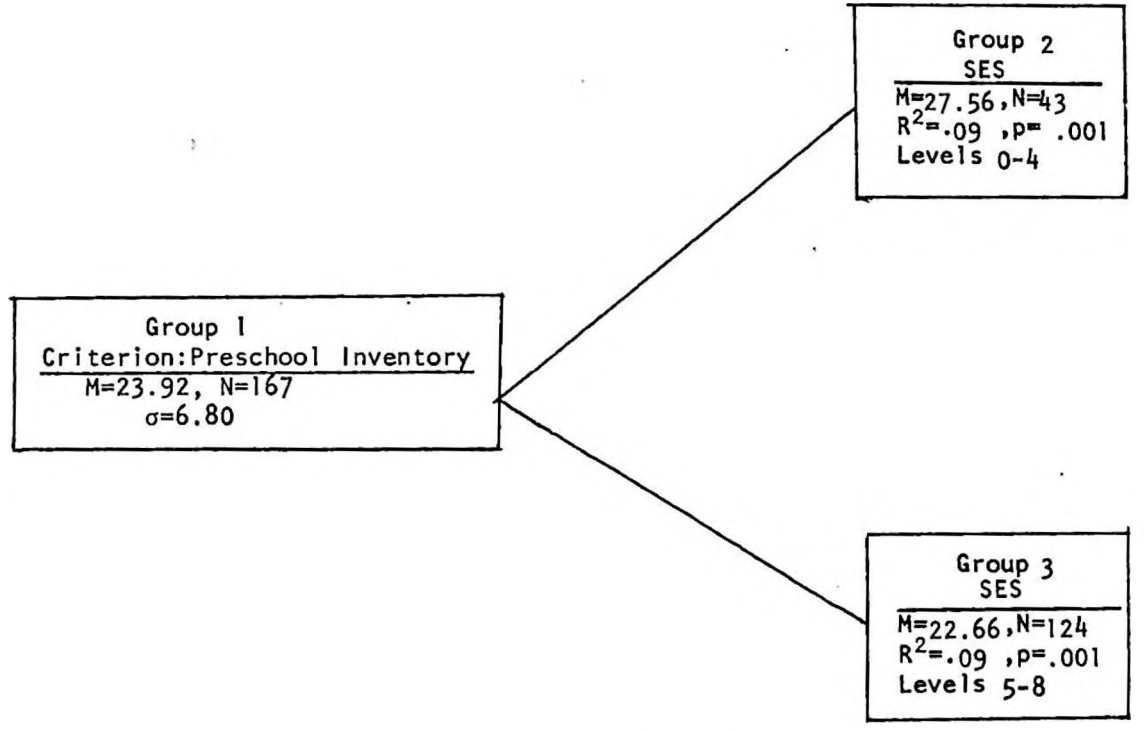


Figure 5

AID-4 TREE FOR 48 MONTHS PRESCHOOL INVENTORY SCORES



is observed in group 7, which is the highest level of AFI_{65} (authoritarian family ideology). The group 7 mean of 7.60 in Figure 4 is at the seventh percentile of the cohort scores for 408 children.

The second four-year criterion, the Preschool Inventory, and its parsimonious set of predictors were available for one hundred and sixty seven children. The second of the two predictors, race, was dropped, and the resultant tree in Figure 5 was a simple split based on SES. The form it takes is the predictable one; high levels of McGuire and White 3-factor scores indicative of low status are in group 3. The mean Preschool Inventory score of group 3, 22.66 is at the 19th percentile, which is much higher than the percentile levels of the lowest means for other criterion groups. The R^2 value for the brief one-predictor model was .09.

Five Year Results

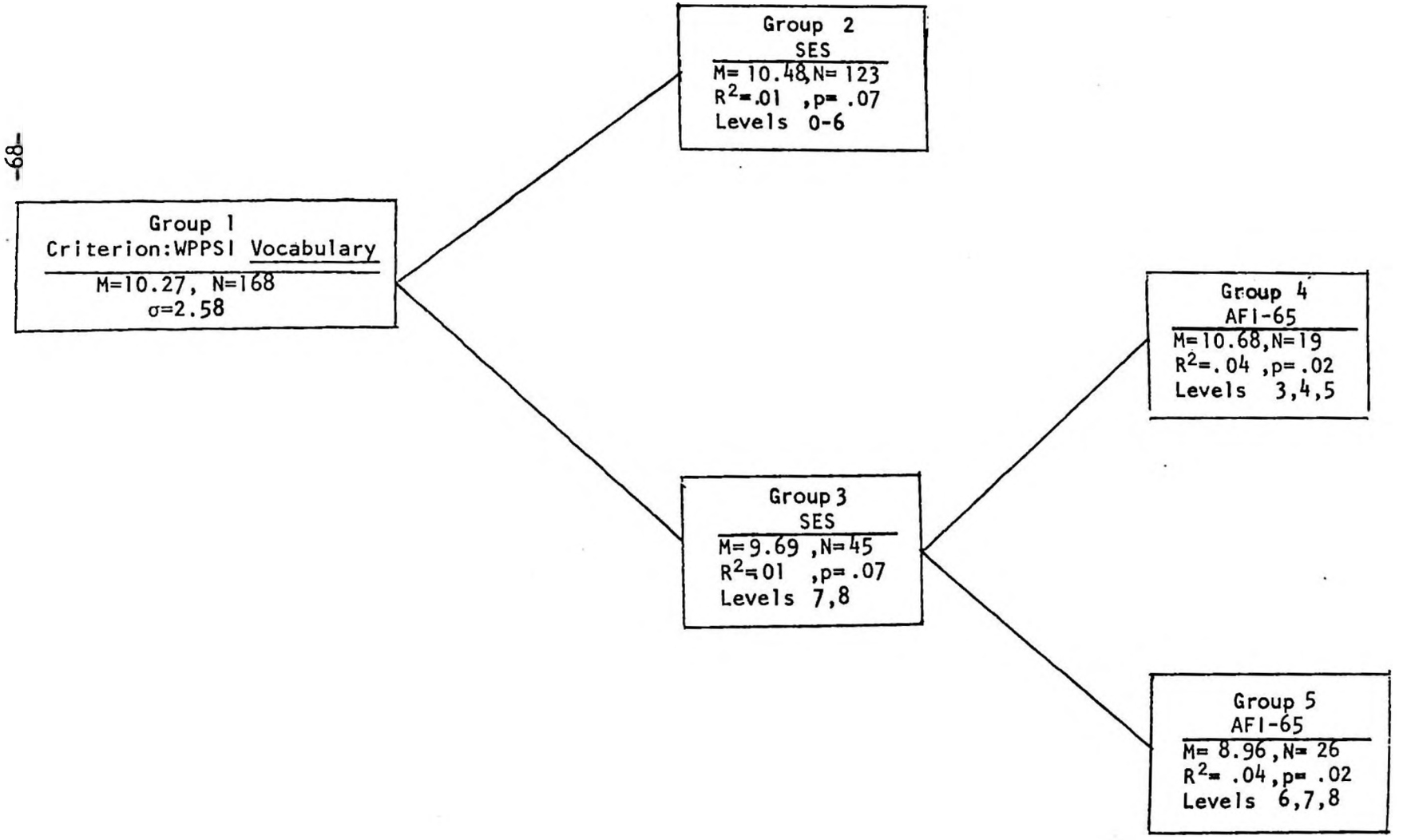
Three tests formed the AID-4 criterion series. The first, WPPSI Vocabulary, was used with one hundred and sixty eight children, the second, the ITPA Auditory Association subtest was used with predictor data from one hundred and sixty three children, and there were two hundred and seventy four cases used in the AID-4 analysis of the third criterion, the number of digit span test items correctly reproduced from the ITPA.

