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ABSTRACT

In empirically examining and developing a cultural diffusion model for the explanation of racial differences in mental ability scores, the major hypothesis of the model is that racial differences in mean IQ scores are a function, among other factors, of the degree and nature of contact a group has with the mainstream culture. The data were drawn from the cumulative school records of all the ninth graders who were in the Pittsburgh Public School System in the 1970-71 school year. The major part of the analysis involves the examination of the pattern of change in the IQ scores of the students who entered the system in the kindergarten and remained enrolled until the ninth grade. It was found that school and community segregation is related to an overall decrease in mean IQ scores between grades K-8 for both blacks and whites. The IQ of students in lower social class school environments decreases over time while that of students in upper social class environments increases. Two major policy recommendations are suggested by these results and the overall approach. The first concerns the potential value of the use of information contained in school records for formulating and monitoring educational policy related to equality of educational opportunity. The second policy recommendation discusses the importance of school social class integration in the early grades. (Author/RJ)

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November 1973

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

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ABSTRACT

A cultural diffusion model for the explanation of racial differences in mental ability scores is developed and empirically examined. The major hypothesis of this model is that racial differences in mean IQ scores are a function, among other factors, of the degree and nature of contact a group has with the mainstream culture (middle-class America). The data were drawn from the cumulative school records of all the ninth graders who were in the Pittsburgh Public School System in the 1970-1971 school year. The major part of the analysis involves the examination of the pattern of change in the IQ scores of the students who entered the system in kindergarten and remained enrolled until the ninth grade. It was found that school and community segregation is related to an overall decrease in mean IQ scores between kindergarten and eighth grade for both Blacks and Whites. The IQ of students in lower social class school environments decreases over time while the IQ of students in upper social class environments increases. Two major policy recommendations are suggested by these results and the overall approach. The first concerns the potential value of the use of information contained in school records for formulating and monitoring educational policy related to equality of educational opportunity. The second policy recommendation discusses the importance of school social class integration in the early grades.

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S. C. Sanday, a major consultant on the project, was responsible for formalizing the diffusion model in terms of a continuum model. The mathematical version of this model which appears in Appendix A was developed by him with the aid of Richard Staelin. S. C. Sanday was also responsible for the section on the scientific method and its applicability to the scientific study of the intra-cultural diffusion. His patience and sustained interest are greatly appreciated. Daniel Rosen contributed significantly throughout the project period in his capacity as computer programmer. Thomas Gregg, who served as an occasional consultant, developed with P. R. Sanday the original problem including the idea of using a longitudinal design.

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CONTENTS

Introduction 1

Chapter 1. THE BACKGROUND AND PROBLEM STATEMENT 3
The Argument and Its Roots.................... 3
The Approach to be Taken in This Report....... 8

Chapter 2. A DIFFUSION MODEL FOR THE ANALYSIS OF BETWEEN-GROUP DIFFERENCES IN IQ............. 10
Place of Continuum Models in the Scientific Study of Intra-Cultural Diffusion........... 10
A Model for the Analysis of Between-Group Differences in IQ.......................... 16

Chapter 3. THE LONGITUDINAL DESIGN 18
Procedure for Collecting Data................. 18
Procedure for Coding School Records and School-Related Data........................ 19

Chapter 4. ANATOMY OF AN URBAN SCHOOL SYSTEM: THE SOCIO-CULTURAL CONTEXT OF LEARNING.......... 22

Chapter 5. THE PATTERN AND CORRELATES OF CHANGE IN IQ SCORES: TEST OF THE DIFFUSION HYPOTHESIS... 52
The Relationship Between Gain and Loss in IQ Over Time as a Function of Subcultural Affiliation and Degree of Contact........... 52
Analysis of the Effects of Environmental Variables on Change in IQ Scores............ 69

Chapter 6. A CONTINUUM MODEL OF INTRA-CULTURAL DIFFUSION 72
Model of Intra-Cultural Diffusion............. 73

Chapter 7. CONCLUSION 83
Implications for Educational Policy........... 85
Implications for Further Research............ 88

Appendix A. MATHEMATICAL MODEL OF INTRA-CULTURAL DIFFUSION 89
The General Model........................... 89
Illustrative Examples 91

Bibliography 98

TABLES

Table No.		Page No.
1	RACE AND SEX OF TOTAL SAMPLE	23
2	BIRTHPLACE OF STUDENT	24
3	BIRTHPLACE OF MALE HEAD	25
4	BIRTHPLACE OF FEMALE HEAD	26
5	FAMILY STRUCTURE - STATUS OF FATHER	28
6	AVERAGE NUMBER OF BROTHERS AND SISTERS	29
7	OCCUPATION OF PARENTS	30
8	EDUCATION OF FATHER	31
9	EDUCATION OF MOTHER	32
10	BREAKDOWN OF SAMPLE BY INDEX OF SOCIAL POSITION (SES)...................................	33
11	AVERAGE IQ SCORES GRADES K, 4, 6, 8	35
12	MEAN IQ SCORES IN KINDERGARTEN, FOURTH, SIXTH, AND EIGHTH GRADES	36
13	DISTRIBUTION BY RACE AND PARENTS' SES IN SCHOOL PEER GROUP ENVIRONMENTS AT KINDERGARTEN	37
14	DISTRIBUTION BY RACE AND PARENTS' SES IN SCHOOL PEER GROUP ENVIRONMENTS AT EIGHTH GRADE	38
15	PERCENT OF BLACKS AND WHITES IN TYPES OF SCHOOL ENVIRONMENT	39
16	RACIAL COMPOSITION OF THE SCHOOLS	40
17	(Omit)	
18	NUMBER OF DIFFERENT ADDRESSES K-9	41
19	NUMBER OF SCHOOLS ATTENDED K-9	42
20	NUMBER OF GRADES REPEATED K-6	43
21	AVERAGE NUMBER OF DAYS ABSENT BY GRADE AND RACE....	44
22	AVERAGE NUMBER OF DAYS TARDY IN GRADES K-8	45
23	AVERAGE NUMBER OF SOCIAL AND WORK HABIT CHECKS IN GRADES K-6	47
24	AVERAGE NUMBER OF HEALTH CHECKS IN GRADES K-6	48
25	CITIZENSHIP RATING 7th AND 8th GRADES	49
26	AVERAGE GRADES OF WHITES AND BLACKS IN GRADES 1-6 AND GRADES 7-8	50
27	INTEREST TEST SCORES GIVEN IN GRADE 9	51
28	AVERAGE GAIN AND LOSS IN IQ POINTS BETWEEN KINDERGARTEN AND EIGHTH GRADE	54
29	AVERAGE GAIN AND LOSS IN IQ SCORES BETWEEN KINDERGARTEN AND EIGHTH GRADES BY INDEX OF SOCIAL POSITION. BLACK SAMPLE	57
30	AVERAGE GAIN AND LOSS IN IQ SCORES BETWEEN KINDERGARTEN AND EIGHTH GRADES BY INDEX OF SOCIAL POSITION. WHITE SAMPLE	58
31	MEAN KINDERGARTEN IQ SCORES CONTROLLING FOR PARENTS' SES AND SES OF PEERS IN KINDERGARTEN ...	65
32	MEAN EIGHTH GRADE IQ SCORES CONTROLLING FOR SES OF PEERS IN KINDERGARTEN AND EIGHTH GRADE	66

33	AVERAGE NUMBER OF POINTS GAINED OR LOST BETWEEN EACH TEST PERIOD	70
34	MEAN IQ SCORES AT K, 4, 6 and 8 BY SES OF PEERS ...	80

FIGURES

Figure No.		Page No.
1	Overall Mean Change Between Kindergarten and Eighth Grade in IQ Scores by SES of Peers	59
2	Overall Mean Change in IQ Between Kindergarten and Eighth Grade by SES of Peers at Kindergarten..	60
3	Mean Loss of Losers in IQ Scores Between Kindergarten and Eighth Grade by Index of Social Position	61
4	Mean Gain of Gainers in IQ Scores Between Kindergarten and Eighth Grade by Index of Social Position	62
5	Percent of Blacks and Percent of Whites in Each SES Category Who Gain IQ Points Between Kindergarten and Eighth Grade	64
6a	Mean Kindergarten IQ Scores (White Sample) Controlling for Parents' SES and SES of Peers at Kindergarten	67
6b	Mean Kindergarten IQ Scores (Black Sample) Controlling for Parents' SES and SES of Peers at Kindergarten	67
7	Eighth Grade IQ Score Controlling for SES of Peers in Kindergarten and in Eighth Grade	68
8	Item Accumulation History	76
9	Item Accumulation Distribution	77
10	Comparison Between Results	79
11	Mean IQ Over Time by Race and SES of Peers	81
12	Mean IQ Over Time for White Sample by SES of Peers..	86
13	Mean IQ Over Time for Black Sample by SES of Peers..	87
14	Item Accumulation History	95
15	Item Accumulation History	96

INTRODUCTION

Mean differences between groups in mental ability test scores are widely reported in the U. S. and in other countries. In the U. S. such differences appear consistently between social classes, rural-urban populations, and between whites and non-whites. As the articles in Cronbach and Drenth (1972) show, similar differences are found in many other countries. It is a common observation in the cross-cultural psychology literature that the less Westernized groups score lower on the commonplace verbal and nonverbal tests than the Westernized. A study by Dennis (1966), which reports the results of the administration of the Goodenough Draw-A-Man Test in 50 countries, provides an interesting case in point. It was found that the mean scores on this test were higher in cultures where there is continual contact with representative, graphic art. The lowest means came from samples of children in cultures where such art is absent or prohibited. Even in these cultures children who had repeated contact with the graphic art of Western civilization, including contact with television, had higher scores than those children who did not. Finally, it has also been noted in the cross-cultural psychology literature that all over the world the score differences between groups, regardless of racial or ethnic affiliation, become much smaller or vanish when socio-economic status is held constant. One might draw the conclusion from these world-wide trends that the standard mental ability tests have a built in middle-class bias. Indeed, as Jensen (1969) admits, these tests were originally developed to measure and predict the cognitive performance of middle-class French school children using as criteria the expectations of their teachers as to what constituted acceptable cognitive performance.

However, this is not the conclusion that the layman has been reading in the popular scholarly journals during the last five years in the U. S. While it is commonly agreed that incomparable populations will score lower on a test than the population for which the test is designed, the source of incomparability is now being hotly disputed in the debate over the explanation of the reported mean differences between U. S. Blacks and Whites on IQ tests. Until the outbreak of this debate, which was stimulated by Jensen's (1969) article, it was generally agreed that incomparability between Blacks and Whites was based on cultural differences and quality of schooling. Jensen, however, suggested and later Shockley (1972) asserted that Blacks and lower class whites score lower on IQ tests because they are genetically incomparable to middle and upper-class whites. This meant, according to these men, that regardless of what policy makers might do to mitigate cultural differences and to provide quality of education Blacks and lower-class whites would be unable to master certain cogintive skills.

Such arguments have been reported widely in popular scholarly and semi-scholarly journals, and have probably had an important impact on public opinion. No one knows to what extent the local and national outcry and efforts to fight school integration during the past five years were fueled by the widespread dissemination of these arguments. A number of scholars, including the author of this report, have published responses to Jensen and Shockley which strongly suggest that their arguments are inadmissible. It is an interesting commentary on the nature of racism in America that none of these responses have received the same widespread dissemination.

In this report the basis for the statement that Jensen's and Shockley's arguments are inadmissible will be summarized in Chapter 1. The main body of this report (Chapters 2-6) will present a theory which suggests the hypothesis that the test score differences between Blacks and Whites are a function, among other factors, of the degree and nature of contact that Blacks have as a group with the mainstream culture (white middle-class America). The empirical evidence to be examined in this report comes from the cumulative school records of a one-hundred percent sample of the ninth graders in the Pittsburgh public school. The time period examined was 1962 to 1970.

The theoretical development was stimulated by the observation that test score differences always favor groups which either comprise the mainstream culture in a given country or which have had over a long period of time a close and positive contact with Western style institutions or attitudes. The findings reported by Coleman et. al. (1966) that a self-concept conducive to achievement motivation and social class composition of the school were both related to scholastic achievement also inspired the initial development. This approach is in contrast to one seeking to explain differences between groups in terms of intrinsic genetic factors. The genetic point of view, to be discussed in Chapter 1, is untenable given the nature of the present knowledge in human genetics. The durability of this view stems from widespread acceptance in American scholarly and popular thinking of the idea, which stimulated and underlined the early intelligence testing movement in this country and England, that intelligence is a unitary, fixed, and predetermined trait.

Chapter 1. THE BACKGROUND AND PROBLEM STATEMENT

The Argument and Its Roots

Explanations for the test score gap between groups can be divided roughly between those which posit a projective view and those which posit a reflectional or interactive view of the mechanisms underlying the development and expression of cognitive abilities. As Gordon (in Cancro 1971) describes these views, the projective position is concerned with hypothesized, predetermined, intrinsic patterns which are thought to be released by stimulation and projected onto the environment where their specific form is facilitated or inhibited. The emphasis is on the existence in the organism of intrinsic drive states which exist prior to, and independently of, life experiences and which are the basic forces in the determination of cognitive functioning. Observable cognitive abilities, thought to be measured by the standard ability tests, are seen as predetermined by intrinsic genetic factors and modifiable only somewhat by the environment.

The interactionist or reflectionist position, as Gordon (in Cancro 1971: 245-246) describes it, holds that cognitive abilities are reflections of the interaction between the organism and its environment. This interaction is seen as the crucial determinant and molder of patterned cognitive functioning and as the causing and mediating agent rather than the releaser. Cognitive potential is said to be genetically seeded in the sense that the organism includes structural responsivity which is determined by interactions between it and the environment.

In much of the scholarly research and development in psychological testing, and in the U. S. public education system, the projective view has dominated. According to Hunt and Kirk (in Cantro 1971:263), the assumptions of fixed intelligence and predetermined development which form the basis of this view originated in the thought and influence of two followers of Darwin. Darwin's cousin, Francis Galton (1869), introduced the notion of genius fixed by heredity. G. Stanley Hall, an American follower of Galton, focused upon the notion that "ontogeny recapitulates phylogeny" to explain the development of behavior and to assume that behavioral development is essentially predetermined.

Galton and Hall had a lasting influence on education and psychology through their teaching of the early U. S. leaders in these fields. James Cattell, one of Galton's students, was the first to bring mental tests to the U. S. Hall did much to shape the philosophy of the intelligence-testing movement in the U. S. through teaching such leaders as Goddard, Kuhlmann, and Terman. The recapitulation doctrine which he taught helped to establish the faith of American educators and psychologists in the notion of individual differences developing at a constant rate as assessed by the IQ (mental age/chronological age). These ideas of fixed intelligence and predetermined development were also supported by Gesell, a leading investigator of child development during World War I and World War II, and another of Hall's students. It is no surprise then that these ideas strongly influenced both the scholarly research and teaching in college courses of education and psychology throughout the first half of this century.

In the American public education system, the projective view, according to Gordon (in Cancro 1971:246), is reflected in (1) a laissez-faire attitude toward the development of intelligence; (2) a monitoring as opposed to a stimulating approach to academic and social readiness; (3) an exaggerated emphasis on the predictive value of the classification and quantification of psychological appraisal data and the neglect of qualitative appraisal data as the basis for planning and intervention; (4) placement of the burden of proof on the examinee rather than on the appraiser or appraisal method, and on the learner rather than on the teacher or teaching method; (5) overemphasis on selection and placement with an underemphasis on the nurturing of interests and the development and training of capacities and skills.

The present-day status of the projectionist view is exhibited in Jensen's (1969) highly publicized argument that U.S. racial differences in mean IQ scores may be largely due to genetic differences. The impact of Jensen's view beyond academic circles is an indication of the appeal this view has in the wider society. As Hunt and Kirk (in Cancro 1971:268-269) report, Jensen's point of view was discussed at length in newspapers, was summarized with approval several times in the Congressional Record, and became the subject of discussions at meetings of high-level policy-makers in Washington.

Jensen's hypothesis, which in another highly publicized article was claimed as a scientific fact by Shockley (1972), is critically examined and rejected by Sanday (1972a, b) in two articles which have received nowhere near the same attention. This has been true of all the scholarly work indicating that Jensen's position is untenable. This general lack of interest in the non-projectionist point of view suggests how deeply rooted are all the assumptions about the nature of intelligence in the American psyche.

Sanday (1972a, b,c) rejects Jensen's hypothesis on the basis of his misinterpretation of the meaning of the concept of heritability, the difficulties with the heritability formula, and several studies which indicate that when environmental factors are controlled, the correlation between IQ and race vanishes. Discussions by a number of geneticists and psychologists independently support Sanday's criticisms, as well as raise other issues which cast further doubt on the validity of the genetic hypothesis. For example, Hirsch (in Cancro 1971:95) makes the important, but neglected, point that "all discussions of genetic analysis presuppose sufficiently adequate control of environmental conditions so that all observed individual differences have developed under the same, homogeneous environmental conditions, conditions never achieved in any human studies." The closest we can get to such conditions in research in human populations representing different gene pools is to statistically hold constant certain environmental variables thought to influence the expression of mental ability as is the case in the studies summarized by Sanday (1972a), or to compare samples from such populations who are raised in the same environment.

The Smilanskys data reported by Bloom (1969) and summarized by Ginsberg and Laughlin (in Cancro 1971:82-83) most closely approximate the needed conditions. These data were taken from the European and Oriental populations in Israel which are known to constitute distinctive gene pools. The test score gap between these two populations is as wide as those samples of black and white populations in the U.S. which led Jensen and others to advance a genetic hypothesis. Compensatory education programs in Israel, as in the U.S., were not successful in closing the gap. The following quote from Ginsberg and Laughlin describes the research conducted by the Smilanskys with samples from these populations raised in similar conditions.

> In their attempts to find equivalent environments in which ethnicity was the only significant factor in which the populations differed, the Smilanskys turned to children of Oriental and of mixed ethnicity who were born and raised on those agricultural cooperatives, or kibbutzim, in which the Europeans were the majority. Each Oriental or half-Oriental child was paired with a European child of the same age and in the same class at school for evaluation purposes. Parents were equated on the basis of educational information and of the occupational niches they occupied. Since the mothers were on the kibbutzim during their prenatal period, nutritional and prenatal care factors were comparable (cooking is communal). Children live apart from parents in nurseries, children's houses, and school, and they are attended by a specialized staff from the kibbutz. They spend some time with their parents every day. Each kibbutz is affiliated with a social or political movement, and all members, therefore, share in a prevailing ideal and set of political objectives. The Oriental and the European are, therefore, on an equal basis in the life of the settlement. Motivational factors operate equally for their children, and the relationship between education and later opportunities are comparable for both. Classroom instruction is by a project method in which various subjects may be taught together in relation to the project. Special talents and interests are fostered, although the schools themselves are noncompetitive and students help each other in their work. The 1,200 children in the study were followed into adolescence.
>
> Under these circumstances, the Oriental children achieved and maintained a mean IQ that was the same as that of their European counterparts. They also provided as high a proportion of individuals who scored in the exceptional range on a number of separate measures as did the Europeans.

> While it may be argued that self-selection for kibbutz life could introduce a bias, and that the Oriental gene pool is not the same as the Negro gene pool, the face validity of the data suggests that it is at least as plausible to argue that when most conditions of development, motivation, and education are approximately the same for the European and the Oriental gene pools, the mean differences in IQ will disappear and the proportion of individuals who score in the exceptional categories on such tests will be comparable. Further, if this obtains for the Oriental, why not also for the black? (Ginsberg and Laughlin, in Cancro 1971:82-83).

These results do not imply, as Ginsberg and Laughlin point out, that the distribution of genotypes will be the same in the two groups nor does it denigrate the role of genetics. It simply shows that two populations representing two different gene pools can be phenotypically equivalent with respect to a polygenic trait such as intelligence in a truly equivalent environment. In other words, as is known to most geneticists, there are multiple routes to most phenotypes.

It is also possible for the same genotype to give rise to a wide array of phenotypes depending upon the environment in which it develops. This is known as the norm of reaction, a concept crucial for responding to discussions of hypotheses relying on genetic differences to explain behavioral differences in human groups. Hirsch (in Cancro 1971:102) refers to the Israel study described above to illustrate the concept of norm of reaction in a human population. Jewish children of European origin exhibit an average IQ of 105 when reared in individual homes, while those reared in a Kibbutz exhibit an average IQ of 115. In contrast, the Jewish children of mid-Eastern parents brought up in individual homes have an average IQ of only 85, while those brought up in the Kibbutz also have an average IQ of 115. According to Hirsch this indicates that "there is no basis for expecting different overall results for any population in our species."

The Israel research, in addition to illustrating the plasticity of human behavior in the norm of reaction, also emphasizes the potential magnitude of the interaction between environment and heredity in influencing the phenotypic expression of intelligence. The fact that Jensen and his colleagues argue that this interaction is small is an indication of the extent of their predilection for the projectionist point of view. For one could just as easily argue that the extent of the racial differences in IQ is an indication of the magnitude of the interaction term. The Israel data also indicate the extent of racism in the U.S. For nowhere in the history of U.S. racial relations do we find Blacks and Whites raised together under the equivalent conditions found in the Kibbutzim. Until this occurs the hypothesis of genetic differences as the prime factor influencing racial differences in intelligence can neither be accepted nor rejected. As Hirsch (in Cancro 1971:101) states:

> If we now take into consideration the concept of norm of reaction and combine it with the facts of genotypic individuality, then there is no general statement that can be made about the assignment of fixed proportions to the contributions of heredity and environment either to the development of a single individual, because we have not even begun to assess his norm of reaction, or to the differences that might be me sured among members of a population, because we have hardly begun to assess the range of environmental conditions under which its constituent members might develop!

The concept of interaction, mentioned above, and that of heritability are areas of sharp disagreement. Jensen and others dismiss the possibility that interactions can be, may be, and in some instances have been made significant in specified directions. Those who argue the contrary (Gordon in Cancro 1971:242) point out that it is now possible to bring under man's control several physical disorders clearly genetic in origin and which might be regarded as irreversible because genetically "fixed," according to the limited view of the possibilities of environmental interaction. The discovery of insulin, the isolation of Vitamin D, and the uncovering and control of phenylketonuria, according to Goldstein (1969:20):

> ...are all those exceptional environmental changes which will make this interaction term significant. They indicate that environments everywhere are not merely supportive of hereditary potentialities, but can, at times, reverse deleterious effects. The great achievements of mankind lie in making that interaction term significant. Indeed, it could almost be a maxim for schools of education, psychology, public health, and medicine: "Make that interaction significant" (quoted by Gordon in Cancro 1971:242).

Finally, the concept and empirical estimate of heritability which formed the basis for Jensen's conclusions has been shown by Sanday (1972a, b,c) to be meaningless in any discussion of the magnitude of the genetic contribution to any given trait. Sanday's discussion is similar to Hirsch's treatment of heritability. Hirsch refers to work which shows that heritability estimates for behavioral characteristics have been found to increase, decrease, and fluctuate randomly as a function of repeated testing. He concludes his discussion of the limitation of this concept by saying:

> The brilliant Englishman Ronald Fisher (1951), whose authority Jensen cites, indicated how fully he had appreciated

> such limitations when he commented: "the so-called coefficient of heritability, which regard as one of those unfortunate short-cuts which have emerged in biometry for lack of a more thorough analysis of the data (p.271)." The plain facts are that in the study of man a heritability estimate turns out to be a piece of 'knowledge' that is both deceptive and trivial. (Hirsch in Cancro 1971:98)

The Approach to be Taken in this Report

Utilizing concepts from cultural anthropology, this Report will test a diffusion model for the analysis of the cultural determinants of the IQ test score gap between samples of Black and White school children. The basic assumption underlying this model which has been described by Sanday (1972a, b, c) is that the mental acts measured by intelligence tests are differentially diffused to various segments of the populace. A diffusion process is postulated because of the evidence that "the standard intelligence tests were developed to measure cognitive components which are highly correlated with doing well in school" and that "the content of test items is often related to experience and learning which only middle and upper class children would be likely to be exposed to," (Sanday 1972a:420).

