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An Investigation of Teacher Voice Signal Amplification Treatment for Mediating Speech Communication Interference from Jet Aircraft Noise Intrusion and from Minimal Hearing Loss in First and Second Grade Classrooms

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An Investigation of Teacher Voice Signal Amplification Treatment for Mediating Speech Communication Interference from Jet Aircraft Noise Intrusion and from Minimal Hearing Loss in First and Second Grade Classrooms

by

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ABSTRACT

Kenneth Kaufman

AN INVESTIGATION OF TEACHER VOICE SIGNAL AMPLIFICATION TREATMENT FOR MEDIATING SPEECH COMMUNICATION INTERFERENCE FROM JET AIRCRAFT NOISE INTRUSION AND FROM MINIMAL HEARING LOSS IN FIRST AND SECOND GRADE CLASSROOMS

In this investigation, classroom teacher voice amplification technology was evaluated to assess its utility in overcoming two suspected forms of speech communication interference, i.e., jet aircraft noise intrusion (JANI) and minimal hearing loss (MHL).

Descriptive research was employed to summarize the prevailing exterior noise level at three elementary school sites near Chicago's O'Hare International Airport while simultaneously collecting 1,037 hearing acuity threshold values. Results were incorporated into an experimental design to compare prereading performance growth of amplification treatment subjects with control subjects over a ninety-day period. Multivariate analysis of covariance tests of 339 experimental observations generated the following results.

Across six subskill response variables, the overall treatment effect was significant, $p = 0.0012$. Significant treatment effects were evidenced on three isolated responses i.e., phoneme-grapheme-consonants, $p = 0.0311$; auditory discrimination, $p = 0.0134$; and phonetic analysis, $p = 0.0001$. Overall, it appears that the magnitude and practical significance of treatment effects were substantial. In grade level equivalents, the difference was comparable to one year and one month on the

auditory discrimination response and five months on the phonetic analysis response.

The attempt to isolate treatment effects on the MHL factor was successful, $p = 0.0017$. The attempt to isolate treatment effects on the JANI factor was inconclusive. Differences in treatment effects between school sites did not parallel differences in noise levels between school sites. It can be generalized, however, that amplification intervention was functional across exterior noise levels (Leq) ranging from 65.5 to 71.5 decibels.

The following inferences about the nature of MHL appear to have been supported by the separate nonparametric tests of the hearing threshold observations. Using 15 dB HL as a low-fence cut-off, 66% of the pooled first and second grade sample evidenced MHL as compared with 45% of the pooled fifth and sixth grade sample. In addition to the age-dependent tendency, MHL demonstrated a propensity toward reidentification over time. Also, contrary to public perception, MHL prevalence did not align itself with exterior noise levels among the three school sites.

Recommendations for applying the findings to school organizational practice and for improving present and future research on the topic are presented.

ACKNOWLEDGMENTS

Many people and organizations contributed to the completion of this investigation. Appreciation is extended to the Bensenville Elementary School District 2 Board of Education for supporting the study over a two year period; to Dr. J.R. Coad, Superintendent of Schools, for perceiving the need for the study; and to the 764 students, eighteen teachers and three principals who actively participated.

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VITA

The author, Kenneth Kaufman, was born September 21, 1932, in Springfield, Illinois.

He received his elementary, secondary and junior college education in Springfield. The degree of Bachelor of Science in education was obtained in June, 1958 from Illinois State University. The degree of Master of Science in educational administration was received in June, 1963, from Northern Illinois University.

Following five years of teaching at the junior high school level, Mr. Kaufman served for three years as Superintendent of the Steward, Illinois Elementary School District. For the past eighteen years, Mr. Kaufman has worked as the assistant superintendent of Bensenville Elementary School District

Mr. Kaufman served as president of the Board of Trustees for the Bensenville Public Library District for ten years and is currently on the educational advisory board of Elmhurst College, Elmhurst, Illinois. While engaged in this research project, Mr. Kaufman spoke frequently before airport related groups including The Illinois Pollution Control Board, The Federal Aviation Administration, The City of Chicago - Department of Aviation, The O'Hare Advisory Committee, The Suburban O'Hare Commission and The Bensenville Environmental Protection Coalition.

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CHAPTER I

INTRODUCTION

Attention is being systematically directed towards those variables in educational environments that are alterable. The political and economic climate of the times require curriculum planners to be watchful for incremental advances in efficiency and effectiveness leading to increases in student productivity. Tyler (1982) draws a parallel between the 1980's and the 1930's for educational planning and pleads for inventive solutions and dynamic responses to economically imposed constraints. Walberg proposes that "even small gains in productivity can bring about immense savings, including conservation of those precious resources, time and energy of both educators and students" (Walberg, 1979, p.3).

In a broad sense this investigation focuses on variables in the learning environment suspected of being alterable. The overall goal is to advance the conservation of time and energy of both students and teachers so as to increase productivity.

In a narrower sense, the study examines two factors suspected of contributing to speech communication interference in the auditory environment of elementary school classrooms. One interference factor, jet aircraft noise intrusion, is a man-made acoustical impingement upon the classroom environment. The other interference factor, minimal hearing loss, is a physiological deficit characteristic of some students continuously and of other students intermittently.

Prior to discussing the background of the problem for both interference factors, there is a need to present a theoretical framework supporting the rationale for including two separate analyses in the investigation. Denes and Pinson (1963) have developed a paradigm for describing the complex chain of events that occurs from the inception of a message in the mind of a speaker to its reception in the mind of a listener. This temporal sequence of events has been entitled "The Speech Chain" by its originators.

Figure 1 illustrates five different levels of classification in the speech chain. This paradigm enables one to isolate attention on either discrete events or on continuous phenomena along the speech chain. It will be utilized throughout the study as a theoretical framework to facilitate discussion and analysis of the interference problems from jet aircraft noise intrusion at the acoustical level and from minimal hearing loss at the physiological level. An intervention procedure to mediate either or both problems is tested. The utility of the treatment is evaluated in terms of its success at the linguistic level of the listener on the speech chain.

Background of Problem

Researchers O'Fallon and Young (1982), affiliated with the School Planning Laboratory at the University of Tennessee, report on a variety of facility variables that interact with programmatic variables to affect educational outcomes. Facility variables found to affect learning include thermal, visual, classroom environmental, and aural factors. In reviewing their findings on hearing and sound, the researchers postulate that "a school by nature produces noise and by necessity requires

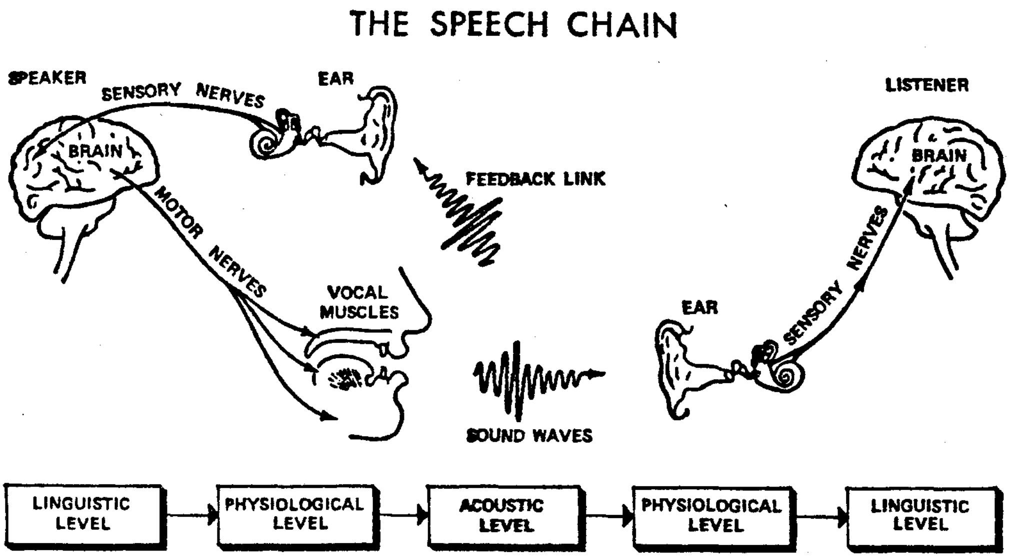

Fig. 1. The Speech Chain: the different forms in which a spoken message exists in its progress from the mind of the speaker to the mind of the listener.

Figure 1: The Speech Chain

Source: Figure 1 reproduced from The Speech Chain by Peter B. Denes and Elliot N. Dinson. Copyright 1963 by Bell Telephone Laboratories Incorporated. Reproduced by permission of Doubleday and Company, Inc. (February 23, 1983).

quiet" (O'Fallon and Young, 1982, p.286).

The O'Fallon and Young postulate crystallizes the paradox faced by schools and introduces the nature of the problem being studied. All schools must abate and control sounds from within; some schools, particularly those located by large metropolitan airports, must additionally attend to sounds intruding from the exterior. Further, regardless of its source, sound is suspected to have a differential impact on students. An understanding of the interaction between sound, noise, and hearing acuity is central to managing an efficient and effective auditory environment for learners. Sound, noise, and hearing acuity are conceptual variables that defy precise classification. Noise is defined as "unwanted sound" by the U.S. Environmental Protection Agency (1976, p.11). By definition, noise is a subjective phenomenon, i.e., sound to some is noise to others. Similarly, hearing acuity has a distribution of values unique for each individual.

Using the Speech Chain as a theoretical model, this investigation examines the utility of teacher voice signal amplification for mediating two distinct speech communication interference problems in a public school setting.

Jet Aircraft Noise Intrusion Problem

An unresolved, social and educational issue is the impetus for the study. Bensenville, Illinois, a collar community of O'Hare International Airport, is located adjacent to the westbound and most frequently used runway of the airport (Chicago, Department of Aviation, May, 1982, IV-52). Community and school officials are concerned about the current and projected levels of noise disruption and the resultant effect on citizens and on the learning process in schools. Resolution of the conflict between expanding airports and sensitive neighbors is receiving attention at all governmental levels including local, area, state, national and international.

According to a research report of the Illinois Institute of Natural Resources (1981), "aircraft noise is a significant annoyance to more than 850,000 Illinois residents, about 8 percent of the state's population. The problem is especially serious at Chicago's O'Hare International Airport..." (Illinois Institute of Natural Resources, 1981, p.vii).

Cooperative effort by the participants in the conflict has been urged by the Illinois Institute of Natural Resources (1981).

> Coordinated joint action by airport proprietors and local governments in noise impacted areas surrounding airports in the preparation and implementation of noise abatement programs offers the most promising means for making the optimum use of available techniques for dealing with airport noise (p.1-6).

In recognition of the national magnitude of the problem, the United States Congress on September 3, 1982 legislated Public Law 97-248, <u>Tax Equity And Fiscal Responsibility Act of 1982</u>, which includes subsection 505, "Airport Improvement Program" (United States Congress, 1982). A provision is made for airport noise compatibility programs including soundproofing of public buildings. An aggregate amount of $4,789,700,000 through fiscal year 1987 for administering the airport improvement program has been allocated by Congress in the act.

Internationally, an issue of critical importance was identified at the Third International Congress on Noise as a Public Health Problem (Freiburg, West Germany, 1978). The acceptability of an effect, caused by noise, was positioned as a political decision not a scientific problem, although "....scientific evidence will hopefully be used" (Rylander, 1978, p.602). In effect, there is no prevailing demarcation point or regulation identifying an unacceptable noise level for schools such that specific mitigation measures are required. In recognition of the political nature of the noise issue at O'Hare Airport, a variety of organized community advocacy groups were formed during the early 1980's to resist further noise intrusion and to advocate noise mitigation measures.

At the community level, an intergovernmental group, the Bensenville Environmental Protection Coalition, was formed in 1980 to resist further aircraft noise intrusion. At the area level, the Suburban O'Hare Commission was formed in 1981 to provide a communications vehicle between the airport owner, the City of Chicago, and the collar communities. Further, the O'Hare Advisory Committee was formed in 1982 to serve a function of planning and articulating between all affected parties including the people of the area, represented by the Suburban O'Hare Commission, the airport owner, and the Federal Aviation Administration.