The first five year criterion, WPPSI Vocabulary, is shown in Figure 6. The predictors employed were, first, SES, in which group 3 was formed by the highest scores, i.e. lowest levels. A split from group 3 was formed by high AFI_{65} scores and the highest R^2 generated was .04. Within the Figure 6 tree the lowest scores are those in group 5, the group constituted from low social class and high authoritarianism. The mean for this group, 8.96, is at the ninth percentile in terms of SLBS cohort values for just over 400 children.

An even simpler AID-4 structure was generated for ITPA Auditory Associa-

Figure 6

AID-4 TREE FOR 60 MONTHS WPPSI VOCABULARY SCORES



tion scores. Two of three selected predictors maternal age at delivery and race were set aside. The resulting tree in Figure 7 was formed by splitting the authoritarianism (AFI_{65}) score. The low scores were created by the two highest levels of maternal authoritarian family ideology. Group 3's mean of 9.92 is at the twelfth percentile in terms of normative data. This simple regression model generated an R^2 value of .04.

A more complex picture was generated by the use of AFI_{65} and SES scores in explicating the optimal regression model for digit span items from the ITPA. After setting aside delivery age the tree in Figure 8 was formed. The primary split was effected through the AFI_{65} predictor, and, as with previous analyses high scores were associated with low mental test performance. For both groups 2 and 3 in Figure 7 a statistically significant increment in R^2 was generated by use of SES scores. The levels of SES in groups 5, 4 interacted with group 2's AFI_{65} scores to increase the R^2 significantly ($R^2 = .03$, $p = .01$). For these high criterion scores a further elaboration was generated by the use of AFI_{65} once more in a special interaction vector, in groups 7, 6. On the low side of the tree in Figure 8 group 9 represents the interaction of high authoritarianism and low social class. The mean digit items score of this group, 6.53, represents the tenth percentile of the normative group.