The process of diffusion is one of several factors which may affect the phenotypic expression of intelligence (as it is measured by the IQ test) within or between groups. Variation in measured intelligence within groups has traditionally been seen, rather simplistically, as a function of genetic and environmental components acting independently. The recent work, however, emphasizes the complex interaction and possible feedback relationship between these two components. For example, a number of authors (Montagu 1972, Sanday 1972a, Scarr-Salapatek 1971) refer to the importance of prenatal and postnatal medical care and diet as factors which may inhibit the expression of an individual's genetic potential, thereby reducing the genotype-phenotype correlation. According to Gordon (in Cancro 1971:242), who cites the work of Birch (1968), the phenotypic expression of a trait is a result of a continuous biochemical and physiological interaction of the gene complex, cytoplasm, internal milieu, and external environment throughout the life of the organism. Even at birth, due to the influence of the maternal environment, phenotypic expressions do not correlate one-to-one with genotype. Furthermore, differences in rates of maturation and in the patterning of maturation times among separate traits may lead to alterations in the patterns of phenotypic expression which do not arise from genetic differences in that trait.

These arguments and those cited above suggest to the author that the interactionist point of view is the most consistent with the available knowledge. As noted above, the appropriate design for investigating the genetic influence in the score differential between Blacks and Whites would be one which observes test scores in samples raised in equivalent environments such that race would be the only factor which was free to vary. Data of this kind are unavailable in the U. S. Another approach would be to observe the score pattern of matched Black and White children attending the same schools over time. A longitudinal study is called for because only in this fashion can the gene pool be held constant. While such a study is ideal, it is not possible due to time and limited funds. The increasing cost of research, the difficulty faced by the individual researcher in gaining access to the appropriate school samples, and the desire to get data on large representative samples influenced the decision to test the diffusion model using cumulative school records.

The procedure was to first develop a verbal theory of the diffusion of intelligence. The theory is presented in Chapter 2. A mathematical model of this theory is presented in Appendix A. The underlying conception of the nature of science as applied to the study of human behavior which motivates these two developments is presented in the first part of Chapter 2.

The longitudinal design which formed the basis of the empirical examination of the verbal and mathematical model is presented in Chapter 3. This chapter discusses the type of data contained in the school records, the procedure for coding these records, and the samples employed in the empirical analysis. Chapter 4 presents the data which most closely approximates the socio-cultural context (called the cultural medium) in which the diffusion process is hypothesized to have taken place during the nine years covered by the school records. Chapter 5 presents the hypotheses derived from the diffusion model and tests these hypotheses with the longitudinal data.

Chapter 6 discusses the mathematical model of intra-cultural diffusion. The application of this model to the diffusion of intelligence is discussed, and some of the longitudinal data is employed in providing a preliminary test. Chapter 7 concludes the study by summarizing the major results and discussing the policy implications of the report.

Chapter 2. A DIFFUSION MODEL FOR THE ANALYSIS OF BETWEEN-GROUP DIFFERENCES IN IQ

The epistemological basis for the theory development in this Report was inspired by continuum models used in physics and related fields to model the response of materials of varying shapes and states to different stimuli. Continuum models can be distinguished from other physical models by a holistic rather than particularistic emphasis. The holistic emphasis requires that the major unit of analysis be the material itself and that subcomponents of the material be analyzed in terms of their behavior in the context of the medium in which they are embedded. This approach has recently been superceded by the discovery of the superscopes and the ability to look at smaller and smaller units. This has led physicists to dedicate their attention to a more microscopic approach and to concentrate largely on the description and analysis of the subcomponents. It was felt that by doing so the behavior of the whole might be more explicitly understood.

In the behavioral sciences a parallel trend can be observed. Gestalt psychologists and cultural anthropologists have traditionally utilized a holistic, macroscopic approach. In cultural anthropology, culture is conceptualized as an extra-individual phenomenon which has a life of its own and which is transmitted by individuals in the socialization process. In Gestalt psychology experience was seen as having specific properties which can neither be derived from the elements of the whole nor considered simply as the sum of these elements. Consequently the response of an organism to external stimuli is a complete and unanalyzable whole. In recent years this point of view has been reversed somewhat with the advent of more refined laboratory techniques and tools of analysis in psychology and the development of ethnoscience techniques in anthropology. This has led, as it did in the physical sciences, to a tendency to adopt a microscopic view leading to questioning again whether the whole can be viewed as a sum of its parts. Such questions, at least at present, can best be resolved by pragmatic considerations. Depending on the nature of the data and the type of research problem, one may choose a macroscopic or microscopic approach, or better yet, a mix between the two.

The research problem of this Report is to explain the reported mean differences between racial groups in performance on tests measuring general intelligence. Intra-cultural diffusion is one of several factors posited to explain such differences. In this chapter the place of continuum models in the scientific study of cultural diffusion will be discussed first, followed by a general discussion of the place of the diffusion hypothesis in the explanation of racial differences in IQ scores.

Place of Continuum Models in the Scientific Study of Intra-Cultural Diffusion

In this section, the applicability of the continuum approach for modeling the response of human groups to the diffusion of cultural phenomena is explored. Cultural diffusion has been defined by anthropologists (Driver 1971) as the spread of material objects or learned behaviors from a point of origin within a single society to any number of other societies. Cultural diffusion, as it will be discussed here, refers to an intra-cultural process by which material objects or learned behaviors are spread from some origin within a society to other points throughout the same society. By adopting societies as the unit of analysis, cultural diffusion studies have employed the holistic approach. By adopting individuals and the transfer between individuals as the primary unit of analysis, most intra-cultural diffusion studies are particularistic in nature, and the workings of the total process can be obscured. The continuum approach by bypassing the individual and concentrating on the group as the primary unit of analysis provides understanding of the total process.

In order to gain a perspective on the nature of continuum models and their heuristic value for the study of intra-cultural diffusion, there will be a brief digression in order to present the author's conceptualization of a scientific study of intra-cultural diffusion. This overall conceptualization provided the framework for many of the decisions which were made during the research period as well as the suggestions for future work. It should be noted that the following discussion of the scientific method constitutes the author's view culled from a number of sources.

The scientific method is a process of successive iterations through a number of research phases. These phases in the order in which they might be carried out in the first iteration through the process are:

(1) choice of unit of analysis and scale of observation
(2) empirical observations
(3) assumptions
(4) modeling
(5) pilot or controlled experiment
(6) predictions
(7) data collection at large, or in controlled experimentation
(8) comparison of fit between predictions and data
(9) suggestions for revisions and further iterations

Each of the above steps are believed to be essential in any thorough analysis of a given substantive area. In this research the only step which was omitted was Step 5 -- pilot or controlled experiment. This is a stage which is often missing in social science research due to the necessity of investing limited funds in collecting a body of data in a short time period. Each one of the outlined steps can now be defined as they relate to the general subject of intra-cultural diffusion. This will provide the necessary vocabulary for the discussion on the diffusion of intelligence to be presented in the next section.

(1) Choice of unit of analysis. In most diffusion studies the approach is to view the individual reacting to various influences as an isolated entity.

Accordingly, the individual is selected as the unit of analysis, and the major variables which are examined are individual variables. While such an approach may lead to predictions of the probability of an individual with certain characteristics adopting a certain object in a given period of time, it is not adequate for understanding differential rates of diffusion in the area where the diffusion process is taking place, an important part of understanding the behavior of the whole.

The scale of observation employed in the continuum approach is to view the total area as inhabited by a series of subsets of people. The global characteristics of these subsets aid the investigator in analysing the larger set in a given area. In a sense sociologists and anthropologists employ this notion when they use the concept of socio-economic classes or subcultures. Both these concepts refer to subsets of people who can be identified along certain parameters which predict group behavior, which in turn enables social scientists to predict the manner in which the larger society will respond. The field of macro-economics consistently employs a scale of observation appropriate to continuum models in predictions of national economic behavior. This scale can best be characterized as one of low magnification with the emphasis on viewing people as part of an environment. In other words, groups of people are viewed from such a distance so as not to be able to identify or characterize individuals.

(2) Observations. This phase is one in which the investigator utilizes all that he knows about the environment being studied in order to make the assumptions which will determine the factors and mechanisms to be included in the model. During this phase, observations on individuals are allowable and may be a crucial factor in determining activities in other phases. For example, the assumptions and modeling phases of this study were influenced by the observation that group test score differences normally favor groups which either comprise the mainstream culture in Western and Westernizing countries,or,groups whose cultures include an emphasis on cognitive and motivational states which are analogous to those found in mainstream Western groups. Other important observations are contained in the findings reported by Sanday (1972a, b, c) that U.S. children, regardless of their race, who are isolated from the white middle class do less well on the standard performance tests than children who are not isolated. The isolated groups include mountain children, orphan children, and children attending homogeneous lower-social-class schools. Such results are consistent with the work summarized in Chapter 1 on the Israeli children of different racial backgrounds raised in equivalent environments. All of these factors led to the assumption and modeling phases which set the tone for the analysis of the data collected.

(3) Assumptions. Assumptions are essential in reducing the number of factors posited to affect the process under study to a manageable maximum. Some may argue that assumptions should or do come before the observations. In the case of an emotionally charged issue such as the causes of racial differences in intelligence it may be that the assumptions do come first, and the observations are then made to support the assumptions. It is

clear, for example, from the discussion in Chapter 1 that there has been a tendency for many scholars in the U.S. to first assume that intelligence is a fixed and predetermined trait in spite of the evidence indicating the magnitude of the interaction between behavior and the environment. There has also been the opposite tendency to favor an environmental determinism point of view. This view holds that all humans are born with the same potential and that it is the environment only which shapes later abilities. The evidence presented in Chapter 1 suggests that neither view is tenable. If the latter view were correct, then one would expect that there would be little or no variance in test scores of children raised in equivalent environments.

The proponents of both views have selectively ignored evidence and have made a series of assumptions in their empirical work which has greatly reduced the number of factors believed to affect the expression of intelligence. The approach here has been to examine carefully the evidence presented by the environmental and genetic determinists. It is interesting to note that the genetic point of view remains extreme and simplistic, while the environmental determinists now recognize the importance of the interaction between genes and environment and the complexity of the whole issue. The evidence, discussed briefly in Chapter 1 and in detail in Sanday (1972a, b, c), led to the assumptions which guided the empirical portion of this Report.

(4) Model. This phase provides a description of the interaction of the factors remaining after the assumptions are made. The description of the interaction of factors in continuum models can be divided into two classes of relationships. The first consists of expressions relating the dependent and independent variables through operations and parametric relations that describe the state of the group. This type of relation is called a constitutive relation. When it applies to most groups of the species being studied (in this case human groups) by only changing the value or expression of the group-identifying parametric relation, it is called a constitutive law. A law that does not explicitly or implicitly involve group-identifying parameters but that expresses an interaction between factors for all groups in all states is called a basic law. The analogue of the constitutive relation in cultural anthropology is the cultural model or the cultural theory as this term is used by Goodenough (1971). A theory of a culture consists of expressions relating a number of cultural factors which enable the ethnographer to predict and describe behavior. This is normally referred to as an emic model. An etic model is similar to the constitutive law. This includes relationships which hold for a representative sample of societies by changing the value of group-identifying variables. A relationship which does not involve variables which change value dependent upon the culture of a particular society is called a cultural universal in anthropology and is the analogue of a basic law. In the diffusion literature in anthropology there is little or nothing which can be called a constitutive relation or law. Certainly there is nothing which can be called a basic law.

The second class of relationships in continuum models are called initial and boundary conditions. These refer to the values that the dependent variable in the model must attain either at a particular time everywhere in the domain of the model, or at particular points at all times. The specification of these conditions can come from the observation phase, the controlled or pilot experiment phase, or from the statement of the hypotheses in the model phase.

The concern of this Report will be to model the diffusion of mental acts which are related to IQ tests. This model is derived from a general mathematical model of intra-cultural diffusion which will be presented in Appendix A. The essentials of this model are discussed here as they relate to the specific analysis of mean differences in IQ.

In Chapter 6 intra-cultural diffusion is modeled in a macro sense, employing the approach in continuum modeling, in that interactions between individuals are only implicitly represented. Thus, no statements can be made about the effects of the diffusion process on specific individuals except in the sense that they may lie on different points along a continuum. This approach is analogous to continuum models of heat transfer where the emphasis is on the flow of heat in a continuum of a homogeneous material, as opposed to modeling the interactions between particles (molecules).

Two other concepts from the general model in Chapter 6 will be used here. These are the receptivity to the item being diffused and the generation or loss of the item being diffused. Receptivity is specified by a number of group-identifying parameters which may be a function of the characteristics of the group and/or circumstances surrounding the diffusion process. The concept of generation or loss of the item being diffused is particularly important in the diffusion of non-material items. It refers to the possibility that at a point in the domain of the group items can be added or subtracted at a certain rate per unit time per unit area.

(5) Pilot or Controlled Experiment. The values (if constant) of the expression of the group-identifying relations, the initial and boundary conditions can be determined either in a pilot experiment or in a controlled experiment. A pilot experiment consists of selecting a representative sample of the group and allowing the process under study to take place in situ while making the proper measurements. Usually only the simplest type of identifying function can be found this way, i.e., a constant. If large amounts of data are available for the process under study, a portion of that data can be used in lieu of the pilot experiment procedure. The construction of a more complex group-identifying constitutive relation usually necessitates carefully planned controlled experiments where the influence of each of the candidate variables selected by intuition is studied separately.

Ideally the pilot or controlled experiment reflects the history of change, as well as the current values of the dependent variables at every point in the expressions obtained for the group-identifying relations. While this may be possible in the study of heat transfer, it is rarely possible in human studies.

(6) Predictions. These are the expected values of the dependent variables as the independent variables take on a range of values. In the mathematical expression of a continuum model these values result from the solution of the model's constitutive equation given specified initial and boundary conditions. In the verbal expression of the model presented later in this chapter the predictions are made solely on the basis of the trends which would be expected to appear in the data from the hypothesized relations.

(7) Data Gathering. This phase consists of taking measurements of the dependent variables for known values of the independent variables for the groups in the area where the model is to be applied. The methods employed may be quite different, but by the time the data is reduced to final form it must conform to the scale of observation decided on at the outset and employed in the previous steps so as to make the comparison phase meaningful.

(8) Comparison. This consists of comparing the values or trends resulting from the predictions with the values or trends found in the data. The fit between the two is a measure of how well the model fulfills its intended purpose.

(9) Suggestions. One iteration through these phases does not necessarily constitute the completion of a given problem. Many iterations may be necessary depending on the overall evaluation which is carried out during the suggestion phase. Through successive iterations refinements can be made until the precision specified by the model at a particular scale of observation is reached. In such a way, basic laws -- defined by the physicist Feynman (1965) as "the rhythm and pattern between the phenomena of nature which is not apparent to the eye, but only to the eye of analysis" -- might be uncovered for social and cultural phenomena.

Some of the steps outlined above may conceivably be omitted. For example, the pilot experiment phase might be by-passed in the first iteration; or, the empirical observation, pilot experiment, and/or data collection phases might be by-passed in subsequent iterations. Any other omission disqualifies the work as scientific. Scientific social research must include at a minimum the following phases: assumptions, modeling, predictions, data collection, and comparison of the fit between predictions and data.

A Model for the Analysis of Between-Group Differences in IQ

The above section may seem to be an irrelevent digression from the central question. It has been included here because it explicates the epistemological and substantive position which has guided the approach adopted in this research. This is believed to be particularly important in the analysis of social issues as controversial as the IQ question. The anthropologist, probably more than other social and behavioral scientists, is trained to be sensitive to ethnocentric or other biases which may result in neglecting some aspects of a question in favor of others. Since social scientists cannot be entirely free of biases, it is essential that the principles guiding a particular approach to a problem be openly discussed. If this author is biased it is toward the interactionist view of the factors determining the expression of cognitive abilities. It is felt that this view is the most consistent with the available knowledge. A diffusion process is hypothesized to be one of several factors which may affect the phenotypic expression of intelligence (as it is measured by the IQ test) within or between groups.

The variation of IQ within groups is generally agreed to be largely a function of genetic and environmental components. The expression of genetic variation, according to Sanday (1972a:419) is a function of (1) prenatal and postnatal care and health, (2) diet, and (3) the actual genetic structure of individual. Environmental variation is a function of (1) individual emotional, motivational factors and (2) degree and nature of contact with the mainstream culture.

If all of the above factors contributing to the variation within groups were equally distributed across groups, group correlations with IQ would disappear. In the presence of significant differences in test performance between groups representing different gene pools, those who adopt the genetic incomparability explanation generally attempt to show that the actual genetic structure of the individual is the only factor which is significantly related to the expression of intelligence as measured by the IQ test. Those who adopt the environmental incomparability explanation generally assume that the distribution of genotypes affecting the expression of intelligence is either the same for all groups or is irrelevant to the question of IQ differences between groups and attempt to show that one or more of the remaining factors are unequally distributed and significantly related to the expression of intelligence.

The ideal research design for examining the influence of the diffusion process on the test-score gap between groups representing different gene pools would be one in which all of the above factors which affect the variation of intelligence within groups are held constant with the exception of degree and nature of contact with the mainstream culture and, of course, actual genetic structure of individuals. Degree and nature of contact are group-itentifying parameters which influence receptivity to the spread of mental acts (the item being diffused). The basic assumption, then, underlying the diffusion model is that the mental acts measured by intelligence tests are differentially diffused to various segments of the populace. Given that all of the other factors can be controlled, the diffusion model is postulated to explain remaining differences between groups in test scores. The reported mean differences in IQ scores, then, are related to (1) an unequal distribution of biological environmental advantages (i.e. pre and postnatal care and health; diet), and to (2) differential diffusion from the mainstream culture (the locus of the components being measured) of the cognitive components measured by IQ tests.

The main hypothesis of the diffusion model is that the mean differences in test scores are a function of a group's degree and nature of contact with the mainstream. Degree of contact is a measure of psychological, social, and geographical distance from the mainstream culture unit. Nature of contact is a measure of the type of affective interaction between members of the nonmainstream and the mainstream unit. This hypothesis is evaluated here by examining change in IQ scores over time in a population of school children and correlated changes in cultural variables, which, it will be argued, are measures of degree and nature of contact with the mainstream culture. The nature of the data, to be discussed in the next chapter, permit only minimal control for biological environmental disadvantages.

The approach is similar to the continuum approach in that the unit of analysis are groups which because of differing cultural characteristics have differing identifying parameters. Each group can also be said to lie along continua of degree and nature of contact with the locus of the items being diffused. The locus is set as the White middle and upper classes and continua are operationalized interms of socio-economic class and variables measuring affective contact. Each group can also be characterized by receptivity parameters which are a function of the group's degree and nature of contact with the source. Nature of contact includes any type of affective interaction with parents, peers, or teachers which impedes or enhances the development of cognitive abilities. Finally, something will be said about the generation or loss of the items being diffused.

The predictions and the comparison between the predictions and the data will be presented in Chapter 5. In the following chapter the research design will be discussed.

Chapter 3. THE LONGITUDINAL DESIGN

The data were collected in the summer of 1971 from the cumulative school records of all students who had just finished the ninth grade in the Pittsburgh public school system. The time period examined is nine years between 1962 and 1970 during which time a proportion of the total sample passed from kindergarten to the eighth grade. Group or individual IQ tests were administered during this period to children in kindergarten, fourth, sixth, and eighth grades. A large part of the data analysis includes only those children who had taken all four group tests. The group tests administered are the Detroit (kindergarten), the Kuhlmann-Anderson (fourth grade), Otis Beta FM (sixth grade) and Otis Lennon (eighth grade).

The data provided in the school records were selected for the test of the diffusion hypothesis because they were the only source available for the pattern of test scores over time in a large sample representing different subcultures. The school records used also contained measures of variables which could be taken as proxies of degree and nature of contact. While the data provided in the school records do not provide the detail noted in other studies, the value of restricting the analysis to data available in these records outweighs the loss in information. First of all, school records yield a rich, and as yet largely untapped, source of unobtrusive measures. Such a source has great potential in the formulation and monitoring of educational policy because school records can be used to yield adequate sample sizes of representative geographical areas without the cost of collecting data. The fact that the existing form of record-keeping may not include all of the appropriate data only indicates the necessity of instituting a standardized and reliable form of record-keeping.

Procedure for Collecting Data

In a two-week period during the summer of 1971 the school records of all ninth graders were microfilmed. Members of the school board were extremely cooperative once it was agreed that all information which might identify individuals would not be microfilmed. This was possible since all such information was contained in one location and was easily covered during the microfilming. To further insure anonymity school counselors were employed to examine each record before microfilming and to blot out any identifying information.

Three work teams were employed, each headed by a school counselor. Each team was trained in microfilming and in the procedure to be employed. Each team was trained to process at least 200 records each day. The records were located at nineteen schools. The work format, as it was given to each team, follows.

(1) Call the school and notify the clerk that the team is coming.
(2) Go to the school and locate the records.
(3) Microfilm a form which says HERE BEGINS ____________ SCHOOL.
(4) Two team members working in parallel prepare a batch of 20 sets of records by placing them into templates and using the pressure-sensitive tape to eradicate any information which could lead to the student's identity. The order for microfilming each record is:
    (a) Front side of Cumulative Elementary Record
    (b) Back side of same
    (c) Front side of Permanent Record
    (d) Back side of Permanent Record
(5) Microfilm the batch. One person operates the microfilmer while the other removes the records from templates.
(6) If for some reason an exposure of a record is invalidated (perhaps entry into the machine at the wrong angle), place a card with DISREGARD PREVIOUS EXPOSURE into machine and microfilm, then remicrofilm the record.
(7) Put microfilmed records away.
(8) Return to (4) until records at that school have been completely microfilmed. Then go to (9).
(9) Microfilm a form saying HERE ENDS ____________ SCHOOL.
(10) Call the next school and inform them of your coming.

As is noted in the above, each team was instructed to microfilm the elementary and secondary record (the permanent record) on each ninth grader. In many cases only one record might be present if the child either entered or left the system during the time period of the study. In such cases the team was instructed to microfilm whatever record was present.

Procedure for Coding School Records and School-Related Data

Once the records were microfilmed and each film processed, coders were hired to transform the information contained in the records to IBM sheets which were later key-punched. A subsample (N=210) was examined in order to develop a coding format for the total sample. Each coder was instructed to code only those cases where there was both an elementary cumulative record and a permanent record. This decision was made in order to reduce the amount to be coded and to ensure that longitudinal data was present for the sample members. The number of records coded was 3,762. It required a full year and three to four part-time coders to complete the final sample. A list of some of the variables coded follows:

(1) School attended in ninth grade
(2) Sex
(3) Race
(4) Place of birth

(5) Date of Birth
(6) Number of schools attended (counting all schools attended both inside and outside of school system studied -- if child attended the same school twice this is counted as two schools)
(7) Number of grades repeated K-6
(8) Type of school attended before attending city school system
(9) Number of brothers (recorded when child entered school system)
(10) Number of sisters (recorded when child entered school system)
(11) Family structure -- status of father (recorded when child entered)
(12) Family structure -- status of mother (recorded when child entered)
(13) Birthplace of male head of family
(14) Birthplace of female head of family
(15) Education of father
(16) Education of mother
(17) Occupation of father
(18) Occupation of mother
(19) Pre-school reading readiness test grades
(20) Pre-school number readiness test grades
(21) Pre-school total readiness test grades
(22) Total number of suspensions mentioned for all grades
(23) Number of different addresses K-9
(24) Number of grades repeated 7-9
(25) Number of days absent K-8
(26) Citizenship rating 7th and 8th grades
(27) Number of health checks in grades K-6
(28) Number of days tardy in grades K-8
(29) Number of work habit checks in grades K-6
(30) Number of social habit checks in grades K-6
(31) IQ scores in grades K, 4, 6, 8
(32) Interest test scores given in grade 9
(33) Achievement scores grades 1-8

Once all cases were coded, a check for coder reliability was carried out. Approximately four hundred of a possible five hundred columns were checked in every third case. Where consistent errors were found for a particular coder, all of the coders cases were checked. Whenever an error in coding was found, the appropriate correction was made. The percentage of error was calculated before and after the corrections were made. The percentage error was computed by dividing the number of columns in error by the total number of columns checked. The error formula was

$$\frac{\text{Number of errors}}{\text{Number of cases checked times number of columns checked per case}}$$

where the number of columns checked per case is either 396 or 495. The average percent of errors made by all coders on the total set of data before corrections were made was 1.2%. The average percent of error remaining in the data after all corrections were made is estimated to be 0.8%.

In addition to coding the individual school records, data were also obtained from the Board of Education on a number of school-related characteristics for each school for each year of the study. The variables coded are listed below.

