WARE, Donald Lavonne, 1934-
THE EFFECTS OF CULTURAL BILINGUALISM UPON THE
ABILITY OF SPECIAL CLASS EDUCABLE MENTALLY
RETARDED CHILDREN TO TRANSFER WORD MEANINGS FROM
NON-STANDARD ENGLISH TO STANDARD ENGLISH.

The Ohio State University, Ph.D., 1970
Education, special
University Microfilms, A XEROX Company, Ann Arbor, Michigan

THIS DISSERTATION HAS BEEN MICROFILMED EXACTLY AS RECEIVED
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NON-STANDARD ENGLISH TO STANDARD ENGLISH.

DISSERTATION
Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By
Donald Lavonne Ware, B.A., M.A.

* * * * * *

The Ohio State University
1970

Approved by

[Signature]
Advisor
College of Education
Dedicated To:

My wife Lillian, my sons D'Andre and Roget, and to Daddy's pretty little girl Rachelle.
ACKNOWLEDGMENTS

The writer wishes to express his appreciation to Dr. G. Orville Johnson, Adviser, for all of the guidance and encouragement which he extended and to Dr. David Lema and Dr. Joseph Quaranta for their help with special problems. A warm thanks to my friends Dr. Carolyn Lavely, Dr. Elizabeth Lawerence, Dr. John Johnson and Dr. Robert Green for being my friends. To my parents John and Marjorie Ware a special thanks for everything.
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CHAPTER I

INTRODUCTION

Introduction to the Problem

Interest in this area came about as a result of considerable research in the past decade, that has been devoted to the educational problems of children from lower socioeconomic populations. Poor academic performance in the schools, has been attributed to a cultural deficit as a result of an impoverished environment in their early years. One salient aspect of cultural deprivation, which has commanded considerable attention, and which has been used by educators and psychologists to lend support to the deficit theory, is in the area of language development. In this area, the deficit theory appears as the concept of "verbal deprivation."

The literature is replete with statements to the effect that lower-class children receive little verbal stimulation, are recipients of very little well-formed language, and as a result are impoverished in their means of verbal expression: they cannot speak complete sentences, do not know the names of common objects, cannot form concepts or convey logical thoughts.
Cynthia Deutsch states:

The disadvantaged home is not a very verbal household; a lot of communication tends to be in gestures or in single words or phrases. Many of the homes have no books, nor is a daily newspaper a regular feature, so the child is not exposed to very much reading or verbal or library material.¹

Taking this orientation even further, the most extreme view concerning the language deficit in lower-class children is that they have no language at all. Bernstein supports this theory in his earlier writings to the effect that "much of lower class language consists of a kind of incidental 'emotional accompaniment' to action here and now."²

One can proceed through a range of such views until one comes to a more definitive view of the language deficit of Bereiter, Engleman and their associates. Bereiter's programs for language development in pre-school children is based upon their empirical findings that lower-class children come to school with a language that is in direct conflict to school language.³


The problem of a language deficit becomes one that can be clearly defined in terms of the functional characteristics displayed, such as divergent language as opposed to standard English, rather than being confused within obscure theoretical absurdities as "nonverbal" and/or no language at all.

Riessman goes on to attempt to clarify the language problem of lower-class groups as consisting of distinctive language differences when comparisons are based upon the usage of nonstandard as opposed to standard English. In discussing lower-class and middle-class language differences, Riessman uses qualitative descriptions, and suggests:

The quality of language employed has its limitations and I think herein lies the deficit. The difference is between a language in a written book and informal every day language. There is no doubt in my mind that there is a deficit. This is fairly clear, the question might be asked, why make such an issue of the positive verbaility of these children? The reason is that it is easy to believe what too many people have come to believe, that this formal deficit in language means that deprived people are characteristically non-verbal. 4

The Problem

One of the greatest obstacles standing between lower-class children achieving their academic potential appears to be concentrated in divergent verbal behavior. As a

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group, they consistently demonstrate an inability to express themselves in what the school construes to be acceptable verbal manners; which are requisite to meeting the kinds of cognitive, effective and social demands associated with successful school achievement. Although early childhood development of lower class children is by no means monolithic in family structure, experiences, and attitudes toward learning; in the area of language usage, specifically standard English, a bilingual coexistence is prevalent among the children to the extent that the kinds of words they use, are not words used and/or understood in the school.

In the case of educable retarded and borderline children whose intellectual development is significantly below that of their normal peers from the same lower class community, cultural bilingualism for these groups presents an even greater deterrent to achieving the educational objectives of the school.

Before teachers, and educators as a group may condemn the cultural bilingual or divergent speaking child as being devoid of academic cognitions, they must first understand the nature of cultural bilingualism and its effect upon the present and future development of the child.

Kenneth Goodman says,

Every child brings to school, when he comes, five or six years of language and experiences. His
language is closely intertwined with the culture of his community; it embodies the cultural values and structured the way in which he may perceive his world and communicate his reactions to others.

... All children develop vocabulary which falls generally within the vocabulary pool of their speech community. Through repeated experiences common for their culture they have begun to develop complex concepts and express them in their mother tongue.

In every respect the process of language development of the divergent speaker is exactly the same as that of the standard speaker. His language when he enters school is just as systematic, just as grammatical within the norms of his dialect, just as much a part of him as any other child's is. Most important, it is a vital link with those important to him and to the world of man.5

This investigator is concerned about the degree of understanding on the part of educators of the problem of cultural bilingualism and its effect upon cognition in lower-class children.

The major purpose of this study was to investigate the relationship between the use of public language by educable retarded and borderline children and its effects upon verbal cognition. The study is specifically concerned with word meaning, and the ability of the child to transfer world concepts from non-standard English to standard English.

5Kenneth S. Goodman, "Dialect Barriers to Reading Comprehension," in Beratz and Shery Teaching Black Children to Read, Center for Applied Linguistics, 1717 Massachusetts Avenue, N.W., Washington, D.C., p. 16.
**Significance**

If no differences are found to exist between the way the child perceives word concepts in his informal language and the way these same concepts are transferred to formal language, the information obtained could be useful to educators in developing more functional language curriculums which will not only incorporate present school experiences, but also will reflect and utilized the effective kinds of language experiences the child brings to school. There is also the possibility that the results of this study might add some information that will help determine the need for highly trained languaged specialists at the pre-school and elementary school levels, in addition to, better defined grouping procedures for purposes of instruction.

**Hypothesis and Questions**

This study was designed to determine the relationship between the use of public language by educable retarded and borderline children and its effects upon the ability to transfer word meanings from non-standard English to standard English.

The null-hypothesis listed in this investigation was:

There will be no significant differences between the educable mentally retarded and borderline group's ability to transfer word meanings from non-standard English to standard English as measured by both the standard and a modified version
of the Word Meaning Test of The Stanford Achievement Test, Form W Primary Battery II.

Questions to be answered were: With lower class educable mentally-retarded children with varying degrees of intellectual development:

1. What is the significance of difference between each subject's score determined from the standardized and modified methods of test administration for both groups?

2. How homogeneous is each group based on test scores for both the standardized and modified methods of test administration?

3. What is the significance of difference of achievement scores of the top subjects in the special class determined by previous IQ scores as compared to the bottom subjects in the regular class determined by previous IQ scores, for both groups?

4. What is the significance of difference of achievement scores of both the older special class and regular subjects with the highest IQ scores, as compared to the younger special class and regular class subjects also with the highest IQ scores?
Definition of Terms

1. Educable mentally retarded—Those pupils whose I.Q.'s. range from 58-83 as determined by a standardized intelligence test.

2. Borderline—Those pupils whose I.Q.'s range from 83-96 as determined by a standardized intelligence test.

3. Public language (non-standard English)—The neighborhood environmental language spoken by the pupils.

4. Formal language (standard English)—The kind of language required in school.

5. Lower socioeconomic—Those communities which meet established guidelines as set by the Department of Health, Education, and Welfare in the allocation of funds under Title I—Elementary and Secondary Education Act.

6. Cultural bilingualism—The ability to use two languages interchangeably.

Assumptions

The assumptions used in determining the location of the elementary school in the lowest socioeconomic neighborhood in this study was based on the guidelines set by the Department of Health, Education and Welfare in the allocation of funds under Title I—Elementary and Secondary
Education ACT (ESEA) of 1965.  

A more definitive description of Title I-ESEA will be discussed in Chapter III under the section titled, "Section of Subjects."

Other assumptions are:

1. That the educable retarded and borderline children have no severe speech defects and were able to adequately respond to the testing instrument.

2. That both the standardized and modified versions of the Word Meaning Test of the Stanford Achievement Test, Primary Battery II, measure the ability to transfer word meanings from non-standard to standard English.

Limitations of the Study

Educable mentally retarded and borderline children from lower social class populations are not monolithic in nature; therefore the sample of the special class educable retarded and borderline regular class groups being studied in this investigation cannot be considered to be representative of all educable and borderline retarded lower-socioeconomic school children.

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CHAPTER II

REVIEW OF THE LITERATURE

The nature of the condition which we call mental retardation is rarely given sufficient attention. Formal definitions and their adequacy seem to take precedence over empirical attempts to identify and delineate those areas of behavior which are affected in a functional sense. Language behavior is one aspect of mental retardation which has received relatively little empirical attention, and specifically, the research literature is almost devoid of studies designed to describe the functional language of that group which comprises the largest percentage of our mentally retarded population—the cultural-familial retardates.

In general the majority of studies have centered around language deficiencies in the form of speech defects (Targan, et al., 1961; Mathews, 1957; Karlin and Strazzulla; 1952, Wolfensburger, et al., 1963; Gens, 1950; Lyle, 1960; and Goodwin, 1955).¹ These studies all show

that as a group, mentally retarded children have a higher incidence of articulatory defects and other aspects of defective speech production than can be found in the general population as a whole.

Definitive studies recording the frequency of defective speech occurrences has been reported for various populations. The results of these studies correlate highly with the over-all results of the general retarded population studies, and the differences between them reflect not so much inconsistencies as accurate representations of specific populations. However, not all retarded persons are alike, and the articulatory differences found among them clearly indicate that language

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defects found within various groups of retarded individuals should be viewed within a framework of degree rather than kind. All of these studies indicate a significant correlation between mental retardation and retarded speech. Still the nature of the association is yet in question.

This study is concerned with the functional language of educable mentally retarded children from a cultural bilingual viewpoint and its effect upon verbal cognition. It is evident from the literature that articulatory defects which are manifested in speech productive problems have been considered to be the primary area of focus, rather than as a part of a more pervasive communication problem. Schiefelbusch suggests strongly that until educators are able to resolve the speech defect and functional language (communication behavior) controversy, the development of a broad program designed to improve the child's functional communication skills become irrational and confused.³

Using communication behavior as a theoretical form of reference from which a developmental language program may originate, Schiefelbusch begins by examining a functional definition of mental retardational which has been adopted by the American Association on Mental Deficiency. Mental retardation refers to subaverage general intellectual functioning which originates during

the developmental period and is associated with impairment in adaptive behavior.

The critical issue contained in this definition is the phrase "impairment in adaptive behavior." Heber (1962) states that precise objective measures of adaptive behavior, although extremely desirable, are, for the most part, presently unavailable. He points to the Vineland-Social Maturity Scale as probably the best single measure of adaptive behavior currently available. He makes no reference to communication behavior as a feature of adaptive behavior and lists speech skills under the heading of sensory motor skills, referring to them as defects in vocalization such as a lisp, stuttering, stammering, and so forth.\(^5\)

It is apparent that this is a constrictive concept of "speech disability," one which leaves out the reciprocal response concepts of interpersonal (communication) behaviors. Consequently, the categorizing of speech under sensory motor headings either suggests the need for a new term, e.g., communication, or a new definition for speech, one that is broader and more inclusive. For the time being 


we might resolve the problem by using the term "communication behavior." Further clarifying the meaning of communication behavior Schiefelbusch states

The meaning of this term is suggested by Spradlin's 1963 definition of language as "The speech one gestures of a speaker and the responses to speech and gestures made by a listener." If we include the responses of the listener as a feature of a reciprocal response system, we must then analyze the effect of these responses upon the child and, indeed must accept these responses as part of a communication system of which he is a stimulus-response feature. 6

The review of the literature will contain (1) only those studies which have defined language usage in broader terms of which communicational behavior becomes the functional basis for direct observation and evaluation, and (2) whose subjects are reflective of lower socioeconomic noninstitutional populations.