Figure 7

AID-4 TREE FOR 60 MONTHS ITPA AUDITORY ASSOCIATION SCORES

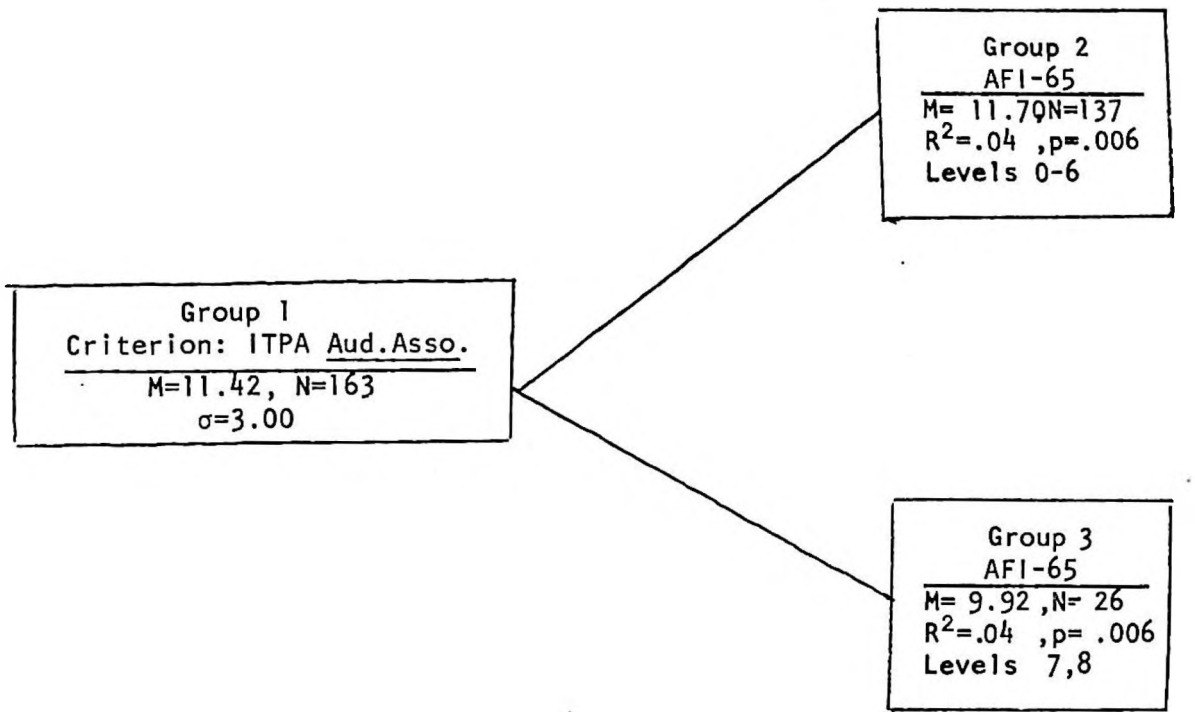
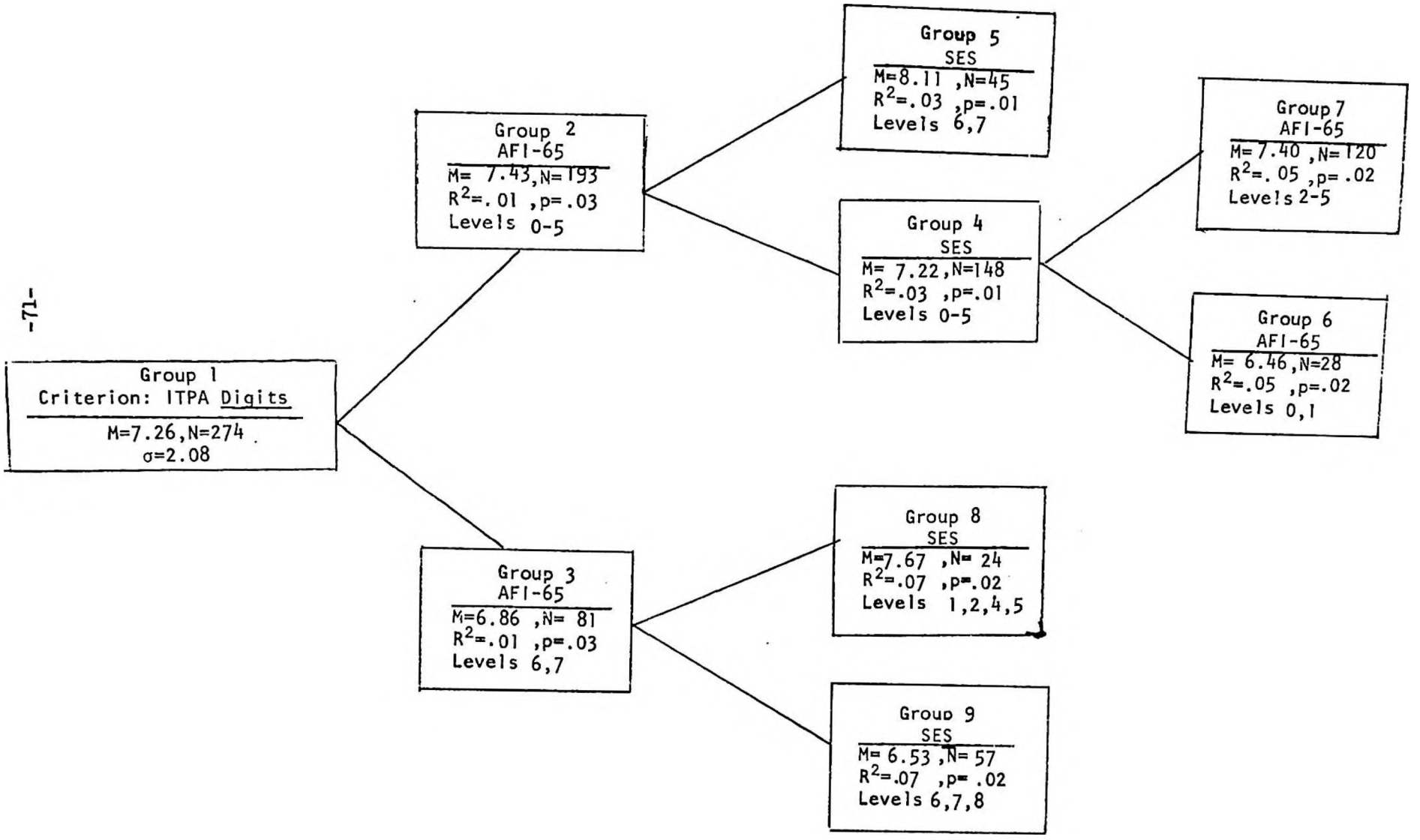


Figure 8

AID-4 TREE FOR 60 MONTHS ITPA DIGIT ITEMS



CHAPTER V

DISCUSSION

Regression Models

The process of testing hypotheses in multiple linear regression is based on the initial generation of regression models. In the present investigation the models were quite extensive, reflecting the use of twelve pieces of data on all children. The predictor series extends from birth information, to attainment at age one year. The predictor elements in the regression models follow the early development process, and are related to cognitive attainment at or near the first five birthdays. In this regard the data conform to Werts and Linn's (1970) comments on the need to use both initial and final status data in order to maximize the value of regression models for studying growth.

It is generally conceded that regression models of development in early childhood produce relationships which are approximate, and which are also relatively low in predictive value. The linear regression models in Tables 4 - 8 tend to give generally modest accounts of criterion variance. At two years of age both Mecham and PAR regression models 1(a) and 1(b) (Table 4) give low accounts of the criterion variances, .20 and .12, when all data are included. Both full models are statistically different from zero, however, to a high degree when compared with a hypothetical "model zero" of zero weights. In the case of the three year PPVT criterion the R^2 value of the full model, 1(c), remains at .20. It is similar to the Mecham full model, although at a lower level of probability due to difference in the degrees of freedom. The four year regression model of Preschool Inventory raw scores, 1(d) has a higher value, $R^2 = .37$, and it is different from a theoretical model zero to a highly significant

degree. The Boehm Test full regression model is less powerful, R^2 = .30; it accounts for more criterion variance than the regression models of two and three year criterion measures, and two of the three five year measures. Boehm R^2 and sixty month Digit Span R^2 values were the same, R^2 = .30, as Table 9 shows.

The modest size of the R^2 values of linear models in Tables 4 - 9 is noteworthy because the number of predictor variables employed was quite large. Even so, there is a substantial amount of unassigned variance. This finding persists in the AID-4 analyses whose maximum R^2 values are recorded in Table 11. The proportion of explained variance is as low as .04 in two cases, the five year WPPSI Vocabulary and ITPA Auditory Association scores, and only a little higher in the case of the third five year criterion, ITPA digits. The highest R^2 value is that for the two year PAR Intellectual score (R^2 = .22). What is noteworthy about this state of affairs is that the regression models are parsimonious predictor sets derived from the prior phase of linear analysis. The R^2 values in Table 11 and Figures 1 - 8 are optimal values being derived from complex models, shown in Table 11, which contain interaction terms and exponential values.

In passing, it is appropriate to note that the full model R^2 values of the linear analyses in Tables 4 - 8 are higher than those in Table 11. In so doing it should be kept in mind that the MULR-05 linear and AID-4 interaction models were applied to slightly different populations; there is no reason to expect similar R^2 values, although the criterion measures were identical in both analyses.