(1) Total number of teachers in each school for each year
(2) Total number of students in each school for each year
(3) Total number of new teachers in each school in each year
(4) Total number of male teachers in each school in each year
(5) Percentage Black students in each school in each year
(6) Total number of counselors in each school in each year
(7) Racial composition of staff (available for years 1964-1969 only)

In the next two chapters the results of the data analyses are presented. Chapter 4 summarizes the socio-cultural context of the school system during the nine-year period. Chapter 5 presents and tests the hypotheses derived from the diffusion model.

Chapter 4. ANATOMY OF AN URBAN SCHOOL SYSTEM: THE SOCIO-CULTURAL CONTEXT OF LEARNING

In the school system studied there are two discernible subcultural groups. This assertion, to be supported by the data collected from the school records, is based on work in the same city by Johnson and Sanday (1971) who inductively established a Black and White subculture using a number of criteria previously suggested for classifying cultural systems. Johnson and Sanday found, for example, that the Black sample in their study, as opposed to the White sample, was less futuristic in orientation, did not trust people, and did not believe that by working hard they could get ahead. Such variables were used as measures of cultural themes which, since themes are thought to control behavior, can aid in understanding differences in behavior across subcultural systems. For example, the belief on the part of the Black sample that fate was more important than hard work in getting ahead may be significant in influencing receptivity to the diffusion of mental acts. Greenfield (in Cancro 1971:257) reports the results of a study which found that the more a mother feels externally controlled when her child is 4 years old, the more likely the child is to have a low IQ and a poor academic record at age 6 or 7. Greenfield relates the mother's sense of control over her environment to the ability to set goals for her children which is an important precondition to the development of cognitive abilities. In the context of the diffusion model, this suggests something about the effect of the nature of contact on the development of a child's mental abilities.

The data collected from the school records indicates many areas in which there are significant differences between Blacks and Whites and hence supports the contention of Johnson and Sanday of separate subcultural systems. Of the total sample (N=3,762), 45% are Black (N=1,679) and 55% are White (N=2,082). The breakdown of the total sample by race and sex appears in Table 1. Most of the Black sample (89%) and most of the White sample (90%) were born in the city which was studied (see Table 2). This indicates the relative stability of the Black population in Pittsburgh, which is known to have been relatively unaffected by recent migration from the South. This, however, is not the case for parents. Less than 50% of the Black parents were born in the city, while over 50% of the White parents were born in this city. As is indicated in Tables 3 and 4, 46% of Black male heads and 40% of Black female heads were born in the South. The majority of the rest of the Black parents were, however, born in the city studied.

Differences in the two samples begin to appear in family structure and occupation of father. As would be expected from national statistics and from the findings reported in Johnson and Sanday (1971) there are more White families where father is present. However, as shown in Table 5, this

TABLE 1. RACE AND SEX OF TOTAL SAMPLE

		Black		White		Total	
		N	%	N	%	N	%
Male	N	874		1108		1982	
	%	(52.1)		(53.2)		(52.7)	
Female	N	805		974		1779	
	%	(47.9)		(46.8)		(47.3)	
Total	N	1679	(44.6)	2082*	(55.4)	3761	100
	%	(100)		(100)		(100)	

*Total White sample is 2083. The sex of 1 White student was not indicated in the records

TABLE 2. BIRTHPLACE OF STUDENT

		Black	White
Pittsburgh	N	1479	1868
	%	(88.5)	(90.1)
Pennsylvania	N	43	63
	%	(2.6)	(3.0)
South	N	99	20
	%	(5.9)	(1.0)
Rest of U.S.	N	48	96
	%	(2.9)	(4.6)
Non-U.S.	N	3	26
	%	(.2)	(1.3)
Subtotal	N	1672	2073
	%	(100.1)	(100.0)
No Information		7*	10**
Total	N	1679	2083

*4% of Black Sample.

**5% of White Sample.

TABLE 3. BIRTHPLACE OF MALE HEAD

		Black	White
Pittsburgh	N	595	1408
	%	(39.2)	(70.4)
Pennsylvania	N	99	255
	%	(6.5)	(12.8)
South	N	697	44
	%	(45.9)	(2.2)
Rest of U.S.	N	126	177
	%	(8.3)	(8.9)
Out of U.S.	N	2	115
	%	(.1)	(5.8)
Subtotal	N	1519	1999
	%	(100.0)	(100.1)
No Information		160	84
Total	N	1679	2083

*9.5% of Black Sample
**4% of White Sample

TABLE 4. BIRTHPLACE OF FEMALE HEAD

		Black	White
Pittsburgh	N	720	1457
	%	(44.4)	(71.8)
Pennsylvania	N	124	276
	%	(7.6)	(13.6)
South	N	644	33
	%	(39.7)	(1.6)
Rest of U.S.	N	130	165
	%	(8.0)	(8.1)
Out of U.S.	N	4	98
	%	(.2)	(4.8)
Subtotal	N	1622	2029
	%	(99.9)	(99.9)
No Information		57*	54**
Total	N	1679	2083

*3.4% of Black Sample.

**2.6% of White Sample

difference is not nearly as great as has been reported previously. Among the Black children 79% come from families where father is present as compared with 89% of the White children. The average number of brothers and sisters (see Table 6) is slightly higher for the Blacks. Size of family has been shown to be related to IQ (see Tyler 1965). Size of family would also be important in the diffusion hypothesis since it is a factor which might determine the degree of attention a child might receive from parents.

The occupation of the Black fathers ranges from semi-skilled to clerical (see Table 7). The modal category for the Black fathers is unskilled while the modal category for the White fathers is semi-skilled and skilled. This is somewhat surprising in view of the fact that the modal educational level for both Black and White fathers is the same (high school graduate) as shown in Table 8. This finding is consistent with the data which indicates that Blacks have traditionally experienced barriers to occupational advancement regardless of educational achievement. The educational level of mothers is also similar for both samples (see Table 9). Combined education and occupation of fathers is presented in Table 10 in the computation of the index of social position (SES). Table 10 is based on data from the longitudinal sample. This sample includes those students who entered the Pittsburgh schools in kindergarten and were also enrolled in 4th, 6th, and 8th grades. As would be expected from Tables 6 and 7 the Black sample is clustered in the lower SES positions while the White sample is clustered in the middle SES position.

The factors which begin to differentiate the Black and White samples are those which can be taken as measures of degree and nature of contact and the mental test scores which indicate a progressive loss on the part of Blacks relative to the Whites. The most startling indication of the sharp differences in degree of contact comes from the extent of racial segregation in the school system and from the data on the social class composition of the schools. These variables are interpreted as measuring degree of contact since they can be seen as widening or closing the gap between the child and the mainstream culture. If Blacks comprise a separate subculture, then the higher the percentage Black in the school, the more distant a child is from the mainstream culture, and the more likely it will be that non-mainstream values and components will be diffused in the school environment. The average SES of peers can be viewed in the same way since it is assumed that the locus of the diffusion process is in the White middle and upper classes.

The importance of SES of peers and racial composition of the schools in affecting Black scholastic and social performance has been discussed by Johnson and Sanday (1971) and by Henderson (1967). These authors point out that the uniformity and isolation of the Black community is reinforced in a segregated school system where students are exposed to a homogeneous context in class as well as race. The overall result is a leveling effect in the schools where Black children, regardless of their background, begin to perform alike on measures of social and scholastic performance. White children, on the other hand, regardless of their community background, tend to be exposed to an ever-expanding series of class and ethnic contexts in the schools.

TABLE 5. FAMILY STRUCTURE - STATUS OF FATHER
(Recorded when Child entered School System)

		Blacks	Whites
With Family	N	1236	1806
	%	(78.5)	(89.1)
Separated Not With Family	N	110	58
	%	(7.0)	(2.9)
Divorced	N	27	74
	%	(1.7)	(3.7)
Not With Family	N	135	24
	%	(8.6)	(1.2)
Never With Family (Mother Not Married)	N	21	3
	%	(1.3)	(.1)
Deceased	N	42	60
	%	(2.7)	(3.0)
Hospitalized	N	4	2
	%	(.3)	(.1)
Subtotal	N	1575	2027
	%	(100.1)	(100.1)
No Information		104*	56**
Total	N	1679	2083

*6.2% of Black Sample.

**2.7% of White Sample.

TABLE 6. AVERAGE NUMBER OF BROTHERS AND SISTERS
(Recorded when child entered School System)

		Blacks Brothers
	$\bar{X}$	1.79
	SD	1.69
Sub Total	N	1318
No Info	N	361
TOTAL	N	1679
		Sisters
	$\bar{X}$	1.68
	SD	1.52
Sub Total	N	1323
No Info	N	356
TOTAL	N	1679

		Whites Brothers
	$\bar{X}$	1.34
	SD	1.25
Sub Total	N	1827
No Info	N	256
TOTAL	N	2083
		Sisters
	$\bar{X}$	1.33
	SD	1.25
Sub Total	N	1837
No Info	N	246
TOTAL	N	2083

TABLE 7. OCCUPATION OF PARENTS
(Recorded when Child was in Kindergarten)

		Father		Mother	
		Black	White	Black	White
Higher Executives	N	8	96	0	6
Major Professionals	%	(.6)	(5.2)	(0)	(.3)
Business Managers	N	9	94	10	52
and Lesser Professionals	%	(.7)	(5.1)	(.7)	(2.7)
Administrative Personnel	N	29	160	6	11
and Minor Professional	%	(2.3)	(8.6)	(.4)	(.6)
Clerical - Owners of	N	77	316	32	65
Small Businesses	%	(6.0)	(17.0)	(2.1)	(3.3)
Skilled	N	178	501	10	9
Manual	%	(13.9)	(27.0)	(.7)	(.5)
Semi-skilled	N	390	489	67	46
	%	(30.5)	(26.3)	(4.4)	(2.4)
Unskilled	N	426	160	100	40
	%	(33.4)	(8.6)	(6.6)	(2.1)
Retired or	N	11	5	72	10
Disabled Veterans	%	(.9)	(.3)	(4.8)	(.5)
Unemployed	N	149	37	1210	1706
	%	(11.7)	(2.0)	(80.3)	(87.7)
Subtotal	N	1277	1858	1507	1945
	%	(100.0)	(100.1)	(100.0)	(100.1)
No Information		402*	225**	172***	138****
Total	N	1679	2083	1679	2083

*23% of Black Sample.

**10.8% of White Sample

***10.2% of Black Sample

****6.6% of White Sample

TABLE 8. EDUCATION OF FATHER

			Black	White
1.	Graduate Professional Training	N	4	66
		%	(.3)	(3.4)
2.	College Graduate	N	23	158
		%	(1.7)	(8.2)
3.	Some College	N	58	148
		%	(4.4)	(7.7)
4.	High School Graduate	N	437	753
		%	(32.9)	(39.0)
5.	Some High School	N	380	432
		%	(28.6)	(22.3)
6.	Junior High School	N	289	304
		%	(21.7)	(15.7)
7.	Less than 7 Years of School	N	139	72
		%	(10.5)	(3.7)
	Subtotal	N	1330	1933
		%	(100.1)	(100.0)
	No Information	N	349*	150**
	Total	%	1679	2083
	Median		4.88	4.29
	Mode		4.00	4.00

*20.8% of Black Sample.

**7.2% of White Sample.

TABLE 9 . EDUCATION OF MOTHER

			Black	White
1.	Graduate Professional	N	0	25
	Training	%	(0.0)	(1.3)
2.	College Graduate	N	15	110
		%	(1.0)	(5.5)
3.	Some College	N	44	159
		%	(2.8)	(8.0)
4.	High School	N	611	935
	Graduate	%	(39.0)	(46.9)
5.	Some High School	N	529	465
		%	(33.7)	(23.3)
6.	Junior High School	N	304	239
		%	(19.4)	(12.0)
7.	Less than 7 Years	N	65	62
	of School	%	(4.1)	(3.1)
	Subtotal	N	1568	1995
		%	(100.0)	(100.0)
	No Information		111*	88**
	Total	N	1679	2083
	Median		4.72	4.25
	Mode		4.00	4.00

*6.6% of Black Sample.

**4.2% of White Sample.

TABLE 10. BREAKDOWN OF SAMPLE[1] BY INDEX OF SOCIAL POSITION (SES)

		Index Score of Social Position[2]			
		11-37	38-57	58-77	TOTAL
Blacks	N	30	182	663	875
	%	3	21	76	100
Whites	N	268	502	422	1192
	%	23	42	35	100

[1]The data in this Table were drawn from those students who entered the Pittsburgh schools in Kindergarten and were enrolled in 4th, 6th, and 8th grades (hereafter called the longitudinal sample)

[2]Computed using Hollingshead's (1957) Two Factor Index of Social Position which assigns each individual an index value according to occupation and education (with occupation weighted more heavily). Hollingshead (1957:10) suggests that social class position be determined on the basis of index score as follows:

Social Class		Range of Computed Scores
Upper	I	11-17
	II	18-27
	III	28-43
	IV	44-60
Lower	V	61-77

The leveling effect is well illustrated by the data of this study. For example, the trend in the magnitude of the variation in the Black and White IQ scores between kindergarten and eighth grade supports the notion of the leveling effect. As Blacks move from kindergarten to the eighth grade, the variation in their IQ scores becomes more homogeneous, as illustrated by the decrease in the size of their standard deviation (see Table 11). On the other hand, the variation in the White scores remains consistently higher than those of the Blacks. Table 11 presents the raw scores for the total sample, which includes different sample sizes for different grades. Table 12 illustrates this process more dramatically for the subsample which was in the school system for all nine grades (the longitudinal sample). The scores reported in this Table are standardized (see next chapter for procedure) so that tests from one grade to another can be compared. This Table shows that the variation in the Black IQ scores become more homogeneous while the variation in the White scores remains higher and approximately the same. Thus, Henderson's emphasis on the leveling effect is indicated by the fact that while Black children as a group come to school with greater variation in measured intelligence, by the time they reach the eighth grade this variation has been reduced along with the reduction in overall mean scores.

The leveling effect may be due to the fact that regardless of the socio-economic background of their parents Black children attend schools where the average SES of their peers is low. This is indicated in Tables 13 and 14 which present for the longitudinal sample the distribution of Blacks and Whites in high, middle, and low SES school environments controlling for SES of parents. For example, at kindergarten 50% of the Blacks coming from high SES backgrounds are in low SES schools (Table 13). By the eighth grade the process of allocating Blacks to low SES schools has worsened, with 77% of the high SES Blacks attending low SES schools with only 5% of the Whites of similar backgrounds attending such schools (Table 14). As can be seen from Table 15, almost all of the Black children (i. e., 84% at kindergarten and 90% at the eighth grade) are in schools where the average SES of their peers is low. The figures for the White children are drastically different (19% at kindergarten and 21% at eighth grade are in similar low SES school environments). These figures are tragic when it is considered that an important finding of the Coleman et. al. (1966) study of equality of educational opportunity was that SES of peers influences scholastic achievement.

The data on racial segregation, as might be expected, are very similar. The percentage of Blacks in each student's school for each year of the study for the total Black and White sample is presented in Table 16. Many of these variables will be incorporated into the empirical analysis of the factors affecting change in IQ scores. Other variables which distinguish between Blacks and Whites are number of different addresses (Table 18), number of schools attended (Table 19 showing only a slight difference between the samples), number of grades repeated (Table 20) and average number of days absent and tardy (Tables 21 and 22). It is interesting to note from the latter two tables that the difference between the Black

TABLE 11 . AVERAGE IQ SCORES GRADES K, 4, 6, 8. (RAW SCORES)

Grades		A Blacks	B Whites	B-A
K	$\overline{X}$	98.06	112.36	14.30
	SD	15.81	17.05	
	N	1498	1596	
	No Info	181	487	
4	$\overline{X}$	94.66	105.04	10.38
	SD	12.27	12.03	
	N	1413	1725	
	No Info	266	358	
6	$\overline{X}$	95.03	106.76	11.73
	SD	12.01	13.50	
	N	1463	1860	
	No Info	216	223	
8	$\overline{X}$	89.10	103.54	14.44
	SD	12.31	15.34	
	N	1389	1968	
	No Info	290	115	

TABLE 12. - MEAN (STANDARDIZED) IQ SCORES IN KINDERGARTEN, FOURTH, SIXTH, AND EIGHTH GRADES (LONGITUDINAL SAMPLE)

Q Score	Black					White				
	K	4	6	8	T	K	4	6	8	T
$\overline{X}$	93.61	93.82	92.86	92.02	2.637*	105.53	105.40	106.10	106.76	2.095**
SD	13.31	14.16	12.87	11.87		14.43	13.70	14.14	14.23	
N	875	875	875	875		1192	1192	1192	1192	

*Black Mean at Kindergarten versus Black Mean at Eighth Grade Sig. at .005

**White Mean at Kindergarten versus White Mean at Eighth Grade Sig. at .025

TABLE 13. DISTRIBUTION BY RACE AND PARENTS' SES IN SCHOOL PEER GROUP ENVIRONMENTS AT KINDERGARTEN* (LONGITUDINAL SAMPLE)

Parents' SES			SES of Peers at Kindergarten: High (11-37)*	Medium (38-57)	Low (58-77)	Total
High	Whites	N	76	183	9	268
		%	28	68	3	99
	Blacks	N	0	15	15	30
		%	0	50	50	100
Medium	Whites	N	25	407	70	502
		%	5	81	14	100
	Blacks	N	0	46	136	182
		%	0	25	75	100
Low	Whites	N	4	270	148	422
		%	.09	64	35	99.9
	Blacks	N	0	83	580	663
		%	0	13	87	100
	Total	N	105	1004	958	2067

*Hollingshead's Index Scores (See Table 10 for explanation)

TABLE 14. DISTRIBUTION BY RACE AND PARENTS' SES IN SCHOOL PEER GROUP ENVIRONMENTS AT EIGHTH GRADE* (LONGITUDINAL SAMPLE)

Parents' SES			SES of Peers in Eighth Grade: High (11-37)*	Medium (38-57)	Low (58-77)	Total
High	Whites	N	148	107	13	268
		%	55	40	5	100
	Blacks	N	0	7	23	30
		%	0	23	77	100
Medium	Whites	N	73	345	84	502
		%	14	69	17	100
	Blacks	N	1	33	148	182
		%	0	18	81	99
Low	Whites	N	30	246	146	422
		%	7	58	35	100
	Blacks	N	1	48	614	663
		%	0	7	93	100

*Hollingshead's Index Scores (see Table 10 for explanation)

TABLE 15. PERCENT OF BLACKS AND WHITES IN TYPES OF SCHOOL ENVIRONMENT* (LONGITUDINAL SAMPLE)

			High (11-37)*	Medium (38-57)	Low (58-77)	Total
Kindergarten	Whites	N	105	860	227	1192
		%	8	72	19	99
	Blacks	N	0	144	731	875
		%	0	16	84	100
Eighth Grade	Whites	N	251	698	243	1192
		%	21	58	21	100
	Blacks	N	2	88	785	875
		%	0	10	90	100

*Hollingshead's Index Scores (see Table 10 for explanation)

TABLE 16. RACIAL COMPOSITION OF THE SCHOOLS (TOTAL SAMPLE)

Grades		Black % of Black Students in Each Student's School	White % of Black Students in Each Student's School
K or 1	$\bar{X}$	79.86	12.84
2	$\bar{X}$	79.57	13.11
3	$\bar{X}$	80.17	12.92
4	$\bar{X}$	79.89	12.95
5	$\bar{X}$	80.61	12.67
6	$\bar{X}$	78.50	14.24
7	$\bar{X}$	72.98	15.52
8		No Data	No Data

TABLE 18. NUMBFR OF DIFFERENT ADDRESSES K-9

No. of Addresses		Black	White
0	N	1	4
	%	(.1)	(.2)
1	N	408	1140
	%	(24.3)	(54.7)
2-3	N	734	733
	%	(43.7)	(35.2)
4-5	N	301	147
	%	(17.9)	(7.1)
6-7	N	138	33
	%	(8.2)	(1.6)
8-9	N	63	14
	%	(3.8)	(.7)
10+	N	34	12
	%	(2.0)	(.6)
Total	N	1679	2083
	%	(100.0)	(100.0)
Mean		3.17	1.89
Median		2.49	1.41
Mode		2.00	1.00

TABLE 19. NUMBER OF SCHOOLS ATTENDED K-9

# of Schools*		Black	White
1	N	4	7
	%	(.2)	(.3)
2	N	557	827
	%	(33.9)	(40.2)
3	N	438	705
	%	(26.7)	(34.3)
4	N	256	297
	%	(15.6)	(14.4)
5	N	172	119
	%	(10.5)	(5.8)
6	N	108	57
	%	(6.6)	(2.8)
7	N	55	24
	%	(3.3)	(1.2)
8	N	33	9
	%	(2.0)	(.4)
9+	N	20	12
	%	(1.2)	(.6)
Subtotal	N	1643	2057
	%	(100.0)	(100.0)
No Information		36**	26***
Total	N	1679	2083
Mean		3.53	3.04
Median		3.10	2.78
Mode		2.00	2.00

*Includes all schools listed on records both in and outside of school system studied. A school is counted twice if child transfers out and then back in.

**2.1% of Black Sample.

***1.2% of White Sample

TABLE 20. NUMBER OF GRADES REPEATED K-6

No. Grades Repeated		Black	White
0	N	851	1614
	%	(50.7)	(77.5)
1	N	587	363
	%	(35.0)	(17.4)
2	N	228	101
	%	(13.6)	(4.8)
3	N	11	5
	%	(.7)	(.2)
4+	N	2	0
	%	(.1)	(0.0)
Total	N	1679	2083
	%	(100.1)	(99.9)
	Mean	.65	.28
	Median	0.00	0.00
	Mode	0.00	0.00

TABLE 21 . AVERAGE NUMBER OF DAYS ABSENT BY GRADE & RACE

Grades		A Black N=1679	B White N=2083	A-B
K	$\overline{X}$	23.68	18.28	5.40
	SD	22.51	20.09	
1	$\overline{X}$	16.70	13.14	3.56
	SD	14.49	12.60	
2	$\overline{X}$	12.61	9.53	3.08
	SD	12.46	9.77	
3	$\overline{X}$	11.33	9.18	2.15
	SD	10.94	9.60	
4	$\overline{X}$	12.52	10.19	2.33
	SD	12.35	10.41	
5	$\overline{X}$	12.32	10.07	2.25
	SD	13.67	10.54	
6	$\overline{X}$	15.27	12.0	3.27
	SD	14.72	12.0	
7	$\overline{X}$	19.15	14.17	4.98
	SD	20.28	14.01	
8	$\overline{X}$	22.26	16.02	6.24
	SD	23.31	16.45	

TABLE 22: AVERAGE NUMBER OF DAYS TARDY IN GRADES K-8

Grades		A Black	B White	A-B
K	$\bar{X}$	.21	.08	.13
	SD	2.03	1.16	
1	$\bar{X}$	3.93	1.23	2.70
	SD	7.23	3.32	
2	$\bar{X}$	4.48	1.10	3.38
	SD	8.64	3.41	
3	$\bar{X}$	5.68	1.23	4.45
	SD	10.50	3.98	
4	$\bar{X}$	7.73	1.71	6.02
	SD	13.23	5.43	
5	$\bar{X}$	8.64	1.45	7.19
	SD	14.48	4.78	
6	$\bar{X}$	8.85	1.68	7.17
	SD	13.94	4.53	
7	$\bar{X}$	10.23	2.47	7.76
	SD	14.04	5.90	
8	$\bar{X}$	16.97	3.92	13.05
	SD	20.35	7.97	

and the White samples increases over time. This is also the case in the trend of the IQ scores presented in Table 12.

Finally, there are some indications of teachers' perceptions of students as indicated in the average number of social, health, and work habit checks, academic grades, and citizenship ratings in the 7th and 8th grades (Tables 23-27). These data again indicate that the Blacks come off looking consistently worse than the Whites. The only case where this is not so is indicated in the rather odd results of Table 27 which presents the interest test scores for Blacks and Whites in the total sample.

Interests tests are given only in some of the schools. They tend to be given in those schools which are predominantly White and are attended by academically oriented students. For example, in one predominantly college-bound White school, 84% of the students took the Interests Test. In one predominantly Black vocational school, nobody took it. This is the reason why the sample size for Blacks is so much smaller than that of Whites. The Black students who do take the test are probably in predominantly White schools. It is interesting to note that they consistently outscore the White students on the interests tests. This suggests a number of hypotheses which cannot be tested with the data from the school records.