At the school district level, considerable effort has been expended to influence the O'Hare Airport proprietor, i.e., the City of Chicago, to assume responsibility for school specific noise mitigation measures, particularly the soundproofing objective. Appendix F includes recent FAA documentation on the status of soundproofing two of the three school in this investigation.

School district officials in Bensenville have adopted a pragmatic approach to the resolution of the noise problem. At times, the school district has acted independently, and at other times, it has acted in concert with any and all other public agencies intent on noise abatement advocacy. Since 1980 three generalized objectives have been pursued by school district officials. First, effort has been directed towards lessening the noise at its source. Attention has been drawn to aircraft engine modification, restricted flight paths, redirected flight paths and fewer overflights. Second, attention has focused on obtaining federal funding and funds from the airport owner for financing school soundproofing remodeling. Third, amplification equipment has been installed in ten classrooms in speculation that speech communication interference from jet aircraft noise will be lessened.

This investigation focuses on the third school district objective, i.e., speech communication interference mediation by teacher voice signal amplification. The need for a valid assessment of the amplification solution to the problem has a relationship with the school district's other noise mitigation efforts. For example, should some schools receive soundproofing treatment while others are completely outfitted with amplification equipment? Does the grade level of a student have a relationship with the proposed solution? These, and many other unanswered questions must be verified and presented in the political arena where decision-makers control funding resources.

Minimal Hearing Loss Problem

An emerging concept in the literature about schoolchildren's hearing is being termed variously, mild, minimal, marginal, peripheral, and/or educationally significant hearing loss. Authorities in the field of classroom auditory environments have recently advanced estimates that the incidence of minimal hearing loss in schoolchildren is much higher than heretofore suspected. These authorities include Northern, 1978; Roeser, 1981; Downs, 1981; and Sarff, 1981.

Schoolchildren throughout the State of Illinois are screened annually for hearing loss by state certificated audiometric technicians. This procedure is similar to the hearing conservation programs utilized throughout the country. A very conservative pass/fail criterion of 25 decibels hearing level (dB HL) is universally applied. Advocates of the minimal hearing loss concept argue that a low-fence of 25 dB HL fails to identify a high percentage of the school population who would fail the test at a lower and more sensitive fence of 15 dB HL or 10 dB HL. Further, it is claimed by these authorities that some children, identified with the lower decibel criterion, possess educational deficits, particularly in language processing, that co-exist with minimal hearing loss (Quigley, 1968; Skinner, 1978; Downs, 1981; and Sarff, 1981).

Minimal hearing loss advocates recommend changes in the classification scheme of hearing acuity for children. The recommended changes would replace the present categorical classification with a more continuous one. It is argued that the revised classification would be more congruent with the physiological distribution of hearing acuity values in children.

Researchers in an Illinois special education district have addressed the issue of minimal hearing loss in a continuing program of identification and treatment since 1977. Utilizing a more continuous classification scheme, more than 2,900 schoolchildren have been identified with hearing acuity deficits. An innovative soundfield amplification treatment methodology has been introduced at the classroom acoustical level. It is hypothesized that by amplifying the teacher's voice (signal), the minimal hearing loss deficits at the physiological level will be mediated resulting in improved performance at the linguistic task performance level.

The results of the Illinois research have led to the innovation's being endorsed by both the State and National Dissemination Network (Title IVc) for utilization in schools throughout the state and nation (Sarff, 1981).

Statement of the Problem

Stated most succinctly, the schools in Bensenville have a serious noise problem. Located adjacent to the western side of O'Hare International Airport and beneath its most frequently used runway, the schools are exposed regularly to jet aircraft noise intrusion publicly documented at a high level (appendix E). Noise mitigation efforts by the school district are directed towards lessening the noise at its source, acquiring federal and City of Chicago funding for soundproofing school district buildings, and teacher voice signal amplification mediation. This investigation focuses on evaluating the utility of the third objective, i.e., mediating speech communication interference from jet aircraft noise by teacher voice signal amplification treatment.

The treatment variable, amplification, was originally developed by special education researchers as a method for mediating speech communication interference caused by minimal hearing loss. In this investigation, a treatment originally designed to resolve one problem, i.e., minimal hearing loss, is now being applied to resolve a different problem, jet aircraft noise intrusion. In the process of evaluating the treatment for the new problem,(JANI), an evaluation of the treatment for the original problem, (MHL), is also made. The jet aircraft noise intrusion analysis represents exploratory research. The minimal hearing loss analysis extends[1] and corroborates previous research. The jet aircraft noise intrusion analysis focuses on the speech communication interference problem at the acoustical level on the speech chain. The minimal hearing loss analysis focuses on the speech communication interference problem at the physiological level.

Purpose of Investigation

There are two major purposes of this investigation. One relates to accumulating evidence about the unresolved social and educational issue of jet aircraft noise intrusion at school sites. An attendant purpose of this objective is to explore thoroughly the range of accumulated knowledge on the issue so as to prepare local officials for informed participation in the ongoing public dialogue. The other major purpose of the investigation is to expand and corroborate previous research on the impact of minimal hearing loss on learning.

As discussed in Chapter II below, there is little research evidence connecting jet aircraft noise intrusion with learning degradation in schoolchildren. Federal authorities, however, have accumulated research evidence that jet aircraft noise intrusion does adversely affect the speech communication process in schools (U.S. DOT-FAA, 1977, p. 21).

In acknowledgment of the speech communication problem in schools,

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[1] Existing minimal hearing loss research is extended to unexplored age (grades one and two) and aptitude level (high, middle and low) contexts.

funds have been appropriated for soundproofing treatment (U.S. Congress, 1982). Eligible schools are reimbursed 80% of the soundproofing cost from the federal government. Responsibility for funding the remaining 20% is an issue currently being debated at the local and area level.[2]

As previously indicated, "the acceptability of an effect is not a scientific problem but a political decision in which scientific evidence will hopefully be used" (Rylander, 1978, p. 602). Noise mitigation by means other than soundproofing is an attractive alternative to political decision-makers because of the high costs of soundproofing construction. Teacher voice signal amplification treatment is an alternative to soundproofing. To date, however, there is little evidence to evaluate the worth of amplification treatment in resolving the problem. Accordingly, one purpose of this investigation is to address the following questions:

1. How prevalent is jet aircraft noise intrusion at the local school sites?
2. Does teacher voice signal amplification intervention mediate speech communication interference from jet aircraft noise intrusion? If so, is the effect measurable?
3. Is the amplification treatment more beneficial to some students than to others? Is the treatment more beneficial at some school sites than at others?
   a. Particularly, is the treatment more beneficial to the youngest students, just learning to read?
   b. Also, is the treatment more beneficial to lower ability stu-

[2] On November 10, 1983 the City of Chicago's Department of Aviation announced it would pay 10% of the soundproofing costs for three suburban schools, including Site I of the study.

dents, suspected of being easily distracted by interruptions of any kind including interruptions from jet aircraft noise intrusion.

c. Finally, is the treatment more beneficial at some school sites than at others depending on the level of jet aircraft noise intrusion?

In addition to finding answers to these specific questions, a related purpose of the jet aircraft noise intrusion analysis component is to explore thoroughly the range of accumulated, relevant knowledge on the issue.

In the minimal hearing loss component of the investigation, an attempt is made to integrate reported correlational findings and probe the limits of their generalizability in contexts previously not investigated, i.e., first and second grade levels and high, middle and low aptitude strata. Several questions are of interest to local school district decision-makers. They are:

1. How prevalent are minimal hearing acuity deficits in the elementary school population?
2. What are the effects of minimal hearing acuity deficits on student performance?
3. Do students with minimal hearing acuity deficits demonstrate improved performance when exposed to teacher voice signal amplification treatment?
4. Do some students with minimal hearing acuity deficits, exposed to teacher voice signal amplification treatment, benefit more than other students, exposed to the treatment?
5. Is the treatment for minimal hearing acuity deficits more benefi-

cial at some school sites than at others?

Assumptions

After a review of the literature and personal interaction with specialists in the fields of aviation administration and listening environments, the following conceptual assumptions were posited:

- There are both discrete and continuous phenomena occurring along the chain of events in speech communication.
    - Noise intrusion in learning environments from jet aircraft overflights represents measurable, discrete events.
    - Hearing acuity deficits in schoolchildren represent measurable, discrete events.
    - Both noise intrusion and hearing acuity deficits may be isolated and analyzed for their separate effect on the listener at the linguistic task performance level.
    - While there are numerous additional variables in the speech communication chain, e.g., spectral characteristics and voice efforts of the speaker, environmental (acoustic) conditions of the communicating space, and amount of hearing loss (Webster, 1978, p.223), it is appropriate for a research effort to include more than one factor while limiting the study to fewer than all possible factors.
- Exterior noise levels are attenuated approximately 21 decibels as sound filters into a classroom. This noise reduction (NR) effect is based upon the U.S. Department of Transportation-Federal Aviation Administration, 1977 study of sixty public buildings (p. 3-18). Speech communication interference begins at 45 dBA indoors

(U.S. EPA, 1974, p. 18; U.S.- DOT-FAA, 1977, p. 20; Houtgast, 1980, p. 183). For the purposes of the jet aircraft noise intrusion analysis in this investigation, exterior noise levels 66 dBA or greater are assumed to represent the threshold level for the onset of speech communication interference indoors.

- At the listener's position in speech communication, as distinguished from the speaker's position, performance of linguistic tasks is an appropriate molar level[3] assessment of a subject's having received and processed spoken communication over time. This assumption is based on the speech chain paradigm, Figure 1, where the listener's processing of spoken communication occurs at the linguistic level.

Definition of Terms

For the purposes of this study the following terms are conceptually defined. An attempt has been made to include the most pertinent existing information and knowledge having a bearing on the problem. The interrelationships of the conceptual terms presented and their relevance to resolving the problem are described in the Research Problem subsection below.

Acoustics: The qualities of a room that determine how well sounds can be heard. Acoustic factors critical to speech intelligibility in a classroom environment include the level of ambient noise and accompanying reverberation (Finitzo-Hieber, 1981, p. 250).

Activity Interference: Within buildings, primary activities sus-

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[3] Molar level refers to causal laws expressed in terms of large, complex, probabilistic connections (see definitions below).

ceptible to noise intrusion have been identified by federal authorities. "For schools, the primary consideration for interior noise is speech communication" (United States DOT-FAA, 1977, p. 2-2). In this investigation, speech communication interference, a subset of activity interference, is the primary focus in the analysis of both jet aircraft noise intrusion and minimal hearing loss.

Age-Dependent Effect: An effect in which there is an interaction between the cause, e.g., noise exposure, and the age of the subject.

Air Conduction: The course of sounds that are conveyed to the inner ear by way of the outer ear and middle ear.

Ambient Noise: Any noise exclusive of an intentional signal in a classroom or test room environment. The noise may come from outside or from within the room.

American National Standards Institute (ANSI): Whenever sound level measurements are made, the recommendations of the applicable national and international standards are utilized. In the United States, sound measurement techniques and specifications are published by the American National Standards Institute. Citations include the date of the most recent applicable standard, e.g. ANSI (1969).

Aptitude-Dependent Effect: An effect which is partially dependent upon the subject's aptitude.

Articulation Index (AI): The term articulation is used to express the connection between the speaker and listener. An (AI) is a numerically calculated measure of the intelligibility of transmitted speech. It takes into account the limitations of the transmission path and the ambient noise. The (AI) ranges in magnitude between 0 and 1.0.

Attenuation: The reduction of energy (e.g. sound).

Audiometric Technician: An individual, who, after appropriate training and state certification, has the skills necessary to administer, but not interpret, basic hearing tests.

Auditory Discrimination: The ability to hear similarities and differences among the sounds in words. Auditory discrimination is generally thought to be a prerequisite to the acquisition of visual decoding skills.

Auditory Processing: An occurrence on the listener's end of the speech chain. Incoming sound activates the hearing mechanism. The chain continues on the physiological level with neural activity in the hearing and perceptual mechanisms. The event is completed when the listener recognizes the words and sentences transmitted by the speaker.