Linear Predictor Sets

Three aggregates of predictor variables were examined as hypothetically contributing to prediction of five criteria. At child age two years, the first aggregate, child data, contributed significantly to linear prediction

of cognitive attainment. Criterion scores were affected by the presence of the data on sex and twelve month development. The second aggregate, maternal data, was less significant, affecting PAR Intellectual scores, but not Mecham language development scores. The third aggregate, ecological data, affected PAR scores at a modestly significant level ($p = .08$) and affected Mecham language scores more significantly ($p = .002$).

At three years the aggregates of predictors were quite different. The child data and ecological data groups were not significant in relation to the criterion series, although the maternal data was significant. The lack of significance associated with the child data is probably not entirely novel, since it contains several measures which are generally not potential predictors for all criteria. On the other hand the lack of predictive value in the ecological aggregate is interesting. Most cognitive measures tend to respond to social class influences, but race and social class did not affect PPVT scores. The explanation may well lie with the criterion, rather than the predictors, and will be considered in that context.

At four years the three linear predictor aggregates were all significant, although the variance acounted for was not overwhelming for either criterion. The child data was less significant in the case of the Preschool Inventory. The reduction in R^2 from .37 to .34 was half of that for the Boehm test whose R^2 dropped from .30 to .24. Maternal data were essentially equal in contribution to the criterion variance of both tests. The probability level was high for the Preschool Inventory, but is probably due to the difference in degrees of freedom. Ecological data accounted for five percent of the Preschool Inventory variance, and six percent of the Boehm test variance. Expressed in terms of criterion variance the maternal and ecological models were equally significant in their effects. Child data, by the same mechanism, was twice as significant for the

Preschool Inventory.

At five years the child data aggregate made no contribution to any of the three criterion measures. Maternal data contributed to one criterion, Digit Span. In contrast, the ecological data contributed to all three criteria. The contribution was not simply to a larger number of criteria; it also took the form of largest proportional contribution to individual R^2 values. As Table 12 shows the R^2 contributions were the largest, on the average, for the criteria. The mean R^2 contribution of the ecological data group to the set of three criterion measures was .06. When these same values are expressed as proportions of the full model R^2 of the three five year criteria the proportions are 24% for WPPSI Vocabulary, 43% for Auditory Association, and 20% for Digit Span.

The child data aggregate of six factors from the first year of life is largely biological in nature. Its significance is particularly clear for cognitive attainment at age two years, but then declines sharply. Maternal data, an aggregate of four elements, is statistically significant for one cognitive measure at age two years, but does not affect the second. It has no apparent effect at three years, but is significant at four years. Ecological information is initially low in significance, but rises over the years from two to five. These results may be usefully compared with those reported by Jordan and Spaner (1970). In that study, similar models were applied to study of development at age one year. The ecological model was an insignificant influence on three aspects of development at age one year. A second model composed of maternal data was also insignificantly associated with three criteria at one year of age. A model of child data, largely biological, was associated significantly with three criteria of development at age one year.

Generated Predictor Sets

Table 11 reveals that the most extensive of the abbreviated predictor sets is the eight-predictor set for two year PAR Intellectual scores. When applied to the lower half of the study population by means of the AID-4 program only race was deleted as a useful predictor. This longest of the parsimonious predictor sets also generated the highest R^2 value, .22. It is by far the most complex model, as Table 11 shows. The value of the interactive component of the AID-4 models is seen in Figure 1 where maternal delivery age occurs three times as a component of complex interaction terms for both high and low criterion scores. Similarly, SES appears twice as an element in interactive terms, as does the 12 month development score. Equally complex is the nature of the Mecham Verbal Langugae Development Scale regression model. Maternal anxiety is present three times, including its function as first and last of seven dichotomies. SES and 12 month development scores appear twice in Figure 2 as elements of complex interaction terms.

The nature of the interaction models shifted with the 36 month PPVT criterion. The model shown in Table 11 and Figure 3 contains three elements. Only one of them, maternal anxiety, occurred in two dichotomies. This comparative simplicity in generated models is also seen in the Four-year Boehm concept test (see Table 11 and Figure 4) which consisted of three predictors. The most parsimonious predictor model is that generated for the second four-year criterion, the Preschool Inventory; it consisted of the SES score. Slightly more complexity appears in Figure 6, which is composed of two predictors, SES and AFI_{65}. Figure 7 shows a model of AFI_{65} scores. Finally, the eighth criterion was composed of AFI_{65} and SES scores.

In evaluating these brief models, it is important to observe that

the brevity of the AID-4 selected predictors is matched by the low R^2 values. In general, a finding of low R^2 values in models of developmental data is not unusual; most analyses of development in very young children (e.g., Wilson, Parmelee and Huggins, 1963) report accounting for rather low porportions of criterion variance and low correlation coefficients. The phenomenon illustrates the opportunities for building substantial accounts of how children grow, that is, description of the vectors of influence on growing children. On the whole, explanations of all but abnormal development leave much to be desired. The task of specifying the variables which influence growth remains one of the challenges to investigators. It is not to be anticipated that inquiry will lead to explanations of criterion variance on the order of those attained in the physical sciences. However, it is not unreasonable to expect that inquiry will eventually raise the proportion of criterion variance in studies of early development beyond the level achieved here.

As a final point, it is helpful to offer an alternative comment on the low R^2 values of the AID-4 selected predictor sets in Table 11. It is that the drop in R^2 values may also be explained as non-replication. That is, it may be that the restricted mental attainment of the second study (sub)population explains the low AID-4 R^2 values. However correct that observation may be, it is an after the fact comment. The prior decision to use a heterogeneous sample for the linear exploration contributed to the variability of the results from the second (sub)population with its limited upper level of ability.

Aligning the Jordan and Spaner (1970) data with the materials of this investigation permits some speculation on the influence of sets of environmental and maternal, and (largely) biological influences. Biological data is initially the best linear predictor of development up to age

two years. In this regard they resemble biological data on smoking by pregnant women, a trait which produces initial differences in child development, but only in the earliest years of life (Hardy and Mellitts, 1972). The influence declines from that time in the data of this investigation. Maternal characteristics have little influence in the first year of life, but assume a more significant role, subsequently. In particular, the AFI_{65} authoritarianism score is influential at ages four and five. Similarly, environmental influences are initially not detectable at age one year, but become significant by age two years, and increase in the following years.