TABLE 23. AVERAGE NUMBER OF SOCIAL AND WORK HABIT CHECKS*
IN GRADES K-6

Grades		Social A Blacks	Social B Whites	Social A-B	Work A Blacks	Work B Whites	Work A-B
K	$\bar{X}$	.47	.13	.34	.49	.17	.32
	SD	1.42	.77		1.36	.79	
1	$\bar{X}$	.80	.30	.50	1.29	.65	.64
	SD	1.45	.81		1.81	1.32	
2	$\bar{X}$	.93	.37	.56	1.43	.74	.69
	SD	1.48	.82		1.80	1.35	
3	$\bar{X}$	1.18	.49	.69	1.55	.94	.61
	SD	1.63	1.05		1.77	1.48	
4	$\bar{X}$	1.37	.64	.77	1.85	1.02	.83
	SD	1.76	1.23		1.84	1.56	
5	$\bar{X}$	1.41	.61	.80	1.72	1.07	.65
	SD	1.83	1.09		1.81	1.58	
6	$\bar{X}$	1.40	.75	.65	1.72	1.07	.65
	SD	1.96	1.29		1.88	1.60	

* A check denotes a habit which needs improvement

TABLE 24. AVERAGE NUMBER OF HEALTH CHECKS* IN GRADES K-6

Grades		A Black	White	A-B
K	$\bar{X}$	.13	.04	.09
	SD	.53	.30	
1	$\bar{X}$	.15	.04	.11
	SD	.51	.23	
2	$\bar{X}$	.12	.04	.08
	SD	.44	.23	
3	$\bar{X}$	.15	.07	.08
	SD	.50	.35	
4	$\bar{X}$	.15	.09	.06
	SD	.56	.43	
5	$\bar{X}$	.14	.04	.10
	SD	.53	.27	
6	$\bar{X}$	.17	.04	.13
	SD	.60	.24	

* A check denotes a habit which needs improvement

TABLE 25.- CITIZENSHIP RATING 7th AND 8th GRADES

		7th Grade		8th Grade	
		Black	White	Black	White
1. Fail	N	69	13	98	33
	%	(5.3)	(.8)	(7.5)	(1.8)
2. D	N	240	146	267	157
	%	(18.3)	(8.6)	(20.3)	(8.4)
3. C	N	539	602	526	579
	%	(41.1)	(35.5)	(40.0)	(31.1)
4. B	N	326	682	294	759
	%	(24.8)	(40.2)	(22.4)	(40.7)
5. A	N	71	225	69	300
	%	(5.4)	(13.3)	(5.2)	(16.1)
8. Special A	N	54	26	47	22
	%	(4.1)	(1.5)	(3.6)	(1.2)
9. Grade Skipped	N	13	4	12	14
	%	(1.0)	(.2)	(.9)	(.8)
Sub Total		1312	1698	1313	1864
		(100.0)	(100.1)	(99.9)	(100.1)
No Info		367*	385**	366*	219**
Median		3.14	3.63	3.06	3.72
Mode		3.00	4.00	3.00	4.00

7th Grade:
* 21.9% of Black Sample
** 18.5% of White Sample

8th Grade:
* 21.7% of Black Sample
** 10.5% of White Sample

TABLE 26. AVERAGE GRADES OF WHITES AND BLACKS IN GRADES 1-6 AND GRADES 7-8

	Index Score of Parents' Social Position			Total
	11-37	38-57	58-77	
White Sample				
Grades 1-6				
$\bar{X}$	3.84	3.52	3.18	3.45
SD	.70	.76	.79	.80
N	391	775	775	1941
Grades 7-8				
$\bar{X}$	3.74	3.47	3.17	3.40
SD	.71	.82	.85	.84
N	396	794	782	1972
Black Sample				
Grades 1-6				
$\bar{X}$	3.34	3.08	2.86	2.92
SD	.81	[illegible]	.67	.69
N	51	[illegible]3	1187	1526
Grades 7-8				
$\bar{X}$	3.15	2.97	2.76	2.81
SD	.90	.77	.78	.79
N	50	262	1042	1354

TABLE 27. INTEREST TEST SCORES GIVEN IN GRADE 9.

Interest Tests		A Black	B White	A-B
1. Outdoor	$\bar{X}$	30.196	41.27	-11.074
	SD	23.90	26.09	
	N	(332)	(1216)	
	No Info N	(1347)	(867)	
2. Mechanical	$\bar{X}$	44.77	41.93	2.81
	SD	25.90	25.87	
	N	(333)	(1213)	
	No Info N	(1346)	(870)	
3. Computational	$\bar{X}$	62.87	53.47	9.40
	SD	26.85	29.04	
	N	(334)	(1216)	
	No Info N	(1345)	(867)	
4. Scientific	$\bar{X}$	43.99	50.03	- 6.04
	SD	25.58	25.77	
	N	(333)	(1220)	
	No Info N	(1346)	(863)	
5. Persuasive	$\bar{X}$	51.97	49.92	2.05
	SD	25.97	26.05	
	N	(334)	(1216)	
	No Info N	(1345)	(867)	
6. Artistic	$\bar{X}$	54.00	53.97	0.03
	SD	27.09	28.09	
	N	(334)	(1216)	
	No Info N	(1345)	(867)	
7. Literary	$\bar{X}$	49.80	44.13	5.67
	SD	26.30	28.09	
	N	(333)	(1216)	
	No Info N	(1346)	(867)	
8. Musical	$\bar{X}$	43.68	35.03	8.35
	SD	27.44	26.62	
	N	(334)	(1211)	
	No Info N	(1345)	(872)	
9. Social Service	$\bar{X}$	62.43	56.06	6.37
	SD	24.29	27.60	
	N	(333)	(1211)	
	No Info N	(1346)	(872)	
10. Clerical	$\bar{X}$	59.78	49.72	10.06
	SD	24.15	26.99	
	N	(327)	(1205)	
	No Info N	(1352)	(878)	

Chapter 5. THE PATTERN AND CORRELATES OF CHANGE IN IQ SCORES: TEST OF THE DIFFUSION HYPOTHESIS

The diffusion model implies that if one or more subcultures receives transmitted knowledge differentially, age groups from these subcultures tested at different points in time will show a gain or loss in measured knowledge over time. The first hypothesis of this study is that an age cohort from the subculture which is distant from the mainstream subculture will show a loss in measured knowledge, while an age cohort from the mainstream group will show a gain. The second hypothesis is that variables which measure degree and nature of contact will be significantly related to change in measured intelligence. In this analysis the White sample is taken as representing the mainstream subculture and the Black sample as the subculture which is distant from the mainstream. This conceptualization of Whites and Blacks has received ample support in numerous empirical and conceptual analyses (see Liebow 1967; Valentine 1972; Hannerz 1969; Johnson and Sanday 1971; and Sanday 1972d).

The Relationship Between Gain and Loss in IQ Over Time as a Function of Subcultural Affiliation and Degree of Contact

If transmitted knowledge is diffused differentially from the mainstream subculture, the Black sample should demonstrate an overall mean loss in IQ points over time relative to the White sample. Furthermore, those members of the Black sample who are exposed to a White context during their schooling should exhibit a trend in IQ scores which is similar to members of the White sample. Since the tests administered at each grade level (i.e., K, 4, 6, 8) were versions of different IQ tests, in order to perform these analyses, it was first necessary to standardize the scores for each individual for each test. Setting the overall mean at 100 and the standard deviation at 15, the formula for standardizing was:

$$Z_{iG} = \frac{15}{s_G} (IQ_{iG} - \overline{IQ}_G) + 100$$

where Z_{iG} = standardized score for individual i at grade K, 4, 6, or 8,

s_G = standard deviation of the scores for a given grade,

IQ_{iG} = IQ of individual i for a given grade G, and

$\overline{IQ}_G$ = mean IQ for a given grade.

To compute the average gain and loss over time, each of the racial samples was divided into those who gain and those who lose points between kindergarten and the eighth grade. This resulted in four subsamples which will be called Black gainers, Black losers, White gainers, and White losers. For each of these four subsamples the average number of points lost or gained was computed as well as the percentage in each of the racial samples who gain or lose. The results, presented in Table 28, confirm the expected trend. Blacks gain on the average less than Whites. Slightly more than fifty percent of the White sample are gainers, and more than fifty percent of the Black sample are losers. Finally, while on the average Blacks lose more than they gain, Whites gain more than they lose.

Before accepting these results as confirmation of the trend predicted by the diffusion hypothesis, there are several important considerations. The first is whether these results could have occurred by chance. To make this determination the T-test for the significance of the difference between the overall mean change in the two samples was carried out. As can be seen in Table 28, the difference in the overall mean change for the two samples is significant at the .001 level. Furthermore, an examination of the significance of the difference in the mean scores for each of the racial samples at kindergarten and eighth grade indicates that the change could not be due to chance. As can be seen in Table 28, both the Black and the White mean scores at kindergarten are significantly different from their corresponding mean scores in the eighth grade.

The regression effect is the second important consideration in evaluating the change in the scores of the racial samples. The regression effect is defined as the pulling toward the mean of post-test scores. This phenomenon occurs because scores on tests (supposed to measure the same dimension) which are administered at two points in time are never perfectly correlated (i.e., the reliability coefficient is always less than 1). On the average, those individuals who are below the mean when the first test is administered will gain points at the second administration (i.e., will be pulled toward the mean) and those who are above the mean will lose.

In terms of the regression effect alone, we would expect the Black mean to be higher in the eighth grade <u>if the two subsamples are regressing toward the population mean of 100</u>. The reason for this is that because Blacks have an initial mean which is less than 100 (i.e., 93.61, see Table 12), we would expect more Blacks to gain than to lose. Furthermore, since Whites have an initial mean of greater than 100 (i.e., 105.53), we would expect more Whites to lose. According to Lord (1963:24), when two samples of different means are drawn from the same population, under the null hypothesis of no treatment effect, one would expect the lower group to gain more and the higher group to lose more. As is demonstrated in Table 28, the reverse is true in the case under consideration here. That is, the lower group loses more and the higher group gains more.

TABLE 28. AVERAGE GAIN AND LOSS IN IQ POINTS BETWEEN KINDERGARTEN AND EIGHTH GRADE

IQ Change Between K and 8		Black Gainers	Black Losers	Black Total	Black T	White Gainers	White Losers	White Total	White T
IQ8-IQK	$\overline{X}$	8.78	-9.94	-1.60	2.25*	11.04	-9.84	1.23	2.57**
	SD	7.24	7.96	7.64		8.49	7.66	8.10	
Subsample	N	390	485	875		632	560	1192	
	%	45	55	100		53	47	100	
					8.11***				8.11***

*	Black Gainers Mean Versus Black Losers Mean	Sig at .025
**	White Gainers Mean Versus White Losers Mean	Sig at .01
***	Black Total Mean Versus White Total Mean	Sig at .001

The points made above would hold only if the two subsamples are regressing toward the population mean of 100. There is ample reason for assuming that this is not the case. If the diffusion hypothesis is correct, it would be expected to operate before kindergarten, indeed to begin at birth. Therefore, the initial means at kindergarten should be different, and it is legitimate to question whether the two samples are regressing toward the initial subsample means. If this were the case, there should be an equal gain and loss (an equal proportion of those who gain and lose) if the distribution of the initial scores at kindergarten for each of the racial samples is approximately normal. Looking at Table 28, it can be seen that while the proportion of Whites who gain and lose is approximately the same, the average amount gained and lost is significantly different. There is a larger gap between the proportion of Blacks who gain and those who lose. As with the Whites, the amount gained and lost is significantly different. It can be concluded, therefore, that the gain and loss of the two subsamples can not be explained by chance or by the operation of the regression effect.

This conclusion is supported by other work which has presented evidence that Black children tend to lose and White children tend to gain in tests of mental abilities. In a cross-sectional study of a sample of Black and White first and fifth graders in New York City schools Whiteman and Deutsch (1968) present data similar to the longitudinal results discussed here. Whiteman and Deutsch found that the mean IQ for the Black fifth graders is less than the mean for Black first graders, while the mean IQ for the White fifth graders was greater than the mean for the White first graders. They refer to the loss in the Black children's scores relative to those of the White children as a cumulative deficit. As these authors point out (1968: 87), cumulative deficits refer to the tendency for the decrement in test scores to become more pronounced with time and have been observed frequently in deprived children.

In an analysis of the correlates of cumulative deficit in their sample Whiteman and Deutsch find that race, SES (defined in terms of occupation and education of parents), and an index of family variables (called the Deprivation Index[1]) are all related to the cumulative deficit exhibited on at least one test. The variables included in the Deprivation Index are ones which can be seen as affecting the rate of diffusion. For example, some of the variables -- such as dinner conversation and total number of cultural

[1]The Deprivation Index (Whiteman and Deutsch, 1968:100) was constructed from the following six variables:

(1) Housing dilapidation,
(2) Aspiration of parents for child's education,
(3) Number of children under 18 at home,
(4) Dinner conversation,
(5) Total number of cultural experiences anticipated by child for the coming weekend, and
(6) Attendance of child in kindergarten.

experiences anticipated by the child for the coming weekend (such as visiting relatives, museums, library, zoo, etc) -- can be seen as cultural factors which mediate the motivational and cognitive components associated with growth in intellectual ability. It is interesting to note that on some of the test results examined, the effect of race and SES disappear when deprivation level is controlled.

The study by Whiteman and Deutsch is important because it provides an indication of the factors which may explain the difference in the initial IQ means for Blacks and Whites noted in Table 12. Since the kind of detail noted by them in the Deprivation Index was not available in the data provided by the school records, this can only be a suggestion.

The continuum model of the diffusion of intelligence hypothesizes that gain and loss in IQ points will be a function of group members' place on a continuum of degree of contact. This can be examined here by looking at the pattern of gain and loss in the two racial samples when socio-economic class of parents is controlled as well as socio-economic class of peers. Tables 29 and 30 present the mean gain and loss and the percentage who gain and lose, controlling for SES of peers at kindergarten and SES of parents. The latter variables provide the initial and boundary conditions, the point in time when the Black sample may begin to have more contact with the mainstream, and the home context which remains relatively fixed.

Looking at the overall mean change in IQ scores between kindergarten and eighth grade (Figure 1) indicates that in the higher range of parents' SES, students gain points and in the lower ranges they either lose or gain very few points. The pattern of change is similar for both Blacks and Whites which indicates that diffusion along the dimension degree of contact is important for both groups. The amount of change for the two samples however is different, suggesting that the group-identifying parameters for the two are different. Figure 2 presents the overall mean change controlling for SES of peers at kindergarten. Again there is a decrease as one moves from the higher to the lower SES ranges. Unfortunately, there were no Blacks in the sample who attended kindergarten where the average SES of peers was high. It would appear from the different slopes of the Black/White lines between the middle and lower SES range that SES of peers at kindergarten has a greater effect on the decrease in Black IQ scores in this range.

The effect of the SES variables on the average amount gained by the gainers and lost by the losers is presented in Figures 3 and 4. SES of peers at kindergarten is related to the average amount lost for both Blacks and Whites (although the effect occurs in different SES ranges, as can be seen in Figure 3a). Figures 3b and 4a indicate that SES of

TABLE 29. AVERAGE GAIN AND LOSS IN IQ SCORES BETWEEN KINDERGARTEN AND EIGHTH GRADES BY INDEX OF SOCIAL POSITION. BLACK SAMPLE

		SES of Parents							
		Index Score of Social Position*							
		High				Low			
SES of Peers at Kindergarten		11 - 37 Gainers	11 - 37 Losers	38 - 57 Gainers	38 - 57 Losers	58 - 77 Gainers	58 - 77 Losers	Raw Total Gainers	Raw Total Losers
igh 11-37	$\bar{X}$								
	SD								
	N	NO		BLACK		STUDENTS			
	%								
38-57	$\bar{X}$	8.91	-1.64	8.66	-8.57	33	50	9.04	- 7.95
	SD	9.76	1.81	7.06	6.84	9.72	- 7.85		
	N	13	2	24	22	7.68	6.70	70	74
	%	87	13	52	48	40	60	49	51
Low 58-77	$\bar{X}$	8.19	-10.99	9.50	-10.65	8.53	-10.19	8.68	-10.302
	SD	5.55	10.64	7.47	8.76	7.10	7.90		
	N	6	9	52	84	262	313	320	411
	%	40	60	38	62	45	55	44	56
COLUMN TOTAL	$\bar{X}$	8.68	- 9.290	9.24	-10.22	8.66	- 9.87		
	SD								
	N	19	11	76	106	295	368		
	%	63	37	42	68	44	56		

* See Table 10 for explanation of Index Score of Social Position

TABLE 30. AVERAGE GAIN AND LOSS IN IQ SCORES BETWEEN KINDERGARTEN AND EIGHTH GRADES BY INDEX OF SOCIAL POSITION. WHITE SAMPLE

SES of Peers at Kindergarten		SES of Parents — Index Score of Social Position* High 11 - 37 Gainers	High 11 - 37 Losers	38 - 57 Gainers	38 - 57 Losers	Low 58 - 77 Gainers	Low 58 - 77 Losers	Raw Total Gainers	Raw Total Losers
High 11-37	$\bar{X}$	9.74	-7.67	13.67	-8.85	13.45	-3.105	10.61	- 7.95
	SD	7.79	5.75	9.46	6.15	11.41	--		
	N	52	24	12	13	3	1	67	38
	%	68	32	48	52	75	25	64	36
38-57	$\bar{X}$	13.27	-8.95	10.79	-10.71	10.36	-10.27	11.29	-10.27
	SD	8.78	7.14	8.47	7.72	8.15	8.34		
	N	115	68	199	208	139	131	453	407
	%	63	37	49	51	51	49	53	47
Low 58-77	$\bar{X}$	15.54	-5.66	11.40	- 9.53	9.49	- 8.81	10.29	- 8.95
	SD	10.54	3.38	9.90	7.31	7.72	7.62		
	N	5	4	31	39	76	72	112	115
	%	56	44	44	56	51	49	49	51
COLUMN TOTAL	$\bar{X}$	12.27	-8.49	11.01	-10.44	10.10	- 9.72		
	SD								
	N	172	96	242	260	218	204		
	%	64	36	48	52	51	49		

* See Table 10 for explanation of Index Score of Social Position

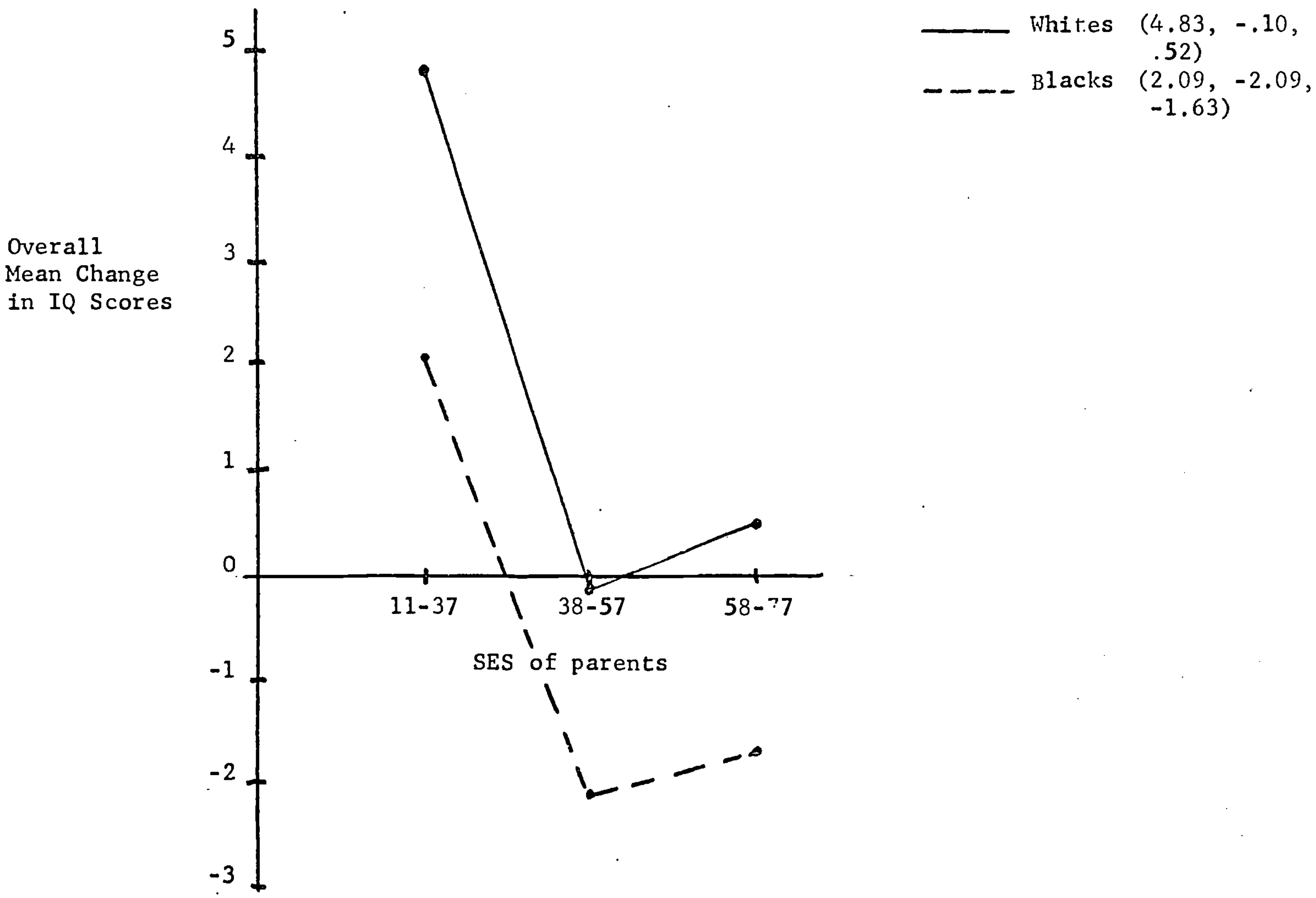


Figure 1. Overall Mean Change Between Kindergarten and Eighth Grade in IQ Scores by SES of Parents

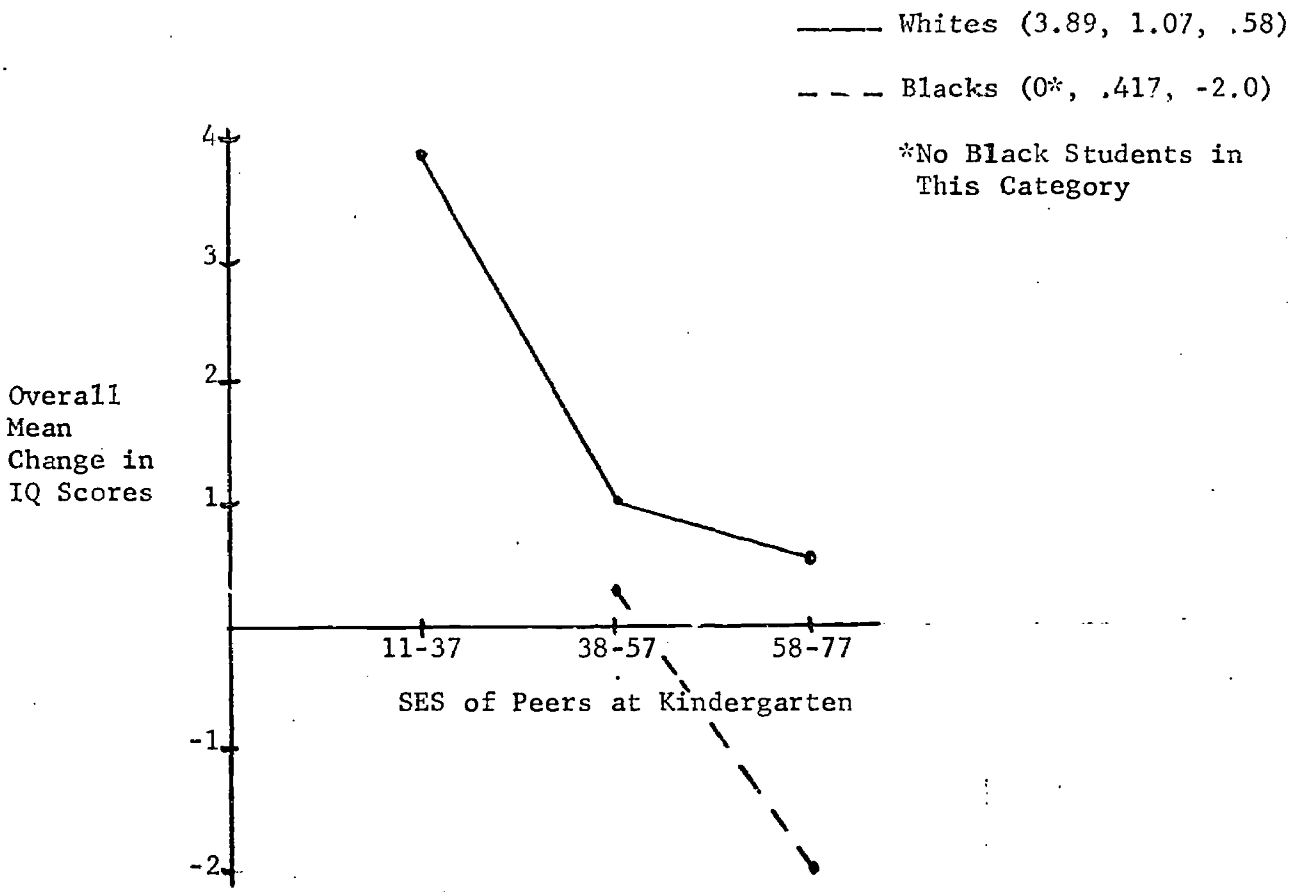


Figure 2. Overall Mean Change in IQ Between Kindergarten and Eighth Grade by SES of Peers at Kindergarten