Newton describes a bilingual coexistence and the inequalities involved among lower social class children in stating

The standard form of a child's native tongue may be "a foreign language" for the child who has heard non-standard forms throughout his formative years." . . . Language, a vital facet of culture is not equally available to all members of society. For a long time we have known that a society does not distribute its wealth, institutional services, privileges or vocations with impartial regard. The material, both abstract and concrete are stretched out on a continuum of distribution from the "have-nots" to the "haves." The opportunities for language development are stretched on a

6 Schiefelbusch, op. cit.
continuum, too, and the economic "have-nots" are often the verbal "have-nots" as well. 7

Within the last decade a profile of the child who has comprehensive verbal problems has been developed with increased clarity by Gordon, Isenberg, Sexton, Frazier, Conant et al. He has been reviewed in terms of his socio-economic status, personal, social and emotional characteristics, as well as language patterns. Even though results have several perplexing gaps which definitive research must fill, we are, however, at present able to extract a fair picture of the non-standard languaged child.

A. He is usually a member of a family in which there are less than two full generation of literacy.
B. He frequently in the second or third generation of an "inherited poverty" family.
C. He was born in and lived during his formative years in the culturally barren regions of the United States (the Southern rural farm or mountains, Appalachia, or the metropolitan ghetto).
D. He is often a member of a submerged but visible cultural minority.
E. During his formative years, his verbal environment was permeated with (a) casual observance of standard English inflections, (b) simple monosyllabic words, (c) frequently mispronounced words, (d) rare use of "socially acceptable" descriptive or qualifying terms, (e) the simpler or sentence fragment; and (f) profuse use of regionalisms, slang, and cant.
F. He frequently performs several years below grade expectancy on verbal tests (and tests requiring reading skills for their operation), but often demonstrates normal learning potential or non-verbal tests.

G. His styles and modes of peripheral habitation do not complement the emphasis which are important to traditional academic success.

H. He has marked weakness in utilizing abstract cognitive processes (due to vocabulary difficulties), and favors concrete, stimulus-bound learning situations.

I. His limited horizon in his limited life function as a depressent to his motivation, aspirations, and thus his achievement.

J. General disenchantment with any type of book-centered learning is frequently displayed by him and takes the form of aggressive, defensive, or dissociative behavior.

K. He has a better than fifty-fifty chance of becoming a drop-out by the end of the tenth grade and almost certainly will not finish high school.

L. He frequently has contradictory attitudes toward self and others with low self concept and the resultant exaggerated positive and negative attitudes towards others.

M. The socio-cultural standard of his family (and neighborhood) are noncomplementary to social stability and academic achievement—hypermobility, family instability, distorted model relationship, housing inadequacy, economic insufficiency, as well as hyper and hypo stimulation.

In Strang's discussion of "The Linguistically Handicapped: Learning English as a Second Language—A Theoretical Model," she says,

There are approximately twenty-two million children and young people in the United States for whom English is a second language. Too many of them have ineptitude in speaking, reading, and writing English is a serious educational, vocational, emotional, and a social handicap. Some, as they become increasingly retarded in reading, develop feelings of inadequacy or inferiority and become apparently or actually indifferent to learning. These pupils are likely to drop out of school prematurely and become hostile to school and society. We could help them a great deal by

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teaching them more skillfully in the area of
listening, speaking, writing, and reading.

Although Strang's article is directed primarily
towards two specific ethnic groups—American Indians and
Mexican Americans, the problem which nonstandard English
impose and its direct relationship to successful or
unsuccessful school experiences in terms of negative
behavioral outcomes, appear to be the same as for any
lower-social class minority group.

It is estimated that 75 percent of all retards in the United States fall within the classification of
cultural familial retardation. Etiological classification of this group reflects varied and widely different
explanations. The U.S. government, however, has adapted a
developmental relationships of causality, using cultural
depprivation as a causation factor. Project Head Start pre-
school programs which our government supported have become
the national media through which educational intervention
of developmental factors which may be related to cultural-
familial retardation may be explored. A great part of the
Head Start program is centered around improving the child's
usage of standard English by providing experiences from

9Ruth Strang, "The Linguistically Handicapped:
Learning English as a Second Language," Excep. Chil.,

10R. Heber, "A Manual on Terminology in Mental
which the child may develop, establish and reinforce verbal skills.

Hyman and Sill\textsuperscript{11} used twenty pre-school children from disadvantaged homes to investigate the academic readiness of children who have participated in Head Start programs and one year of kindergarten. The results indicate that the experimental group did not score significantly higher on the Metropolitan Readiness Test when compared with a control group which did not have Head Start experiences. The mean percentile rank, however, of 40.5 of the Head Start group as compared with a mean of 30.50 for the control group indicates an advantage in favor of the Head Start experience. It was interesting to note that despite initial gains as a result of Head Start, the experimental group was still disadvantaged in terms of academic readiness when they entered first grade. The authors suggest that the gains accrued as a result of Head Start are not sufficiently reinforced and consolidated.

Adams,\textsuperscript{12} approaches the development of communication behavior from three disciplines psycholinguistics, neuro-

\begin{itemize}
\item \textsuperscript{11}Irwin Hyman et al., "First Grade Readiness of Children Who Have Had Head Start Programs," \textit{Training School Bulletin}, 63 (1966-67), 163-67.
\end{itemize}
physiology, and education. He suggests that

Verbal symbolic behavior is organismic, ontological, and developmental in nature, and that speech, language, and cognition are integrated central brain processed leading to the highest adaptive processed in man--abstract conceptualization and creative thinking. The main mechanism underlying sensory regulation is the reticular formation. If the organism is subjected to reduced stimuli from birth; the functioning of the reticular formation and development of higher mental process will be adversely affected.

In the case of disadvantaged groups, Adams suggests that in order to raise the level of academic achievement and school adjustment, programs should begin at age 3, with concomitant emphasis placed upon auditory language, and linguistic research. Teachers in turn should have more training in the diagnostic and clinical aspects of language development.

A study to test the growth of control of grammar in imitation comprehension and production was conducted by Lovell.13 Two hundred nursery school children falling within the normal range of intelligence, chronological ages between 2 and 6 years, and 80 educationally retarded (ESN) children, between 6 and 7 years of age, were tested on grammatical contrasts from Imitation Comprehension and Production Test. The normals were also selected from among students whose socioeconomic studies was representative of lower economic classes. The results indicated that at all

age levels in both normal and ESN children, imitation is more advanced than production. These results tend to be consistent with Piaget's theories concerning the nature of the relationship between language and thought. This study also suggests that language acquisition in children follows primarily the same kinds of developmental patterns. However, in the case of children from lower socioeconomic groups the channels for stabilizing higher forms of standard English patterns are not as readily available as they are in higher social levels.

Pointing further to several variables which foster nonstabilization of standard English patterns among children from lower-socioeconomic groups, which in turn perpetuates the deficit theory in language development, McCandlass\textsuperscript{14} has ascribed to (1) a lesser degree of socialization with adults; (2) bilingualism; (3) the level of conversation of the parent; and (4) a general lack of reinforcement as salient causal factors.

II. Language Development and Intelligence

The literature of education, sociology and psychology is replete with evidence which shows that sociocultural factors can depress or raise the level of educational performance.

Clearly, extreme social groups within societies produce children who from a very early age are exposed to separate and distinct patterns of learning. When comparisons of communication behavior and speech of lower- and middle-class children are made, conspicuous deficits are usually found in the lower-class group (Irwin, 1948, Templin, 1957). Anastasi and Cordova, 1953; Cooper, 1964; John, 1963, have shown that the difficulties of culturally disadvantaged children in acquiring and processing information have an adverse effect on both measured intelligence and school achievement. Further, these intellectual impairments have been shown to be cumulative; that is, the older the child becomes, the greater the deficit (Deutsch, 1964, Klineberg, 1963).

A study by Dawe used a planned training paradigm with a group of orphaned children, eleven pairs of

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children were matched on age, sex, I.Q., and school group. The trained group reflected gains in average I.Q. from 80.6 points to 94.8 points. Although the relation between language ability and I.Q. is one of complex reciprocity, this study indicated that the functional level of performance may be independent of the I.Q. in an environment detrimental to the development of language skills.

There has been very little research conducted in which the verbal behavior of Negro children from lower socioeconomic groups are compared with Negro children from middle-class groups. In a study by John, Negro elementary school children were classified and placed in one of three socioeconomic groups, lower-lower class (Class I), upper-lower class (Class II) and middle-class (Class III), as determined by the Index of Status Characteristics developed by Warner, Meeker and Eels. Middle-class children surpassed their lower-class age mates in possessing a larger vocabulary (WISC vocabulary results) and a higher non-verbal I.Q. (Lorge-Thorndike) with their ability to produce a best-fit type of response. It is the author's contention that the emergence of significant group differences on the various verbal tasks at the fifth-grade level may reflect stable patterns of language conceptual behaviors on the middle-class children. Similar trends were found

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to exist at the first-grade level and they could be attenuated by the fact that with younger children, irrespective of social class, primary occupation at this age is focused upon the acquisition of the rudiments of language.

Very few significant differences were found in the verbal behavior of lower-lower and upper-lower class children.

There are many investigations that have been concerned with determining the relationship between language development and intelligence in retarded children. Many of these studies have employed an undefined group of institutional retardates, rather than public school retardates as subjects. An even more confusing factor is that the results are somewhat obscured by the selection of intelligence and language measures. It is also evident that a standard method of instrument selection is non-existent giving further reasons for invalidating much of the results obtained from the wide variety of intelligence and language measures used. There is also considerable overlap between techniques and content of intelligence and language measures. High correlation are envitable when such redundancy in measurement exists.

A survey of the current research reveals little that is specifically devoted to an exploration of cultural bilingualism and/or bi-dialectalism as being a type of communication behavior model that is not necessarily a
culturally imposed characteristic indigenous only to foreign emigrant children. Educators and linguists as well are beginning to assume wide interest in the problem of diametrically opposed communication behavior between lower socioeconomic and middle-class populations. The teaching of English as a second language to children who do not employ the standard English paradigm of behavior is strongly suggested by Raspberry,\(^{18}\) who believes that if total adoption culturally disadvantaged to any standard English paradigm is to be at all effective, then a total English emersion systems approach should be used.

A comprehensive survey of the literature on the intellectual and educational effects of bilingualism would include many, many early studies which, while interesting from a historical point of view, were completely packing in experimental method. Therefore, the review of this section will be limited to only those studies which both educationally and socially could be transposed from one culture to another employing certain theoretical considerations, based upon the present existence of certain educational and social conditions.

Saer\(^{19}\) conducted a series of experimental investi-


gations to determine the effect of bilingualism on the measurement of intelligence. The subjects included children from both urban and rural districts in Wales. In six of the urban districts Welsh was the mother tongue, but the urban children learned English at school and English was also the language of their play activities. The rural children also learned English at school but spoke only Welsh in their homes and play activities. The 1916 Stanford-Binet Scale was translated into the Welsh language for those who used Welsh as the mother tongue. The results indicated a significant inferiority of the rural bilingualists and suggested that this deficit tended to be cumulative in nature. Saer concluded that children who become bilingual at an early age, by learning the second language during play activities and in contact with other children, have a definite advantage over those who learn the second language only in a school setting.

Pinter and Keller,\(^{20}\) reported an investigation in which children in kindergarten, first and second grades of three Youngstown, Ohio schools were divided into an English-speaking group and a foreign group. The English-speaking group included Negro, American-white, Canadian, English, Irish, Scotch and Welsh populations, while the

foreign group consisted mainly of children of Spanish and Italian parentage. All subjects were given a special revision of the 1916 Stanford-Binet Scale. The authors concluded that children from homes in which a foreign language is predominantly spoken receive lower scores on revisions of the Stanford-Binet Scale than they do on tests in which a minimum of English is used, and that these children may suffer a serious handicap if compared with English-speaking children on the basis of MA's achieved only on revisions of the Binet Scale.

Another investigation by Pinter\textsuperscript{21} attempted to determine whether or not a verbal group-test is a valid measure of the intelligence of foreign children. The National Intelligence Test and the Pinter Non-Language Test was administered to a group of third and fourth grade children in a New York City school. In studying the percentage of foreign children who reached or exceeded the median, MA of the American group, the author found no difference between the foreign group as a whole and the American group on the Pinter-Non-Language Test. Significant differences were found in favor of the American group on the National Intelligence Test. Pinter concluded that caution should be exercised in drawing inclusive conclusions concerning the intelligence of foreign-born children.

when verbal tests of intelligence are used as the sole criterion of measurement.