Child Variables

The effects of aggregates of predictors representing three domains constitute an opportunity to comment on the generalized problem of significant influences on child development. It is also possible to look at predictors at a molecular level, and examine the elements which account for the larger phenomena.

Within the child data aggregate sex differences may be seen. In the linear analysis they appear at age two for both criteria, and at age four on the Preschool Inventory. The differences favor higher scores for girls on three of eight criteria. However, when the sex effects are examined with other selected influences in the AID-4 analysis, the role of sex declines sharply as an influence. In Figure 1 at two years sex constitutes the final dichotomy in groups 20, 21 on the PAR Intellectual criterion and is omitted entirely in Figure 2's analysis of language development. It is also omitted from the branching tree in Figure 4.

An interesting predictor is the 12 month development score on the writer's (1967c) Ad Hoc Scale which assesses growth in four domains. This predictor, as Table 12 indicates, correlates significantly with Mecham Language scores at age two years ($r = .21$, $p = <.01$). The 12 month

TABLE 12

MATRIX OF SIGNIFICANT CORRELATIONS

	PAR Intellectual	Peabody PVT	Preschool Inventory	Boehm Test	ITPA Aud.Assoc.	ITPA Digit Span	WPPSI Vocabulary	Sex (M)	Birth Weight	Apgar	12 Mo. Weight	12 Mo. Devpm.	Anxiety	Delivery Age	AFI$_{GS}$	Married	Social Class	Race (M)
Mecham VLDS	.64**	.49**	.41**	.39**	.28**	.23**	.24**	-.26**				.21**	-.23**		-.25**		.32**	-.18**
PAR Intellectual		.34**	.34**	.31**	.21**	.16**							-.24**				-.20*	
Peabody PPVT					.45**	.19**	.48**						-.25**		-.35**		-.32**	-.30**
Preschool Inventory					.68**	.27**	.54**			-.27**			-.24**		-.44**		-.54**	-.43**
Boehm Test					.57**		.44**			-.16*			-.16*		-.26**		-.35**	-.22**
ITPA Aud. Assoc.						.28**	.28**											.20**
ITPA Digit Span							.61**			-.13*					.43**		-.47**	-.30**
WPPSI Vocabulary										-.16*					-.26**		-.35**	-.22*
Sex (M)									.21**		.34**						-.18**	
Birth Weight											.32**							
Apgar																	.32**	.36**
12 Month Weight																		
12 Month Devpm.																		
Anxiety															.33**		.32**	.22**
Delivery Age															-.24**		-.19*	-.15*
AFI$_{GS}$																-.24**	.57**	.54**
Married																	-.18*	-.42**
Social Class																		.58**

*p = .05
**p = .01

development score emerges as the primary dichotomy in Figure 1's schematic of PAR Intellectual scores, and is more influential in the branching tree than social class (SES) or maternal traits. A rather similar role is played in Figure 2, where the 12 month development score emerges as the second most important variable raising the R^2 value of the brief predictor set from .04 to .08 ($p = .002$) in groups 4,5. Beyond age two, only one of the predictors from the first year of life played an influential role. In Figure 4, 12 month weight played a brief and statistically insignificant role in raising R^2 values of the Boehm concepts test. In groups 4,5 12 month weight raised the R^2 from .08 to .10 ($p = .18$). These findings indicate that broad development at age 12 months can be related to more narrow aspects, e.g. cognitive attainment, for brief spans of the early years.

Birth weight was not related to any of the five criteria. This is an interesting finding since birth weights as low as 2.56 pounds were present in the children studied at 12 months of age, and in view of the finding by Kastein and Fowler (1959), and by DeHirsch, Jansky, and Langford (1964), that low birth weight tends to be followed by reduced attainment in language. Conversely, Babson, Henderson and Clark's (1969) work indicates that high birth weights are more likely to result in lowered intelligence test scores than low birth weights. The number of cases of low test scores at age four reported by Babson, Henderson, and Clark was twice the incidence in children of normal birth weight.

Apgar scores had no relation at the four ages to the criteria. This may be explained by the relative absence of low Apgar scores in children studied in this investigation. Apgar scores are positively skewed; only low scores have emerged as significant. This finding is reflected in the practice of assigning critical meaning to Apgar scores below seven only

(Gleiss and Holdenburg, 1963); this practice has been essentially used by others, e.g., Shipe, Vandenburg and Brooke Williams (1968), and Klatskin, McGarry and Steward (1966). Data from Finland (Ikonen, 1967) show that a substantial rise in infant mortality begins to appear with Apgar scores below seven. Although the regression analysis failed to relate Apgar scores to the criteria, there were several significant correlation coefficients in the data matrix. Out of five correlations relating Apgars to criteria, those for the four and five year measures were statistically significant, although not large. The Apgar/Boehm Test correlation was $-.21$, $p<.01$, and the Apgar/Preschool Inventory correlation was slightly higher $-.21$, $p<.01$. It should be noted that all the correlations in Table 12 are derived from the four and five year data, and the Apgar/four year criterion measures may be spuriously correlated. If the significant correlations have value, they tend to suggest a relationship between depressed natal condition and preschool attainment. It seems likely that such a relationship is valid since low Apgars indicate depressed physiological state. The correlations in question while statistically significant are not excessively robust.

The last element in the predictor series composed of child development data was the risk factor, that is the presence of perinatal elements putting development "at risk." This predictor was associated with none of the eight criteria. The insignificant relationship may be understood in terms of the heterogeneity of this predictor. Related research on this factor alone (Jordan, 1971a) has established that the category of multiple perinatal complications is strongly associated with developmental delay at twenty-four months. A lack of broadly generalizable association between categorical forms of risk conditions and subsequent development was also established and has been confirmed subsequently (Jordan, 1976).

Maternal Variables

This aggregate consists of anxiety score six months post partum, age at delivery, authoritarianism score, and marital status. Within the aggregate age at delivery influences attainment on one measure at child age two years and on two at age five years. The effects take the form of higher child attainment for younger mothers. At child ages four and five consistent results emerge for authoritarianism scores. The results favor high achievement in children whose mothers have low scores.