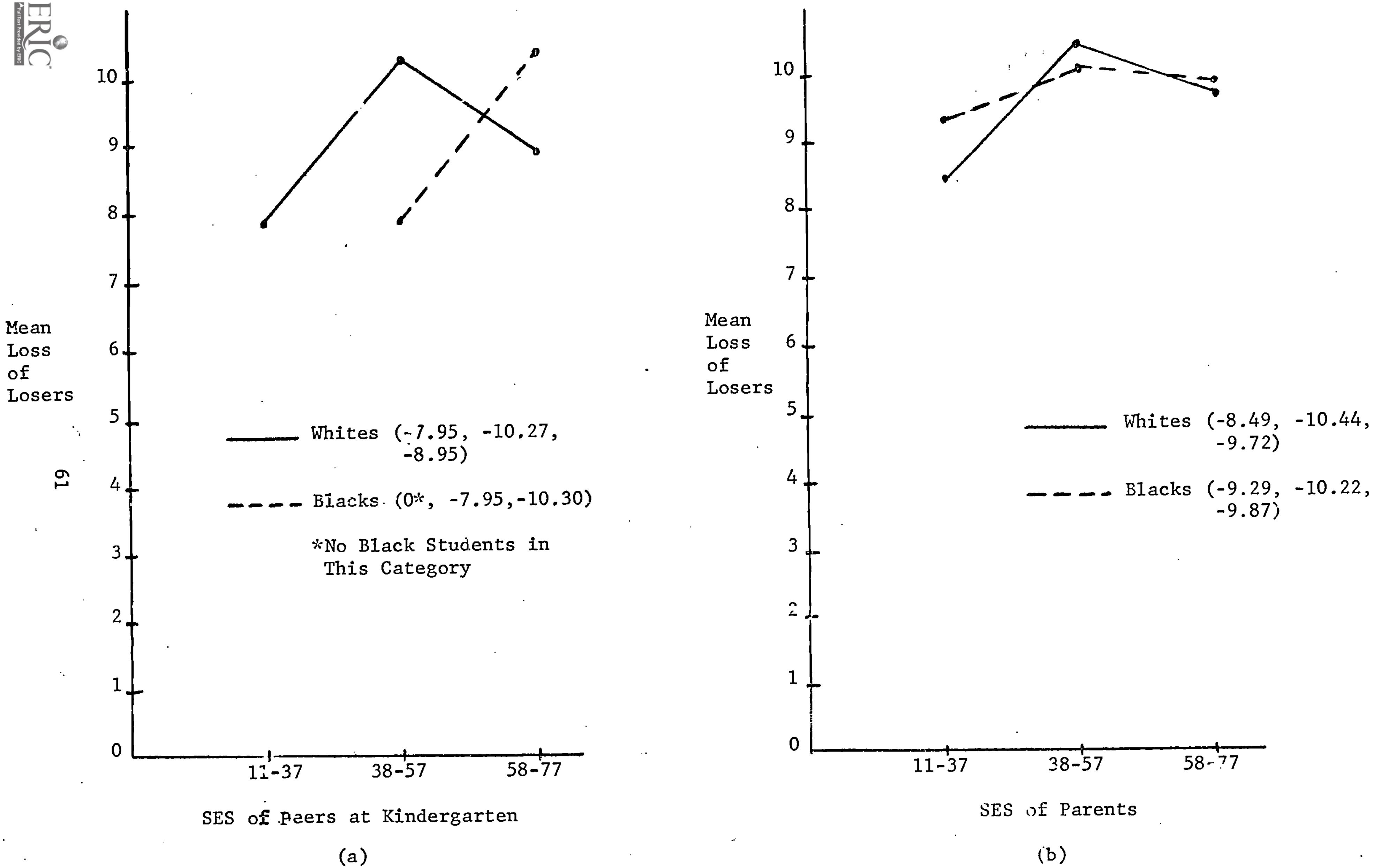


Figure 3. Mean Loss of Losers in IQ Scores Between Kindergarten and Eighth Grade by Index of Social Position

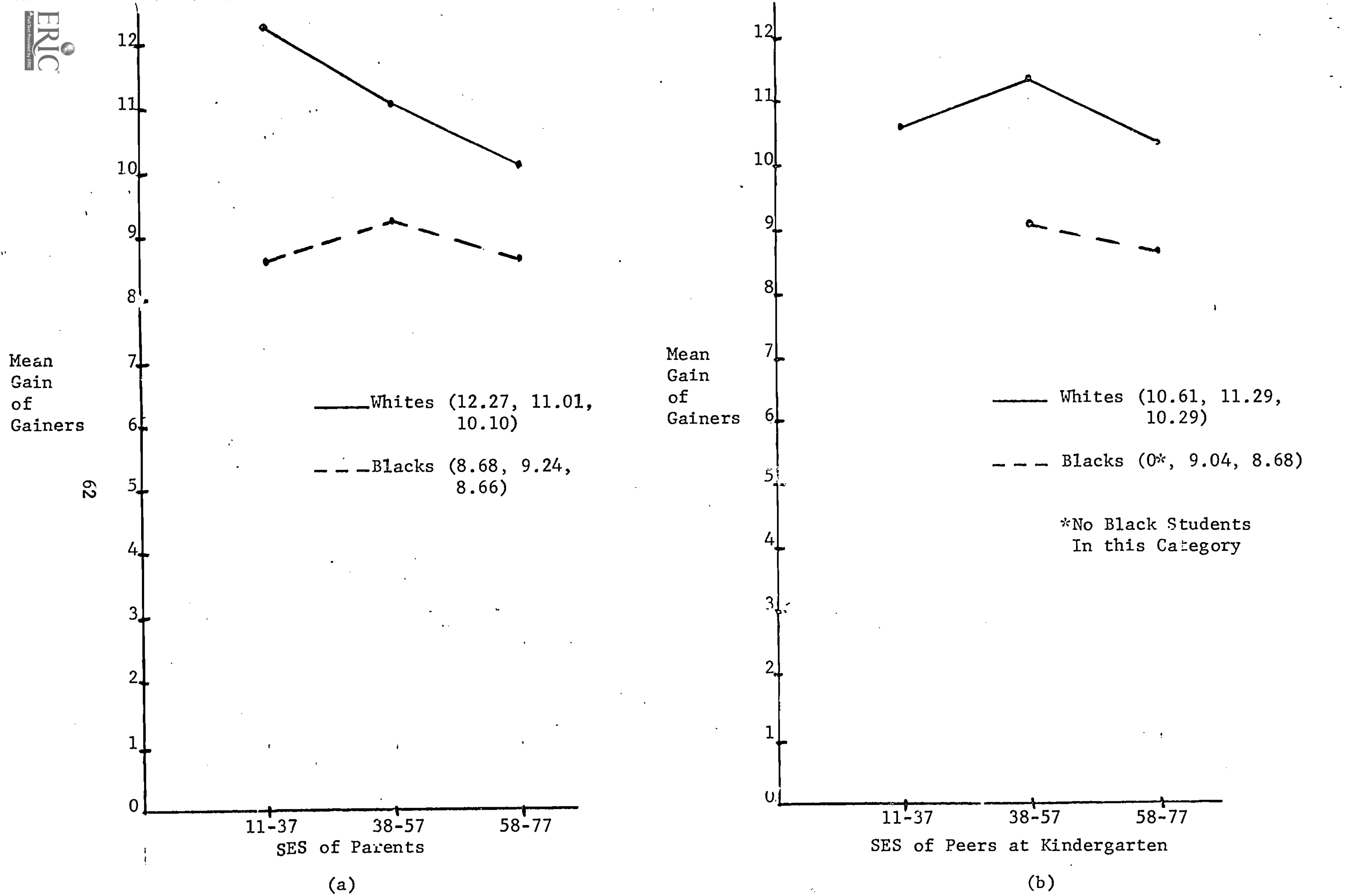


Figure 4. Mean Gain of Gainers in IQ Scores Between Kindergarten and Eighth Grade by Index of Social Position

parents is related to the amount that Whites gain and lose. This variable, however, seems to have a negligible effect on the amount Blacks gain or lose. Similarly SES of kindergarten peers seems to be unrelated to the amount gained by Blacks (Figure 4b). Figure 5, however, indicates that both the SES variables are related to the percentage in both samples who gain points between kindergarten and eighth grade.

The possible effect of the SES variables, the best available measures of degree of contact in this study, is more dramatic when the pattern of the mean IQ scores is examined controlling for parents' SES and SES of peers in kindergarten and eighth grade. Tables 31 and 32 display the data points which are graphed in Figures 6 and 7. The purpose of these figures is to demonstrate the relationship between average IQ score and the degree of contact measured at the approximate time period when the IQ test was taken. For example, Figure 6 graphs the relationship between kindergarten IQ scores and SES of peers at this time and SES of parents which was recorded when the child entered kindergarten. SES of peers at kindergarten is an indicator of degree of contact in the community before entering school, since the elementary schools in the system studied are usually small neighborhood schools. The results indicate an interaction between the SES dimensions in their relationship to the mean IQ scores. In the White sample (Figure 6a) the highest mean IQs are found among those students who are either in both of the high SES categories or at least in a kindergarten where the average SES of peers is high. These students score higher than those who are in lower SES peer environments regardless of their parents' SES. This occurs also among the students who are in the lowest SES peer environments. They score the lowest irrespective of their parents's SES.

These trends are not as clearly exhibited in the Black sample. In the first place, none of the Blacks attend kindergarten where the average SES of peers is in the highest category. It would appear that SES of parents has more influence on the Black students' initial IQ scores than SES of peers. The lowest mean score, however, is found again among students in both of the low SES categories. Since 66% of the Black sample fall in this group and only 2% in the highest SES category, there is not sufficient variation to adequately examine the trend in Black scores.

Figure 7 graphs the relationship between eighth-grade IQ score and SES of peers in this grade and in kindergarten. It would appear from this figure that eighth-grade peer group is related to the magnitude of the mean eighth-grade IQ score regardless of kindergarten peer group. This pattern is quite striking in the White sample. There is a sharp downward trend in mean IQ scores in the White sample as the eight-grade SES categories go from high to low even though the kindergarten SES categories are allowed to vary for each eighth-grade SES category. This trend is not as obvious in the Black sample. However, it is clear also for the

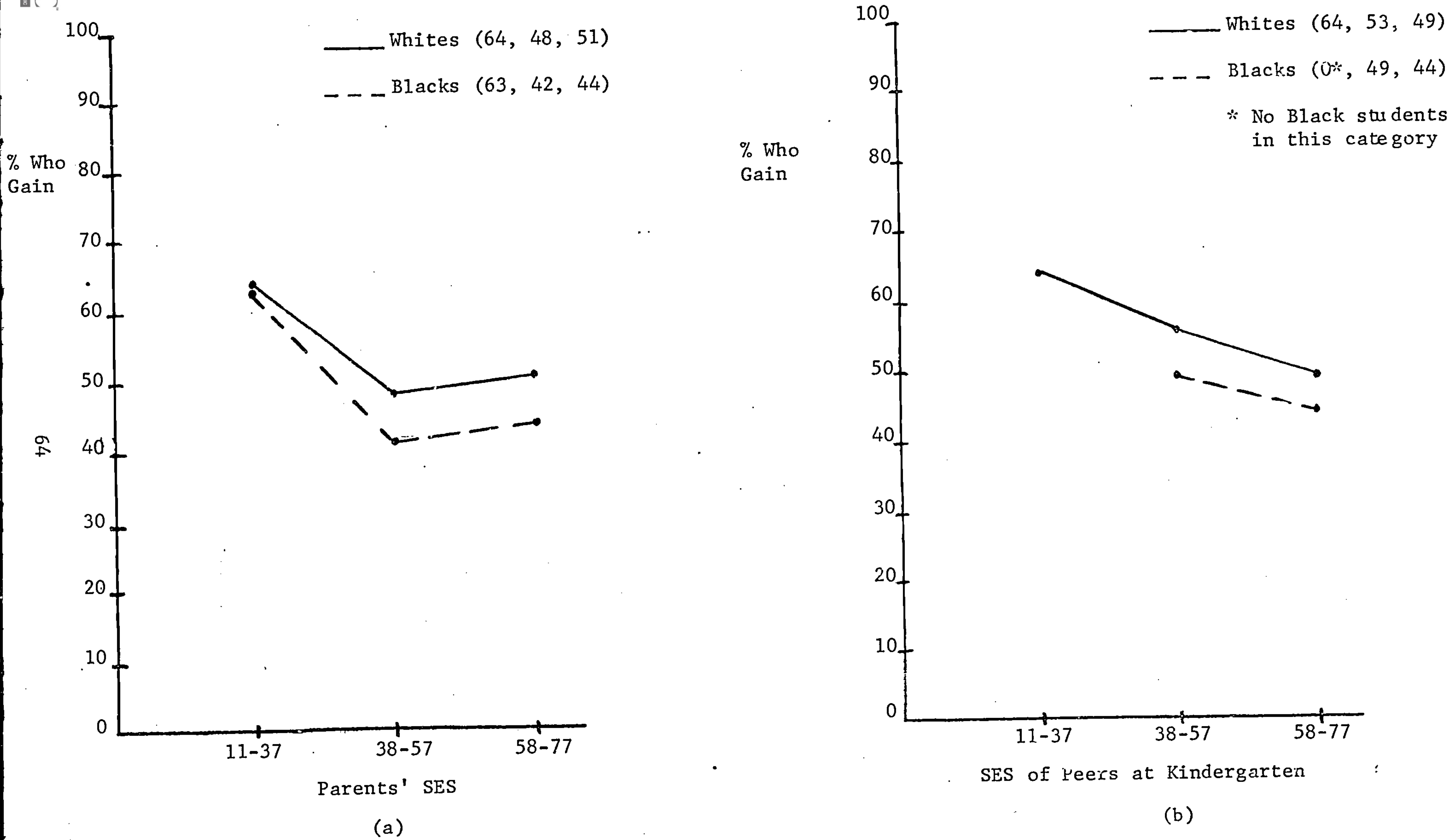


Figure 5. Percent of Blacks and Percent of Whites in Each SES Category Who Gain IQ Points Between Kindergarten and Eighth Grade

TABLE 31. MEAN KINDERGARTEN IQ SCORES CONTROLLING FOR PARENTS' SES AND SES OF PEERS IN KINDERGARTEN

		Parents' SES					
		Blacks			Whites		
SES of Peers at* Kindergarten		11-37	38-57	58-77	11-37	38-57	58-77
	$\overline{X}$				116.32	107.52	111.40
High 11-37	SD	NO STUDENTS			12.27	16.42	9.53
	N				76	25	4
	$\overline{X}$	96.35	95.44	94.75	107.95	107.31	102.53
38-57	SD	10.07	13.90	13.46	13.60	13.84	14.15
	N	15	46	83	183	407	270
	$\overline{X}$	100.93	96.18	92.45	108.46	100.97	99.20
Low 58-77	SD	15.00	13.66	12.99	13.80	14.44	12.81
	N	15	136	580	9	70	148

*See Table 10 for explanation

TABLE 32. MEAN 8th GRADE IQ SCORES CONTROLLING FOR SES OF PEERS IN KINDERGARTEN AND EIGHTH GRADE

		SES of Peers at Eighth Grade					
		Blacks			Whites		
SES of Peers at* Kindergarten		11-37	38-57	58-77	11-37	38-57	58-77
11-37	$\overline{X}$	NO STUDENTS			118.66	105.97	--
	SD				12.27	6.59	--
	N				99	6	0
38-57	$\overline{X}$	--	98.25	94.81	112.55	106.85	100.80
	SD	--	15.39	12.89	13.61	13.45	13.35
	N	0	31	113	146	602	112
58-77	$\overline{X}$	97.85	92.33	91.22	107.29	102.96	98.76
	SD	4.92	12.31	11.30	20.14	13.10	11.65
	N	2	57	672	6	90	131

*See Table 10 for explanation

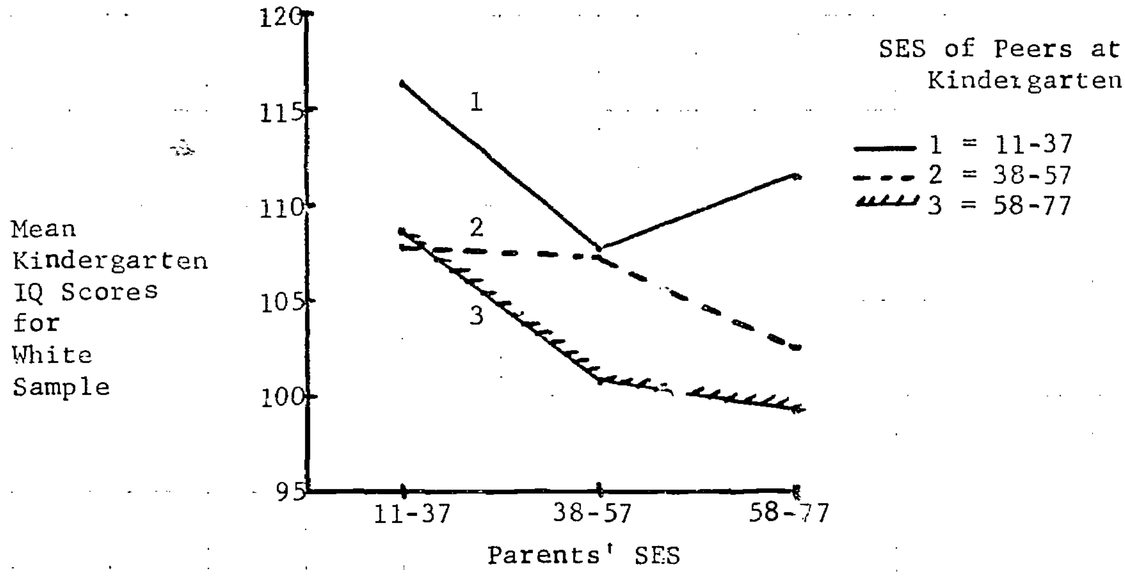


Figure 6a. Mean Kindergarten IQ Scores (White Sample) Controlling for Parents' SES and SES of Peers at Kindergarten

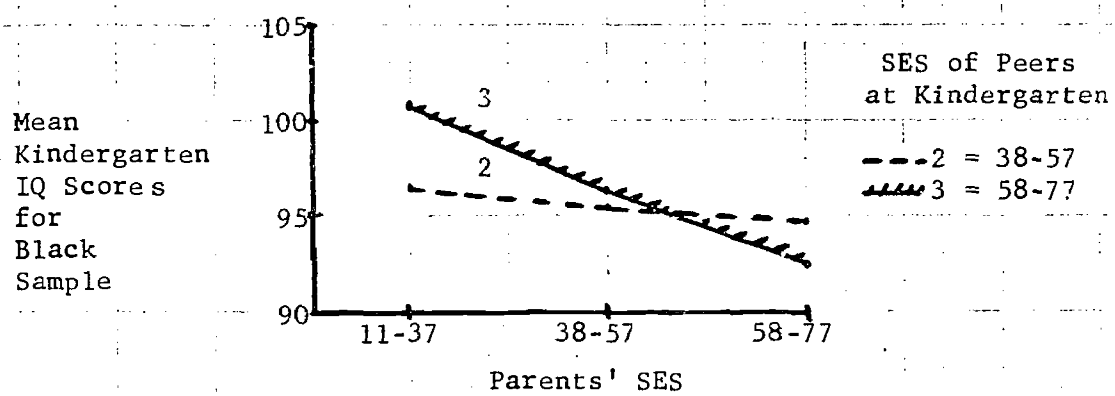
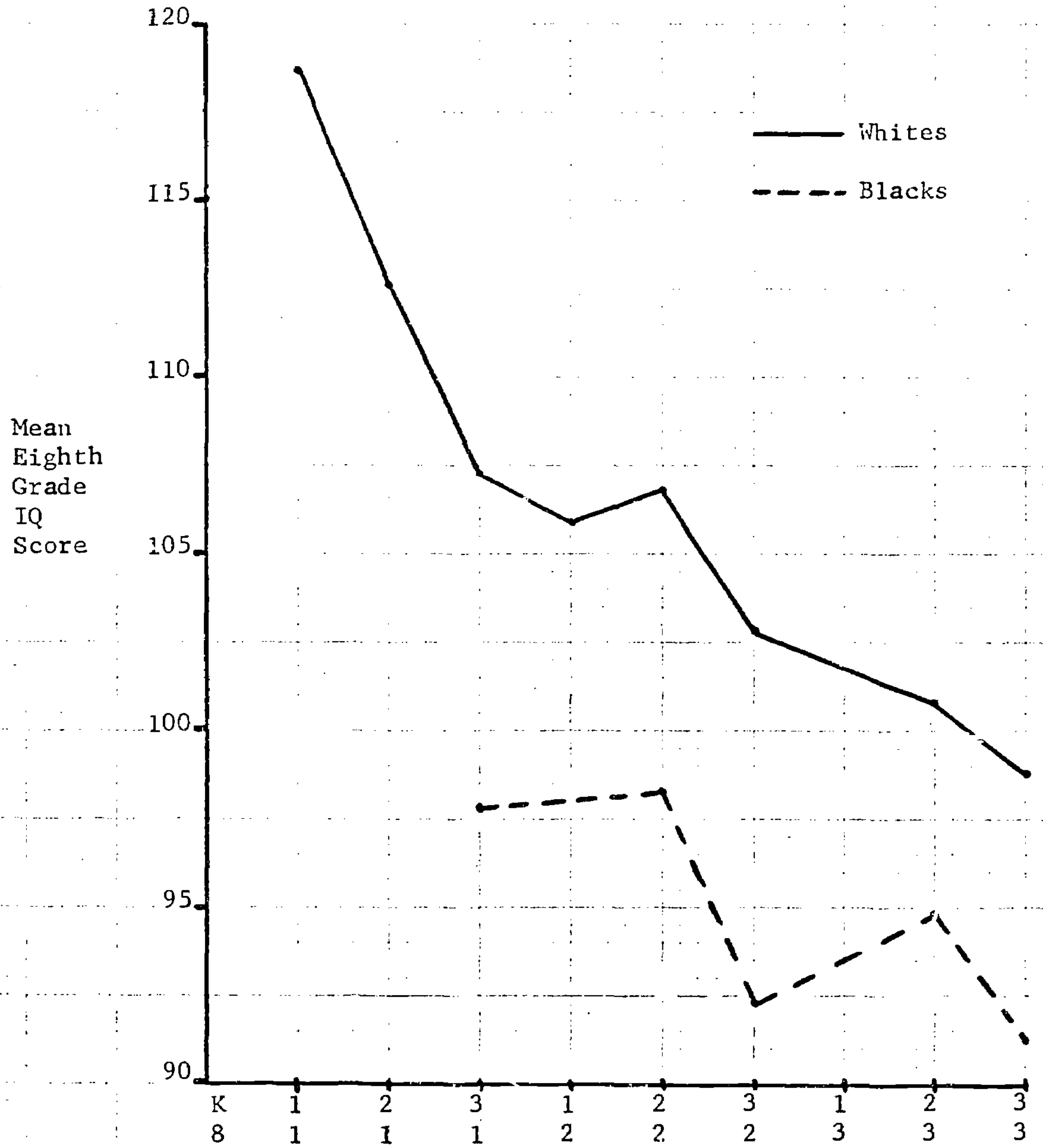


Figure 6b. Mean Kindergarten IQ Scores (Black Sample) Controlling for Parents' SES and SES of Peers at Kindergarten



1 = 11-37 2 = 38-57 3 = 58-77
(Hollingshead's Index of Social Position. See Table 10 for explanation)

Figure 7. Eighth Grade IQ Score Controlling for SES of Peers in Kindergarten and in Eighth Grade

Blacks that those who are in the high SES eighth-grade category do better than those in the lowest. Again, the problem in interpreting the effect of peer-group environment on Black IQ scores is that 77% of the Blacks are in the lowest K and 8 SES environments.