Wang,\textsuperscript{22} conducted a study in which he paired native-born white students with Chinese students, Negro students, and Russian students with respect to college attended, class, sex and age. All subjects were given the \textit{Ohio State University Intelligence Test}. The results showed that native-born subjects were significantly superior to the Chinese subjects in the \textit{General Information Test}. The scores between native-born white students and Russians or Negroes and native-born whites were not significantly different. The author stated that the Chinese students were handicapped by the language difficulty and that in the case of the Negroes and the Russians, the language factor did not seem to be an appreciable one. Wang admitted that his subjects were selected and were not representative of these ethnic groups in the country at large. He concluded as a result of his investigation that definite conclusions concerning the relative intelligence of ethnic groups not thoroughly Americanized and Americans is experimentally fallacious, unless there are definite controls for the language factor.

Yoshioka\textsuperscript{23} administered the National-Intelligence Test both in Japanese and in English to a group of Japanese children in California. In both forms of the test, the subjects scored far below both the American and Japanese norms. The investigator explained this on the basis of the language difficulty caused by bilingualism and stated that the low correlation between the Japanese and English forms gave further proof of the language difficulty, although the investigator added that the children on whom the norms have been based for the Japanese form of the test were of higher socioeconomic status than the subjects of his investigation.

The investigator also continued that older children are better bilingualists and bilingualism in young children as a definite hardship and devoid of apparent advantage because bilingualism appears to require a certain degree of mental maturation in order to successfully master the process.

\textbf{Summary}

A review of the related research clearly demonstrated limited evidence concerned directly with a functional approach to communication behavior among children of lower socioeconomic status in terms of (1) the kinds of

cognitive equations to standard English that take place when public language becomes the standard form and (2) the various degrees of inter and intra group differential language abilities that exists among those disenfranchised populations. Most of the studies were given primary emphases to the prevalence of speech pathology per se, rather than an attempt to study the total language process of reception, internal manipulation and expression. These studies were indicative of a higher incidence of speech disorders.

Among retardates as a group; in the majority of cases institutionalized retardates were subjects of the investigations, and finally such variables as I.Q., M.A., C.A., environment, and etiology were used collectively to apply to both institutional and public school educable mental retardates. These studies as well as their collective implications were not considered to be relevant for this particular investigation and therefore were listed briefly by author's name in the beginning of this chapter.

Other related studies indicated that retarded children from lower socioeconomic groups have expressive language difficulties when they were equated with normal children from middle class groups.

With reference to previous research, the major purpose of this study was to determine the ability of educable mentally retarded and borderline children from
lower socioeconomic groups to transfer word meanings from non-standard to standard English. The fulfillment of this purpose should provide functional information needed to enhance the continuing improvement of educational programs for children from disenfranchised populations.
CHAPTER III

PROCEDURES

The procedures used in conducting the research of this study in an attempt to make a comparative analysis of specific public and formal word understandings, in educable mentally retarded and borderline children was divided into five sections. The first section is a statement of the hypothesis that was formulated and tested. The second section constitutes a description of the type of data collected. The third describes the selection of the subjects. A description of the subjects is presented in the fourth section. The fifth section concludes the design and research with a description of the administration of the instrument in conjunction with the statistical analysis used in the treatment of the data presented.

I. Hypothesis to be Tested

The problem is formulated in a major hypothesis which is stated in the null-form:

It was hypothesized that there will be no significant differences between the educable mentally retarded and borderline group's ability to transfer word meanings from non-
standard English to standard English as measured by both the standard and a modified version of the Word Meaning Test of The Stanford Achievement Test, Form W, Primary Battery II.

II. Type of Data Collected

One section of a standardized published test was administered to the total sample of educable mentally retarded and borderline children in collecting data to test this hypothesis: the Stanford Achievement Test, Primary Battery II, Grades 2-3, Form W.¹

The Stanford Achievement Test is a group administered test designed to measure basic skills and understandings which are usually accepted as the primary objectives of elementary school curriculums. The test becomes a diagnostic tool for the teacher in that in addition to an over-all group survey of achievement, individual areas of abilities and disabilities may be detected with the use of the profile information. The total battery assesses the broad areas of language achievement, reading achievement and arithmetic achievement. The composite of these scores may be translated to yield grade scores, grade equivalents, percentile ranks and standards. These tests are so constructed that the average teacher with minimal

¹T. L. Kelley, R. Madden, E. F. Gardner, and H. C. Rudman, Stanford Achievement Test Form W, Primary Battery II (New York: Harcourt, Brace and World, Inc.).
training in testing and measurement can administer, score as well as interpret the results by following the specific directions in the manual.\textsuperscript{2}

For the purpose of this study the investigator chose to use only the \textit{Word Meaning Test}, Primary Battery II. This test consists of 36 multiple-choice items which are graduated in varying degrees of difficulty. The pupil is required to read a sentence and then select the correct word which will then complete the sentence. The test in its standard form requires, at this level, the ability to read. Taking into consideration the low reading ability of both the educable mentally retarded and borderline subjects, the test was administered individually and verbally to each subject, requiring a verbal response in the selection of the correct word. Each item was carefully read to each subject along with the four response choice words. There was no time response limit imposed on the subject. There was a maximum number of three times that the subject was allowed a verbal repetition of the complete item.

The \textit{Word Meaning Test} of 36 multiple-choice items was modified by the investigator for the purpose of obtaining comparative data of both public and formal (standard English) understanding in educable mentally retarded and borderline children in the following manner:

\textsuperscript{2}\textit{Ibid.}, pp. 2-31.
1. The Word Meaning Test of the Stanford Achievement Test, Primary Battery II, was first administered both individually and verbally in its standardized form, representing formal language, to each subject.

2. The Word Meaning Test of the Stanford Achievement Test, Primary Battery II, was then modified, representing public-language; and was again administered both individually and verbally to each subject.

3. The modification of the test consisted of rewording the complete sentence and/or portions of the sentence into non-standard English forms. The four choice word items in each sentence were not changed.

The subjects were divided into two groups. One group consisted of educable mentally retarded children in special education classes, and the second group consisted of borderline children who were still in regular elementary classes. The data was analyzed to yield inter group as well as intra group comparisons. The responses recorded by the investigator on each item of the standardized test form were compared to normative data.

It was hypothesized that there would be no significant differences between the subjects' verbal achievement
scores on either the standardized form or the modified form of the Word Meaning Test.

An attempt was made to determine whether or not educable mentally retarded and borderline children from lower socioeconomic groups, regardless of ethnic affiliation, exhibit a particular bilingual pattern when word meaning is involved.

III. Selection of Subjects

The subjects included in this study were drawn from one elementary school located in the lowest socioeconomic neighborhood of an urban city in West Virginia. The socioeconomic status of the selected subjects was determined from the fact that thirty-seven schools in the county are eligible for and receive Title I funds allocated under the Elementary and Secondary Education Act of 1965. Title I of ESEA was designed to meet special education needs of certain groups of children, including:

1. Disadvantaged children in low income areas.

2. Children in institutions for handicapped, neglected, or delinquent.

3. Children of migratory agriculture workers.

The primary purpose of Title I was to help children who educational achievement was below the norm for their age grade. Requirements for eligibility, allocation of funds, and participation in the program was established by surveying all school districts in the county school system to determine the number of children from economically depressed homes. In order for a school to be eligible for participation in the program in the county, the requirements were that 11 percent (11%) of students had to be from homes (1) with annual incomes of less than $3,000 per year, or (2) from families receiving benefits from AFDC (Aid for Dependent Children) programs:

The survey of family income was implemented by:

1. Survey of forms sent to homes and completed by families in each school district;

2. Records of various governmental agencies, such as the Census Bureau and Welfare Departments being checked.

Data collected indicated that thirty-seven (37) of the schools in the county were eligible for participation in the original Title I program. Of the thirty-seven schools eligible for Title I funds, the population sample school received the largest share of Federal monies due to its large pupil enrollment, and its location which enables the school to provide educational services for both inner-city Negro and emigrant Appalachian white children.
IV. Description of the Sample

All subjects were educable mentally retarded and borderline children attending public school in an urban city in West Virginia who met predetermined criteria.

Tables 1 and 2 give the means and standard deviations by groups on all variables used in the study. Table 1 gives the means for the C.A., I.Q., and M.A. variables on the special class and borderline subjects as separate groups. Table 2 gives the means and standard deviations for the C.A., I.Q., and M.A. variables for the special class and borderline subjects as one group.
TABLE 1

MEANS OF THE C.A., I.Q. AND M.A. VARIABLES FOR THE EDUCABLE MENTALLY RETARDED AND BORDERLINE SUBJECTS TAKEN AS SEPARATE GROUPS

<table>
<thead>
<tr>
<th>Special Class Educable Mentally Retarded</th>
<th>C.A.</th>
<th>I.Q.</th>
<th>M.A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>11-04</td>
<td>58</td>
<td>6-06</td>
</tr>
<tr>
<td>2</td>
<td>10-05</td>
<td>60</td>
<td>6-06</td>
</tr>
<tr>
<td>3</td>
<td>11-05</td>
<td>49</td>
<td>5-08</td>
</tr>
<tr>
<td>4</td>
<td>13-03</td>
<td>72</td>
<td>9-06</td>
</tr>
<tr>
<td>5</td>
<td>11-06</td>
<td>83</td>
<td>9-06</td>
</tr>
<tr>
<td>6</td>
<td>11-02</td>
<td>68</td>
<td>7-06</td>
</tr>
<tr>
<td>7</td>
<td>11-00</td>
<td>75</td>
<td>8-02</td>
</tr>
<tr>
<td>8</td>
<td>12-09</td>
<td>72</td>
<td>9-01</td>
</tr>
<tr>
<td>9</td>
<td>12-07</td>
<td>80</td>
<td>10-07</td>
</tr>
<tr>
<td>10</td>
<td>12-02</td>
<td>90</td>
<td>11-00</td>
</tr>
</tbody>
</table>

\[ \bar{X} = 11-07 \quad \bar{X} = 70 \quad \bar{X} = 8-04 \]

<table>
<thead>
<tr>
<th>Regular Class Borderline</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>8-11</td>
<td>94</td>
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<tr>
<td>2</td>
<td>8-04</td>
<td>87</td>
<td>7-02</td>
</tr>
<tr>
<td>3</td>
<td>10-00</td>
<td>82</td>
<td>7-09</td>
</tr>
<tr>
<td>4</td>
<td>8-08</td>
<td>96</td>
<td>8-03</td>
</tr>
<tr>
<td>5</td>
<td>8-04</td>
<td>76</td>
<td>6-02</td>
</tr>
<tr>
<td>6</td>
<td>8-04</td>
<td>94</td>
<td>7-10</td>
</tr>
<tr>
<td>7</td>
<td>8-05</td>
<td>82</td>
<td>6-09</td>
</tr>
<tr>
<td>8</td>
<td>8-10</td>
<td>99</td>
<td>8-10</td>
</tr>
<tr>
<td>9</td>
<td>8-05</td>
<td>93</td>
<td>7-09</td>
</tr>
<tr>
<td>10</td>
<td>10-01</td>
<td>81</td>
<td>7-08</td>
</tr>
</tbody>
</table>

\[ \bar{X} = 8-08 \quad \bar{X} = 88 \quad \bar{X} = 7-06 \]
TABLE 2
MEANS OF THE C.A., I.Q. AND M.A. VARIABLES FOR THE EDUCABLE MENTALLY RETARDED AND BORDERLINE SUBJECTS TAKEN AS ONE GROUP