A more precise understanding of the role of maternal variables in the development of children of low cognitive attainment was not attainable for the child variables, but is possible for maternal variables. All of the parsimonious predictor sets generated from the linear MULR-05 analysis contained maternal traits. These sets were reduced further by the AID-4 analysis. The maternal trait most frequently present in the AID-4 trees in Figures 1 to 8 were anxiety and authoritarian family ideology (AFI_{65}). The relative placement in time in the lives of the subgroup of children with poor to average cognitive attainment is interesting. Maternal anxiety 6 months post partum was present and the most frequent element at ages one and two years. In contrast the role of most frequent element was played by AFI_{65} scores at ages four and five. The third most frequent element was age at delivery, and it occurred three times in the PAR AID-4 trees at age two and once at age three.

Another way to identify the salient influences on cognitive attainment in this study's subset of children with an average level of mental test performance around the twentieth percentile is to consider the extent to which maternal traits, which are one sub-set in the original group of twelve predictors, provide the first dichotomy in the branching trees. The logic to this lies in the AID-4 program's ordering of the importance of all

potential dichotomies in order of the magnitude of the increment in the value of the R^2 statistic. Whatever is most powerful is placed first, groups 1,2 and other predictors are placed in subsequent branches in declining order of increment in R^2. We see that in four branching trees the first dichotomy is a maternal trait. In Figure 2, the Mecham language measure, the trait is anxiety, and in Figure 3 marital status is the first split on the three year PPVT. In Figures 7 and 8, five year ITPA Auditory Association, and ITPA digit, the major dichotomy is generated by the score on the scale of Authoritarian Family Ideology.

A different way to approach the influence of maternal traits on cognitive attainment is to consider the predictors at all ages which were associated at whatever level in the trees with the lowest criterion scores. By this approach we observe two things. First, at all four ages and for all criteria a maternal trait is associated with the lowest score six out of eight possible times. This is evidence of the role of maternal traits in low cognitive attainment. A second more analytic observation is that a pattern is evident at ages four and five. For the five criteria at those ages maternal traits are associated with the lowest group mean. In all four cases the trait is maternal authoritarian family ideology, as measured by the scale developed by Ernhart and Loevinger (1969).

Ecological Variables

The evidence of the linear portion of this prospective inquiry showed that social class and race are a significant aggregate of predictors. On closer examination it emerges that it is social class rather than race which is doing the work. This is interesting in view of the fact that the study contained a substantial proportion of black children, a situation permitting racial effects to appear. They do so at age four years on the Preschool Inventory and at age five years on the ITPA Auditory Association

task. In this regard the correlation shown in Table 12 for black/Preschool Inventory and SES/Preschool Inventory are helpful, the former is -.44, and latter is -.55. The correlation between black and SES score is .58 ($p = <.001$), indicating that blacks are more likely to be in the lower classes than whites. (The negative values are due to high McGuire and White SES scores meaning low SES level.) Accordingly, the influence of social class is probably best retained as the more significant interpretation.

The amount of criterion variance accounted for by single predictors tends to be small in the linear models. Deletion of predictors from the full model accounts for proportions of variance ranging from .01 to .10. This means that that the absolute effects of significant predictors are slight. More pronounced effects are evident in aggregates of predictors, but they are not large either. However a more substantial picture emerges when the significantly assigned variance is expressed as a proportion of full model R^2 values. A further observation is that the predictors which account for the variance tend to form social aggregates in the real world of child development. Race and social class tend to be compatible, with most black children growing in lower class homes. Authoritarianism tends to inhibit mental growth, and it too is associated with class membership (Jordan, 1970). Younger mothers tend to be more authoritarian, and in the linear analysis, they tend to be black and lower class too. The effect then, is that of a nexus of socially determined factors producing a cumulative effect on the cognitive development of children. This picture of social class influence is elucidated in the case of children of limited cognitive attainment. At age two years social class is evident in both Figures 1 and 2, but at subsidiary levels of the schematic trees. By age four it becomes more pronounced and is the primary source for maximizing the variance of both the Boehm Test of Basic Concepts and the Preschool Inventory. This observation

is repeated at age five on the WPPSI Vocabulary test. Accordingly, it is appropriate to conclude that the effects of social class is confirmed in the lives of young children of low cognitive attainment.

Maternal and Ecological Variables

Tables and Figures show that predictors and criteria are related by regression effects and correlation coefficients. The maternal and ecological predictors which are significant tend to be related also. The lower right area of Table 12 shows the relationships between several maternal traits and ecological factors. Thirteen of sixteen correlations in that portion of the matrix are significant, and nine of the thirteen are quite significant ($p = .01$). This means that the characteristics of mothers are related to the gross environmental circumstances of their lives. In the upper right hand portion of Table 12 a number of maternal-social variables are shown to be significantly correlated with cognitive measures at several child ages.

The conclusion emerges that environmental-maternal factors are a predictive complex of great significance for child development. The significance of the complex increases from the two year criterion series to the five year series.

It seems that there is a slight increase in the influence of selected maternal/environmental factors. Presumably, the factors themselves, social class and authoritarianism as illustrations, are capable of some degree of modification through intervention processes. Such a vector of social change, one designed to alter the effects of circumstances on maternal ideology could indirectly alter cognitive development in children. The strategies which suggest themselves are two. The first is the possibility of gross changes in peoples' life styles. This is a change which does not seem likely. The second is acceptance of the gross circumstances of life and introduction of the selective changes in maternal traits vis à vis their

children. The value of educating young lower class mothers to adopt less inhibiting beliefs and practices seems worth trying.

Criteria

The two year criterion measures are highly related to each other ($r = .64$) indicating that they are representative of the same domain of cognition. The similarity is further indicated by the largely compatible nature of their predictability. That is, there are fifteen relationships which might arise between predictors and the critera. In eight instances the criteria were affected by predictors, and in five of these the effect was simultaneous in both predictors, although at different levels. Of the two criteria at age two years PAR Intellectual score was the more responsive to antecedent variables. In contrast Mecham Verbal Language Development scores responded to fewer antecedent variables, but at a more statistically significant level in the linear models. PAR score is most different from the Mecham Language score because the PAR is affected by maternal anxiety score and age at delivery. The correlation between anxiety score and delivery age is -.06, an insignificant value.