A-Weighted Sound Level: A single number with more emphasis on the speech range frequencies, i.e., 500, 1000, 2000 hertz(Hz). The A-weighted sound level is also called the noise level. A-weighted sound level readings are expressed in decibels, e.g., 45 dBA represents a sound level or noise level of 45 decibels on the A-weighted scale. There are also B and C weighted scales but they are not used in this investigation.

Conductive Hearing Loss: An obstruction in the movement of sound wave as it passes through the external and middle ear on its way to the inner ear. This kind of hearing loss usually can be corrected and/or improved by medical treatment.

Decibel (dB): A unit for measuring the relative intensity of sounds, equal to one tenth of a Bel. Whereas most quantities are measured by fixed units like watts or grams, sound intensity is measured along the decibel scale, which is a logarithmic scale referenced to the human ear. Presently, the quietest sound that can be heard by the average person has been standardized as the nominal hearing threshold for the purpose of sound level measurement. The zero on the decibel scale is based upon the standardized threshold. Because the scale is logarithmic, each increase of 10 decibels means that acoustical energy is multiplied by 10. This means that a sound of 75 dB is 10 times as intense as 65 dB and 100 times as intense as 55 dB. However, an increase of 10 dB is perceived by humans as only a doubling of the loudness rather than as a ten-fold increase.

Fence: A term used by researchers to specify a demarcation point on a scale for purposes of dichotomous classification.

Frequency: The physical measurement of what is physiologically perceived as pitch. Frequencies specify the number of vibrations per second. Frequencies are now expressed in hertz (Hz). Formally, cycles per second was the appropriate standard. The human ear responds to frequencies between 20 and 20,000 Hz.

Hearing Acuity: The sharpness, clearness, or distinctiveness with which one is able to hear sounds. Hearing acuity deficits represent degradations in hearing acuity. In this investigation, hearing acuity deficits and minimal hearing loss are used interchangeably depending upon the context. Hearing acuity is usually reported in decibels of hearing level, e.g., 15 dB HL.

Hertz: See Frequency

Jet Aircraft Noise Intrusion (JANI): Ambient noise within a classroom caused by jet aircraft overflights.

(Ldn) Contour: (Ldn) is the official U.S. FAA acronym for level of noise, day and night. An Ldn contour is a map with rings circling outward from an airport. Each ring has a number which depicts generalized areas within which varying degrees of aircraft noise levels are likely to exist. The Ldn is the A-weighted sound level over a 24 hour period including a 10 db penalty for the night time hours between 10:00 p.m. and 7:00 a.m..

Linguistic Task Performance: On the speech chain, oral communication is processed by the listener at the linguistic level (Denes and Pinson, 1963). Researchers on noise have specified the need for task performance analysis as distinguished from health degradation analysis (Loeb, 1978, p.313; Goldstein and Dejoy, 1978, p. 370). In the sample classrooms of this research setting, uninterrupted reception of oral communication is particularly important for performing linguistic tasks because the subjects are unable to read and because of the phonetic content and whole-group instructional methodology employed.

Masking: The action of bringing one sound to unintelligibility by the introduction of another sound.

MARRS: This acronym is an abbreviation for Mainstream Amplification Resource Room Study. Project MARRS was developed and implemented in 1977 in three southern Illinois public schools in grades four, five and six. Project MARRS was subsequently funded by Title IVc, ESEA, Illinois State Board of Education and is now part of the National Diffusion Network, USOE. Project MARRS provides a procedure for the identification and treatment of schoolchildren with minimal hearing acuity deficits.

Minimal Hearing Loss (MHL): Currently there is no universally accepted criteria for defining MHL cases. For this investigation the following upper and lower fences were applied:

Upper Fence: Across six frequencies, i.e., 500, 1000, 2000, 4000, 6000 and 8000 Hz, a subject was considered to be beyond the upper fence if s/he: 1) failed to hear any one tone at 35 dB in either ear, or 2) failed to hear any two tones at 25 dB in the same ear.

Lower Fence: Across six frequencies, i.e., 500 1000, 2000, 4000 6000 and 8000 Hz, a subject was considered to be below the lower fence if s/he heard all tones at < 15 dB in either ear.

Subjects beyond the upper fence were classified as having hearing loss and were excluded from the experimental design. Subjects registering thresholds below the upper fence and above the lower fence were classified as MHL cases. Subjects below the lower fence were classified as non-MHL cases and were included in the a posteriori analysis of task performance comparisons between MHL and non-MhL subjects.

Molar Level: Refers to causal laws expressed in terms of large, complex, probabilistic connections. Molar level causal assertions are meaningful even though the underlying smaller particles (micromediators) are not always known. This theory of causation has been advanced by Cook and Campbell (1979, p.32). Molar and micromediation theory are discussed Chapter III and applied in Chapters IV and V.

Noise Descriptors: Noise impacts created by aircraft operations can be quantified using any of the following descriptors:

- Day-night average sound level (LDN)[4]
- Equivalent Sound Level (Leq)

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[4] As per FAA order 1050.1c "Policies and Procedures for Considering Environmental Impacts", the (LDN) is the statistical noise descriptor utilized by the FAA and other major governmental agencies involved in measuring and evaluating aircraft noise.

- Noise Exposure Forecast (NEF)
- Time of Exposure Above a Threshold A-Weighted Sound Level (TA)

Noise Reduction (NR): The difference between the exterior noise level and the interior noise level due to the exterior noise.

Noise Sensitive Area: An area in which aircraft noise may interfere with the normal activity associated with the use of the land. Whether noise interferes with a particular use depends upon the level of noise exposure received and the type of activity involved. Sleep in hospitals and speech communication in schools are types of activities found to be noise sensitive.

Overflight The passing of a jet aircraft overhead. Near an airport, aircraft are low-flying in the process of takeoffs or landings.

Physiological Level: Neural and muscular activity initiated by the speaker to transmit oral communication and by the listener to receive oral communication.

Pure Tone Air Conduction Audiometry: This kind of hearing screening involves the measurement of auditory sensitivity using specific pure tones presented to the listener through ear phones mounted in a headset and placed over the ears. This procedure is widely used in elementary schools throughout the country and is commonly referred to as hearing screening.

Pure Tone Average (PTA): The three octave bands (frequencies) used to calculate the pure tone average are 500, 1000, 2000 hertz. These three frequencies have been designated presently by authorities as most important for understanding speech. For example, thresholds of 15, 20, 25 db hearing level at 500, 1000, 2000 Hz would result in a PTA of 20 db HL. Some authorities now argue for the inclusion of 4000 Hz in

PTA calculations.

Separation Distance: The linear distance between a speaker and listener measured in feet or meters.

Signal-to-Noise Ratio (S/N): The difference in decibels between the speech signal and the extraneous background noise in an environment. An S/N ratio of +5 means that spoken communication in an environment is 5 dB greater than the ambient noise in the environment. The S/N ratio is a paradigm utilized by specialists to evaluate the acoustical acceptability of an environment.

Soundproofing: A procedure to reduce or to eliminate the transmission of sound into a building.

Speech Chain: A paradigm for describing the complex chain of events that occur from the inception of a message in the mind of the speaker to its reception in the mind of a listener. The operational constructs encompassed by the speech chain in this investigation are defined in Chapter III.

Speech Communication: The primary activity within schools which has been identified by authorities as the most noise sensitive activity (United States DOT-FAA, 1977, p. 2-2).

Speech Intelligibility: An individual's ability to understand spoken words. Speech intelligibility is a psychological factor and psychological techniques are required for its measurement. Intelligibility is tested when the reception of words, phrases or sentences is the measure of performance. Articulation is tested when individual speech sounds are the measure of performance.

Speech Interference Level (SIL): Arithmetic average of the three octave bands, 500 Hz, 1k Hz, and 2k Hz. (SIL) is usually compared with the average value of the voice band and has become a widely used rating for speech interference assessment. SIL provides an indication of the ability of noise to mask speech and has the advantage of being readily calculated using only a portable sound level meter (Bruel and Kjaer, 1979, p. 67).

Teacher Voice Signal Amplification treatment: Technology for increasing the intensity and distribution of a teacher's voice signal throughout a classroom environment. The teacher wears a cordless, unidirectional microphone which allows freedom of movement and permits oral instruction from any area of the classroom while maintaining a consistent voice level.

Threshold: The audiometric level at which sound is perceived by an individual. In noise interference analysis threshold refers to the dB level at which an individual's speech intelligibility or discrimination facility begins to deteriorate. In hearing acuity analysis, threshold refers to the dB level at which sound becomes detectable.

U.S. DOT-FAA: United States Department of Transportation - Federal Aviation Administration.

U.S. EPA: United States Environmental Protection Agency.

Research Problem

The research problem was structured from the relevant facts and concepts underlying the speech communication interference problem. Speech communication interference has been identified as the major problem in schools resulting from jet aircraft noise intrusion (U.S. DOT-FAA, 1977, p. 21). Current theoretical models specify the components of speech communication interference (Figure 3). Noise level, a major component of the models, has been quantified for the schools in this analysis. School sites, with their attendant noise level, represent one form of the independent variable of major interest, i.e., speech communication interference.

Another component of the speech interference theoretical models is separation distance between speaker and listener. Teacher voice signal amplification treatment reduces separation distance, allowing a student in the back of a classroom (near a speaker box) to receive an amplified voice signal. Reduced separation distance mediates speech communication interference (Figure 3). Teacher voice signal amplification treatment is the other independent variable of major interest. It is the variable which is manipulated in the research setting classrooms. Experimental subjects receive the treatment. Control subjects do not receive treatment. The major substantive hypothesis being tested is that the manipulated treatment variable (teacher voice signal amplification) mediates speech communication interference (by reducing separation distance) whether the interference emanates from noise (an independent variable representing one form of speech communication interference) or from minimal hearing loss (an independent variable representing a different form of speech communication interference.

To assess the effect of the treatment variable on speech communication interference from noise, a comparison with the school site factor is required. To assess the effect of the treatment variable on speech communication interference from minimal hearing loss, a comparison with the minimal hearing loss factor is required. The speech communication interference from jet aircraft noise intrusion factor is represented by the quantified noise level at sites I, II and III. The speech communication interference from minimal hearing loss factor is represented by two levels, presence or absence.

Table 1, a preliminary design layout, is provided to aid in visualizing the relationship between the research variables. The upper design is the basis for answering questions about the relationship between teacher voice signal amplification treatment and speech communication interference from jet aircraft noise intrusion. The lower design is the basis for answering questions about the relationship between teacher voice signal amplification treatment and speech communication interference from minimal hearing loss.

An independent variable of lesser interest, grade level, may be added to either design layout on Table 1 to assess the relationship between the treatment variable and grade level. Still another variable, subject aptitude is assessed by a post hoc stratification of the concomitant variable, student aptitude.

The dependent variable chosen to compare performance between experimental and control subjects is linguistic task performance. The term linguistic is based upon the speech chain theoretical model, where the listener ultimately operates at the linguistic level in processing spoken communication. Task performance, as distinguished, for example, from other effects of noise such as health degradation, has been singularly identified by authorities on noise as an effect in need of further research (Goldstein and Dejoy, 1978, p. 370; Loeb, 1978, p. 313).

Spoken communication in the research setting classrooms is predominately in the form of teacher-directed, whole-group instruction. For approximately two hours each morning, teacher initiated communication is focused on sounding and blending consonants and vowels into words, and

TABLE 1

Preliminary Design Layout

Teacher Voice Signal Amplification Treatment Factor		Speech Communication Interference From Jet Aircraft Noise Intrusion Factor		
		Level 1 Site 1	Level 2 Site 2	Level 3 Site 3
	Level 1 Treatment			
	Level 2 Control			

Teacher Voice Signal Amplification Treatment Factor		Speech Communication Interference From Minimal Hearing Loss Factor	
		Level 1 MHL = > 15 dB HL Loss	Level 2 MHL = < 15 dB HL Hearing Loss
	Level 1 Treatment		
	Level 2 Control		

words into sentences. During this time, students listen to the teacher's voice signal, and react by seeing, saying and writing the cues being presented. Auditory discrimination, phonetic analysis, oral vocabulary, word reading and simple sentence reading are the linguistic tasks receiving primary instructional emphasis in the research setting. Test instruments congruent with classroom instructional content and oral processes[5] are utilized to measure linguistic task performance.