<table>
<thead>
<tr>
<th>Subjects</th>
<th>C.A.</th>
<th>I.Q.</th>
<th>M.A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11-04</td>
<td>58</td>
<td>6-06</td>
</tr>
<tr>
<td>2</td>
<td>10-05</td>
<td>60</td>
<td>6-06</td>
</tr>
<tr>
<td>3</td>
<td>11-05</td>
<td>49</td>
<td>5-08</td>
</tr>
<tr>
<td>4</td>
<td>13-03</td>
<td>72</td>
<td>9-06</td>
</tr>
<tr>
<td>5</td>
<td>11-06</td>
<td>83</td>
<td>9-06</td>
</tr>
<tr>
<td>6</td>
<td>11-02</td>
<td>68</td>
<td>7-06</td>
</tr>
<tr>
<td>7</td>
<td>11-00</td>
<td>75</td>
<td>8-02</td>
</tr>
<tr>
<td>8</td>
<td>12-09</td>
<td>72</td>
<td>9-01</td>
</tr>
<tr>
<td>9</td>
<td>12-07</td>
<td>80</td>
<td>10-07</td>
</tr>
<tr>
<td>10</td>
<td>12-02</td>
<td>90</td>
<td>11-00</td>
</tr>
<tr>
<td>11</td>
<td>8-11</td>
<td>94</td>
<td>8-03</td>
</tr>
<tr>
<td>12</td>
<td>8-04</td>
<td>87</td>
<td>7-02</td>
</tr>
<tr>
<td>13</td>
<td>10-00</td>
<td>82</td>
<td>7-09</td>
</tr>
<tr>
<td>14</td>
<td>8-08</td>
<td>96</td>
<td>8-03</td>
</tr>
<tr>
<td>15</td>
<td>8-04</td>
<td>76</td>
<td>6-02</td>
</tr>
<tr>
<td>16</td>
<td>8-04</td>
<td>94</td>
<td>7-10</td>
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<tr>
<td>17</td>
<td>8-05</td>
<td>92</td>
<td>6-09</td>
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<tr>
<td>18</td>
<td>8-10</td>
<td>99</td>
<td>8-10</td>
</tr>
<tr>
<td>19</td>
<td>8-05</td>
<td>93</td>
<td>7-09</td>
</tr>
<tr>
<td>20</td>
<td>10-01</td>
<td>91</td>
<td>7-08</td>
</tr>
</tbody>
</table>

\[
\bar{X} = 10-02 \quad \bar{X} = 79 \quad \bar{X} = 8-03
\]
V. Administration of the Instrument

The **Word Meaning Test** of the **Stanford Achievement Test**, Primary Battery II was administered first in its standardized form, and then administered in a modified form to a group of educable mentally retarded and a group of borderline children from the same lower socioeconomic status and neighborhood.

Research on the academic abilities of children from lower socioeconomic groups has revealed profound weaknesses in divergent language and reading development.

The sample groups were not only of lower socioeconomic status, but diagnosed educable and borderline retardates as well, adding even further deterents to successful performances in language and reading achievement. The investigator decided to not only administer the test individually, rather than as a group, but also to reac each item individually. This technique not only gave reasonable guarantee that each child would respond to each item, but also gave each child an opportunity to have clarified a sentence or a word not heard clearly.

The investigator administered the **Word Meaning Test** individually to both groups of educable and borderline retardates. A period of one week was allotted to each group for testing. Each subject was allotted one half-hour testing period. The testing conditions were ideal.
in that a private room was provided by the principal which afforded minimal interferences during testing sessions.

Prior to initial testing sessions, the teachers of both groups were contacted by the investigator. Each teacher was given a complete briefing as to the purpose of the study, the test being used, and the hypothesis being tested.

All subjects and teachers involved in the study were informed that their responses would be completely confidential and their identities would remain anonymous.

The investigator attempted to make each child less anxious by chatting briefly before each test began. Each testing situation began with the investigator saying, "All of us, many times say words in a different way. I want to see how many words you can understand when I say them in a different way." The investigator encountered no difficulty in keeping the attention and apparent interest of each subject throughout the test sessions.

**Statistical Analysis**

The basic questions asked by the investigator were stated in a major hypothesis with adjunct questions. The major hypothesis was stated in the null-form. Appropriate data were collected and analyzed according to specific statistical procedures to verify these hypotheses.
Each item was assigned a score value of one. A raw score was determined for each subject by subtracting the number of correct responses from the total possible number (36) of correct responses. A comparison was then made of each subject's score determined from the standardized and modified methods of test administration for both groups. The total scores for each subject were then computed and the relationship between subject's scores on both the standardized and modified test administration were determined by the use of the t-test. This is a parametric test used to determine the significance of difference between correlated and/or uncorrelated means. The t-test is applicable for this investigation since the major hypothesis attempted to determine the significance of difference between means obtained from the same group upon two occasions. A control group was not used, for when a later performance is compared with some earlier trial, the group then becomes both the experimental and control group.
CHAPTER IV

RESULTS OF THE STUDY

The primary purpose of this study was to investigate the relationship between the use of public language by educable mentally retarded and borderline children and its effects upon verbal communication behavior. The study was specifically concerned with word meaning, and the ability of the child to transfer word concepts from non-standard English to standard English. In addition, an attempt was made to determine if certain developmental and/or grouping effects were directly or indirectly related to verbal achievement within these sample groups.

The Word Meaning Test of the Stanford Achievement Test, Primary Battery II, was administered on both standardized and modified form to ten special class educable mentally retarded and ten borderline regular class children who attended an elementary school located in the lowest socioeconomic neighborhood of an urban city in West Virginia.

The major hypothesis and three adjunct questions were tested on the basis of the existence or non-existence of significant differences between (1) group achievement
scores on both the standard and modified method, (2) group homogeneity based on test scores for both group administration techniques in both categories, (3) the top subjects in the special class determined by previous I.Q. scores, compared to the bottom subjects in the regular class determined by previous I.Q. scores for both categories, and (4) oldest special class plus borderline subjects with highest I.Q.'s compared to youngest special-class plus borderline subjects with highest I.Q.'s. The major hypothesis was stated in the null-form. An analysis of variance was compiled and t-values obtained for each adjunct question to determine the significance of the developmental and/or grouping effects mentioned above.

The .05 level of significance was used as the critical probability level in determining significant differences and interaction effects. This meant that to reject the null-hypothesis there would have to be less than five chances in one hundred that the obtained differences occurred by chance. The critical t-values were 2.26 at the .05 level of significance and 3.25 at the .01 level with 6 degrees of freedom.\(^1\) Values of t less than 3.25 were considered non-significant and the null-hypothesis of no difference was accepted:

---

Hypothesis: Special class educable mentally retarded children and borderline regular class children do not differ significantly in their ability to transfer word concepts from non-standard English to standard English forms as measured by a standardized and modified administration of the Word Meaning Test of the Stanford Achievement Test, Primary Battery II.

An analysis of variance was used to determine if there were significant differences with respect to raw scores. Table 3 gives the type of group, the mean, standard deviation and t-values for both the standardized and modified test administrations.

<table>
<thead>
<tr>
<th>Type of Group</th>
<th>Standard Method (N=10)</th>
<th>Modified Method (N=10)</th>
<th>t-Values Between Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
</tr>
<tr>
<td>Special Class</td>
<td>24.7</td>
<td>6.89</td>
<td>26.5</td>
</tr>
<tr>
<td>Borderline</td>
<td>28.8</td>
<td>5.75</td>
<td>30.1</td>
</tr>
</tbody>
</table>

*Not significant at .05 level.

Inspection of Table 3 indicates that neither of the t-values for raw scores for both groups exceeded the critical t-value of 2.26. Therefore the null-hypothesis
for no significant difference in ability to transfer word concepts from non-standard English to standard English was as measured by the standardized and modified method was accepted for both groups.

**Question 1**: How homogeneous is each group based on test scores for both group administration techniques in both categories?

Standard deviation based on raw scores was used to determine the rank order of both groups for homogeneity using both the standardized and modified method. Raw scores were also converted to grade scores using the conversion table at the end of the Word Meaning Test.\(^2\) Inspection of Table 4 indicates, using rank order of standard deviations, with converted grade scores, that the groups are not homogeneous.

### TABLE 4

**RANK ORDER OF TWO GROUPS FOR HOMOGENEITY ACCORDING TO STANDARD DEVIATIONS AND GRADE SCORES USING THE STANDARD AND MODIFIED METHOD**

<table>
<thead>
<tr>
<th>Category</th>
<th>S.D.</th>
<th>Grade Range</th>
<th>Rank*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borderline Modified</td>
<td>5.14</td>
<td>2.7-6.9</td>
<td>1</td>
</tr>
<tr>
<td>Borderline Standard</td>
<td>5.75</td>
<td>2.3-6.4</td>
<td>2</td>
</tr>
<tr>
<td>Special Class Standard</td>
<td>6.89</td>
<td>2.3-5.1</td>
<td>3</td>
</tr>
<tr>
<td>Special Class Modified</td>
<td>7.003</td>
<td>2.4-5.7</td>
<td>4</td>
</tr>
</tbody>
</table>

*The lower the rank the more homogeneous the group.*

\(^2\)Stanford Achievement Test, Form W, Primary Battery II, p. 2.
Question 2: What is the significance of differences of verbal scores of the top subjects in the special class determined by previous I.Q. scores as compared to the bottom borderline subjects in the regular class determined by I.Q. scores, for both groups?

An analysis of variance was utilized to determine if there were significant differences with respect to I.Q. and verbal ability as measured by both the standardized and modified method. Table 5 gives the subjects selected from each group, the degrees of freedom, I.Q. and t-values for \( N_1 \) and \( N_2 \) using the standardized method.

**TABLE 5**

**SPECIAL CLASS--STANDARD METHOD--(HIGH I.Q.)**

<table>
<thead>
<tr>
<th>( N_1 )</th>
<th>Degrees of Freedom</th>
<th>( X )</th>
<th>I.Q.</th>
<th>t-Values--Standard Method (Uncorrelated Means)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>30</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>30</td>
<td>83</td>
<td>1.35</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>33</td>
<td>80</td>
<td></td>
</tr>
</tbody>
</table>

**BORDERLINE--STANDARD METHOD--(LOW I.Q.)**

<table>
<thead>
<tr>
<th>( N_2 )</th>
<th>Degrees of Freedom</th>
<th>( X )</th>
<th>I.Q.</th>
<th>t-Values--Standard Method (Uncorrelated Means)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>30</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>28</td>
<td>82</td>
<td>1.35</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>30</td>
<td>81</td>
<td></td>
</tr>
</tbody>
</table>
An inspection of Table 5 indicates that the t-values used with uncorrelated means did not exceed the critical t-value of 2.26. Therefore no significant difference was found to exist between $N_1$ and $N_2$ with respect to I.Q. and verbal ability as measured by the standardized method.

Table 6 gives the subjects selected from each group, the degrees of freedom, I.Q. and t-values for $N_1$ and $N_2$ using the modified method.

### TABLE 6

**SPECIAL CLASS--MODIFIED METHOD--(HIGH I.Q.)**

<table>
<thead>
<tr>
<th>$N_1$</th>
<th>Degrees of Freedom</th>
<th>$X$</th>
<th>I.Q.</th>
<th>$t$-Values--Modified Method (Uncorrelated Means)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>31</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>30</td>
<td>83</td>
<td>4.36</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>32</td>
<td>80</td>
<td></td>
</tr>
</tbody>
</table>

**BORDERLINE--MODIFIED METHOD--(LOW I.Q.)**

<table>
<thead>
<tr>
<th>$N_2$</th>
<th>Degrees of Freedom</th>
<th>$X$</th>
<th>I.Q.</th>
<th>$t$-Values--Modified Method (Uncorrelated Means)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>28</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>27</td>
<td>82</td>
<td>4.36</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>28</td>
<td>81</td>
<td></td>
</tr>
</tbody>
</table>

An inspection of Table 6 indicates that the t-values used with uncorrelated means did far exceed the critical t-value of 2.26. Therefore a significant difference was
found to exist between $N_1$ and $N_2$ with respect to I.Q. and verbal ability as measured by the modified method.

**Question 3:** What is the significance of difference of verbal scores of both the older special class and borderline subjects with the highest I.Q. scores, as compared to the younger special class and borderline subjects also with the highest I.Q. scores.