Before ending this section, it is interesting to observe the point at which the process of gaining or losing begins to occur. Table 33 shows for each year the average number of points gained or lost. This amount is the same for both Blacks and Whites until after the fourth grade. Between kindergarten and the fourth grade the magnitude per year of the change is small and the amount gained and lost is the same for both samples as is the percentage who gain or lose. After the fourth grade the pattern of gain and loss described earlier begins to appear. That is, Whites gain more than they lose, and Blacks lose more than they gain. The magnitude of the amount gained or lost each year also increases after the fourth grade. Remembering that the students in the gain-loss sample were in the school system between kindergarten and the eighth grade, this finding would suggest a number of hypotheses. One hypothesis might be that the school has a lagged effect on students' cognitive abilities, i.e., students must be in the same socio-cultural context for a period of years before the effects of the diffusion process can be observed. If this is the case, then any study having as a goal the analysis of the effect of a school variable on change in cognitive abilities must adopt a longitudinal design. For example, studies of compensatory education or school integration should adopt a research design in which it is possible to examine the effects of these variables on the same population over a five- or six-year period at least. Since children are normally exposed to one or at most two years of compensatory education, these results would further suggest that such programs should be lengthened in time.

Analysis of the Effects of Environmental Variables on Change in IQ Scores

The second major hypothesis of this study, stated at the beginning of the chapter, is that variables measuring degree and nature of contact with the mainstream subculture will be significantly related to change in measured intelligence. In the above section it was shown that the Black children lose points over time and the White children gain. It was also shown that the pattern of gain and loss covarys with such measures of degree of contact as socio-economic class of peers and points. The question here is whether changes in IQ scores are significantly related to environmental factors which can be taken as proxies for degree and nature of contact.

In order to test this hypothesis it was necessary to develop an appropriate statistical model and estimation procedure. At the writing of this report the estimation of the model was not yet completed, hence no

TABLE 33. AVERAGE NUMBER OF POINTS GAINED OR LOST BETWEEN EACH TEST PERIOD

Average change per year during test periods	Blacks		Whites	
	Gainers	Losers	Gainers	Losers
Mean change per year between 8 and 6	3.04	-3.32	3.51	-3.12
% who gain or lose	46	54	52	48
Mean change per year between 6 and 4	3.51	-3.98	4.16	-3.62
% who gain or lose	47	53	51	49
Mean change per year between 4 and K	2.55	-2.41	2.54	-2.54
% who gain or lose	50	50	49	51

results can be reported here. However, interested readers can obtain a report on this work in early 1974 (see Kadane, McGuire, Sanday and Staelin 1973).

Chapter 6. A CONTINUUM MODEL OF INTRA-CULTURAL DIFFUSION

The scientific method, as it was discussed in Chapter 2, usually involves an interplay between a number of research activities. A series of observations lead to the delineation of a problem, a model is developed after a number of assumptions are made, a series of predictions are deduced from the model, data are collected, and the empirical trends noted in the data are compared with the predictions. How much emphasis is placed on each activity ideally depends on the state of knowledge as well as the state of development and idiosyncracies of the problem under study. Practically speaking, however, factors such as lack of funds, time, and the availability of the appropriate data often interfere, resulting in less than the optimal mix.

In this chapter a general model of intra-cultural diffusion, which is based on features of continuum models employed in the physical sciences, is presented and compared with a number of empirical models of diffusion within human groups. It is suggested that these empirical models can be derived from the general model to be proposed. To further explore the validity of the general model, it is applied to data bearing on a problem not previously modeled as a diffusion process. This problem concerns the explanation of differential intelligence, as measured by the IQ test, in terms of the diffusion of measured knowledge within a society.

Cultural theory in general, and the study of cultural diffusion in particular, has traditionally adopted an approach somewhat analogous to that used in continuum models of heat transfer. Cultural theory has been used in anthropology for the explanation and description of human behavior in terms of shared beliefs, values, and attitudes which shape the style(s) for living which can be observed in a given community. As such, culture is conceptualized as an extra-individual phenomenon which has a life of its own and which is transmitted by individuals in the socialization process. In describing cultures and in studying particular cultural processes, such as diffusion, anthropologists have traditionally used the society as the unit of analysis instead of individuals.

Cultural diffusion, as it has been studied by anthropologists (Driver 1971), has involved the analysis of the paths by which material objects or learned behaviors are relayed from a point of origin within a single society to any number of other societies. In this study we will be interested in the paths by which items are relayed from a point of origin and spread within a single society. The unit of analysis here is a group (of people) within which elements (people) have characterizing dimensions which may be assumed to form a continuum. The diffusion process is modeled in a macro sense in that the model does not explicitly take into account the interactions of each individual within the group, although implicitly this interaction is represented within the model. Thus no statements can be made about the effects of the diffusion process on specific individuals except in the sense that, in general, to different individuals there will correspond different values of the dimension(s) being studied. This approach is analogous to continuum modeling of heat transfer where the emphasis is on the flow of heat in a continuum, as in a homogeneous material, as opposed to modeling the interactions between particles (molecules). Thus, the continuum approach yields a series of functional relationships which describe the total process under study, only implicitly taking into consideration the molecular interaction.

Model of Intra-Cultural Diffusion

The diffusion of cultural phenomena has been characterized in the past as a two stage process. The first stage is one of acquiring awareness and the second one of adoption and use (see Coleman, Katz and Menzel 1966:57 for further discussion). A third stage of saturation during which the rate of adoption decreases in most cases to zero has been described by McVoy (1940:219). In some cases a period of rejection can be identified after total adoption.

Diffusion models have been widely used to study the spread of disease, the diffusion of innovations, migration, and the spread of information. In general these models (see Brown 1968) contain three basic elements: (1) an area or environment, (2) an item being diffused, and (3) the process by which the item diffuses. Three basic mechanisms have been postulated as operative in the diffusion process. These mechanisms -- expansion, relocation, and radiation -- describe different means by which an item is spread from one location or source to another location or receiver.

Expansion can be thought of as the spread of the item of interest by personal contact. Since the susceptibility of item spread within a group may vary from group to group or circumstance to circumstance, it is necessary to denote the receptivity to the spread of the item by personal contact with the expansivity parameter ε, which may be a function of the characteristics of the group and/or circumstances surrounding the diffusion process. Relocation is defined as the spread of the item through migration or the transfer of people from one location to another and is measured by the relocativity parameter L, which like ε may be a function of a number of variables. Finally, radiation represents the spread of an item from the emitter to the receiver when they are located noncontiguously as would be the case in the spread of items through the mass media. This diffusion mechanism is characterized by a parameter called radiativity, denoted by R. Diffusion may occur by means of one of the above or by some combination of two or three of the mechanisms. In any case, these mechanisms define how the item is transported between origin places and destination places.

Many of the existing models of diffusion in human groups employ the individual as the basic unit of analysis. An individual is viewed as reacting to various influences as an isolated entity and the major variables which are examined are individual variables. While such an approach may lead to predictions of the probability of an individual with certain characteristics adopting a certain object in a given period of time, it is not adequate for understanding differential rates of diffusion in the area where the diffusion process is taking place.

The model to be developed employs the group as the basic unit of analysis. The elements within the group, in this case people, are assumed to lie along a continuum which may vary along a number of independent dimensions. In the general model discussed in Chapters 2 and 5 for the diffusion of measured knowledge, these independent dimensions were variables measuring degree and nature of contact with the mainstream culture. Rather than observing the effects on the interaction of particular individuals on the diffusion of an item to other individuals, (the kind of data which is lacking in most diffusion problems of interest to the anthropologist), the parameter values (i.e., ϵ, L, R) are estimated along each dimension for each group. Once these parameters are estimated, it is then possible to predict the intensity (i.e., the acceptance or rejection) of the item at any point in time for members of the group located at a given point along the continuum.

In addition to estimating parameter values for each dimension in each group, separate parameter estimates should be included for between-dimension interaction. Thus, if there are two dimensions such as degree and nature of contact, four parameters will be necessary to describe each diffusion mechanism. Taking the ϵ parameter, for example, one estimate of ϵ is necessary for the degree of contact dimension, a second for the nature of contact dimension, a third for the interaction of degree of contact with nature of contact, and a fourth for the interaction of nature of contact with degree of contact.

The diffusion model should also allow for the possibility of the generation or loss of the item being diffused. This is particularly important in the diffusion of nonmaterial items because it is entirely possible that during the diffusion process items will be generated or lost at a certain rate per unit time per unit dimension at points in the domain of a group.

The above relationships are incorporated in a mathematical model of intra-cultural diffusion which is presented in Appendix A. By way of a preliminary empirical test of this model, qualitative comparisons are made between this model and several empirical models of diffusion reported in the diffusion literature. The first comparison involves one of the simplest and most widely described diffusion processes in the social science literature. This process has been discussed by McVoy (1940) for intra-cultural diffusion and by Linton (1964) for cross-cultural diffusion. Both authors describe the diffusion of cultural elements in terms of degree of contact with the origin. Linton states that elements of culture will be taken up first by societies which are close to the point where the element originates and later by societies which are more remote or which have less direct contacts. McVoy states that inventions will arise at certain centers within a culture area and spread by degrees to the periphery of the area. He characterizes the form of this general pattern as one in which there is first slow growth and resistance to innovation followed by rapid growth and finally diminished growth. Figures 8 and 9 present the theoretical curves in relation to the empirical curves of this diffusion process. Curves (a) and (b) of Figure 8 and 9 were plotted from equations 6 and 8 (see mathematical presentation in Appendix A). The remaining curves in these figures were plotted from data reported by McVoy (1940:226) on the adoption of city manager plans in the U. S. between 1915 and 1938, and from data reported by Coleman, Katz, and Menzel (1966) on the adoption of a new drug among doctors.

The first of two qualitative comparisons of the mathematical model with the McVoy data can be made by comparing curve (d) in Figure 8 with curves (a) and (b). These curves represent the expected and actual rate of adoption over time (t) of city manager plans holding space (x) constant. Time is represented in Figure 8 in terms of the theoretical data points and the time periods in the McVoy data. McVoy selected these plans as an example of what he calls the gradient hypothesis of diffusion, i. e., city manager plans become more sparse as the distance from the center of their origin increases. The data he presents (McVoy 1940:226) include the number of cities adopting these plans in 6 time periods and in 6 geographical zones in the U. S. The time periods range from before 1915 to 1938. Zone 1 (the zone represented in Figure 8) is the place of origin of these plans and zone 6 is the farthest from the origin. McVoy found that after an initial period of slow growth there was a period of rapid growth followed by a slacking off in the rate of increase in the adoption of these plans. This is the pattern depicted in curves (a) and (b). For a fuller discussion of these curves see Appendix A.

The second qualitative comparison can be made by comparing curve (c) in Figure 9 with curves (a) and (b). These curves represent the expected and actual rate of adoption over space (x) at one particular time (t). Two different distance scales are shown in this figure: one for the theoretical model and the other represents the zones given by McVoy. McVoy found that city manager plans become more sparse as the distance from the center of origin increases, thus confirming the gradient hypothesis. This is the pattern which is depicted in the theoretical curves (a) and (b) thus demonstrating a fit between the model of the data.

Curve (c) of Figure 8 is derived from data presented by Coleman, Katz, and Menzel (1966) on the rate of adoption of a new drug by doctors. In Figures 8 and 9 there is a qualitative agreement between the empirical and theoretical curves. A closer fit between the Coleman data the the model is presented in Appendix A (see Figure 14). It must be emphasized that the Coleman and the McVoy data are presented only for purposes of making a qualitative comparison between the theoretical model and the data. This does not by itself constitute an ad quate test of the theoretical model. The qualitative fit suggests, however, that the empirical models of diffusion presented by McVoy and Coleman et. al. can be derived from the general model of intra-cultural diffusion of this chapter and Appendix A. The usefulness of this model for understanding change in IQ over time

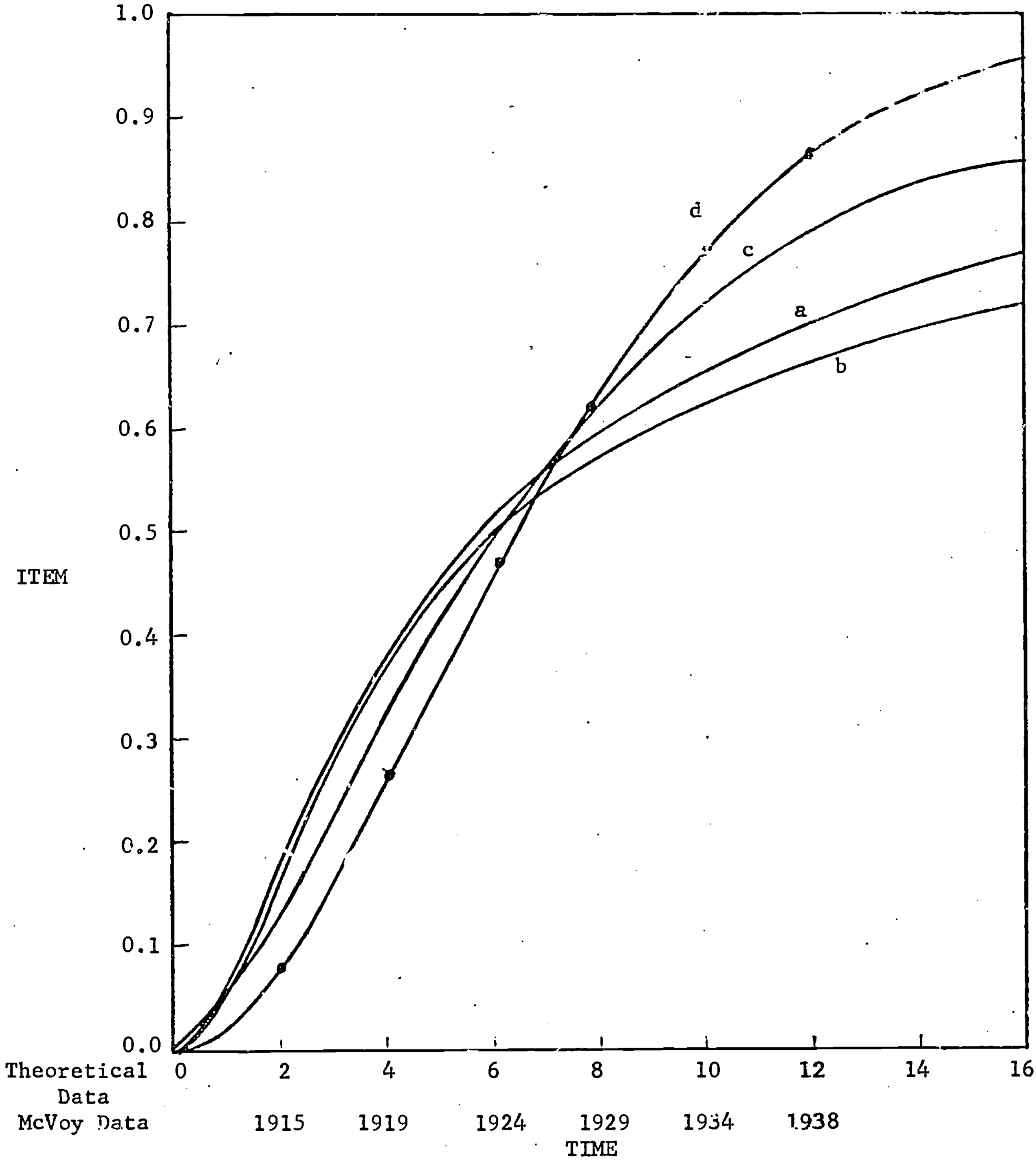


FIG. 8 - Item Accumulation History at a Location $x = 1.25$ for $\varepsilon = 0.1$, a) Without Item Loss ($\lambda = 0.0$), b) With Item Loss ($\lambda = 0.01$) Proportional to Item Intensity, c) Data From Coleman et. al. (1966), d) Data from McVoy (1940:226) Showing Cumulative Proportion of Cities Adopting City Manager Plans in Zone 1 between 1915 and 1938 (Normalized with 170 = 1.0).

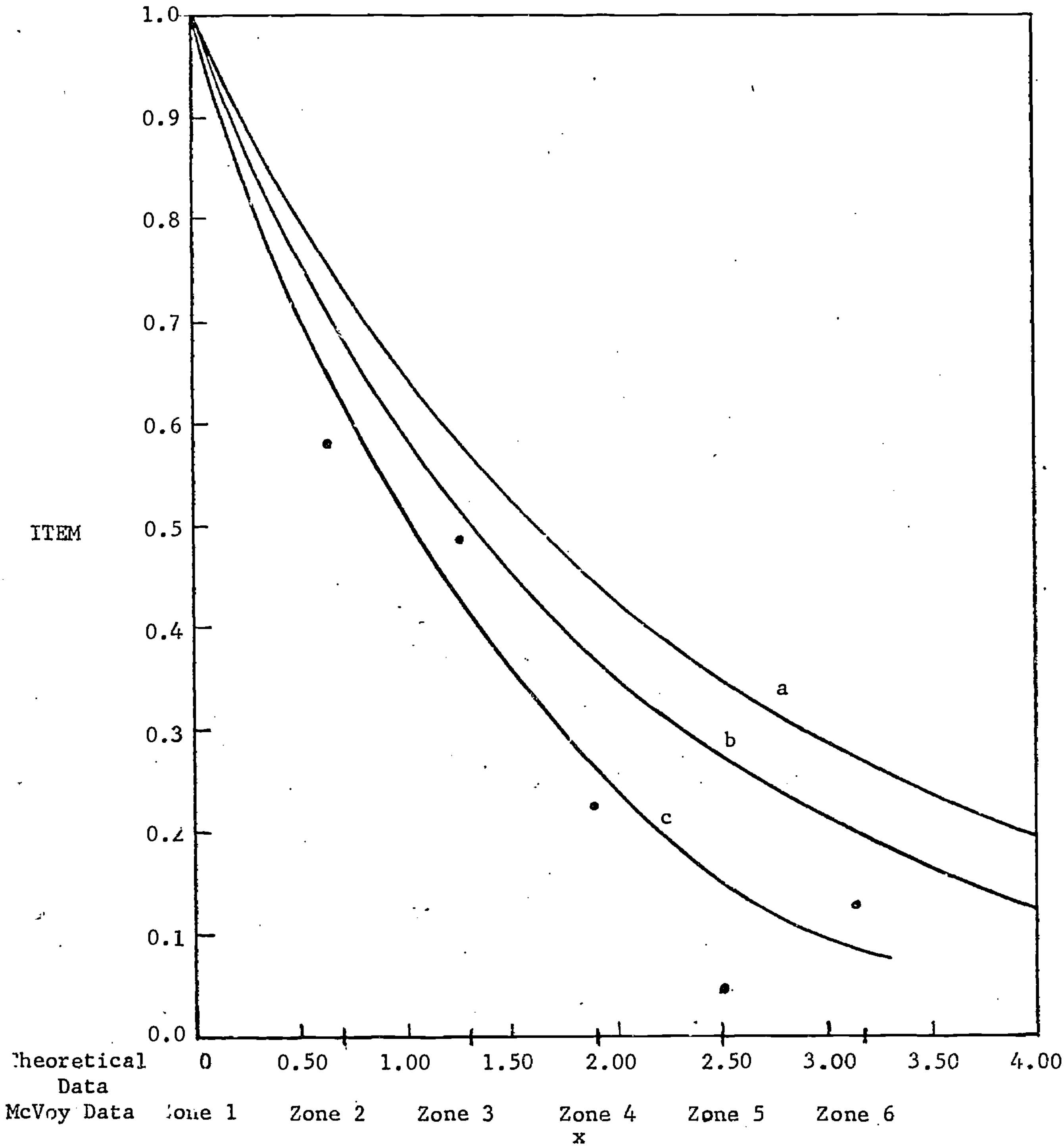


FIG. 9 - Item Accumulation Distribution at Time $t = 2$ for $\varepsilon = 0.1$, a) Without Item Loss ($\lambda = 0.0$), b) With Item Loss ($\lambda = 0.01$) Proportional to Item Intensity, c) Data from McVoy (1940:226) Showing Cumulative Proportion of Cities Adopting City Manager Plans in 6 Locations in the U. S. by 1919

will be explored next.

Figure 10 presents the plot of the predicted (curve a) and the actual (curve b) change in IQ between kindergarten and eighth grade for the Black sample holding the space dimension constant. In this case space is taken as SES of peers. The upper and middle-classes are taken as the origin and the lower-classes as the points farthest away from the origin. It can be noted that both curves indicate an initial increase in mean IQ score followed by a decrease. This is a graphic representation of the empirical pattern noted in Chapter 5 that Blacks tend to lose points after initial increase.

In Figure 10 curve b represents the mean IQ scores for the Black sample whose average SES of peers in Kindergarten, fourth, sixth, and eighth grades was in the 11-53 range (data presented in Table 34). In order to include the White sample in this Figure it would have been necessary to solve the theoretical equation (equation 8) with a different value of ε (the group identifying parameter) and the constant λ (constant determining the amount lost over time). The data presented in Table 34 and graphed in Figure 11 indicate that these parameters may be a function of race, SES of peers, and time. For example, if one compares the curves for Whites in Figure 11 (curves a_1 and b) it can be seen that in the highest SES of peers category (curve a_1) White IQ increases over time, while, in the lowest SES of peers category (curve b) White IQ increases initially and then decreases. On the other hand if one compares the curves for the Black sample (curves a_2 and c) it can be seen that in the highest SES of peers category (curve a_2) Black IQ increases until the sixth grade where it begins to decrease in a manner similar to curve b for Whites. In the lowest SES of peers category (curve c) Black IQ decreases steadily over time from K to 8.

It is clear from Figure 11 that the pattern of IQ scores over time is not the same for the two races when SES of peers is held constant (one measure of degree of contact). In terms of the diffusion hypothesis this dissimilarity is to be expected. Consider the Blacks and Whites of curves a_1 and a_2. Both samples are in schools where the average SES of peers is working or middle class. However, the Blacks in such schools probably live in ghetto communities which are on the edge of a middle class white community. The housing segregation patterns in Pittsburgh would suggest that while these Black children may be going to non-ghetto schools their out of school contacts are probably confined to the ghetto in which they live. Consequently their exposure to the mainstream occurs only in the schools where they must also face the debilitating effects of prejudice (measure of nature of contact). Their white peers in these schools face neither of these handicaps.