The Peabody Picture Vocabulary Scale is in some ways the most interesting criterion because of its general lack of response to the predictors used in the investigation. PPVT scores were affected by only one element, the aggregate of maternal traits. This aggregate accounted for five percent of the variance in the full regression model. This is not a large amount, but it is twenty-five percent of the variance accounted for by the full model. The scale stands in marked contrast to the other criteria because of its insensitivity to many influences. It seems fair to say that sensitivity to a wide range of influences is probably quite diffused. Examination of Table 4 shows that the reduction in variance associated with given maternal traits are all on the order of one percent. What is illustrated is the resistance

of the PPVT to a host of elements which generally plague cognitive measures and reduce their value in clinical study.

At four years the Boehm Test and the Caldwell Preschool Inventory are responsive to the three major aggregates of predictors. The degree of responsiveness expressed by probability level is reversed for child and maternal data, and more consistent for ecological data. The Boehm test is less responsive to discrete elements in the predictor series than the Preschool Inventory. The latter is affected by SES, race, and sex. The differences favor higher performance on the criterion measures by children who are female, white, and middle class. Interestingly, the effects of of maternal authoritarianism seem almost identical for both criterion measures. Ecological influences on both tests are interesting. Social class affects Boehm test scores at a high level ($p = .0001$), without race effects in the linear models. It is the prime source of increased variance in the complex models of mental development in the subset of children with reduced levels, on the average, of cognitive attainment. Preschool Inventory scores are modestly affected by both SES and race to an equal degree ($p = .03$) in the linear models, but only by SES in the complex models of low attainment.

At five years Digit Span was the most predictable criterion in linear form, $R^2 = .30$, with the other two criterion measures being about half as predictable ($R^2 = .17$ and $.14$). Digit Span was also responsive to two of the three predictor aggregates, maternal and ecological data. None of the criteria were predicted by the aggregate of child data. About twenty-five percent of WPPSI Vocabulary variance was due to social class, while two maternal traits AFI_{65} and marital status contributed slightly less. Nearly half of the Auditory Association variance came from ethnic group, and maternal age and AFI_{65} contributed only a little less. For Digit Span vari-

ance Figure 8 indicates that social class but not ethnic group is a major source.

For the four and five year criteria the influence of AFI_{65} scores is evident. Cognitive development is inhibited by the assertion of punitive and repressive influences in the lives of children. Before that time such influence is not apparent in this investigation. Parallel and also contributing to understanding the sources of criterion variance at ages four and five is social class. Within the R^2 values of four out of five criterion measures social class' contribution is slightly higher. Overall, the criterion series at four ages is more influenced by child data at lower ages and by maternal and ecological influences at the upper ages. At no age are the criteria greatly affected by the predictor series; the basis for this observation is the low R^2 value generated for each criterion. We are left with the generalizable view that there is much unaccounted for variance in these early developmental measures.

Finally, we may turn to consideration of the investigation as a whole. The first observation to be made is that the findings emerge from a single cohort, the 1966-67 birth group. While single cohort analysis has its virtues, principally, the value of the data over time on a study group, it is not without its limitations. The chief of these is the absence of a second cohort which might be used to replicate findings. It follows that acceptance of the findings of this inquiry should be tempered by awareness that the experiences of the cohort could, possibly, have been unique. That is, the experience of black and white preschoolers in metropolitan St. Louis could have been so unique that generalizations are risky. Research on fourteen indicators of "quality of life" in eighteen metropolitan areas reported by Kihss (1973) indicates that the St. Louis area is tenth; that is, close to the mid-point in quality.

A second hazard to be acknowledged in generalizing from these data is the possible effect of repeated measures. There is little doubt that annual testing on clinical instruments has been well remembered by the children from one year to the next. This generally pleasant experience for the children has made them sophisticated test subjects with potential effects on their test performance. However, two investigations of the effects of repeated testing suggest this phenomenon may not be a problem. The Denver longitudinal study (Hilden, 1949) reported that repeated administration of mental tests had relatively little effect on obtained scores. Similarly, Bayley (1968) has reported a similar finding from persons examined and tested several times as a part of the Berkeley Growth Study. As a third note, it is wise to keep in mind the possibility of regression effects, changes in scores which tend over repeated testing to gravitate towards the average from the extremes of possible test scores.

To this point we have discussed the findings of the regression analysis in conservative terms, that is, commenting on the findings within the context of the study. We may now extend discussion beyond the study, attempting to give some sense of application of the regression models to mental development.

The statistical significance of child data at three of the criterion ages is evident. Beyond the mathematical significance of probability levels there is developmental significance. It is apparent that low cognitive development can be understood, to some extent, at least, in the light of biological data on early growth. This stands in contrast to the tendency to ascribe influence to environment rather than non-environmental factors. The significance of the child data aggregate of birth weight, Apgar, sex, risk status, and weight and development at twelve months suggests that environmentalism might well be balanced by recognition that cognitive traits have biological correlates. The data of this investigation preclude adopting

the view that biological and cognitive measures are isomorphic. They suggest, rather, that early biological information may be more relevant than current popular wisdom suggests.

In the linear analyses, environmental data, race and social class, are obviously meaningful. At virtually every age the R^2 contribution of social class is evident. The contribution is best at the lower ages, the developmental stages when the child data aggregate is more influential. The contribution doubles at ages four-five, and is tripled on five year measures. At these ages biological influence is extinguished. The comparative contribution of biological data and social data is reversed at early and late ages in the preschool period. We may speculate that nature's influence is primary, to begin with, and is subsequently replaced by society's. In view of the low R^2 values generated this statement should be viewed as speculative in intent rather than conclusive.

Maternal data in this investigation were influential at ages two to five years on criteria. The consistency of influence is seen in the relatively stable R^2 contributions. From this we may speculate that mothers and mothering constitute a modest point of leverage in advancing cognitive development, one which may be capitalized on in order to increase the effectiveness of socialization processes. This finding is supported by common sense, and the data indicate that authoritarianism inhibits growth. The data in Tables 6 - 8 and Figures 4 - 8 between AFI_{65} scores and cognitive growth are substantial. Educating mothers to a less restrictive pattern of child rearing seems both feasible and advisable as a way to advance the mental development of children at social risk for low cognitive attainment.