The interrelated variables form the basis for the research hypotheses discussed below. The hypotheses are divided into two groups, i.e., JANI and MHL; and then further subdivided into nonexperimental and experimental groups.

Research Hypotheses

JANI Analysis

Hypothesis 1 Group

The two hypotheses in this group address quantification of the noise level dimension.

Hypothesis 1 A

There is a difference in the average level of noise(Leq) from jet aircraft overflights between school sites I, II and III.

Hypothesis 1 B

There is a difference in the average hourly noise level(Leq) across the school day from 8:00 a.m. to 4:00 p.m. at school sites I, II and III combined.

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[5] All pre and post tests components (except reading comprehension) were presented orally to all subjects by their regular classroom teacher. To maximize the variance of the substantive hypothesis, experimental subjects received pre and post test questions via teacher voice signal amplification while control subjects did not.

Experimental Design Hypotheses

Hypothesis 2 Group

The four hypotheses in this group address the treatment dimension of the JANI analysis.

Hypothesis 2 A

Among first and second grade subjects, the linguistic task performance of amplification treatment subjects will be higher than the linguistic task performance of non-amplification subjects.

Hypothesis 2 B

The effect of teacher voice signal amplification treatment on linguistic task performance will be greater among comparisons within the first grade group than among comparisons within the second grade group.

Hypothesis 2 C

Among first and second grade subjects, the effect of teacher voice signal amplification treatment on linguistic task performance will be greater among comparisons within the low aptitude group than among comparisons within the middle or high aptitude groups.

Hypothesis 2 D

Among first and second grade subjects, there is a statistical relationship between teacher voice signal amplification treatment, speech communication interference (from either JANI or from MHL) and linguistic task performance.

MHL Analysis

Hypothesis 3 Group

The six hypotheses in this group address quantification and analysis of MHL prevalence.

Hypothesis 3 A

The proportion of MHL in the local population is greater than the proportion of MHL in the comparable exterior data set.

Hypothesis 3 B

There is a difference in the proportion of MHL between school sites I, II and III.

Hypothesis 3 C

There is a difference in the proportion of MHL subjects across hearing level threshold classes.

Hypothesis 3 D

There is an inverse relationship between MHL prevalence (by proportions) and grade level.

Hypothesis 3 E

The probability that any subject will repeat positive identification for MHL is greater than one half.

Hypothesis 3 F

Before treatment, linguistic task performance of MHL subjects will be less than linguistic task performance of non-MHL subjects.

Hypothesis 4 Group

The four hypotheses in this group address the treatment dimension of the MHL analysis.

Hypothesis 4 A

Among first and second grade subjects with MHL, the linguistic task performance of amplification treatment subjects will be higher than the linguistic task performance of non-amplification subjects.

Hypothesis 4 B

Among subjects with MHL, the effect of teacher voice signal amplification treatment will be greater among first grade comparisons than among second grade comparisons.

Hypothesis 4 C

Among first and second grade subjects with MHL, the effect of teacher voice signal amplification treatment on linguistic task performance will be greater among comparisons within the low aptitude group than among comparisons within the high or middle or aptitude groups.

Hypothesis 4 D

Among first and second grade subjects with MHL, there is a difference in teacher voice signal amplification treatment across four different hearing level threshold classes.

Procedures

An initial overview of procedures is now presented. Details of the research design and method are presented in chapter III.

Subjects: The subjects selected for the experiment included the district's population (n=396) of first and second grade students representing eighteen intact classes from three schools, labeled Sites I, II and III. Ten classes were randomly selected to serve as the experimental group receiving teacher voice signal amplification treatment for ninety days from January 10, 1983 to June 8, 1983. The remaining eight classes served as the control group.

Procedure: The speech communication interference construct was quantified by collecting noise level samples at sites I, II and III for the jet aircraft noise intrusion factor and by conducting audiometry screening on all subjects for the minimal hearing loss factor. Teacher voice signal amplification treatment was administered to all experimental subjects for ninety days after collecting pretest observations on aptitude and on linguistic task performance. During the experiment all classes (ten experimental and eight control) received similar classroom instruction based upon the district's prevailing curriculum. Following ninety days of treatment, linguistic task performance data were collected on all subjects using an alternate form of the pretest. The posttest data were then analyzed to compare growth between experimental and control subjects.

Importance of the Study

A search of the literature about the impact of speech communication interference on students' task performance revealed the need for additional applied research in a naturalistic setting. Direction to fill the applied research void has been provided by authorities, particularly by researchers at the Third International Congress on Noise as a Public Health Problem (1978).

It is hoped that the JANI analysis in this investigation will make a contribution to educational and scientific theory as well as contemporary practice because:

- The analysis addresses "....a definite need for methodologically sound, performance oriented field studies (of noise effects) in various types of work environments" (Goldstein and Dejoy, 1978, p.371).
- The analysis addresses specific task performance areas, i.e., auditory discrimination and reading achievement, recommended for research by authorities (Goldstein and Dejoy, 1978, p. 370; Loeb, 1978, p. 313; Downs, 1981, p. 179).
- The analysis addresses the age-dependent effect specified by the U.S. DOT-FAA (1978, pp. 21-22) and the aptitude-dependent effect posited by Maser, (1978) and by Schomer (1981, p. 143).
- The analysis includes noise dose descriptions as recommended by Rylander (1978, p. 600).
- The analysis incorporates an experimental design to examine relationships between incremental levels of aircraft noise and corresponding linguistic task performance in a complex field setting. Archival data and correlational procedures were not the major design components employed. The unit of observation was based on a sample of 396 individual subjects rather than on aggregated classrooms or building units.
- The analysis responds to a request by the Illinois Institute of Natural Resources for research evidence from a Chicago area, airport-specific school, linking noise and learning (1981, p. iii).
- Finally, the analysis represents an attempt by the local school

district to: 1) find ways to enhance its students' task performance, and 2) fortify political decision-making with scientific evidence.

Because the MHL analysis of this investigation examines minimal hearing acuity deficits in contexts previously not investigated, knowledge about the concept is advanced. Theories posited by authorities[6] are tested for their generalizability and application in a public school field setting. Connections between theorists in laboratory settings and practitioners in the field are important in bringing about the "small gains in productivity" advocated by Walberg (1979).

According to the policy of the Illinois State Board of Education, "It is imperative for parents, educators, and administrators to know that hearing impaired children should be evaluated, not only audiometrically, but through performance evaluation as well" (Department of Specialized Educational Services, 1980, p.8). The MHL analysis of this investigation examines the causal relationship between identified subjects with minimal hearing acuity deficits and their corresponding linguistic task performance. It is hoped that the MHL analysis will also make a contribution to educational and scientific theory as well as to contemporary practice.

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[6] The theories and research of Skinner (1978), Downs (1981) and Sarff (1981), particularly, form the basis or foundation for the MHL hypotheses advanced in this investigation.

Organization

The remainder of this dissertation is as follows:

Chapter II reviews existing studies, public documents and public policy on jet aircraft noise intrusion with emphasis on O'Hare Airport specific documentation. More attention is given to findings about speech communication interference effects than to findings about health degradation and attitudinal effects.

The emerging literature on the concept of minimal hearing loss is summarized. Findings about the prevalence and effects of MHL are reported. A review of studies on amplification treatment in the MHL context is given.

Chapter III describes the procedure for collecting noise quantification and hearing acuity data. The components of an experimental design for making amplification and non-amplification performance comparisons are presented. A description of a pilot study for the minimal hearing loss factor is also provided.

In Chapter IV, the results are exhibited; in Chapter V the results are discussed, conclusions are formulated and recommendation are advanced.

CHAPTER II

REVIEW OF LITERATURE

Jet Aircraft Noise Intrusion Literature

During the last two decades there has been an increasing awareness of the quality of man's environment. According to the U.S. Environmental Protection Agency, "along with air and water contaminants, noise has been recognized as a serious pollutant. As noise levels have risen, the effects of noise have become more pervasive and more apparent" (1978, p. 1). The contributing offenders include transportation noise, industrial noise, construction noise, internal building noise and people noise (Jensen, 1978, pp. 245-51). In this investigation, the noise factor studied, jet aircraft noise intrusion, is a subset of the general classification, transportation noise.

Jensen (1978) traces the problem of noise from aircraft to three causes: 1) the development of jet engines, 2) increasing public awareness, and 3) expansion of the suburbs. Jet aircraft have extended and accelerated the reliance of the nation's society and economy on a technologically advanced transportation system. Simultaneously, suburbs near large metropolitan airports have become more sensitive to increasing noise pollution. In a position paper contracted by the Illinois Institute of Natural Resources, the conflict between the airport and its neighbors is characterized as a "tug-of-war" with "irreconcilable conflicts between the interests of the airport proprietor and those of the surrounding communities" (Ducharme, 1981, p. 8-5).

A survey of existing literature and research findings on JANI reveals that studies on the topic emanate principally from two sources. Public sector policy authorities represent one source. At the national level this includes the U.S. Department of Transportation (DOT), the Federal Aviation Administration (FAA) and the Environmental Protection Agency (EPA). At the state level, sources of authority in Illinois include, The Illinois Department of Energy and Natural Resources, The Illinois Pollution Control Board, and The Illinois Institute of Natural Resources. Additionally, four international conferences on noise as a public health problem have been held with the most recent occurring in Turin, Italy, June, 1983. Eight separate noise research groups have been formed by the international commission ".... to cover, as throughly as possible, the entire spectrum of the effects of noise...." (Jansen, 1978, p. 54).

The second source of research comes from a variety of contributors geographically concentrated near large metropolitan airports in the United States and major cities throughout the world. These studies frequently have a public policy orientation at the local or area level. This type of research can be traced to an institutional commission or sanction such as a university or public sector health agency.

This review of literature addresses the research from both sources, i.e., from state, national, and international level documentation as well as from airport specific studies. In the review, emphasis is given to noise intrusion effects claimed to be most detrimental to student linguistic task performance.

Insight about the relationship between JANI and task performance has been provided jointly by two federal authorities, i.e., the U.S.

Department of Transportation and the Federal Aviation Administration in response to a requirement by The Airport and Airway Development Act of 1976 (P.L. 94-353). In their Report to Congress, 1977, on the feasibility of soundproofing schools to reduce the possible adverse effects of aircraft noise, the U.S. DOT-FAA specified the parameters of the problem. Three general categories of adverse effects from jet aircraft noise intrusion were identified:

- Degradation of health
- Attitudinal reactions
- Activity interference (p. 21)

Of the three, activity interference was found to include the most noise sensitive thresholds of interference. Sleep in hospitals and speech communication in schools were reported as the people activities most intruded upon by jet aircraft noise (p. 21).

Based upon the classifications by federal level authorities, this review will address each of the categories of problems, with extended emphasis to the activity interference classification because of its pertinence to the problem being analyzed.

Degradation of Health

On July 14, 1977, the U.S. Secretary of Transportation submitted the aforementioned Report to Congress to the U.S. Senate. Regarding degradation of health from aircraft the report stated, "There is no known direct health effect (e.g. hearing loss) on the occupants of public buildings due to aircraft noise in the U.S." (U.S. DOT-FAA, 1977, p. 1). The basis for the Report to Congress was a study undertaken by Trans Systems Corporation in association with Wyle Laboratories under the direction of the Office of Environmental Quality. The source of the claim that health degradation does not result from aircraft noise is not discussed. The research does reference a comprehensive search of the literature regarding noise threshold levels, a topic to be discussed in the activity interference section below.

Because of the authority involved, i.e., the U.S. Congress, and the U.S. DOT-FAA, there is a presumption of evidence that health degradation is not currently associated with aircraft noise in the minds of national level policy-makers.

A study by Green (1980) of the association between aircraft noise exposure and the risk and severity of hearing loss in children exemplifies research emanating from specific airports environments. The research was partially supported by the New York Energy Research and Development Authority and by the New York University Medical Center. In an analysis of previous research on the effects of environmental noise exposure on hearing, Green found the results contradictory.