The Blacks of curve a_2 would begin school with similar out of school exposure as the Whites of curve b and Blacks of curve c. All come from lower socio-economic communities. This may explain the initial closeness in their mean IQ scores. The fact that the Blacks of curve a_2 have a higher degree of contact with the mainstream by attending higher socio-economic class schools may be the reason why their mean IQ increases over time while the IQ scores of the other two groups show an overall decrease. With the exception of the mean IQ scores in Grade 6 the Blacks and Whites of curves

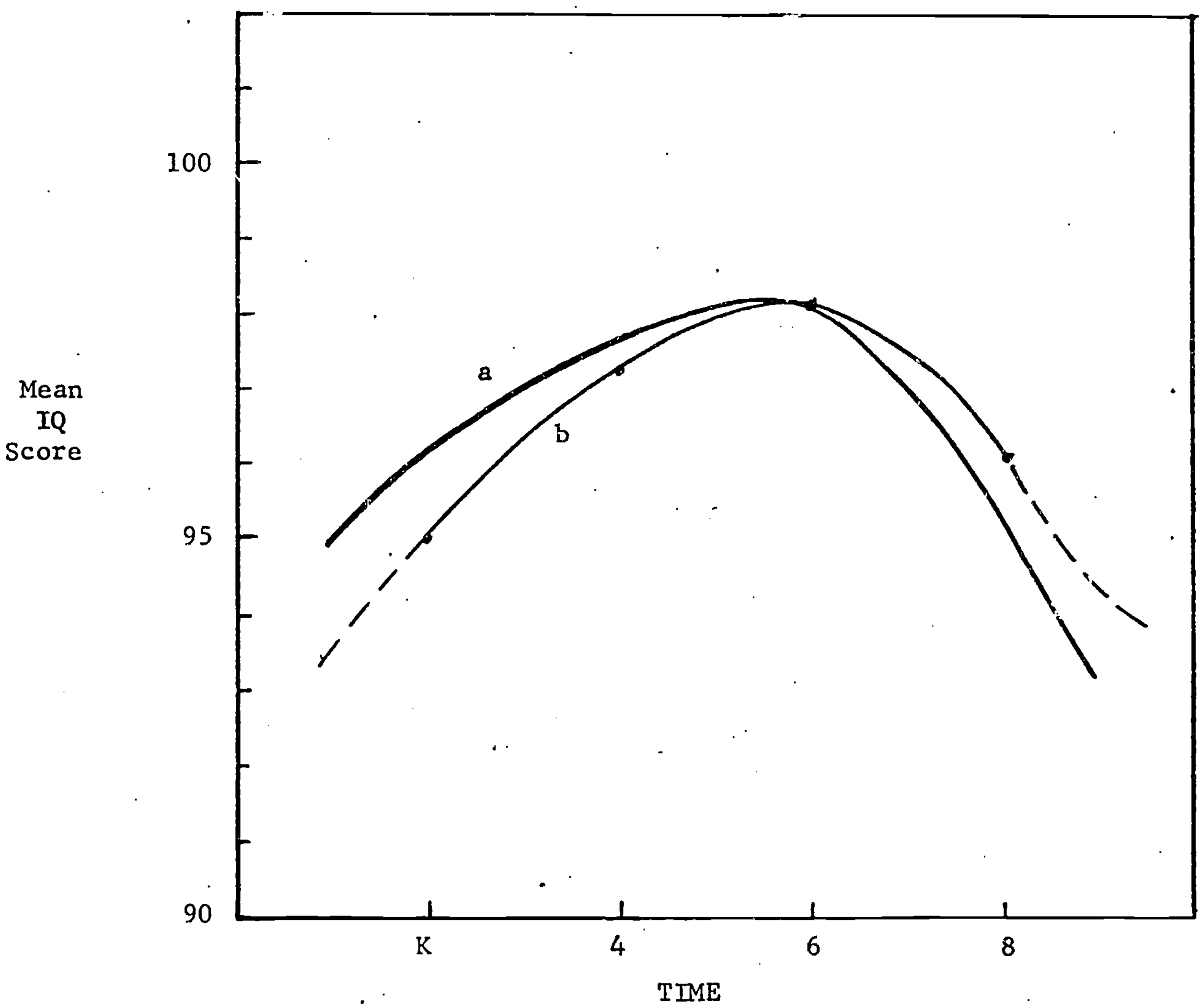


FIG. 10 - Comparison Between Results from Equation 8, Curve a, with $\varepsilon = 0.01$ and $\lambda = -0.1$, and IQ scores (Curve b) for Black Students Whose Average SES of Peers Was in the 11-53 Range (see Table 34)

TABLE 34. MEAN IQ SCORES AT K, 4, 6 and 8 BY SES OF PEERS

Mean SES of Peers*				Mean IQ Scores							
				K		4		6		8	
				B	W	B	W	B	W	B	W
High	1.	11-53	$\overline{X}$	95.0	105.5	97.2	107.5	98.2	108.7	96.1	109.0
			SD	15.1	14.3	15.7	13.3	12.6	13.5	14.2	14.2
			N	70	766	28	773	44	775	65	871
	2.	54-57	$\overline{X}$	93.8	104.7	96.1	101.7	93.8	103.0	92.4	103.8
			SD	12.5	14.3	15.0	13.2	13.3	13.7	12.2	12.5
			N	135	231	172	214	208	212	120	127
	3.	58-59	$\overline{X}$	93.9	101.2	94.1	103.0	92.0	99.4	94.2	99.7
			SD	14.5	12.6	13.2	13.2	11.2	12.7	13.1	12.7
			N	170	103	184	136	131	119	136	66
	4.	60-62	$\overline{X}$	93.1	100.5	93.3	100.9	92.9	102.8	91.5	98.9
			SD	12.9	13.3	13.7	13.4	14.0	17.0	10.5	11.6
			N	297	72	223	39	258	53	291	117
	5.	63-64	$\overline{X}$	94.4	105.9	92.5	96.0	91.9	97.4	90.4	91.6
			SD	9.34	13.8	14.2	13.3	10.1	13.1	10.9	8.6
			N	36	4	100	15	116	28	174	10
Low	6.	65-70	$\overline{X}$	93.5	91.2	92.1	92.7	90.1	89.3	90.2	82.4
			SD	13.4	17.8	14.4	14.6	13.2	17.1	12.5	-
			N	167	16	168	15	118	5	88	1

*See Table 10 for explanation

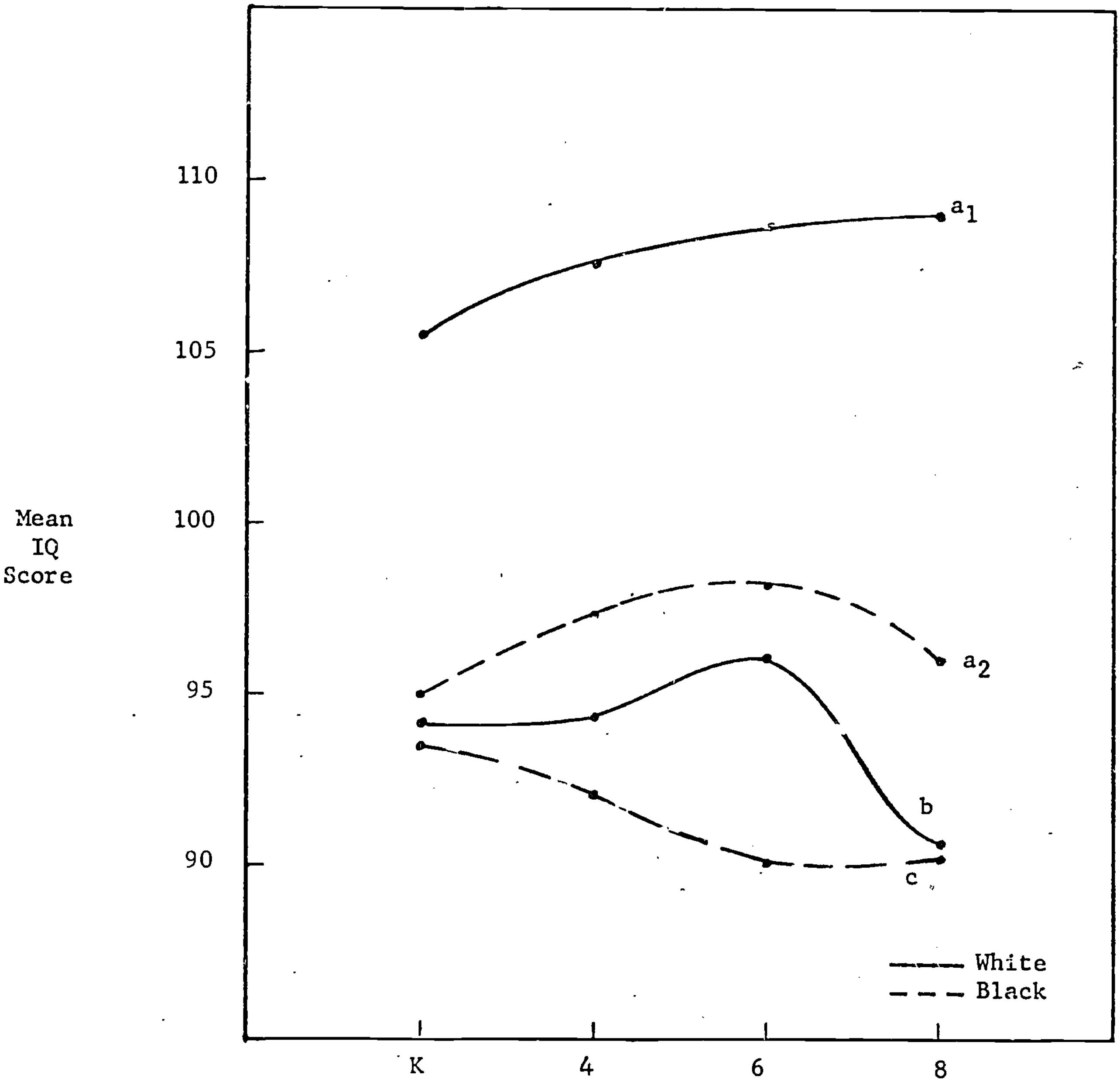


Fig. 11 - Mean IQ Over Time by Race and SES of Peers
a) SES of Peers (11-53), b) SES of Peers (63-70), c) SES of Peers (65-70). Data taken from Table 34

c and b follow a very similar pattern. The sharp divergence at Grade 6 is difficult to explain. One hypothesis which these curves suggest is that while Blacks and Whites in lower socio-economic schools experience similar community and school contacts with the mainstream culture, the nature of contact experienced by the two groups is different. While lower-class Whites may experience some prejudice because of their class or ethnic status, this prejudice may not have as great a debilitating effect as the prejudice experienced by the Black children. Whether or not this is the case, the fact of the matter is that both samples of children begin school with similar mean IQ scores and by the eighth grade both have experienced a mean decrease and again exhibit similar mean scores. In conclusion, while these findings do not constitute proof of the diffusion hypothesis, they certainly indicate trends which are supportive of this hypothesis.

Chapter 7. Conclusion

This report has presented an alternative explanation for the different mean IQ scores for Blacks and Whites. The data examined indicate that school and community segregation have a negative effect on the pattern of Black IQ scores over time. Whereas the IQ of Black children who are in heterogeneous social class school environments tends to increase over time, the IQ of Black children who are in homogeneous lower class school environments tends to decrease. A similar pattern can be observed for White children who are in lower class school environments. These results support a theoretical model which postulates that differences in group IQ scores will be due to environmental and not to genetic factors. The most important hypothesis derived from this model is that school and community segregation together with racial prejudice have a debilitating effect on the cognitive development of Black children with the result that their mean IQ falls below that of White children.

The basis for the genetic hypothesis has been discussed in detail by Sanday (1972 a, b, c) and is further elaborated in Chapter 1. The point is made here that the genetic hypothesis could not be tested in the U. S. for racial samples with the methods presently at our disposal. The only method now available for empirical verification of this hypothesis is to examine the IQ scores over time of Black and White children who are raised in essentially similar environments. This is not possible in the U. S. because o the impossibility of finding a large enough sample of Black children who are both raised in an environment similar to a comparable sample of White children, and, who are ignorant of racial prejudice. Such a method was possible in examining the IQ differences between samples of Oriental and European children in Israel. It was found that when these children are raised together on kibbutzim the mean differences in IQ vanished and the Oriental children achieved and maintained a mean IQ that was the same as that of their European counterparts. In Chapter 1 it is concluded, on this and other grounds, that the genetic argument is inadmissible and that its widespread popularization during the past few years in the U. S. provides further evidence of the endemic nature of racial prejudice in this country.

The body of this report examines the pattern of change over time in a sample of Black and White IQ scores. The time period examined is 1962 to 1970 during which time the sample members passed from kindergarten to the eighth grade in the Pittsburgh public school system. The general theory for the analysis of group differences in IQ is presented in Chapter 2. This theory is unique in several ways. First, it suggests that what academicians call intelligence is not a predetermined trait but one that develops given enough exposure to the style of life and thinking which intelligence tests were developed to measure competency in. Secondly, this theory suggests that bits of knowledge and information diffuse in a manner similar to that of the diffusion of material items in a society and between societies. This suggestion is substantiated in Chapter 6 and Appendix A where the diffusion model utilized here is compared with empirical examples of diffusion of material items. Finally, this theory constitutes the first attempt to systematically develop a formal model from which hypotheses can be derived concerning the mean differences in group IQ scores.

The research design employed in this study (see Chapter 3) involves the use of data derived from cumulative school records. The use of such a data source is another unique characteristic of this study. While the data provided in school records do not provide the detailed noted in other studies, the value of restricting the analysis to data available in these records outweighs the loss in information. First of all, it should be stressed that school records yield a rich, and as yet largely untapped, source of unobtrusive measures. _If_ educational policy is to be formulated on the basis of an appropriate data base, and _if_ the working of such policy is to be adequately monitored, then school records can be used to yield adequate sample sizes of representative geographical areas without the cost of collecting data. The fact that the existing form of record keeping may not include all of the appropriate data only indicates the necessity of instituting a standardized and reliable form of record keeping.

As is immediately obvious in examining the data presented in Chapters 4 and 5 the school records yield some striking patterns. In examining the demographics of the sample (see Chapter 4) one is struck with several facts. First, for a northern city Pittsburgh's Black population is quite stable. Eighty-nine percent of the children in the Black sample were born in Pittsburgh which is the same as the percentage of children in the White sample who were born in Pittsburgh. This provides evidence of a fact which is well known in Pittsburgh, i.e. that the Black population is quite stable.

Secondly, one finds that while the modal education level for both Black and White fathers is the same (high school graduate), the modal occupation level is different. The occupation of the Black fathers ranges from semi-skilled to unemployed, while the occupation of the White fathers ranges from semi-skilled to clerical. The modal category for the Black fathers is unskilled while the modal category for the White fathers is semi-skilled and skilled. This tells us something about the pattern of occupation discrimination experienced by the Black fathers which undoubtedly has some effect on the school motivations and expectations of their children.

Thirdly, the pattern of school segregation is almost complete. It is clear that defacto segregation in Pittsburgh has resulted in what amounts to two separate school systems -- one for Blacks and one for Whites. We find, for example, that in kindergarten 84% of the Black sample are in lower social class schools compared to 19% of the White sample. In the eighth grade 90% of the Black sample are in these schools compared to 21% of the White sample. This pattern is similar to that of racial segregation. On the average each year of the study, the Black children went to schools which were 75% Black, while the White children went to schools which were 13% Black.

The question of whether the social class segregation pattern has an effect on the pattern of gain and loss in mean IQ scores over time is raised. It is clear from the data presented in Chapter 5 that SES of peers is related to the pattern of gain and loss, the percentage of Blacks and Whites who gain and lose, and the magnitude of mean IQ scores. As would be predicted by the diffusion hypothesis Black children lose more than they gain and White children gain more than they lose. Furthermore, the evidence presented in this chapter and in Chapter 6 indicates that the decrement in Black IQ scores begins in the fourth grade.

Implications for Educational Policy

There are two major policy implications of the approach presented here. The first concerns the use of the data contained in school records for monitoring and formulating educational policy. The approach taken in this report indicates that data derived from schools records is adequate for monitoring the effects of school integration over time. It is clear from the theory and the data presented that such effects have to be examined over a prolonged time period. A cross-sectional study gives us a view only of the magnitude of the difference in mean IQ at one point in time. It does not tell us anything about the relative trend in Black and White IQ scores as they progress through the school system. Because of the cost of collecting longitudinal data, it would seem that a standardized system of school record keeping would result in an invaluable source of data which could be developed at minimum cost. It would certainly be a way by which individual school systems could keep account of the consequences of efforts to integrate.

Emphasizing the analysis of data contained in school records can have the healthy effect of focusing attention on looking carefully at the negative and positive influences of the school. While educational policy cannot influence family characteristics, such policy can plan optimal school environments. The progressive decrease in the mean IQ scores of children who are in lower social class school environments indicates that the schools reinforce, rather than reverse, a trend which may begin in the home and community. The progressive increase in the mean IQ scores of Black children who attended higher social class schools indicates that the schools can, in fact, reverse a trend beginning in the community. This along with the other data presented in Chapters 5 and 6 indicate that the recent tendency to place all of the responsibility on the home environment for a child's school performance is simply a rejection of the overwhelming responsibility inherent in administering an enlightened public education system.

The second major policy implication of the results reported herein concerns school integration strategies. The most important characteristic of the segregation pattern emphasized here has been social class rather than racial segregation. The two are, of course, highly correlated due to the labor market discrimination against Blacks. The theory and the data of this report all point to the importance of school social class integration. It is clear from the data graphed in Figures 12 and 13 that such integration must occur in grade school. Figure 12 demonstrates that White children who are confined to lower socio-economic schools begin to show a decrement

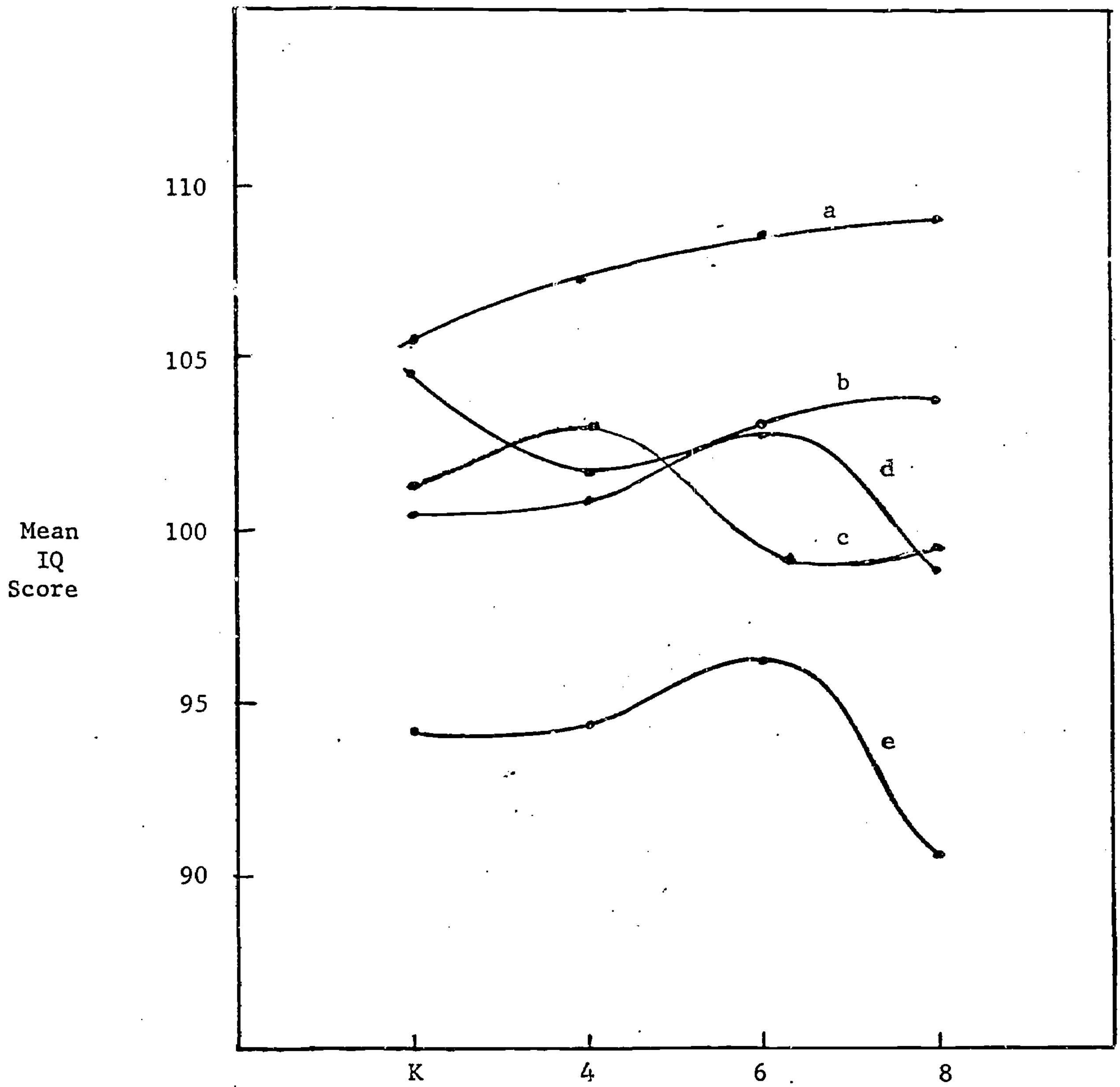


Fig. 12 - Mean IQ Over Time for White Sample by SES of Peers
a) SES of Peers (11-53), b) SES of Peers (54-57),
c) SES of Peers (58-59), d) SES of Peers (60-62),
e) SES of Peers (63-70). Data taken from Table 34

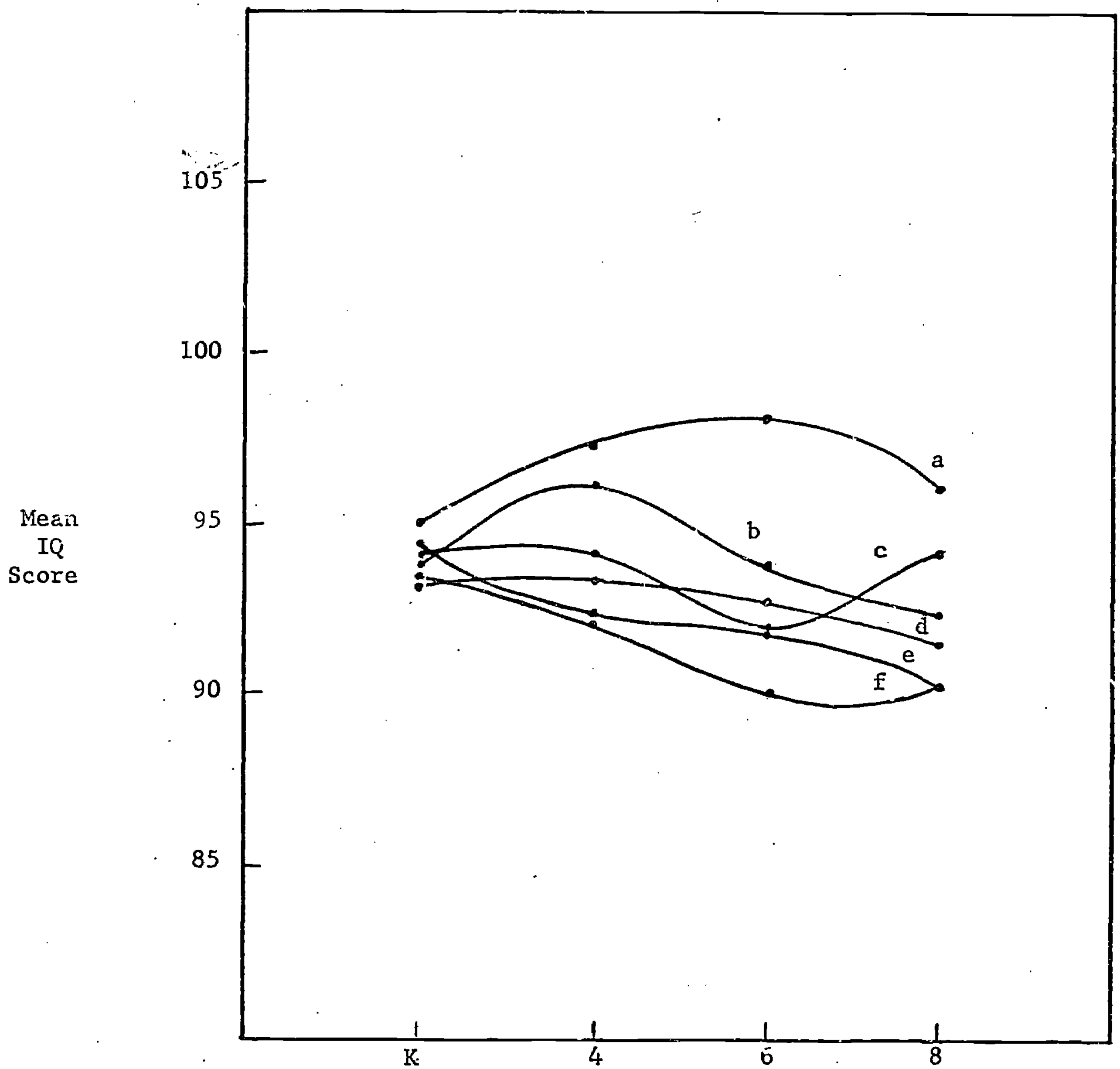


Fig. 13 - Mean IQ Over Time for Black Sample by SES of Peers
a) SES of Peers (11-53), b) SES of Peers (54-57), c) SES of Peers (58-59), d) SES of Peers (60-62), e) SES of Peers (63-64), f) SES of Peers (65-70). Data taken from Table 34

in mean IQ scores in the fourth grade (curve c) or in the sixth grade (curve d and e). Figure 13 indicates that Black children who are confined to lower socio-economic schools begin to show a decrement on the whole earlier than the White children. Curves b, c, and d indicate that the decrement begins in the fourth grade while curves e and f indicate that the decrement begins in kindergarten. School integration at the junior or senior high level might be very destructive for Black and White children coming from lower socio-economic schools. Both would be coming into a situation where the level of their cognitive abilities would be much lower than that of their more advantaged peers. This gap would not be as great if they come into contact with such children in the early grades. Furthermore, if the results of this study are correct this gap would not be widened over time.