An analysis of variance was utilized to determine if there were significant differences with respect to I.Q., C.A., and verbal ability as measured by both the standardized and modified method. Table 7 gives the subjects selected from each group, the degrees of freedom, I.Q., C.A., and t-values for $N_1$ and $N_2$ using the standardized method.
TABLE 7

GROUPED SPECIAL CLASS WITH BORDERLINE OF OLDER + HIGH I.Q. SUBJECTS ON STANDARD METHOD

<table>
<thead>
<tr>
<th>$N_1=6$</th>
<th>Degree of Freedom</th>
<th>I.Q.</th>
<th>C.A.</th>
<th>t-Values--Standard Method (Uncorrelated Means)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>83</td>
<td>11-6</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>80</td>
<td>12-7</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>90</td>
<td>12-2</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>94</td>
<td>8-11</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>82</td>
<td>10-0</td>
<td>.87</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>81</td>
<td>10-1</td>
<td></td>
</tr>
</tbody>
</table>

GROUPED SPECIAL CLASS WITH BORDERLINE OF YOUNGER + HIGH I.Q. SUBJECTS ON STANDARD METHOD

<table>
<thead>
<tr>
<th>$N_2=6$</th>
<th>Degree of Freedom</th>
<th>I.Q.</th>
<th>C.A.</th>
<th>t-Values--Standard Method (Uncorrelated Means)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>60</td>
<td>10-5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>75</td>
<td>11-0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>87</td>
<td>8-4</td>
<td>.87</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>96</td>
<td>8-8</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>99</td>
<td>8-10</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>93</td>
<td>8-5</td>
<td></td>
</tr>
</tbody>
</table>

An inspection of Table 7 indicates that the t-values used with uncorrelated means did not exceed the critical t-value of 2.26. Therefore no significant difference was found to exist between $N_1$ and $N_2$ with respect to I.Q., C.A., and verbal ability as measured by the standardized method.

Table 8 gives the subjects selected from each group, the degrees of freedom, I.Q., C.A. and t-values for $N_1$ and $N_2$ using the modified method.
### TABLE 8

GROUPED SPECIAL CLASS WITH BORDERLINE OLDER + HIGHER I.Q. SUBJECTS ON MODIFIED METHOD

<table>
<thead>
<tr>
<th>N₁=6</th>
<th>Degree of Freedom</th>
<th>I.Q.</th>
<th>C.A.</th>
<th>t-Values—Modified Method (Uncorrelated Means)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>83</td>
<td>11-6</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>80</td>
<td>12-7</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>90</td>
<td>12-2</td>
<td>3.42</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>94</td>
<td>8-11</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>82</td>
<td>10-0</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>81</td>
<td>10-1</td>
<td></td>
</tr>
</tbody>
</table>

GROUPED SPECIAL CLASS WITH BORDERLINE YOUNGER + HIGH I.Q. SUBJECTS ON MODIFIED METHOD

<table>
<thead>
<tr>
<th>N₂=6</th>
<th>Degree of Freedom</th>
<th>I.Q.</th>
<th>C.A.</th>
<th>T-Values—Modified Method (Uncorrelated Means)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>60</td>
<td>10-5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>75</td>
<td>11-0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>87</td>
<td>8-4</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>96</td>
<td>8-8</td>
<td>3.42</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>99</td>
<td>8-10</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>93</td>
<td>8-5</td>
<td></td>
</tr>
</tbody>
</table>

An inspection of Table 8 indicates that the t-values used with uncorrelated means did exceed the critical t-value of 2.26. Therefore a significant difference was found to exist between N₁ and N₂ with respect to I.Q., C.A., and verbal ability as measured by the modified method.

The null-hypothesis (Table 4) tested in this investigation failed to exceed the critical t-value of 2.26 at the .01 level of significance, and, therefore, was accepted for both the special class and borderline groups.
Question 1. (Table 4) indicates that using rank order correlation, with converted grade scores, the groups are not homogeneous.

Question 2. (Tables 5-6) found no significant difference to exist between $N_1$ and $N_2$ with respect to I.Q. and verbal ability as measured by both the standardized method. A significant difference was found to exist when the modified method was used.

Question 3. (Tables 7-8) no significant differences were found to exist between $N_1$ and $N_2$ with respect to I.Q., C.A., and verbal ability as measured by the standard method. A significant difference was found to exist when the modified method was used.

The results indicate a distinct pattern of significance when I.Q., C.A., and grade score variables were tested against verbal ability.
Summary

There has been considerable research in the past decade devoted to the educational problems of children from lower socioeconomic groups. The many books and journal articles that have been written for and/or about lower socioeconomic groups has attributed poor academic performance in the schools to a cultural deficit as a result of an impoverished environment both intellectually and socially in their early years. The nature of cultural deprivation has not as yet been clearly defined, consequently there are as many cause and effects regarding the nature, as there are books and journals devoted to it.

There is, however, one salient aspect of cultural deprivation, which has commanded considerable attention among educators and psychologists; and has been used extensively to lend support to the deficit theory--the area of language development. In this area, the deficit theory appears to be concentrated significantly around the concept of "verbal deprivation." Numerous recommendations for various types of language improvement paradigms have been
suggested by educators in an attempt to remedy and/or refine substandard speech patterns among those who are deprived of an opportunity to become fully integrated into the social and economic life of the middle classes. Many of the recommendations, however, have as a focal point of references, behavioral models which are primarily geared toward the remediation of articulatory defects. The majority of studies perpetuate the concept of speech pathology, specifically articulatory defects as being the essence of the total language process.

The purpose of this present study was to investigate the relationship between the use of public language by educable mentally retarded and borderline children and its effects upon verbal cognitions. The study was specifically concerned with word meaning and the ability of the child to transfer word concepts from non-standard English to standard English forms. In addition, an attempt was made to determine if certain developmental and/or grouping effects would show a significant relationship to verbal ability within these sample groups.

A review of the literature relative to language development in mentally retarded children was reviewed in Chapter II. The first part of the review gave primary emphasis to those studies which (1) defined language usage in broader terms in which communication behavior, rather than speech pathology per se becomes the functional
basis for direct observation and evaluation, and (2) whose subjects are reflective of lower socioeconomic noninstitutional population. The major emphasis in the second section of Chapter II was a review of those studies which are directly related to bilingualism, and in the opinion of the investigator could be transposed from one culture to another employing certain theoretical considerations, based upon the constancy of certain educational and social conditions.

Research procedures in carrying out the investigation were reported in Chapter III. This included a statement of the hypothesis, types of data collected, description, selection and composition of the sample, data collecting procedures, and statistical treatment of the data. All subjects were administered the standardized and a modified method of the Word Meaning Test of the Stanford Achievement Test, Form W, Primary Battery II, Grades 2-3, as a measure of ability to transfer word concepts from non-standard English to standard English. In the treatment of the data, the results indicated a distinct pattern of significance when I.Q., C.A. and grade score variables were tested against verbal ability.

In Chapter IV, an analysis and interpretation of the data collected was presented. The analysis of the data provided evidence for accepting or rejecting the hypothesis which was stated in null-form. In addition,
the data provided evidence for determining significant and/or no significant difference in developmental and/or grouping variables contained within adjunct questions. The final section in Chapter IV was concerned with a brief discussion of the findings.

Conclusions of the Study

Several general statements may be concluded from an interpretation of the results of this study. First, children from lower socioeconomic groups display an ability to conceptualize, transfer and communicate within and between two language forms. This is contrary to what might be expected after a review of the relevant literature. Second, it is also apparent from the results of this study that a bilingual co-existence is prevalent among children from lower class groups. The ability of these children to stratify two language forms in order to meet the cognitive, affective and social demands of the school clearly shows a close relation between language and thought. Therefore functional language behavior becomes the broad framework from which communication, the ultimate goal of language, becomes effective. Language behavior is not a sub-category of speech pathology. A description of the language of children of lower class groups requires attention not only to the way they speak, the length and complexity of their verbal output, and their pronunciation and articulation,
but also the way they think the words and grammatical patterns within their own repertoire freely available to use when conceptualizing and reasoning.

Finally, although the special class educable mentally retarded and regular class borderline subjects were placed in separate rooms and were labeled as separate groups by the school, it is obvious upon inspection of their I.Q., and M.A. levels that they are in essence the same group, differing only in C.A. This would account for little or no significant differences between the two groups when only I.Q. and C.A. variables were used. Also the approximation of their I.Q. and M.A. levels would strongly indicate that factors other than mental retardation exercise an important role in the class placement of these children; since the results indicate that the majority of the special class educable retarded children could function as effectively in the regular class, as the borderline children. It is obvious that I.Q., and M.A. cutting-off points determining special class placement were not consistent.

In general, the acceptance of the null-hypothesis should suggest to educators the need for the development of relevant functional language paradigms which not only will incorporate present school experiences, but will also reflect and utilize the effect of flexible language experiences children bring to school.
Need for Further Research

There is a need for research into communication behavior of children from lower-class groups especially as to how children at various development levels are affected in terms of cognitive and personably development. The investigator suggests a need for additional research in the following areas.

1. The various affects of communication patterns and their relation to thought processes. This might be conducted by comparing educable mentally retarded, borderline and a third group composed of normal children all from the same lower socioeconomic school population.

2. The ways in which communication behavior is related to personality variables such as self-concept and academic achievement.

3. The possibility of teaching standard English as a second language, by doing so, children who wished to retain their environmental language could do so, and yet operate comfortably in school using standard English. In other words, a retention of cultural bilingualism where children could operate effectively within both forms.
APPENDIX A

STANDARD FORM—ADMINISTERED VERBALLY

1. When a girl grows up, she becomes a
teacher sister son woman
2. A man who flies an airplane is a
postman cowboy fireman pilot
3. To sweep a floor, you would use a
broom mop comb curtain
4. A page is a part of a
play poem book party
5. A very small piece of bread is called a
cake ball cut crumb
6. We use a pencil to
write smoke drink dress
7. One who is rich is
rapid not poor brave not selfish
8. When someone lends you a pen, you
lose it but it borrow it break it
9. If a box has nothing in it, it is
empty large heavy open
10. A pail is another name for
a seat a jar a bucket stairs
11. A person who visits your house is your 
   daughter  enemy  brother  guest 
12. When you say the same thing more than once, you 
   repeat it  copy it  forget it  taste it 
13. One who is honest tells the 
   cause  truth  news  time 
14. If you capture a rabbit, you 
   hurt it  kill it  tease it  catch it 
15. A diamond is 
   dull  precious  dirty  brass 
16. There are sixteen ounces in a 
   pound  foot  sack  inch 
17. The exact middle of something is called its 
   edge  side  center  top 
18. Something which does not cost much is said to be 
   lovely  poor  cheap  valuable 
19. To do something right away is to do it 
   wrong  immediately  steadily  backward 
20. Something which is hard to believe is 
   common  amazing  untrue  clear 
21. To destroy something is to 
   praise it  defend it  develop it  ruin it 
22. To glance is to 
   swim  dash  look  fear 
23. To dine is to 
   cash  die  play  eat
24. An object which is standing still is heavy, large, secure, motionless.
25. When you gain weight, you decrease, increase, lose, remain.
26. A small round stone is called a brick, rock, pebble, mill.
27. A common cold is quite ordinary, unusual, good, pretty.
28. If you are not timid, you are mean, polite, brave, cold.
29. To injure is to encourage, help, hinder, hurt.
30. When there is very little to eat, food is scarce, poor, plentiful, abundant.
31. To loosen the ground around the plants in your garden, you might use a sprayer, a captivator, an elevator.
32. When something expands, it becomes smaller, round, bigger, soft.
33. If your hands are bound, they are dirty, tied, small, strong.
34. If you go to the movies frequently, you go seldom, often, alone, once in a while.
35. A man who sings with a low, deep voice is called a bass, soprano, contralto, tenor.
36. If a park is convenient, it is handy, large, crowded, closed.
APPENDIX B

MODIFIED FORM--ADMINISTERED VERBALLY

1. When you have a little sister and she gets grown, she turns into a

   father  sister  son  woman

2. When a man gets a job flying an airplane, you call him a

   postman  cowboy  fireman  pilot

3. When your floor gets dirty and your mother tells you to sweep it, you use a

   broom  mop  comb  curtain

4. A page is fastened on to a

   play  poem  book  party

5. When you eat a piece of cake and drop pieces of it on the floor it's called a

   cake  ball  cut  crumb

6. We use a pencil to

   write  smoke  drink  dress

7. If you got a lot of money and you are rich, then you are

   rapid,  not poor  brave  not selfish

8. When a tight buddy of yours lends you a pen you lose it

   buy  it  borrow  it  break  it

9. If a box has nothing in it, it is

   empty  large  heavy  open

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10. Sometimes a mop pail is called a
   a seat a jar a bucket stairs
11. When a friend drops by to see you, he is your
   daughter enemy brother guest
12. When somebody raps about the same old thing over
    and over again, they
   repeat it copy it forget it taste it
13. When you are honest and "tell it like it is," then
    you are telling the
   cause truth news time
14. If you cop a rabbit, you
   hurt it kill it tease it catch it
15. A diamond is
   dull precious dirty brass
16. There are sixteen ounces in a
   pound foot sack inch
17. The exact middle of something is called its
   edge side center top
18. A tough dress (suit) that doesn't cost much is
    said to be
   lovely poor cheap valuable
19. To do something right now is to do it
   wrong immediately steadily backward
20. Somebody tells you something and you can't quite
    dig it, it is
   common amazing untrue clear
21. To destroy something is to
   praise it defend it develop it ruin it
22. To glance at somebody who is "find" is to swim dash look fear
23. To dine is to cash die play eat
24. An object which is standing still is heavy large secure motionless
25. When you gain weight, you decrease increase lose remain
26. A small round stond is called a brick rock pebble mill
27. When you get a common cold it's "no big thing," it's quite ordinary unusual good pretty
28. If you are not scared, you are mean polite brave cold
29. To injure is to encourage help hinder hurt
30. When your family ain't got enough food to eat, food is scarce poor plentiful abundant
31. To loosen the ground around the plants in your garden, you might use a sprayer a captivator an elevator a cultivator
32. When you blow something up, it becomes smaller round bigger soft
33. If your hands are bound, they are dirty tied small strong
34. If you go to the movies a lot, you go
   seldom often alone once in a while
35. A man who sings in a low, deep voice is called a
   bass soprano contralto tenor
36. If a park is easy to get to, it is
   handy large crowded closed
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WEAVER, Jon Reyburn, 1945-
VATICANUS OTTOBONIANUS LATINUS 1210 AND
VATICANUS PALATINUS LATINUS 869 FF. 62-69
OF THE BELLUM CIVILE OF MARCUS ANNAEUS
LUCANUS. [Latin Text with English
Introduction and Notes].