Green's study population included 201 cases and 208 controls selected from over 16,000 audiometric test reports of Brooklyn and Queens' students exposed to weighted amounts of noise from LaGuardia and J.F. Kennedy Airport as well as exposure to other city noises. The cases had a permanent bilateral high-frequency hearing loss of 25 dB or more. The controls had normal hearing. Age, race, health and attitudinal factors were controlled in the analysis. The methodology employed, utilized cross-tabulation, stepwise discriminant analysis and stepwise multiple regression. A statistically significant association between noise exposure and hearing loss was not demonstrated by the study. However, the study did suggest that the risk of hearing loss might be greater for those living in the highest noise level contours near an airport.

Cohen et al.,(1981) have reported results of two sequentially related studies of the physiological, motivational, and cognitive effects of aircraft noise on third and fourth grade subjects attending school in Los Angeles during the spring of 1977. A follow-up study occurred one year later. This research was supported by grants from the National Science Foundation and the National Institute of Environmental Health Services.

Attention is focused here on the results of both Green's study and Cohen's study with respect to the degradation of health issue. Other findings of the Green research and the Cohen research are reported in later and appropriate subsections below.

Cohen's study involved children attending the four noisiest elementary schools in the air corridor of the Los Angeles International Airport. Peak sound level readings were found as high as 95 dBA at the experimental sites. More than 300 overflights daily were reported, which amounted to approximately one flight every 2.5 minutes. Three control (quiet) schools were matched with four experimental (noisy) schools for similarity of age, SES, and race. A total of 262 subjects (142 experimental and 120 control) were involved in the research. Children with existing hearing loss were excluded from the study so as not to confound the findings.

The study focused on effects occurring outside the noise exposure, i.e., after-effects. Data were collected on subjects in a noise insulated trailer parked outside a quiet school. Each child's blood pressure was recorded twice to test the hypothesis that noise exposure can alter physiological processes.

Regression analysis procedures were used to determine the relationship between noise and blood pressure after functionally equating the experimental and control groups on all other possible confounding variables. The multivariate f for the effects of noise on blood pressure was significant, $p < .05$. Subjects from noisy schools had higher blood pressure than control subjects from quiet schools. Most importantly, however, was the researchers' subsequent report that:

> While these blood pressure differences were statistically reliable, the levels for children attending noise schools do not as a group exceed normative levels for children of similar age, e.g. (Voors, et al., 1976) The long term health consequences, if any, of these elevations of blood pressure in children remain unknown (Cohen et al., 1981, p. 531).

In a follow-up analysis of 163 of the 262 study subjects one year later, no statistically significant difference was found between the blood pressures of experimental and control subjects. The authors attribute the changed finding about blood pressure to attrition in the experimental group rather than to adaptation. An analysis of the subjects having migrated from the original experimental group revealed an association between blood pressure and migration, i.e., a relationship between noise, blood pressure elevation and moving out of a neighborhood.

In summary, the physiological component of the Cohen study fails to provide evidence in support of a claim that health degradation is linked to JANI in schoolchildren. This finding is consistent with the U.S. DOT-FAA's policy level study of 1977 and with Green's New York City Study of 1980.

According to Jansen (1978), at the Third International Congress on

Noise as a Public Health Problem, political decision-makers ultimately determine standards and thus threshold and boundary values. Terms such as danger (to health) have been modified and are now prefaced with the word "considerable" (Jansen, 1978, p. 58). When there is contention between the "....issuing establishment on the one side and the concerned party on the other side 58) considerable danger to health or considerable annoyance must be evidenced. "Up to a certain degree, a tolerance for a disturbance can be presumed" (p. 58). Within this framework, the present analysis failed to find research evidence to support an inference that JANI was linked to considerable danger to health degradation in schoolchildren.

Attitudinal Reactions

In addition to health degradation, attitudinal reactions is a classification into which people responses to aircraft overflights may be placed. According to a report by the U.S. EPA (1978, p. 21) there are two major indices of noise on people: 1) cumulative complaints by individuals or groups, and 2) responses to social survey questionnaires.

Figure 2 portrays a summary of community reaction to intruding noise. These findings are reported by the EPA (1978) based upon twenty-five years of experience and numerous studies exploring the relationship between noise and people's reactions. Adjustments in the data to improve predictability have been made for seven factors:

1. Duration of intruding noises and frequency of occurrence
2. Time of year (windows open or closed)
3. Time of day of noise exposure
4. Outdoor noise level when intruding noises are not present

5. History of prior exposure to the noise source

6. Attitude toward the noise source

7. Presence of pure tones or impulses (p. 21)

The EPA indicates that the data are functionally correct to within plus or minus five dB for predicting community reaction. According to the EPA document "annoyance is quantified by using the percentage of people who are annoyed by noise. This is felt to be the best estimate of the average general adverse response of people...."(p. 21).

A study of eight U.S airports and one near London revealed that 80 dBA annoys 60% of the neighborhood population; 70 dBA annoys 40% of the population; and 60 dBA annoys 20% of the population (p. 23).

Of particular relevance to the current analysis is the research in psychoacoustics reported by the U.S. DOT-FAA in 1977. According to this report, the aggregate emotional response of an individual to noise depends on several factors including "general sensitivity to noise. People vary in their abilities to hear sound, their physiological predisposition to noise and their emotional experience of annoyance to a given noise" (U.S. DOT-FAA, 1977, p. 3).

Related to the variablity and individual sensitivity responses reported above are the findings from a cohort study by Maser(1978). Using a longitudinal file of achievement test scores administered between 1970 and 1976, five distinct cohort groups were stratified into a high, middle, or low level on the basis of academic aptitude. Task performance data of experimental subjects from noisy schools(n=269) near the Seattle-Tacome Airport was compared with task performance data of control subjects from quiet schools(n=370) more distant from the same airport. "These data suggest that effects on tested achievement were

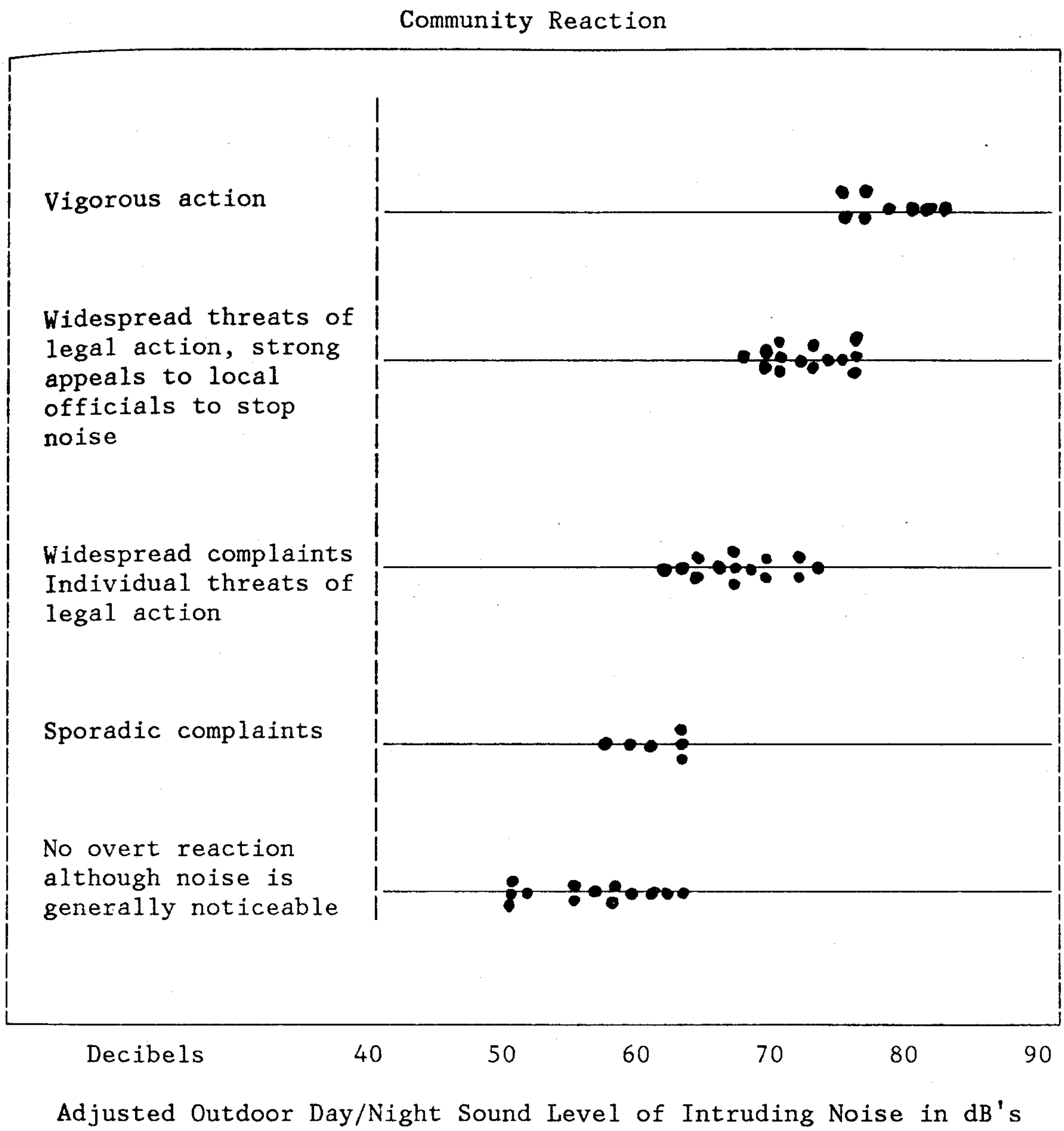

FIGURE 2: Combined Data From Community Case Studies

Source: U.S. Environmental Protection Agency, Protective Noise Levels Condensed Version of EPA Levels Document (Report no. EPA 550/9-79-100), November, 1978, p. 22.

cumulative and greatest for pupils in the lowest aptitude stratum" (Maser et al., 1978). On the basis of Maser study (1978) and the Hawthorne Airport study (Crook and Langdon, 1974,) Schomer (1981) has hypothesized an interactive effect between student aptitude, noise exposure and task performance.[1]

Schomer's has explained his postulate as follows:

> The average and above-average students are able to recover their concentration and thought processes quickly enough after aircraft noise disruption so that their academic achievement is not impaired compared to other students who are not subjected to this noise. However, the poorest third of the students are unable to recover their concentration and thought processes quickly enough. They do not achieve as well as do like students in a quiet setting.
>
> From the above data, one can only calculate that overall class averages sink only slightly while the effect on the poorer one-third of students is far more dramatic. This study shows that while a district may achieve an overall high level of student performance, with many students doing well in national tests, going on to colleges and universities, and otherwise distinguishing themselves and the district, it is the poor students buried in these statistics that are suffering from the noise. Studies which address themselves to the overall class averages or merely the better students fail to get at the real issue (pp. 143-8).

Since 1978 additional airport specific research has addressed the relationship between attitudinal responses toward noise and performance by schoolchildren.

In the aforementioned Cohen et al., Los Angeles study (1981) an interaction was found between the subjects' rating of noise annoyance and blood pressure, i.e., after noise intensity was statistically controlled (equalized), blood pressure (dependent measure) was predictable from the independent variable (child's rating of noise annoyance). The

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[1] Schomer's research was contracted by Illinois Department of Energy and Natural Resources (Document No.81/38). The aptitude/noise exposure/performance effect posited by Schomer has been incorporated into the higher order interaction predictions of the statistical analysis in the present investigation (see Hypotheses 2 C and 4 C).

study also found that subjects from noise schools demonstrated greater feelings of helplessness than subjects from quiet schools. Learned helplessness was measured by quantification of persistence in solving puzzles. Children in the experimental group (noisy schools) were more likely to fail and to give up solving puzzles than their quiet school counterparts (p. 532).

The Cohen study also addressed the question of adaptation to noise over time. Through repeated measures on the dependent variable over a one year span, the researchers found a lack of successful adaptation over time in physiological response to noise. Children from noisy schools and their parents reported more noise and being bothered by noise. Neither the cognitive deficits in helplessness tasks nor the giving-up response lessened with increased length of exposer to noise intrusion (Cohen et al., 1981). Conversely, Lewin (1983) posited increased arousal and habituation as an explanation for finding nonsignificant treatment effects in a field experiment of teacher voice signal amplification intervention. However, since the Lewin investigation did not provide noise dose-response data, evidence supporting habituation and arousal attitudinal reactions to noise is inconclusive.