Implications for Further Research

A number of areas for further research are suggested by this analysis. One area which is presently being completed concerns the development of a statistical model to examine the effects of a large number of environmental variables on change in IQ over time. It was hoped that the results of this endeavor would have been completed in time for the writing of this report. Unfortunately, this was not possible. Interested readers, however, can obtain these results early in 1974 (see Kadane, McGuire, Sanday and Staelin 1973).

A second area for research concerns the testing of the diffusion hypothesis with more complete data. It was not possible with the data contained in the school records to examine the effect of nature of contact. While the school records yielded ample material on degree of contact over time, none of the proxies for nature of contact seemed to be adequate. An adequate measure of this variable would probably require fine grained information which would necessitate interviewing in the schools. This might be difficult to obtain but would be worth the effort in order to establish empirically the importance of this variable.

A third and final area for research concerns the examination of the same patterns in an integrated school system. The ideal location for such a study would be the city of Pittsburgh which has been making efforts to integrate. An extremely interesting before and after situation would then be available for comparison.

In closing, it should be noted that the city of Pittsburgh is not unusual in the patterns reported here. These patterns are probably far less severe in Pittsburgh than they are in many other of the large cities in the U. S. A study similar to the one reported herein ought to be conducted in many of these cities in order to determine the extent to which the patterns uncovered here are typical.

Appendix A. Mathematical Model of Intra-Cultural Diffusion

A number of restrictive assumptions will be made in order to simplify the mathematical presentation. It will be assumed that the relocation and radiation mechanisms are inoperative, leaving the expansion mechanism as the only one active, and that there exist only two dimensions (x and y) along which the item is being diffused. These dimensions, can represent physical or non-physical distances, but they are assumed to be independent.

The General Model

The goal of the model is to establish relationships from which it is possible to determine the intensity of the item being diffused to any point along the dimensions being considered. To do this, the rate of change of the item intensity as a function of time is considered. Let I be the use or intensity of the item being diffused and t be time, then ∂I represents the change of I and ∂t the time interval, thus $\frac{\partial I}{\partial t}$ is the rate of change of I with respect to t. Initally assume that this rate of change is a function of (a) the receptivity of the members of the group to the item being diffused as measured by c and (b) the position of each member of the group relative to x and y. The functional form used to express this relationship is

$$\frac{\partial I}{\partial t} = \varepsilon \text{ div grad } I \tag{1}$$

where $\text{div grad } I = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2}$

Equation (1) is restrictive in that ε is assumed to be independent of such factors as the intensity (I), the importance of the item being diffused (i), the position (x,y), population density (ρ), and other characteristics of the individuals within a group (P) where (P) is a vector of characteristics. Relaxing the assumption of a constant ε, Equation (1) becomes

$$\frac{\partial I}{\partial t} = \text{div } (\varepsilon \text{ grad } I) \tag{2}$$

where $\varepsilon = \varepsilon(I, i, x, y, \rho, P)$.

Rewriting Equation (2) as

$$\text{div } (\varepsilon \text{ grad } I) - \frac{\partial I}{\partial t} = 0 \tag{3}$$

indicates that no generation or loss of the item measured by I is assumed. If item generation or loss is postulated to occur at a specific rate A(I, i, x, y, t, ρ, P), Equation (3) becomes

$$\mathrm{div}\,(\varepsilon\ \mathrm{grad}\ I) - \frac{\partial I}{\partial t} = -A \qquad (4)$$

Item generation is implied when $A > 0$, and item loss is implied when $A < 0$. Equation (4) is the most general statement describing the spread of an item by the expansion mechanism in a two-dimensional medium characterized by the expansion parameter ε in which item generation or loss is allowed. If the relocation or radiation parameters were substituted, the equations would remain the same. However, the inclusion of two or all three of these parameters would require additional analogous equations describing the rate of change in item intensity over time for each of the additional parameters. In this case, any two, or all three equations must be satisfied simultaneously.

The solution of Equation (4) with the appropriate initial and boundary conditions would provide the distribution of the item at any time at all points of the continua for which ε and A are known. However, two kinds of complexities impede the solution of Equation (4). The first is a mathematical one, for the exact solution of this non-homogeneous, non-linear, partial differential equation with general initial and boundary conditions is not available. This can be circumvented partially in many cases by solving it numerically, although some of the insights in interpretation made possible by an exact solution will be lost. The second complexity is experimental since one of the major problems concerns finding the functional form of ε and A as a function of the characteristics of the group. Therefore, how much one can learn from Equation (4) depends on the researcher's ability to reach an optimum equilibrium between reducing generality just enough to avoid these complexities and still retain a model which describes the actual phenomena reasonably well.

There are two independent but possibly complementary paths which could be followed in trying to achieve this equilibrium. The first starts by creating simple controlled experimental setups to determine the form of ε and A and the values of the parameters in ε and A characteristic of the group, and then checking if the model predicts. If it does, the complexity of the controlled experiment may be increased gradually while repeating the process until diffusion along the simplest actual continuum may be modeled. If the model does not predict under the most controlled conditions, then it can be set aside and replaced, or modified, using the insights gained through the experiments. This alternative presents some risks because it may require considerable time and may not always lead to positive results.

The second alternative begins by utilizing a small amount of representative data for a simplified actual case from a pilot experiment or a subset of the total data to evaluate ε and A using a functional form which has been intuitively chosen. At this stage the model is descriptive and must be checked against the total body of data to see if it is predictive. Then the complexity of the actual situation may be increased and the process repeated. Some of these ideas will be exemplified in the next section which models three diffusion examples drawn from the social sciences.

Illustrative Examples

a. Space and time dependent example. One of the simplest and most widely described diffusion processes in the social science literature concerns the diffusion of inventions which arise at certain centers within a culture area and spread by degrees to the periphery of the area (McVoy 1940). This type of diffusion pattern has been used by anthropologists to describe the wide distribution in space and time of certain material culture traits. Linton (1964:328) states as one of the few generally recognized principles of diffusion that "other things being equal, elements of culture will be taken up first by societies which are close to their points of origin and later by societies which are more remote or which have less direct contacts." McVoy (1940:219) characterizes the form of this general pattern as one in which there is first slow growth and resistance to innovation followed by rapid growth and finally diminished growth. This diffusion pattern can be modeled in terms of Equation (4) as follows.

Assume that $A = 0$, ε = constant, the area of diffusion to have a constant population density ρ, that there is only one dimension (i.e., distance) to describe the continuum, and the origin to remain fixed. At $t = 0$, $I = 0$ (the initial condition). The origin $x = 0$ is kept at a constant I for $t > 0$ (the boundary condition). Thus, according to equation (4), the function I has to satisfy:

$$\frac{\partial I}{\partial t} = \varepsilon \frac{\partial^2 I}{\partial x^2} \qquad (5)$$

and the stated initial and boundary conditions.

The solution is

$$I = I_o \operatorname{erfc} \frac{x}{2\sqrt{\varepsilon t}} \qquad (6)$$

where erfc is called the "complementary error function" and can be found tabulated (Carslaw 1959). An interesting extension of this case is obtained if instead of $A = 0$, it is assumed that the medium loses information at a rate proportional to I; letting λ be the constant of proportionality, $A = -\lambda I$, and

$$\frac{\partial I}{\partial t} = \varepsilon \frac{\partial^2 I}{\partial x^2} - \lambda I \qquad (7)$$

By letting $I = \mathcal{L} e^{-\lambda t}$ (7) reduces to (5) with $\mathcal{L}$ instead of I as the dependent variable. Now $\mathcal{L}$ has to vanish for $t = 0$ and be equal to $I_o e^{\lambda t}$ for $x = 0$ and $t > 0$.

The solution of (7) for the stated boundary conditions is

$$\vartheta = \tfrac{1}{2} I_o e^{\lambda t} \{ e^{-x\sqrt{\lambda/\varepsilon}} \operatorname{erfc}(y - \sqrt{\lambda t}) + e^{x\sqrt{\lambda/\varepsilon}} \operatorname{erfc}(y + \sqrt{\lambda t}) \}$$

or, finally

$$\vartheta = \tfrac{1}{2} I_o e^{-x\sqrt{\lambda/\varepsilon}} \operatorname{erfc}(y - \sqrt{\lambda t}) + \tfrac{1}{2} I_o e^{x\sqrt{\lambda/\varepsilon}} \operatorname{erfc}(y + \sqrt{\lambda t}) \quad (8)$$

where $y = \dfrac{x}{2\sqrt{\varepsilon t}}$

Another interesting thing to note in the solut on of (5) is that since the expansivity must be directly related to the density ρ at any point of the medium, if it is assumed that they are related linearly, then the result obtained in (6) for uniform density of the medium need only be multiplied by the factor of proportionality at each point and match solutions to obtain the solution for diffusion and an area with a non-uniform population density. Investigating (6) and (8) it is seen that in both cases $I = 0$ when $t = 0$ which satisfies the initial condition and $I = I_o$ for $x = 0$ and $t > 0$ which satisfies the boundary condition. A location x units from the origin experiences an item accumulation history over time as shown in Figure 8*, where the curve (a) represents the solution (Equation 6) for the case with no item loss (i. e., $A = 0$) and the curve (b) represents the solution (Equation 8) for the case with item loss (i. e., $A < 0$). Similarly, the item distribution at one point in time with respect to the dimension x is shown in Figure 9* for the same two cases. These are sketches that will vary in detail depending on the value of ε and λ. It should be noted that in Equation (8), where information is lost at a rate of λI, the item intensity distribution and the history of the item accumulation at any location show similar trends to the previous case ($A = 0$) but they now approach different maxima.

Curve (c) of Figure 8* is derived from data presented by Coleman et. al. (1966) on the rate of adoption of a new drug by doctors. This data also shows a qualitative agreement with the diffusion model of Equations (6) and (8). A closer fit with this data, however, is presented in the next section.

b. Space independent example. The empirical portion of this example is drawn from the Coleman, Katz, and Menzel (1966) study of the diffusion of a new drug among doctors. This study ignores the dependence of the item being diffused on space variables. The data contained in Coleman, Katz, and Menzel describe the cumulative proportion of general practitioners, internists, and pediatricians who had used the new drug by the end of each time period. The location of each doctor with respect to origin of the drug being diffused is not indicated in the study. In order to use this data, the general model of diffusion where generation is allowed will be specialized.

*See Chapter 6

Recalling Equation (4) for the two-dimensional case, and letting $A = K_t B$,

$$\frac{\partial I}{\partial t} = \text{div}\,(\varepsilon\,\text{grad}\,I) + A = \frac{\partial}{\partial x}\left(\varepsilon\frac{\partial I}{\partial x}\right) + \frac{\partial}{\partial y}\left(\varepsilon\frac{\partial I}{\partial y}\right) + A \quad (9)$$

where $\varepsilon = \varepsilon\,(x, y, t, I, i, \rho)$

$I = I\,(x, y, t)$,

$i =$ importance of I

$\rho =$ density of population

$K_t =$ density of the accumulated count of the item being diffused

and $B = B\,(x, y, t, I, i, \rho)$ is a modified generation function.

If the x,y - dependence is to be ignored, and

$\varepsilon = \varepsilon(I)$ only, $I = I(t)$ only, then Equation (9) becomes

$$\frac{\partial I}{\partial t} = K_t B \quad (10)$$

where K_t is a measure of the density of the accumulated count of the item being diffused over the entire domain of interest at time t. Equation (10) has been used extensively in many fields of science (Brown 1968; Hagerstrand 1965; Avrami 1939) to describe observed relationships.

Assume that K_t is constant for all time and equal to k, then Equation (10) becomes

$$\frac{\partial I}{\partial t} = kB \quad (11)$$

The function B must now be determined. Allowing for discrepancies brought about by the small sample number or by the size of the time interval in the data collected by Coleman, Katz and Menzel, all curves relating cumulative proportion of drug adopters, I, to time have the general shape shown as curve (b) in Figure 14. Curve (b) of Figure 14 represents a least squares fit of the data presented in Figure 1 of the Coleman, Katz and Menzel study (1966:26). This curve also appears as curve (c) in Figure 8 of this study. Coleman proposes two forms for B, namely $B = (1 - I)$ and $B = I(1 - I)$. Assuming the constant of integration to be zero (i.e. the initial condition to be $I = 0$ when $t = 0$) the solution in the first case is

$$I = 1 - e^{-kt} \quad (12)$$

which for $k = 0.15$ is shown as curve (a) in Figure 15. Assuming the constant of integration to be c and letting $e^c = C$, the solution in the second case is

$$I = \frac{1}{1 + Ce^{-kt}} \quad (13)$$

No mention is made by Coleman as to the value of C when a plot is made for $k = 0.15$ for comparison with the first case. If C were made unity I would equal $\frac{1}{2}$ when $t = 0$ which is obviously at odds with the data (curve (b) in Figure 4). Moreover, no matter what value of $C > 0$ is assumed, $I > 0$ for $t = 0$, a fact that seems conceptually wrong since as t approaches 0, I should vanish. It may also be noted, as shown in curve (b) of Figure 15 for $C = 9$, that although a sigmoidal curve results, the addition of a second adjustable parameter, C, does not allow adjusting of the shape of the sigmoidal curve.

The following model is conceptually more appealing and fits Coleman's data very well including the same number of adjustable parameters. Leaving out some lengthy developments, one arrives at the following expression for I,

$$I = 1 - \exp\left(-\int_0^t \phi \, d\tau \right) \tag{14}$$

where ϕ has different forms depending on the dimension of the medium. In general for the two-dimensional case a solution of the following form is obtained

$$I = 1 - \exp\left(-mt^B\right) \tag{15}$$

which, for $m = 0.01$ and $B = 2.0$ is shown as curve (c) in Figure 15 for comparison with the two previous cases and as curve (a) in Figure 14 for $m = 0.004$ and $B = 1.75$ for comparison with Coleman's data (curve (b), Figure 14).

c. Diffusion of Knowledge. The primary purpose of this Report is to explain the reported mean differences between racial groups in performance on tests measuring general intelligence. As mentioned in Chapter 2, intra-cultural diffusion is one of several factors hypothesized to explain such differences. The main hypothesis of the diffusion model as it was applied to mean IQ differences was that such differences are a function of a group's degree and nature of contact with the mainstream culture. In this section this hypothesis is partially evaluated by examining the empirical trend in mean IQ over time and SES of peers and comparing this trend with the theoretical trend derived from the diffusion model presented above in the space and time dependent example. Since only one dimension is included in this model, i.e., distance from the origin, the major hypothesis must be simplified to include only degree of contact which will be operationalized in terms of SES of peers.

Thus, equation (8), involving one space independent variable x, and time as the other independent variable t, is applicable here. In order to model the pattern of initial gain followed by loss noted in Chapter 5, the parameter λ may assume negative values thus making $A < 0$ allowing for the accumulation of I with time to decrease at any location x after having attained a maximum at a previous location. This can be seen

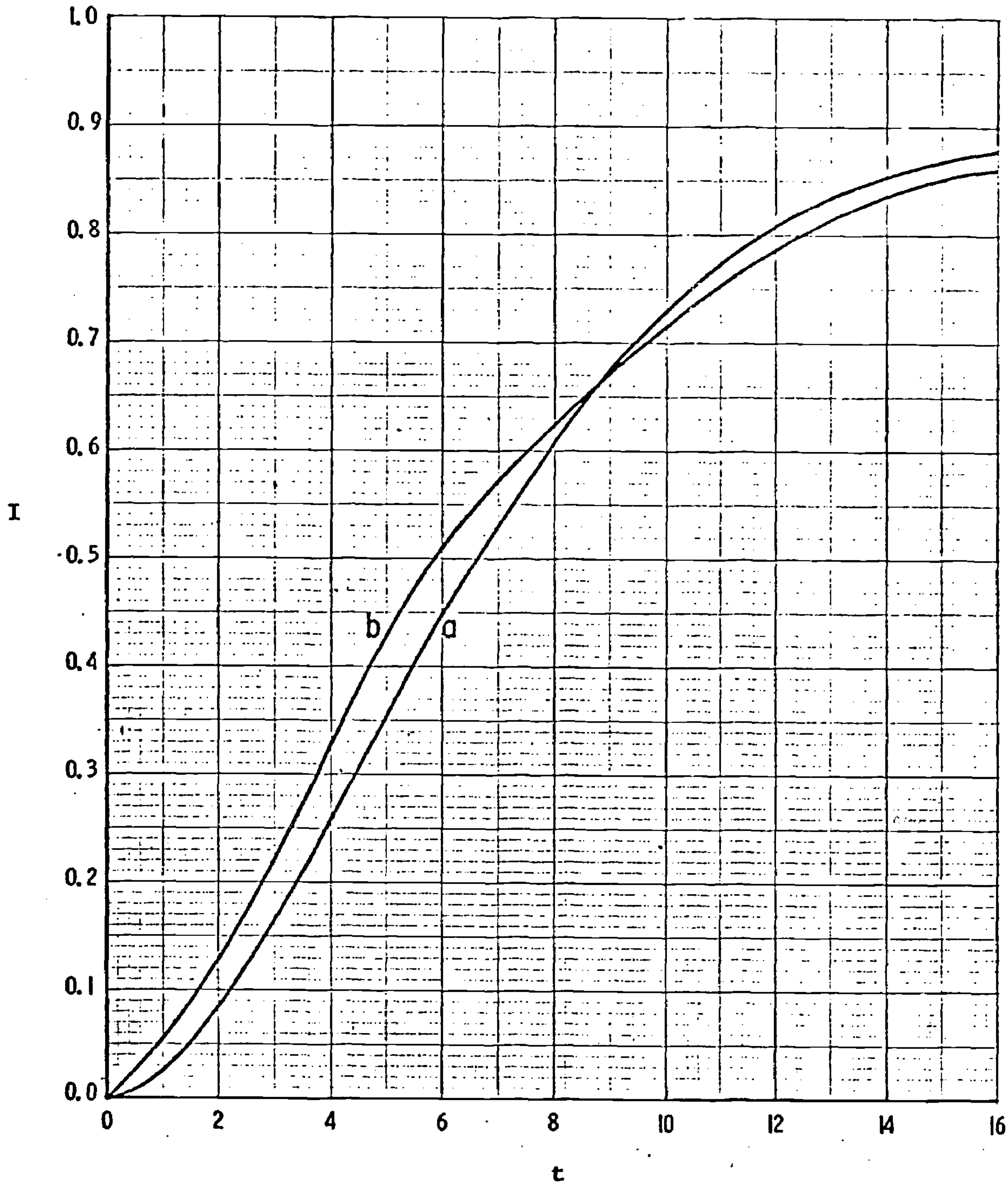


FIG. 14 - ITEM ACCUMULATION HISTORY

a) $I = 1 - \exp(-mt^B)$ for m = 0.004 and B = 1.75

b) Data from Coleman et al. (1965)

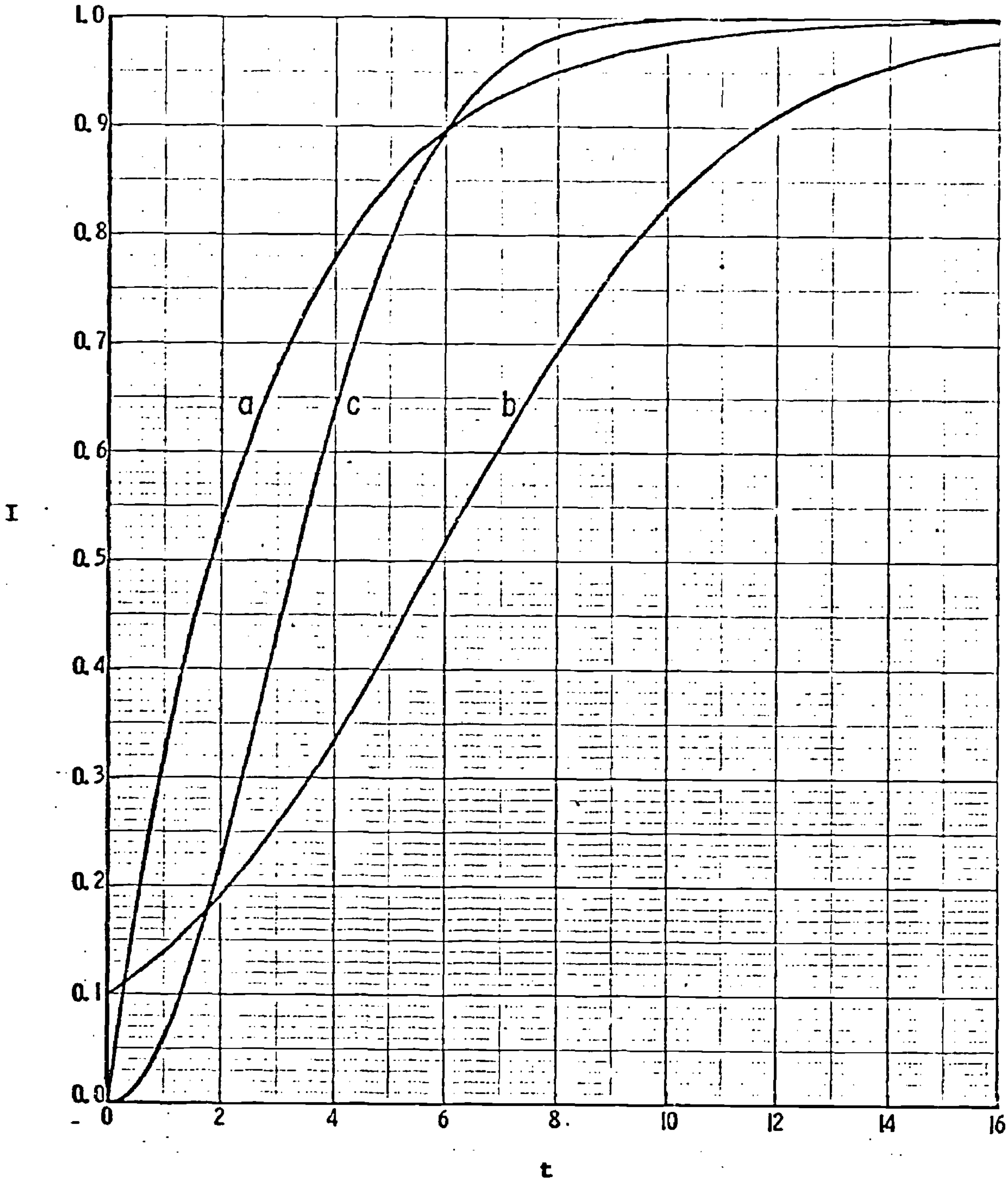


FIG. 15 - ITEM ACCUMULATION HISTORY

a) $I = 1 - \exp(-kt)$ for $k = 0.15$

b) $I = [1 + c \exp(-kt)]^{-1}$ for $k = 0.15$ and $C = 9$

c) $I = 1 - \exp(-mt^{B})$ for $m = 0.01$ and $B = 2.0$

graphically in curve a of Figure 10.* Only one further mathematical complication arises, namely, since the argument of the complementary error function and the argument of the exponential function are now complex, care must be taken in evaluating equation (8). Further, the absolute value of the resulting complex valued function has been chosen. Lacking at the present time guidelines for the rational choice of ε and λ several trial and error cycles were needed until the overall behavior observed in the data was approximated and, after proper scaling the curves shown in Figure 10 were obtained. These seem to be adequate for comparison with the available data and consistent with the broad assumptions made in the formulation of the model. Curve a is obtained from equation (8) by letting $\varepsilon = 0.01$ and $\lambda = -0.1$ and it approximates the data curve b corresponding to the black group whose average SES of Peers in Kindergarten, fourth, sixth and eighth grades was in the 11-53 range. A more thorough verification of this model is obviously needed as well as determining ways to find the functional form for the parameters ε and λ in terms of basic group characteristics. This may be attempted in the future.

*See Chapter 6

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