The Ohio State University, Ph.D., 1970
Language and Literature, classical

University Microfilms, A XEROX Company, Ann Arbor, Michigan
VATICANUS OTTOBONIANUS LATINUS 1210 AND VATICANUS PALATINUS
LATINUS 869 FF. 62-69 OF THE BELLUM CIVILE
OF MARCUS ANNAEUS LUCANUS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By
Jon Reyburn Weaver, B.A.

* * * * * *

The Ohio State University
1970

Approved by

[Signature]
Adviser
Department of Classics
ACKNOWLEDGMENTS

I would like to express my most sincere thanks to Dr. M. P. O. Morford for providing me with the guidance and materials necessary for the undertaking of this study.

A deep debt of gratitude is also due to Dr. Charles L. Babcock whose advice throughout my undergraduate and graduate years has been invaluable.

The research performed at the Vatican Library by Dr. Carl Schlam and Mrs. Ann Hanson on the manuscripts which are the subject of this study has proved to be indispensable and is deserving of my heartfelt thanks.

Especial appreciation is owing to my wife, Nancy, who has offered her unselfish assistance in the typing of the final draft and has been so understanding and patient through this past year.
VITA

March 16, 1945 . . .  Born - Hanover, Pennsylvania


1966-1968 . . . .  Graduate Assistant, Department of Classics, The Ohio State University

1968 . . . . . . . .  Research Assistant, Center for Medieval and Renaissance Studies, The Ohio State University

1968-1969 . . . .  Fellow, National Defense Education Act

1969-1970 . . . .  Fellow, University Dissertation Fellowship
A NOTE ON ABBREVIATIONS

Citations of the two manuscripts which are the subject of this study and of a limited number of texts, articles, and books continually appear in the text in footnotes, and, rather than employing a lengthier form of reference, I have adopted the following abbreviations:

Vat. Ottob. lat. 1210  Vat. Pal. lat. 869 ff. 62-69
Vaticanus Ottobonianus latinus 1210  Vaticanus Palatinus latinus 869 ff.
62-69

Adnotationes

Clark

Commenta Bernensia

Gotoff
<table>
<thead>
<tr>
<th>Author</th>
<th>Reference</th>
</tr>
</thead>
</table>

The following abbreviations have been used for references to scholarly journals:

- **CPh**: Classical Philology
- **RBen**: Revue Bénédictine
- **RFE**: Revista de Filología Española
- **TAPhA**: Transactions and Proceedings of the American Philological Association
- **TCAAS**: Transactions of the Connecticut
Figure 31. Lognormal Probability Density Function Superimposed Over Observed Frequency Histogram for a Volume of 1264 vph
Figure 32. Lognormal Probability Density Function Superimposed Over Observed Frequency Histogram for a Volume of 1346 vph
Figure 33. Lognormal Probability Density Function Superimposed Over Observed Frequency Histogram for a Volume of 1445 vph
Figure 34. Lognormal Probability Density Function Superimposed Over Observed Frequency Histogram for a Volume of 1595 vph
Figure 35. Lognormal Probability Density Function Superimposed Over Observed Frequency Histogram for a Volume of 1633 vph
Figure 36. Scatter Diagram and Corresponding Linear Equations for Estimates of Mean and Variance
Figure 37. Shifted Lognormal Probability Density Function Superimposed Over Observed Frequency Histogram for a Volume of 1185 vph
Figure 38. Shifted Lognormal Probability Density Function Superimposed Over Observed Frequency Histogram for a Volume of 1264 vph
Figure 39. Shifted Lognormal Probability Density Function Superimposed Over Observed Frequency Histogram for a Volume of 1346 vph
Figure 40. Shifted Lognormal Probability Density Function Superimposed Over Observed Frequency Histogram for a Volume of 1445 vph

Ave. Volume = 1445 vph
Figure 41. Shifted Lognormal Probability Density Function Superimposed Over Observed Frequency Histogram for a Volume of 1595 vph
Figure 42. Shifted Lognormal Probability Density Function Superimposed Over Observed Frequency Histogram for a Volume of 1633 vph
seconds as given by the lognormal distribution. Figure 44 expresses these results as the per cent of headways less than or equal to \( t \) seconds. The next two graphs give results for a volume of 1720 vehicles per hour for lane 1. Figures 47 and 48 show the computer output corresponding to these graphs. As can be seen, the "fit" seems very close.

When applying a chi-square test for "goodness of fit," it was found that in most cases the actual chi-square values tend to be rather high. By studying the histograms along with the superimposed probability density functions of the lognormal, we may see why these large chi-square values arise. Although the theoretical curves obviously follow the general shape of the observed histograms, the variance of small groups of headway frequencies is enough to give a high chi-square value. There is also a tendency to assign probability to the tails of the distribution, whereas in reality these headways may range from zero to a significant number. The chi-square test is not a very forgiving analysis and may be thrown off by only a few "bad" points. In reality, obtaining of actual "good" chi-square fits from data which are influenced by so many unpredictable variables is not fully expected. We are concerned with the ability to analyze the data and describe them accurately in mathematical terms.

We may obtain lower chi-square values in a number of ways. One method of better agreement results from using the shifted lognormal distribution. This results in less over prediction of the very small headways as may be seen from the figures. Another help is the elimination or truncation of the tails of the distribution. We may then use the distribution to predict just up to a given head-
Figure 43. Per Cent of Headways Greater than t Seconds for a Volume of 1462 vph
Figure 44. Cumulative Distribution Function Compared with Observed Headways for a Volume of 1462 vph
Figure 45. Per Cent of Headways Greater than t Seconds for a Volume of 1720 vph
Figure 46. Cumulative Distribution Function Compared with Observed Headways for a Volume of 1720 vph
The Estimate for the Mean of Y is 0.82
The Estimate for the Variance of Y is 0.2964

<table>
<thead>
<tr>
<th>OBSF</th>
<th>F(I)</th>
<th>THF(I)</th>
<th>TH(I)</th>
<th>(OBSF-TH).P.2/TH</th>
<th>PDF(I)</th>
</tr>
</thead>
<tbody>
<tr>
<td>43</td>
<td>0.0672</td>
<td>0.0672</td>
<td>98.2086</td>
<td>31.04</td>
<td>.2389</td>
</tr>
<tr>
<td>631</td>
<td>0.4114</td>
<td>0.3442</td>
<td>503.2257</td>
<td>63.48</td>
<td>.3573</td>
</tr>
<tr>
<td>403</td>
<td>0.6987</td>
<td>0.2874</td>
<td>420.1105</td>
<td>64.18</td>
<td>.2133</td>
</tr>
<tr>
<td>212</td>
<td>0.8529</td>
<td>0.1542</td>
<td>225.4673</td>
<td>64.98</td>
<td>.1056</td>
</tr>
<tr>
<td>85</td>
<td>0.9277</td>
<td>0.0748</td>
<td>109.3184</td>
<td>70.39</td>
<td>.0505</td>
</tr>
<tr>
<td>29</td>
<td>0.9636</td>
<td>0.0359</td>
<td>52.4342</td>
<td>80.86</td>
<td>.0244</td>
</tr>
<tr>
<td>7</td>
<td>0.9811</td>
<td>0.0175</td>
<td>25.6068</td>
<td>94.38</td>
<td>.0121</td>
</tr>
</tbody>
</table>

Figure 4.7. Computer Printout of Results of Lognormal Test for a Volume of 1462 vph in Lane 2
The Estimate for the Mean of Y is 0.77

The Estimate for the Variance of Y is 0.138

<table>
<thead>
<tr>
<th>OBSF</th>
<th>F(I)</th>
<th>THF(I)</th>
<th>TH(I)</th>
<th>(OBSF-TH).P.2/TH</th>
<th>PDF(I)</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>0.0200</td>
<td>0.0200</td>
<td>34.3873</td>
<td>0.17</td>
<td>.1299</td>
</tr>
<tr>
<td>806</td>
<td>0.4233</td>
<td>0.4033</td>
<td>693.7282</td>
<td>18.34</td>
<td>.5254</td>
</tr>
<tr>
<td>644</td>
<td>0.8146</td>
<td>0.3913</td>
<td>672.9730</td>
<td>19.58</td>
<td>.2391</td>
</tr>
<tr>
<td>158</td>
<td>0.9523</td>
<td>0.1377</td>
<td>236.7869</td>
<td>45.80</td>
<td>.0667</td>
</tr>
<tr>
<td>56</td>
<td>0.9883</td>
<td>0.0360</td>
<td>61.9590</td>
<td>46.37</td>
<td>.0164</td>
</tr>
<tr>
<td>20</td>
<td>0.9971</td>
<td>0.0088</td>
<td>15.1248</td>
<td>47.94</td>
<td>.0040</td>
</tr>
<tr>
<td>7</td>
<td>0.9992</td>
<td>0.0022</td>
<td>3.7261</td>
<td>50.82</td>
<td>.0010</td>
</tr>
<tr>
<td>2</td>
<td>0.9998</td>
<td>0.0006</td>
<td>0.9538</td>
<td>51.97</td>
<td>.0003</td>
</tr>
</tbody>
</table>

Figure 48. Computer Printout of Results of Lognormal Test for a Volume of 1720 vph in Lane 1
Still another factor to consider in the data tested is the fact that these data represent peak hour traffic flow and thus quite often contain disturbances. By looking at the time-distance trajectories of the vehicles we may see if the headways are collected within a disturbance or not. If the lognormal predicts fairly accurately under these conditions, it should be expected to be even more reliable under more stable flow.

In order to eliminate some of the difficulties inherent in the chi-square test, another statistical test was also applied. This is the Kolmogorov-Smirnov test for goodness of fit. In order to use this test we must have a continuous distribution, which we do have. The Kolmogorov-Smirnov test is concerned with the maximum deviation of the sample distribution function \( F_n(x) \) from the theoretical distribution function \( F(x) \). This test turns out to be much more forgiving and thus more applicable to our situation. The subscript \( n \) represents the number of intervals used.

Let the random variable \( D_n \) be given by: 
\[
D_n = \text{maximum} | F_n(x) - F(x) |
\]

i.e., \( D_n \) is the maximum deviation of the sample distribution function \( F_n(x) \) from the theoretical distribution function \( F(x) \). Then \( D_n \) has itself a distribution function which we may call \( L_n(t) \) and write: 
\[
L_n(t) = \text{Probability} (D_n < t).
\]

If \( D_n \) is small then this implies that \( F(x) \) is a good approximation to the sample distribution. Values of \( D_n \) will be called large if they have a small probability of occurrence when \( F(x) \) is the true distribution. We define the significance level of the
test \( a \) to be
\[
\alpha = P(D_n > t_\alpha \mid F(x) \text{ is the distribution function of } X)
\]
where \( t_\alpha \) is a real number to be determined. Thus if \( D_n \leq t_\alpha \), we accept the hypothesis that \( F(x) \) is the true distribution function.