In addition to Maser's study (1978), the school district surrounding the Seattle-Tacome, Washington, International Airport was the subject of another recent airport specific investigation. Hyatt (1982) investigated the effects of jet aircraft noise on student achievement and on student attitude. Using a random sample from the district's K-12 population, Hyatt demographically matched noisy schools and quiet schools contrasted by varying degrees of noise intrusion from the 220 average daily overflights. Sixth, ninth, and eleventh grade students were surveyed to assess their environmental perception. Experimental students, from noisy schools, perceived their environment less favorably than did their control counterparts, from quiet schools. Students from noisy schools reported that their teachers were difficult to hear, that the teacher's voice was raised, that extreme noise interfered with communication, and that classrooms were more confusing than comparable reports from students attending quiet schools (p. 73).

Hyatt's investigation also examined student attitudes about their physical environment in relationship with performance on standardized achievement tests. From a population sub-sample of sixth, ninth, and eleventh grade students, a multiple correlation coefficient was derived. The results of this analysis indicated a strong likelihood that student attitude toward classroom environment was an excellent predictor of student achievement at the .01 level of significance (Hyatt, 1982, p. 67).

Because the Hyatt research did not control for confounding variables such as age and aptitude, a causal link between attitude toward noise and student performance was inconclusive. The contribution of aptitude toward performance was not measured. One can only conclude that environmental attitude and performance co-varied.

In summary, there is an emerging research database about attitudinal reactions by schoolchildren to JANI. Cohen et al. (1981) have established a link between physiological responses and noise exposure. Studies by Maser (1978) and by Hyatt (1981) of students near the Seattle-Tacome airport suggest a link between attitude, noise exposure and task performance. Schomer (1981) has posited an interaction between aptitude, noise exposure, and task performance. Gulian (1978, p. 694) has posited a relationship between interference and distraction.

Considerable attitudinal data has been accumulated at both national and international levels through general population surveys. Authorities do agree that human response to noise is a subjective variable difficult to relate to noise exposure (Jansen, 1978, p. 252; Bruel and Kjaer, 1979, p. 52; U.S. EPA, 1978, p. 21).

Table 2 presents the U.S. EPA's identified noise level recommendations to protect public health and welfare. Annoyance effects are specified for both outdoor and indoor activities including schools. An Ldn of 45 dB is identified as the threshold of annoyance for indoor activity; an Ldn of 55 dB is specified as the threshold of annoyance for outdoor activity. In literature supporting the recommendations, the EPA indicates, "They (noise level recommendations) are not regulatory goals; they are levels defined by a negotiated scientific consensus (U.S. EPA, 1978, p. 24). This disclaimer by the EPA is consistent with discussion presented above from the Third International Congress. Rylander (1978,. p. 602) indicated that the acceptability of a noise effect was a political not a scientific decision. The U.S. EPA recommendations regarding annoyance are closer to being threshold recommendations than boundary recommendations (refer to Jansen above). In the activity interference discussion (below) threshold guidelines for the onset of speech communication interference are presented.

Activity Interference

Of the three categories of adverse effects from JANI, activity interference has been identified by policy-makers and authorities as most pertinent to the relationship between noise and task performance (U.S. DOT-FAA, 1977, p. 21; Crook and Langdon, 1974, p. 224; Jensen,

TABLE 2

Yearly Ldn Values That Protect Public Health

EFFECT	LEVEL	AREA
Hearing	Leq(24)* < 70 dB	All areas (at the ear)
Outdoor activity interference and annoyance	Ldn < 55 dB	Outdoors in residential areas where people spend varying amounts of time and other places in which quiet is a basis for use.
	Leq(24) < 55 dB	Outdoor areas where people spend limited amounts of time, such as school yards.
Indoor activity interference and annoyance	Ldn < 45 dB	Indoor residential areas
	Leq(24) < 45 dB	Other indoor areas with human activities such as schools.

Source: U.S. Environmental Protection Agency, Protective Noise Levels Condensed Version of EPA Levels Document (Report No. EPA 550/9-79-100), November, 1978, p. 24

* Leq(24) indicates 24 hour exposure

1978, p. 259). The U.S. EPA has indicated explicitly that speech interference is a specifiable adverse effect of noise exposure, "Except in the case of speech interference, however, the degree of interference is hard to specify and difficult to relate to the level of noise exposure" (U.S. EPA, 1978, p. 20).

The national policy level study on the issue states that "aircraft noise does interfere with speech communication in affected schools...." (U.S. DOT-FAA, 1977, p. 1). This finding is based upon a survey of the impact of aircraft noise on 60 school and hospital buildings near six major U.S. airports. Buildings selected were located within the 65 dBA or greater Ldn noise contours. Using noise monitoring technology both indoors and outdoors, threshold levels for sleep interference in hospitals and speech communication interference in schools were identified.

Several school specific findings were reported in the study:

- Speech in schools (and sleep in hospitals) is a noise sensitive activity with a threshold of interference lower than that associated with health degradation or with attitudinal reaction.
- Ambient noise from aircraft is capable of interfering with speech communication.
- Noise level, spectral characteristics, separation distance between speaker and listener, and room acoustics are critical factors.
- A level of 45 dBA was selected as the threshold for the onset of speech interference in classrooms.
- Frequent, short-term disruptions of speech communication can interfere with the efficient flow of verbal instruction.
- Because of inexperience with language, children should have lower

background noise levels to achieve the same degree of speech comprehension as adults (U.S. DOT-FAA, 1977, pp. 21-22).

An outgrowth of the federal level research was Public Law 97-248 (September 3, 1982) which provided funding for numerous noise compatibility measures including soundproofing of schools. To date, only schools in Boston, Massachusetts have received FAA administered soundproofing funds but several school districts nationwide have initiated requests (Rose, March, 1983). Recent FAA recommendations for soundproofing two of the three school sites in this investigation, i.e., Site I and Site II, are included in appendix F.

An early study of the relationship between aircraft noise and learning emanated from the area near the Hawthorne Airport in London, England. Using behavioral observation techniques, teacher interviews and teacher attitude surveys, Crook and Langdon (1974) identified important behavioral characteristics and teacher attitudes in classroom settings manifested during aircraft flyovers. Disruption of speech communications jeopardizing lesson continuity was the most frequently reported ill-effect. Cognate constructs identified included: 1) pauses in verbal communication, 2) raised voice levels, 3) inability to hear, particularly in the back of the room, and 4) changes in student attentional patterns (p. 230-32).

Additionally, the researchers identified several contingency factors in the relationship between noise and task performance. According to teacher responses analyzed, whole-group instructional organization presented auditory problems that were not as evident during individual and small-group organization. "We also noted that the teacher could not be heard in the back of the room during a flyover in 'class' lessons"

(p. 227). The whole-group contingency posited by Crook and Langdon (1974) became an important consideration in the present research. In the experimental design, an attempt was made to minimize separation distance between speaker and listener so that students in the back of a classroom could hear as well as students in the front of the room during whole-group instruction impacted by noise from jet aircraft overflights.

Because of its relationship to runway utilization, wind direction was found to be the determinant of quiet days and noisy days in the Crook and Langdon study. Lacking control of natural phenomena, teachers did not adapt classroom organizational procedures to wind direction (p. 222). That is, teachers did not organize their classrooms on a small-group basis on noisy days or on a whole-group basis on quiet days.

Crook and Langdon's data were gathered from two elementary and three secondary schools. Behavioral observations were based on a sample of 1,260 flyovers during whole-group instruction and 1,118 individual lessons in two classrooms at each school (p.226). Since teacher participation was on a volunteer basis, one might suspect possible selection-treatment interaction to have biased the teachers' attitudinal findings. However, there is no reason to suspect the validity of the observed pupil reactions during the 2,378 discrete flyover events.

Crook and Langdon's findings about communication interference and related contingencies are closely paralleled by teacher testimony gathered by the Illinois Pollution Control Board over seven years of public hearings (Chicago, Department of Law, 1980).

Following is a review of two recently reported airport specific studies on task performance undertaken in the United States.

Green's study of New York City schoolchildren was discussed in an earlier section on health degradation (Green, 1980). Green's research also examined the relationship between high community noise levels and reading performance. The results of his regression analysis indicated a statistically significant correlation between noise levels and percent reading below grade level. The coefficients of the aircraft noise intrusion variable showed that noise could account for up to 5% of the students reading one or more years below grade level. The overall finding was that the percent reading below grade level increased as noise levels increased (p. 140).

Green's research methodology included descriptive statistics to define school noise levels and reading performance outcomes. Correlational methodology was then employed to measure the association between increments of school noise levels and increments of reading performance outcomes. The retrospective analysis from archival school records included 8,230 observations from 1972 to 1976 (p. 17). Suspected confounders statistically controlled were age, sex, race and health. Conclusions from the study were limited to inferences about noise levels by school and aggregated reading performance. Individual performance measures were not analyzed.

Hyatt's 1978-79 study of schools near the Seattle-Tacome Airport also included a correlational analysis of student achievement and aircraft noise (Hyatt, 1982). The noise dimension was isolated by demographically matching quiet and noisy schools. Performance data were collected from the regular testing program in grades 2, 4, 6 and 9. The data analysis indicated that students who attended quiet schools had higher achievement test scores at all grade levels. It was concluded from the study that jet aircraft noise had a detrimental effect on student achievement (p. 79).

Interpretation of the results of Hyatt's study is limited to inferences that student achievement and aircraft noise in the learning environment co-vary. A possible confounding variable, student aptitude, was not controlled. It is possible that achievement differences were attributable to aptitude differences as well as to noise differences.

Hyatt suggested that future JANI research include provisions to account for mediating variables: "Especially valuable in a study of this nature would be transmission versus reception of sound and the relationship between noise and voice transmittal" (p. 43). The direction by Hyatt has been incorporated into the JANI analysis methodology of this investigation.

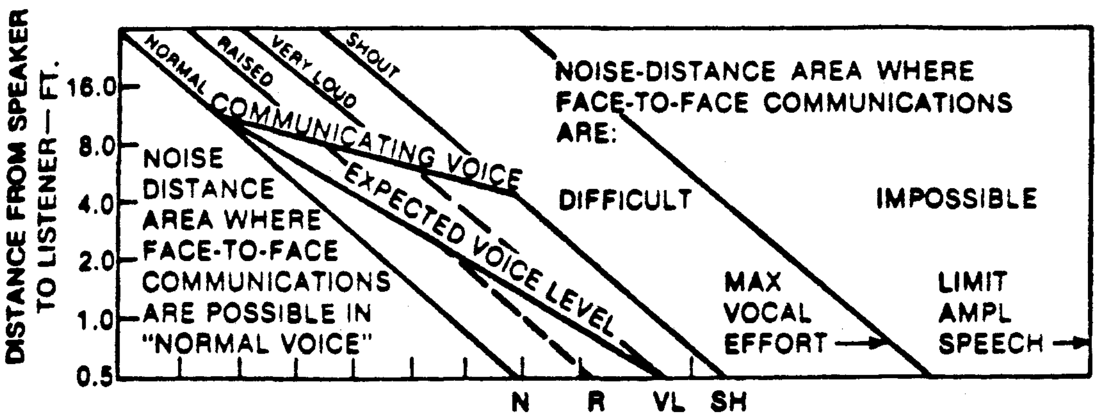
Paralleling the aforementioned field research of Crook and Langdon (1974), Green (1980) and Hyatt (1982) is the work of several authorities on theoretical models to predict levels of speech interference. Two functional, physical schemes to specify the effects of aircraft noise on speech are the Articulation Index (AI) and the Speech Interference Level (SIL). The AI was introduced by French and Steinberg in 1947, simplified and generalized by Beranek in 1947, and improved by Kryter in 1962 (Webster, 1978, p. 198). The AI is used as an estimate of speech interference by noise based on the speech level and ambient noise level at the listener's position. The AI metric was used in the U.S. DOT-FAA's 1977 policy level study on the feasibility of soundproofing schools. The SIL metric was proposed by Beranek (1947) as a simplified substitute for the AI to predict the speech interference level of noise. Used in conjunction with Webster's 1969 graph of separation distance, the SIL has become the most widely used rating for speech interference assessment (Bruel and Kjaer, 1979, p. 67).