Overall, the data suggest that the course of cognitive growth and the major influences on it is a describable phenomenon. It is also one which suggests that the three vectors of influence studied here are not of

equal influence, and rise and fall in statistical significance. This suggests that strategies of intervention need to recognize different points of leverage for development at different stages. By this reasoning nature is the principal influence in the earliest years, being followed by an increased receptivity to the influence of maternal child raising style. Beyond that mode of influence lie the developmental effects of social circumstances. Presumably, the need to anticipate negative social influences needs to be shown in programming before age four. In contrast, programming to increase the effectiveness of mothering should be in operation by age two years.

CHAPTER VI

SUMMARY

Data from a prospective longitudinal study of 364 children have been analyzed. Two series of regression analyses have related twelve predictors to eight criteria of cognitive attainment at four ages in the preschool period.

1. Linear regression models were used to identify predictors in a population of children with all levels of cognitive maturity. The linear models were statistically significant predictors of the criterion.
2. Selected predictors were used to generate complex regression models in a sub-population at the twentieth percentile of criterion scores, on the average. The predictive power of these brief predictor sets was generally low for the sub-population.

The following significant relations have been established at criterion age two years.

Preschool Achievement Record Intellectual Score:

(Full Range Criterion Scores)

3. There is a significant association between a predictor aggregate of risk factor, sex, birth weight, Apgar score, twelve month development and twelve month weight and the criterion.
4. Within the aggregate sex and twelve month development are significantly associated with the criterion.
5. There is a significant association between a predictor aggregate of maternal traits, anxiety, delivery age, authoritarianism, and marital status and the criterion.

6. Within the aggregate delivery age and anxiety are significantly associated with the criterion.
7. There is a significant association between a predictor aggregate of social class and race and the criterion.
8. Within the aggregate social class is significantly associated with the criterion.

(Low Criterion Scores)

9. The primary influence in a complex model of low criterion scores is twelve month development score, followed by SES, maternal age at delivery, and maternal anxiety.

Verbal Language Development Scale

(Full range criterion scores)

10. There is a significant association between a predictor aggregate of risk factor, sex, birth weight, Apgar score, twelve month development and twelve month weight, and the criterion.
11. Within the aggregate sex, and twelve month development are associated with the criterion.
12. There is an insignificant association between a predictor aggregate of maternal traits, anxiety, delivery age, authoritarianism, and marital status, and the criterion.
13. Within the aggregate delivery age is significantly associated with the criterion.
14. There is a significant association between a predictor aggregate of race and social class and the criterion.
15. Within the aggregate social class is associated with the criterion.

(Low Criterion Scores)

16. The primary influence in a complex model of low criterion

scores is maternal anxiety, followed by twelve month development, SES, and maternal anxiety.

The following significant relationships have been established at criterion age three years.

Peabody Picture Vocabulary Test

(Full Range Criterion Scores)

17. There is a significant relationship between a predictor aggregate of maternal traits, anxiety, delivery age, authoritarianism, and marital status, and the criterion.

(Low Criterion Scores)

18. The primary influence in a complex model of low criterion scores is marital status, followed by maternal delivery age and anxiety.

The following significant relationships have been established at criterion age four years.

Boehm Test of Basic Concepts

(Full Range Criterion Scores)

19. There is a significant relationship between a predictor aggregate of risk factor, sex, birth weight, Apgar score, twelve month development and twelve month weight and the criterion. Within the aggregate sex and twelve month weight are significantly associated with the criterion.

20. There is a significant relationship between a predictor aggregate of maternal traits, anxiety, delivery age, authoritarianism, and marital status, and the criterion.

21. Within the aggregate authoritarianism is significantly associated with the criterion.

22. There is a significant association between a predictor aggregate of social class and race and the criterion.
23. Within the aggregat social class, and race are associated with the criterion.

(Low Criterion Scores)

24. The primary influence in complex model of low criterion scores is social class, followed to a limited degree by twelve month weight and authoritarianism.

The Preschool Inventory

(Full Range Criterion Scores)

25. There is a significant association between a predictor aggregate of risk factor, sex, birth weight, Apgar score, twelve month development and twelve month weight, and the criterion.
26. Within the aggregate sex is associated with the criterion.
27. There is a significant association between a predictor aggregate of maternal traits, anxiety, delivery age, authoritarianism, and marital status, and the criterion.
28. Within the aggregate authoritarianism is associated with the criterion.
29. There is a significant association between a predictor aggregate of social class and race and the criterion.
30. Within the aggregate social class is associated with the criterion.
31. Within the aggregate race is associated with the criterion.

(Low Criterion Scores)

32. The sole influence in complex models of low criterion scores is social class.

The following significant relationships have been established at criterion age five years.

WPPSI Vocabulary

(Full Range Criterion Scores)

33. There is a significant relationship between selected maternal traits and the criterion.

34. Within the aggregate authoritarianism and marital status are associated with the criterion.

35. There is a significant relationship between a predictor aggregate of social class and race and the criterion.

36. Within the aggregate social class is associated with the criterion.

(Low Criterion Scores)

37. The primary influence in a complex model of low criterion scores is social class followed by maternal authoritarianism.

ITPA Auditory Association

(Full Range Criterion Scores)

38. There is a significant relationship between selected maternal traits and the criterion.

39. Delivery age is associated with the criterion.

40. Authoritarianism is associated with the criterion.

41. There is a significant relationship between a predictor aggregate of social class and race and the criterion.

42. Within the aggregate race is associated with the criterion.

(Low Criterion Scores)

43. The sole influence in a complex model of low criterion scores is maternal authoritarianism.

ITPA Digit Span

(Full Range Criterion Scores)

44. There is a significant relationship between a predictor aggregate of maternal traits, anxiety, delivery age, authoritarianism, and marital status and the criterion.

45. Within the aggregate anxiety and authoritarianism are associated with the criterion.

46. There is a significant relationship between a predictor aggregate of social class and race and the criterion.

47. Within the aggregate social class is associated with the criterion.

(Low Criterion Scores)

48. The primary influence in a complex model of low criterion scores is maternal authoritarianism, followed by authoritarianism.

The following generalizations may be made about mental development in the preschool years.

49. At age two years predictors of mental development are heterogeneous.

50. By ages four and five predictors of mental development are restricted to maternal and ecological influences and child traits in the first year of life are no longer significant influences.

51. Social class rather than ethnic group is the influential social factor.

52. Authoritarian family ideology of mothers is a significant influence on the cognitive attainment of children.

53. The complex of social class background and maternal characteristics, authoritarianism, delivery age is a significant influence on child development in the preschool years.

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