This test corresponds to comparing the cumulative distribution functions as shown graphically in Figures 44 and 46. An example of the form of table used is shown in Table 12 below. This shows a good fit for a volume of 1720 vehicles per hour at the 5 per cent significance level. Finally, the comparison of the lognormal distribution with other previously used distributions, under the same conditions, provides a direct measure of the relative reliability of the model.

Figure 49 shows the three parameter lognormal fitted over a histogram of observed frequencies for an average volume of 1720 vehicles per hour in lane 1. Figure 46 shows the same fit with the cumulative distribution function. The actual form of the computer output is shown in Figure 48. This gives the cumulative chi-square values so that any large jumps may be seen. Figures 44, 47, and 50 show the same graphs and chi-square tests for an average volume of 1462 vehicles per hour in lane 2.

Time-distance trajectories for the corresponding photographs are shown in Figures 51 and 52. From these, we can see that in lane 1 we are just beginning to leave a disturbance and in lane 2 there is only a slight disturbance.
Table 12. Application of the Kolmogorov-Smirnov Test to a Volume of 1720 vph

<table>
<thead>
<tr>
<th>Range of x</th>
<th>$F_n(x)$</th>
<th>$F(x)$</th>
<th>Differences</th>
<th>$F_n(x) - F(x)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 &lt; x ≤ 1</td>
<td>0.013</td>
<td>0.020</td>
<td>0.002</td>
<td>0.467</td>
</tr>
<tr>
<td>1 &lt; x ≤ 2</td>
<td>0.487</td>
<td>0.423</td>
<td>0.064</td>
<td>0.438</td>
</tr>
<tr>
<td>2 &lt; x ≤ 3</td>
<td>0.861</td>
<td>0.814</td>
<td>0.047</td>
<td>0.039</td>
</tr>
<tr>
<td>3 &lt; x ≤ 4</td>
<td>0.953</td>
<td>0.952</td>
<td>0.001</td>
<td>0.034</td>
</tr>
<tr>
<td>4 &lt; x ≤ 5</td>
<td>0.986</td>
<td>0.988</td>
<td>0.002</td>
<td>0.009</td>
</tr>
<tr>
<td>5 &lt; x ≤ 6</td>
<td>0.997</td>
<td>0.997</td>
<td>0.000</td>
<td>0.002</td>
</tr>
<tr>
<td>6 &lt; x ≤ 8</td>
<td>0.999</td>
<td>0.999</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

$n = 7\quad D_n = 0.467\quad \alpha = 0.05\quad t_\alpha = 0.483$

$D_n = 0.467 < 0.483 = t_\alpha \quad$ good fit at $\alpha = 0.05$
Figure 49. Lognormal Probability Density Function Superimposed Over Observed Frequency Histogram for a Volume of 1720 vph
Figure 50. Lognormal Probability Density Function Superimposed Over Observed Frequency Histogram for a Volume of 1462 vph
Figure 51. Time-Distance Diagram for Lane One Southbound
Showing Region of Collected Data
Figure 52. Time-Distance Diagram for Lane Two Southbound
Showing Region of Collected Data
Comparison of the Lognormal with Other Distributions

In order to further evaluate the model, a comparison with the fit of other models to the same data was made. In particular, computer programs were developed to fit the Pearson Type III and composite exponential to the data. Comparing these, a study of the relative goodness of fit was made in addition to the absolute goodness of fit. The results of the graphical fits are shown in Figures 53 through 62. These show both the shape of the curves and the cumulative distribution curves. As may easily be seen, all cases resulted in much worse fits with either the Pearson Type III or composite exponential. It can be seen that by changing $k$ from 2 to 3 in order to get higher peaks with the Type III, the curve is spread out considerably. Any further increase simply spreads the curve more, as proved in Chapter Two.

The actual computer programs developed may be found following these curves. These are provided for the convenience of anyone wishing to use them.
Figure 53. The Lognormal, Pearson Type III, and Composite Exponential Density Functions Superimposed Over the Observed Frequency Histogram for a Volume of 1462 vph
Figure 54. Comparison of the Cumulative Distribution Functions of the Lognormal, Pearson Type III, and Composite Exponential with the Observed Cumulative Distribution for a Volume of 1462 vph
Figure 55. The Lognormal, Pearson Type III, and Composite Exponential Density Functions Superimposed Over the Observed Frequency Histogram for a Volume of 1720 vph
Figure 56. Comparison of the Cumulative Distribution Functions of the Lognormal, Pearson Type III, and Composite Exponential with the Observed Cumulative Distribution for a Volume of 1720 vph
DIMENSION (OBF(30), THFQ(30), F(30), PDF(30), CHI(30))-
FLOATING (LAMDA)-
INTEGER (OBF)-

START READ INPUT, INPUT1, (JSETS)-
J=1-
READ1 READ INPUT, INPUT2, (K, LAMDA)-
F INPUT1 (I2)-
F INPUT2 (I2, F6.3)-
WRITE OUTPUT, OUT1, (K, LAMDA)-
F OUT1 (97TH1THE FOLLOWING IS A TABLE OF THE TYPE3
   DISTRIBUTION WITH THE PARAMETERS K AND LAMDA
   RESPECTIVELY=, 12, 3X, F6.3)-
WRITE OUTPUT, OUT2-
F OUT2 (30HO X F(X) PDF(X))- 
TRANSFER TO (D)2 PROVIDED (K, G, 1)-
DO1 DO THROUGH (LOOP1), I=1, 1, I.LE.25-
F(I)=I-EXPE. (-LAMDA*I)-
PDF(I)=LAMDA*EXPE. (-LAMDA*I)-
LOOP1 WRITE OUTPUT, OUT3, (I, F(I), PDF(I))- 
TRANSFER TO (END)-
F OUT3 (4HO, 12, 5X, F7.4, 5X, F7.4)-

Figure 57. Pearson Type III Distribution Computer Program
DO2 TRANSFER TO (DO3) PROVIDED (K.G.2)-
DO THROUGH (LOOP2), I=1,1,I.LE.25-
F(I)= -LAMDA*I*EXPE.(-:AMDA*I0+1-EXPE.(-LAMDA*I)-
PDF(I)=LAMDA.P.2*EXPE.(-LAMDA*I)*I-
LOOP2 WRITE OUTPUT, OUT3, (I, F(I), PDF(I))-
TRANSFER TO (END)-

DO3 TRANSFER TO (DO4) PROVIDED (K.G.3)-
DO THROUGH (LOOP3), I=1,1,I.LE.25-
F(I)=(-LAMDA.P.2*I.P.2*EXPE.(-LAMDA*I))/2.-LAMDA*I*
EXPE.(-LAMDA*I)+1-EXPE.(-LAMDA*I)-
PDF(I)=(LAMDA.P.2*EXPE.(-LAMDA*I)*I.P.2)/2.-
LOOP3 WRITE OUTPUT, OUT3, (I, F(I), PDF(I))-
TRANSFER TO (END)-

DO4 DO THROUGH (LOOP4), I=1,1,I.LE.25-
F(I)=(-LAMDA.P.3*I.P.3*EXPE.(-LAMDA*I))/6.-(LAMDA.
P.2*EXPE.(-LAMDA*I))/2.-LAMDA*I*EXPE.(-LAMDA*I)
+1-EXPE.(-LAMDA*I)-
PDF(I)=LAMDA.P.4*EXPE.(-LAMDA*I)*I.P.3)/6.-
LOOP4 WRITE OUTPUT, OUT3(I, F(I), PDF(I))- 
END J=J+1-
READ INPUT, FRNU, (NUM, NUMT)-

Figure 57. Continued
F FRNU (12, 14)-
READ INPUT, OBSFRQ, ((OBF(I), I=1, 1, I.LE.NUM))-F OBSFRQ (2013)-
CHI(0)=0.-
DO THROUGH (CHISQ), I=1, 1, I.LE.NUM-
THFQ(I)=(F(I-1))*NUMT-
CHISQ
CHI(I)=CHI(I-1)+(THFQ(I)-OBF(I)). P. 2/THFQ(I)-
WRITE OUTPUT, HEAD1, (CHI(I-1))-F HEAD1 (25) THE CHI-SQUARE VALUE IS, F8.3)-
WRITE OUTPUT, HEAD2, (2*NUM-1)-F HEAD2 (36) THE NUMBER OF DEGREES OF FREEDOM IS, I2)-
TRANSFER TO (READ1) PROVIDED (J.LE.JSETS)-
CALL SUBROUTINE ()=END JOB. ()-
END PROGRAM (START)-

Figure 57. Concluded
C COMPOSITE EXPONENTIAL DISTRIBUTION -
DIMENSION (F(60), THF(60), OBSF(60), TII(60), CII(60)) -
FLOATING (N) -
INTEGERS (OBSF) -

START READ INPUT, IN1A, (NSETS) -

F IN1A (I2) -
K = 1 -

READ READ INPUT, IN1, (N, B1, B2, TMIN) -

F IN1 (F5. 3, 2F6. 2, F4. 2) -
READ INPUT, IN2, (NUM, NUMT) -

F IN2 (I2, I4) -
READ INPUT, IN3, ((OBSF(I), I = 1, 1, I, LE. NUM)) -

F IN3 (24I3) -
WRITE OUTPUT, OUT1 -

F OUT1 (37HO F(I) THF(I) TH(I) OBSF(I)) -
T = 0. -
F(0) = 0. -

DO THROUGH (LOOP1), I = 1, 1, I, LE. NUM - 1 -
T = T + 0.5 -
F(I) = (1-N)*(1-EXPE. (-T/B2))*(1-EXPE. (-TMIN)/(B1- TMIN)) -

Figure 58 . Composite Exponential Distribution Computer Program
\[ THF(I) = F(I) - F(I-1) \]
\[ TH(I) = NUMT * THF(I) \]

**LOOP1**

WRITE OUTPUT, OUT2, \( (F(I), THF(I), TH(I), OBSF(I)) \)

**OUT2**

\( (2HO, F5.4, 5X, F5.4, 3X, F8.4, 4X, I3) \)

\( T = T + 0.5 \)

\[ F(NUM) = (1-N) * (1 - \text{EXPE.} (-T/B2)) + N \times (1 - \text{EXPE.} (-T / (T-TMIN)) / (B1-TMIN)) \]

\[ TH(NUM) = NUMT - F(NUM) * NUMT \]

\[ THF(NUM) = 1 - F(NUM) \]

WRITE OUTPUT, OUT2, \( (F(NUM), THF(NUM), TH(NUM), OBSF(NUM)) \)

WRITE OUTPUT, OUT3-

**OUT3**

\( (1HO \ (OBSF-TH), P.2 / TH) \)

\[ CHI(I) = 0 \]

DO THROUGH (LOOP2), \( I = 1, 1, I \ . \ LE \ . \ NUM \)

\[ CHI(I) = CHI(I-1) + (OBSF(I) - TH(I)) \times P.2 / TH(I) \]

**LOOP2**

WRITE OUTPUT, OUT4, \( (CHI(I)) \)

WRITE OUTPUT, OUT5, \( (CHI(I-1)) \)

**OUT4**

\( (9HO, F8.2) \)

**OUT5**

\( (25HO \ \text{THE CHI-SQUARE VALUE IS}, F8.2) \)

---

**Figure 58. Continued**
\[ K = K + 1 \]

TRANSFER TO (READ) PROVIDED (K LE NSETS)

CALL SUBROUTINE \( 0 = \) END JOB \( 0 \)

END PROGRAM (START)

Figure 58. Concluded
The obvious question that arises with regard to a mathematical model which describes an aspect of traffic flow is what use may be made of the model. One answer, from the theoretical point of view, is that the model is a use in itself. The more that we are able to describe in theoretical terms, the more we will understand the complex behavior of traffic.

More specifically, a mathematical model provides us with a valuable tool. This tool is even more valuable since the advent of the digital computer. A digital computer may be used to simulate actual traffic conditions. Using simulation we may study situations which are difficult to observe in real life. As two applications of the lognormal, we consider intersection studies and ramp control for merging maneuvers.

Intersection Studies

The simulation of the operation of an intersection is a problem which is being studied since the advent of the high speed digital computer. In order to simulate intersection operation, a necessary variable is the arriving times of vehicles at the entry points of the intersection. These arriving times may be either read into the computer or generated internally. The headways may be
approximated by using the lognormal distribution. Given any volume, previously
derived regression equations may be used to provide estimates for the para-
eters and the appropriate lognormal distribution may be applied.

In order to generate the arrivals, the Monte Carlo method may be used.
To make use of the arrivals, it is necessary to have a table of random numbers.
Since the computer will be used for the simulation, it is desirable to generate
random numbers inside the computer for use. Random number library sub-
routines are usually available at any computer center.