Figure 3 represents additional refinements and standardization of the AI and SIL theoretical models. It is a published document of the U.S. FAA (1984). This theoretical referent and similar versions is widely used to specify speaker-to-listener separation distance for acceptable communications as a function of the interfering noise level.

Still another refinement to the theoretical paradigms was presented by Houtgast at the Third International Congress on Noise as a Public Health Problem, Freiburg West Germany, September 25-29, 1978 (Houtgast, 1980). By adding an indoor reverberation dimension to the calculations, the SIL model was functionally changed from an outdoor noise predictor to an indoor noise predictor. Houtgast's research was supported by the Ministry of Health and Environmental Protection of the Netherlands.

Research findings presented at the International Congress on Noise represent the authoritative contributions of scientific research scholars from throughout the world. The United States was represented by a number of its leading research authorities on noise analysis from the U.S. EPA, universities and private sector noise consulting firms. In summarizing the communication interference component of the International Congress, a long-time contributing American authority, credited Houtgast for his work in defining indoor speech communication interference criteria (Kryter, 1980, p. 711).

The relationship of Houtgast's findings to this analysis will now be discussed. The question pursued by Houtgast was what indoor noise level could be tolerated in terms of speech intelligibility. A general criterion of 45 dBA for tolerable indoor classroom noise was specified



PSIL	40	50	60	70	80	90	100	110	125
SIL	37	47	57	67	77	87	97	107	122
dB(A)	47	57	67	77	87	97	107	117	132
PNdB	60	70	80	90	100	110	120	130	145
dB(C)	54	64	74	84	94	104	114	124	139

Figure 3: Relationship Between Speaker-Listener Separation, Ambient Sound Level and Ability to Communicate

Source: U.S. Department of Transportation and Federal Aviation Administration, Final Environmental Impact Statement: Chicago O'Hare International Airport Chicago, Illinois, 2 Vols. May, 1984, Vol. 1, p. 449. (mimiographed.)

Note: Reproduced with permission from Michael Rose, FAA, November 28, 1984 by Houtgast (1980, p. 183). This criterion coincides precisely with the 45 dBA value identified by the U.S. DOT-FAA (1977, p. 20) and the U.S. EPA (1978, p. 24). The U.S. DOT-FAA study indicated, "Therefore, a level of 45 dB, due to intrusion of aircraft noise inside school buildings, was selected as the threshold level for onset of speech interference effects in such (school) buildings"(U.S. DOT-FAA, 1977, p. 22).

In summary, authorities seem to agree that 45 dBA is the threshold level above which, ambient noise begins to interfere with speech communication, contingent upon separation distance and speaker voice level, as specified in theoretical models (see Figure 3).

In concluding the JANI literature review, summary statements by authorities at the Third International Congress on Noise are presented. The nature of the research problem and direction toward its resolution were specifically addressed at the conference and utilized in this analysis.

Loeb (1978, p. 317) and Gulian (1978, p. 693) reported that little progress was made since 1950 in research to identify the effects of noise on performance. "The years of research that have been performed on noise effects have identified a number of sensitive tasks and critical variables, but much of the work needs to be redone while systematically manipulating these factors" (Loeb, 1978, p. 317). Loeb identified auditory discrimination and reading ability as the primary task performance constructs needing research replication. Goldstein and Dejoy (1978, p. 370) also emphasized the importance of auditory discrimination and reading achievement in the analysis of the effects of noise on performance.

Gulian (1978, p. 692) reported on the unsystematic and haphazard nature of the research on the effects of noise. Goldstein and Dejoy (1978) provided reasons for the lack of systematic findings:

> A major stumbling block to progress is that there are few, if any, direct effects of noise on performance. Under most circumstances, it is not practicable to predict effects by relying only on information concerning the physical parameters of the noise. Although we have acquired some knowledge of the connection between noise and performance, the exact relationship is quite complex and seemingly dependent upon many elusive non-acoustic parameters such as the nature of cognitive and motor demands of the task, intervening factors of the performance situation, and the presence of intrinsic personality variables. Identification, description, and quantification of the many non-physical parameters are clearly required before a concern with performance as disrupted by noise will become a critical factor in influencing the nature, direction, and stringency of noise-control programs (p. 371).

In Chapter III of this investigation, the research design presented attempts to address some of the "major stumbling blocks" discussed by Goldstein and Dejoy. Non-physical parameters incorporated into the design include provisions to evaluate the age-dependent effect described by Mills (1978, p. 232) and the aptitude-dependent effect described by Maser (1978) and by Schomer (1981, p. 143).

Minimal Hearing Loss Literature

A discussion of studies relevant to the MHL factor is now presented.

In 1968 Quigley and others were requested by the Division of Special Educational Services of the Office of the Superintendent of Public Instruction in Illinois to conduct a study of the prevalence, educational significance and treatment of hard of hearing children (Quigley, 1969). The research setting was the public schools in Elgin, Illinois. Study subjects included 116 students in grades 2 through 10 from a population of 173 identified with hearing acuity deficits but receiving no treatment. Air conduction audiometry procedures were employed to define a hearing acuity value for each subject. Quigley found that 31.9% of the study population manifested hearing levels ranging from 15 dB to 26 dB. An additional 50.8% were identified with less than 15 dB HL. Based on his findings, Quigley recommended a reclassification scheme for all Illinois schoolchildren to include a category for cases with slight hearing acuity deficits. He reasoned that "some degree of educational handicap" was suspected (Quigley,1970).

From 1977 to present, Project MARRS (Mainstream Amplification Resource Room Study) has conducted research in southern Illinois schools to identify students with slight hearing acuity deficits. Six hundred and one 4th, 5th, and 6th grade students were included in the original study population. Air conduction thresholds of 10 dB HL to 40 dB HL and a pure tone average of less than 25 dB in the better ear were included in the study. Of the 601 children tested, 197 (32.1%) failed the audiometry screening and demonstrated academic deficits in language, reading, and mathematics at least one-half year below the standard for their actual grade placement. Subjects were randomly assigned to treatment (amplification) and non-treatment groups. Both experimental subjects and control subjects were administered pretests at the beginning of the project and posttests at the end of an academic year. Both groups were exposed to similar curricula. Analysis of posttest data indicated that treatment students consistently out-performed non-treatment students in language and reading. Overall $\underline{t}$ test probability values were statistically significant at the .05 level (Sarff, 1981, p. 269).

Since the 1977-78 study, audiometric threshold and standardized achievement test data on 2,956, 3-6 grade students have been collected by project MARRS researchers (Sarff, May, 1983). A low-fence criteria of > 15 dB has been established for the MARRS research. Subjects identified with hearing thresholds of > 15 dB HL in either ear have been classified as having an educationally significant hearing loss. Identified subjects have demonstrated significantly lower task performance on standardized achievement tests in subskill tests related to reading, e.g., listening (Sarff, May, 1981).

In a related study, Burgener (1980), investigated the effects of soundfield amplification on the test taking performance of children with minimal hearing loss as well as those with normal hearing. The test conditions involved verbally administered reading and spelling tests to 131 second and third grade students. All subjects were exposed to equal increments of both amplified and non-amplified test administration. Minimal hearing loss was defined in Burgener's study as failure to respond to a pure tone signal presented at 10 dB for all frequencies 250 through 8000 Hz for either ear. The results indicated that soundfield amplification significantly improved the test taking performance on the dictated spelling test for all students regardless of hearing acuity levels. Burgener indicated that reading tests results were insignificant because visual, contextual clues counteracted the influence of voice amplification intervention. (Burgener, 1980, p. 62).

According to Roeser and Price, Figure 4, (1981, p. 73), pure tone signals presented to a normal ear at 250 Hz would be inaudible at any intensity level below 25 dB. Burgener's identification procedure utilized a 10 dB criteria across all frequencies 250-8000 Hz. The inclusion of the 250 frequency may have accounted for the inconclusive results on the reading test dependent variable because of invalid subject selection criteria. In the present investigation the 250 frequency was considered inappropriate, since even normal hearing subjects would manifest hearing threshold sensitivity values 25 dB and higher at that particular frequency.

In discussing further research, Burgener indicated the need for an investigation of the age-dependent effect postulated by Northern and Downs (1978). An age-dependent effect analysis has been incorporated into the research design of this investigation as explained in chapter III.

Suter, (1978), an Occupational Safety and Health Administration researcher for the U.S. Department of Labor, described an investigation closely related to the present analysis. The study examined the extent to which subjects, whose hearing levels were better (lower) than the 26 dB fence of the American Academy of Ophthalmology and Otolaryngology (AAOO), differed from one another when listening conditions were degraded by background noise. The study also examined the exclusion of frequencies above 2000 Hz. Subjects were divided into three groups of sixteen each. Each group was stratified by hearing levels and frequency combinations. Subjects were tested for intelligibility acuity in their better ear in three different speech-to-noise ratios ranging from 0 dB to 26 dB. Data were subjected to a three-factor analysis of variance to determine the significance of difference in speech discrimination between groups. The results showed that 500, 1000, and 2000 Hz combinations were less valid than 1000, 2000, and 4000 Hz combinations for predicting speech discrimination performance in noise. Within the area under the 26 dB fence (considered as MHL in the present analysis),

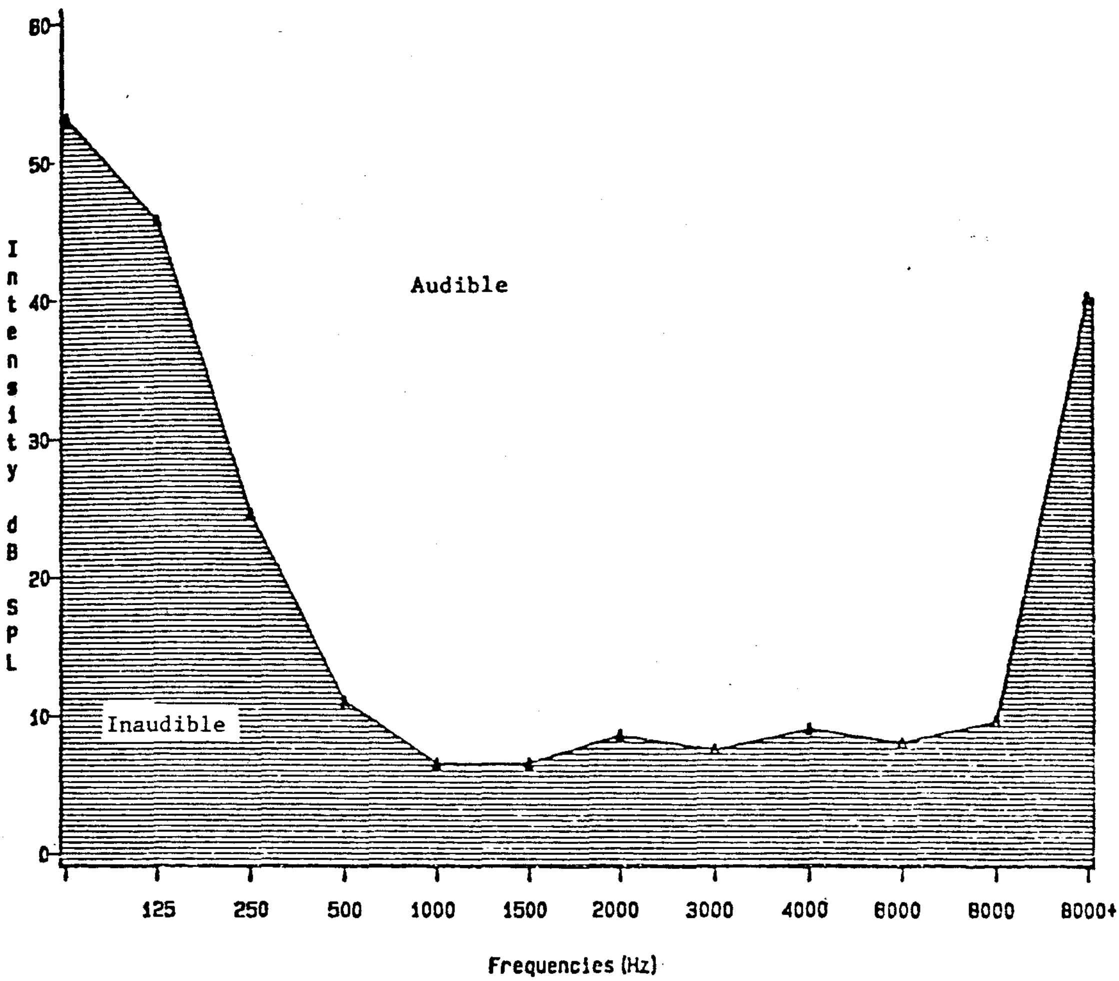


Figure 4: Threshold Sensitivity of the Normal Ear as a Function of Hz

Source: R.J. Roeser and D.R. Price, "Audiometric and Impedance Measures: Principles and Interpretation" In Auditory Disorders in School Children, eds. R.J. Roeser and M.P. Downs (New York: Thieme-Stratton, Inc., 1981), p. 73.