The term random number is a precise definition. It corresponds to what
we intuitively think of as "random." A probabilistic definition may be given as
follows:

Let S be a set of repeated independent trials. Suppose the possible out-
comes of these trials are \( p \) mutually exclusive events with equal probability \( 1/p \).
Let each event be a number containing \( n \) digits. Then the group of numbers which
represents the outcomes of the experiment is called a group of random numbers,
each with \( n \) values.

In order to use the Monte Carlo method, the probability of a given headway
range is computed first by using the lognormal distribution. A group of random
numbers may then be assigned to each possible headway range in direct propor-
tion to the probability of the given range. The random numbers are then drawn
from the table or generated in the computer by calling a random number sub-
routine. To each of the random numbers there corresponds a headway. Each
generated headway may then be added to the previous arriving time to get the
next arrival time.
A computer program has been written to generate arriving times for an intersection with eight lanes, two from each direction. A sample of the typical output from this program is shown below. The lanes are numbered from 0 to 7. ARR(I, J) represents the arrival time of the \( j^{th} \) vehicle in lane I, HW is the headway between vehicles, and T is the actual random number called.

\[
\begin{align*}
\text{ARR}(0, 1) &= 2.0 \quad \text{HW} = 2 \quad T = 0.2011 \\
\text{ARR}(0, 2) &= 4.0 \quad \text{HW} = 2 \quad T = 0.3875 \\
\text{ARR}(0, 3) &= 7.0 \quad \text{HW} = 3 \quad T = 0.4472 \\
\text{ARR}(1, 1) &= 6.0 \quad \text{HW} = 6 \quad T = 0.2342 \\
\text{ARR}(1, 2) &= 15.0 \quad \text{HW} = 9 \quad T = 0.9478
\end{align*}
\]

The new variables used not previously defined are as follows:

- VOL(I) - volume desired in lane I
- TIMEL - time limit set for routine to run
- TIMET - total accumulated headway
- FRANUD. - floating point random number call

The computer program, written in SCATRAN language for use on the IBM 7094 digital computer, is shown below.

```
INTEGER(HW)
DIMENSION(F(1209, NNN), THF(1208, NNN), TH(1208, NNN), HW(1208, NNN), VOL(8), YMEAN(8), VARY(8))
READ INPUT, INAA, (TIMEL, NUM)
FINAA (F5.0,12)
READ INPUT, INAB, ((VOL(I), I=0, 1, I. LE. 7))
```
FINAB (3F4.0)-

DO THROUGH (LOOP 2), I=0,1,I.LE.7-

YMEAN(I) = 2.076-0.001*VOL(I)-
VARY(I) = 0.5670-0.00006*VOL(I)-
S=0.5-

DO THROUGH (LOOP 3), L=1,I.LE.NUM-
S=S + 0.5-

SLN = LN.(S)-
Z=(SLN-YMEAN(I))/SQRT.(VARY(I))- CALL FUNCTION (F(I, L))=NORMAL.(Z)-
THF(I, L)=F(I, L)-F(I, L-1)-

LOOP 3 TH(I, L)=THF(I, L)*VOL(I)-
TH(I, NUM)=VOL(I)-F(I, NUM)*VOL(I)-

LOOP 2 CONTINUE-

DO THROUGH (LOOP C), I=0,1,I.LE.7-

TIMET = 0-

DO THROUGH (LOOP D), J=1,1,J.LE.JMAX(I)- CALL FUNCTION(T) = FRANUD. ()-

DO THROUGH (LOOP B), L=1,1,L.LE.NUM- PROVIDED (T.LE.F(I, L)), TRANSFER TO (SET1)- PROVIDED (T.G.F(I, NUM)), TRANSFER TO (SET2)- TIMET=TIMET + HW(I, J)-

F OUT2B (5HOARR(II,1H,,I3,2I)=,F6.1)-
LOOP B  TRANSFER TO (LOOP C) PROVIDED (TIMET.G.TIMEL)

SET 2   HW(I,J)=7200/VOL(I)
        ARR(I,J)=ARR(I,J-1)+HW(I,J)

TRANSFER TO (LOOP D)

SET 1   HW(I,J)=L
        ARR(I,J)=ARR(I,J-1)+HW(I,J)

LOOP D  WRITE OUTPUT, OUT2B, (I,J,ARR(I,J))

LOOP C  CONTINUE

Ramp Control and Merging Maneuvers

Similarly, the lognormal distribution may be used when studying the acceptance of gaps on a freeway. The purpose of studying freeway merging is to determine the relationships between the variables involved with the interaction of vehicles merging from a ramp into the traffic stream.

One method of studying this is simulation by a digital computer. This simulation may then be used to determine optimum ramp metering. This provides the opportunity to study the effect of metering without direct methods. It may show relationships of variables and which of them are of importance.

The vehicle waiting on the ramp must find an acceptable gap in the traffic stream on the freeway. Once the acceptable conditions are defined, it is necessary to generate the gaps in the traffic flow. This may be accomplished by using the lognormal to determine the distribution of gaps. Next, by using the Monte Carlo method shown above, we may generate random numbers, and their associated headways will give us the arriving rates of vehicles at the points of
merging. The same program developed for simulation at an intersection may be used to generate the gaps. On the freeway, the number of lanes would be reduced from eight to the appropriate number, depending upon the freeway simulation desired.
CHAPTER SIX.

SUMMARY

The objective of this study is the development of a reliable mathematical model for use as a vehicular headway distribution. Although many proposals have been made, none has adequately solved this problem. Different models have been proposed for different traffic volumes, but these are unacceptable over a wide range of conditions.

The approach taken is a probabilistic one, in comparison with a deterministic approach. The probability function used is a derivative of the well established and studied normal distribution. This is an advantage over other distributions because of its simplicity and the vast amount of knowledge that has accumulated concerning the normal distribution. The probability distribution is one that assumes that not the sample values, but the logarithm of the sample values, has a normal distribution. It is appropriately called the lognormal distribution.

In addition to the actual formulation of the model, methods to estimate the parameters involved are developed. These are necessary, since without reliable estimates for the parameters, the distribution could not be applied to actual traffic conditions.

Data collection, reduction, and processing are necessary parts of this study in order to test the model with real life conditions. The testing of the model
covers a wide range of volumes, and along with these, a wide range of conditions. Data are collected by means of aerial photography.

The actual methods of testing the data consist of graphical methods and statistical methods of testing for "goodness of fit". The statistical tests used are the Kolmogorov-Smirnov test and a chi-square test. The fits of the data with the lognormal are compared with the fits obtained with other distributions, namely the composite exponential and the Pearson Type III. These two distributions have previously been used with the best results.

Digital computer programs are developed for using the lognormal, Pearson Type III, and composite exponential distributions. A modified three parameter or shifted lognormal is tested using the computer programs developed.

**Significance of Results**

The results of this study may best be observed by considering Table 13 below. This contains the form of three headway distributions, along with their parameters and the parameter estimations. Specific volume ranges are given, together with results indicating the accuracy of the model and whether any statistically good fits were obtained.

The term "good" refers to obtaining a good statistical fit with the Kolmogorov-Smirnov test at the 5% significance level. The term "very good" refers to obtaining a good statistical fit with the chi-square test. "Fair" refers to a fair graphical fit, while "poor" refers to a poor graphical fit.

The results show that in all cases the lognormal produces significantly
better results than the other two distributions. Even in the case when the flow is extremely high, the lognormal gives good results. Statistically "good" fits are extremely hard to obtain with a chi-square test, mainly because of the ability of small variances in data to invalidate it. The use of the Kolmogorov-Smirnov test overcomes this and produces statistically good fits. In areas where peak hour flow is not being tested and there is less congestion, the chi-square test has yielded "good fits". Shifting the lognormal by use of three parameters normally gives better results. The ability of the lognormal to describe accurately the distribution of vehicular headways is verified over a wide range of volumes. It would seem that the use of either the composite exponential or Pearson Type III for predicting headways would be of no value when compared with the reliability and accuracy of the lognormal.

Specific advantages of the lognormal are:

1. **Simplicity in form.** The form of the probability density function is simpler than either the composite exponential or the Pearson Type III. Although the negative exponential and shifted exponential are less complicated, these are virtually of no use as headway distributions.

2. **Simplicity of use.** The lognormal is simple to use, since it is necessary only to use the normal function with a change of variable.

3. **Completeness of development.** Fortunately, since the lognormal is directly related to the normal distribution, most of the well developed properties hold.

4. **Ease of parameter estimation.** The only two parameters which require
estimation are the mean and variance. These may be systematically estimated by the methods described in the text. In order to estimate the third parameter in the three parameter form, a direct choice may be made from observing the data or previous values may be used.

5. Accuracy. This is the most important advantage. The lognormal is accurate, even under a wide variety of conditions. Neither the the composite exponential or the Pearson Type III provide the same degree of accuracy.

Future Recommendations

A highly reliable and accurate model for the distribution of vehicular headways has been developed and tested in this study. Future work should center on the application of this model.

Ramp control and merging is an area in which this model could be applied to advantage. Lane changing near entrance and exit ramps may be studied to consider the probability of a vehicle leaving the freeway or switching lanes.

The aerial photogrammetric techniques developed would lend themselves to the study of traffic flow in the area of ramps.

Further study could be done on the effect that speed and density have on the distribution, in addition to volume.
Table 13. Summary of Results of Fitting Headways with Various Distributions

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Three Parameter Lognormal</th>
<th>Lognormal</th>
<th>Pearson Type III</th>
<th>Composite Exponential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability Density Function</td>
<td>( \frac{1}{\sigma(x-a)\sqrt{2\pi}} e^{-\frac{[ln(x-a)-\mu]^2}{2\sigma^2}} )</td>
<td>( \frac{1}{\sigma x \sqrt{2\pi}} e^{-\frac{[ln x-\mu]^2}{2\sigma^2}} )</td>
<td>( \lambda k e^{-\lambda x} e^{k-1} \frac{\Gamma(k)}{\Gamma(k)} )</td>
<td>( (1-n)(1-e^{-\frac{t}{b_2}}) + n(1-e^{-\frac{t}{(b_1-\Delta)}}) )</td>
</tr>
<tr>
<td>Parameters Involved</td>
<td>( \mu,\sigma^2,a )</td>
<td>( \mu,\sigma^2 )</td>
<td>( \lambda, k )</td>
<td>( b_1, b_2, \Delta, n )</td>
</tr>
<tr>
<td>Estimates of Parameters</td>
<td>( \hat{\mu} = \frac{1}{n} \sum \ln x_i )</td>
<td>( \hat{\mu} = \frac{1}{n} \sum \ln x_i )</td>
<td>( \lambda = \frac{kn}{\sum x_i} )</td>
<td>( \frac{n_{\text{volume of free moving vehicles}}}{\text{total volume}} )</td>
</tr>
<tr>
<td>( \sigma^2 = \frac{1}{n} \sum (\ln x_i - \hat{\mu})^2 )</td>
<td>( \sigma^2 = \frac{1}{n} \sum (\ln x_i - \hat{\mu})^2 )</td>
<td>( k = \text{constant} )</td>
<td>( b_1 = \text{average headway of free moving vehicles} )</td>
<td></td>
</tr>
<tr>
<td>( a = \text{constant} )</td>
<td>( a = \text{constant} )</td>
<td>( \text{volume of free moving vehicles} )</td>
<td>( b_2 = \text{average headway of constrained vehicles} )</td>
<td></td>
</tr>
<tr>
<td>( \text{Volume Range (vph)} )</td>
<td>( \text{Very Good} )</td>
<td>( \text{Very Good} )</td>
<td>( \text{Fair} )</td>
<td>( \text{Poor-Fair} )</td>
</tr>
<tr>
<td>800-900</td>
<td>-</td>
<td>Very Good</td>
<td>Fair</td>
<td>Poor-Fair</td>
</tr>
<tr>
<td>900-1000</td>
<td>-</td>
<td>Very Good</td>
<td>Fair-Good</td>
<td>Poor-Fair</td>
</tr>
<tr>
<td>1000-1100</td>
<td>-</td>
<td>Very Good</td>
<td>Fair</td>
<td>Poor-Fair</td>
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<td>Very Good</td>
<td>Fair</td>
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<td>Fair</td>
<td>Poor</td>
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REFERENCES.


SELECTED BIBLIOGRAPHY