Note: Reproduced with permission from R. J. Roeser, February 2, 1983 differences among groups were found in the high frequencies. Suter concluded by recommending a low-fence between 15 dB and 30 dB based on a simple average of 1000, 2000, and 4000 Hz. "Until this point is defined more narrowly, it can be assumed to be approximately 22 dB (Suter, 1978, pp. 203-09).

While public health service research aids U.S. Department of Labor authorities in determining " a demarcation point both for compensation and for damage-risk purposes" (Suter, 1978, p. 203) it also aids public school research in determining a demarcation point for student task performance. Both Suter, from the public health sector, and Quigley, Sarff et al. from the public school sector, have provided research evidence which questions the appropriateness of current, public, hearing level criteria. Researchers seem to agree on the need to adopt a lower fence (intensity level) and to extend the frequency range in hearing screening programs to include higher levels such as 4000, 6000, and 8000 Hz.

Downs (1975, 1976, 1978, 1981) has contributed substantially to the emerging literature on MHL by providing chronological summaries of research findings. Following is a brief enumeration of findings reported by Downs:

- 1973 - "National Academy of Sciences questioned the use of a 26 dB criteria for hearing handicapped, stating that mild hearing deficits in the speech range are of functional significance in terms of impairing educability" (Downs, 1975, p. 258).
- 1975 - On the basis of the (above) report a survey in Washington, D.C., by the National Academy of Sciences utilized a 15 dB (ISO 1964) criteria for significant hearing loss......and reported a

total of 6.7% of the 1,639 four to eleven year olds examined with significant hearing loss in one or both ears (Downs, 1978, p. 2).

- 1976 - "An Australian study reported that even a 10 dB loss could be considered a significantly handicapping loss (Northern and Downs, 1978, p. 4).
- 1978 - In a discussion of preventative measures for minimal auditory deficiencies, Northern and Downs (1978) report "....it can be seen that the old criteria of 26 dB can be questioned as a valid expression of minimally significant hearing loss. It may be extremely conservative to place 15 dB as a significantly handicapping hearing loss for a child" (p. 11).
- 1981 - From a review and analysis of several recent studies, Downs (1981) developed the theoretical position that "...conductive loss is more devastating to the educational activity of children than had been previously suspected...." (Downs, 1981, p. 113).

Related to Downs's theory about the prevalence of conductive hearing loss, Illinois Department of Public Health documentation specifies annual hearing impairment prevalence data in schoolchildren. While records are kept on cases > 25 dB only, it is suspected that conductive hearing loss caused by otitis media accounts for a high percentage of MHL cases in schoolchildren. In the present analysis it is assumed that MHL is prevalent in the study population in some unknown quantity. An attempt is made to quantify the prevalence and to measure the effect.

Additional insight about the relationship between language acquisition and hearing acuity has been provided by Skinner (1978). Skinner's research is based upon the study of infants, with normal and abnormal hearing. Information from speech scientists about the speech sounds of general American English is provided by Skinner in support of her theoretical position. Several principles in the relationship between language acquisition and hearing loss in young children have been advanced by Skinner (1978). The principles most pertinent to the present investigation are presented below:

- The speech sounds in the English language used to form words within sentences range in intensity (loudness) over a 25 to 30 dB span. That is, one specific and isolated speech sound may be as much as 30 dB louder or fainter than another. For example, the unvoiced consonants such as the /f/ in <u>for</u> or the /t/ in <u>to</u> are considerably less intense than the voiced consonants, such as the /v/ in <u>vote</u> or the /z/ in <u>zoo</u> (p. 638).
- For adults, who have learned to discriminate between various speech sounds in a contextual manner, the range of speech sound intensity does not present the same barrier to understanding oral communication as with infants and young children (p. 638).
- For a child with any degree of hearing loss, the range of speech sound intensities presents an additional encumbrance in receiving and processing oral communications. The speech sounds at the fainter intensities are more difficult to hear (p. 643).
- Analogously, the principle is the same as turning down the volume on a radio by the intensity equivalent of the hearing loss. As the volume of the radio decreases, speech discrimination becomes more difficult. Conversely, as the volume is amplified, speech discrimination is enhanced (p. 645).
- Because conductive hearing loss is a fluctuating phenomenon,

children so inflicted will discriminate between speech sounds with irregular proficiency. That is, sometime the child will discriminate with ease; other times, the child will discriminate with difficulty (p. 644).

Embellishing upon Skinner's work, Downs (1981) posits that "It is exceedingly more important for a first grader to hear all speech sounds in a new word than it is for you as an experienced listener to hear them" (p. 179).

In summary, evidence seems to support an inference about the relationship between linguistic task performance and hearing acuity, particularly for younger students acquiring speech discrimination facility in a noisy learning environment. Micromediating factors in the relationship include age, the range of speech sounds in general American English, and the irregular pattern of conductive hearing loss. Illinois Public Health Department documentation indicates a high prevalence of conductive hearing loss in schoolchildren. Authorities from both the public health sector and the public school sector have substantiated the need for additional hearing acuity data relating intensity/frequency combinations to corresponding task performance outcomes.

As described in the following chapter, 1,037 audiometric threshold values have been collected over two school years at three school sites. An attempt is made to examine a range of hearing acuity values from 0 dB to 35 dB over a frequency range from 500 to 8000 Hz and to explore the relationship between incremental hearing acuity value combinations and their corresponding incremental linguistic task performance values.

CHAPTER III

DESIGN AND METHODOLOGY

Overview

Multiple research methodologies have been employed to provide answers to the hypotheses of interest in this investigation. Data have been gathered on 764 subjects in 1982-83 and on 276 subjects in 1981-82 in the research setting. The design may be viewed as a two step sequential process applied to the two distinct variables of interest, i.e., speech communication interference from jet aircraft noise intrusion (JANI), and speech communication interference from minimal hearing loss (MHL). As shown on Table 3, step I of both analyses involves the use of descriptive research to quantify the speech communication interference construct. The output from step I is then used as input for the experimental research shown as step II. In step II, experimental procedures are used to investigate possible cause and effect relationships by exposing experimental groups to amplification intervention and comparing the results with control groups not having received the treatment.

The correlational, developmental and additional descriptive research components shown on the bottom of Table 3 are part of the overall MHL analysis but represent mutually exclusive events from the experiment. These additional research procedures are incorporated into the MHL analysis to provide an extensive informational base to local school officials for future classroom environmental decision-making.

The research setting is a K-8 elementary school district with a

TABLE 3

Design Overview

	JANI Analysis	MHL Analysis
Step I	• Descriptive research to quantify speech communication interference from JANI(represented by noise level at sites I,II and III).	• Descriptive research to quantify speech communication interference from MHL(represented by hearing acuity values from 396 first and second grade subjects from Sites I, II and III.
Step II	• Experimental research to test treatment condition (teacher voice signal amplification) on same samples (sites and subjects) as step I.	• experimental research to test treatment condition (teacher voice signal amplification) on same samples (sites and subjects) as step I.

Non-Experimental Design Research Components - MHL Analysis Only

• Additional descriptive research to quantify speech communication interference from MHL for comparison with exterior data sets - using 764 1-6 subjects from sites I, II, and III.

• Correlational research to relate MHL prevalence to age (grade level) and to achievement using 1,037 hearing acuity values collected over two school years.

• Developmental research to study pattern of MHL change over time - based upon 217 hearing acuity values collected over two school years at Site I only.

student population of 2,016 students and five schools. The school district borders the west boundary of Chicago's O'Hare Airport.

The units of observation for the experimental research in both analyses are the same 396 first and second grade subjects and three school sites. The data were collected and the experimental research was conducted during the 1982-83 school year. Data for the expanded descriptive research and the correlational and developmental research of the MHL analysis were collected over two school years, 1981-82 and 1982-83. The units of observation for these components of the investigation were 1,037 hearing acuity threshold values from school sites I, II and III.

The remainder of this chapter is divided into two major sections, representing the two separate analyses, i.e., JANI and MHL.

Jet Aircraft Noise Intrusion Design and Methodology

The JANI analysis is divided into two subsections corresponding to the non-experimental and experimental design components. In the first subsection, descriptive research procedures are presented for quantifying the noise level dimension of the analysis. The second subsection begins with definitions of relevant referent constructs for the experimental design. The constructs serve as the basis for discussing subject selection, data collection and treatment decisions which follow.

Non-experimental Design Component

Noise Level Dimension

There are two independent variables, school site and school hour, and one dependent variable, measured noise level, included in the descriptive procedures used to quantify the physical parameters of the noise problem.

Because of the contention between the collar communities surrounding O'Hare International Airport and the airport owner, the City of Chicago, the prevailing noise levels near the airport have been thoroughly documented. From 1977 to present, numerous noise level contour maps have been published by the City of Chicago's Department of Aviation, the Illinois Pollution Control Board, and the FAA. Appendix E contains noise level documentation relevant to the three research setting school sites in the investigation. The principal noise descriptors used in the documentation are Ldn and Leq values. Recently, the City of Chicago's Department of Aviation has also published a TA (time above) noise descriptor for each public building within the 65 Ldn contour near O'Hare Airport.[1] The TA provides the accumulated time (minutes) per day, per site in excess of 65 Ldn, 70 Ldn, 75 Ldn, and 80 Ldn.

Apart from public documentation, this analysis includes site specific noise monitoring results. Sample data from the population distribution of prevailing noise levels during school hours were gathered at three of the district's five schools. Following is a description of the three school sites from which noise samples were drawn:

- Site I - Mohawk Elementary School is a K-6 school with a population of 350 students. Of the three sites, this attendance center is located closest to O'Hare Airport and lies on a direct line with the westbound and most frequently used runway (Chicago, Department of Aviation March, 1981, IV. 1-10).
- Site II - Tioga Elementary School is a K-3 attendance center with a population of 459 students. This school is located further from O'Hare Airport than is Site I.
- Site III - Johnson Elementary School is a K-6 elementary atten-

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[1] Appendix E contains published TA, Ldn and Leq descriptors for Sites I, II, and III through 1995. Appendix E also contains Leq values collected as part of this investigation.

dance center with a population of 352 students. This attendance center is located further from O'Hare Field than is either Site I or Site II.

The data were gathered daily by a professional engineer independent of the school district. Precision, noise-monitoring equipment was utilized for all data collection. The equipment was made available by the Suburban O'Hare Commission, the officially recognized representative committee, on airport related issues, of all communities surrounding O'Hare Airport. Following is a description of the equipment. All components were manufactured by the Bruel and Kjaer Company and conform with ANSI, 1969, standards.

- Noise Level Analyzer Type 4426 - a small, compact instrument designed to measure and record the standard A-weighted network of noise. Used in conjunction with the 2312 Alphanumeric Printer, the noise analyzer calculated and displayed an equivalent continuous noise level (Leq) based on the equal energy principle. A new Leq value was calculated every 0.83 seconds. The Leq values were based on samples automatically taken each 0.1 second by the noise analyzer. Hourly Leq output values were printed on a tape.
- Outdoor Microphone Unit Type 4921 - an all-weather quartz-coated microphone atop a tubular stand. The microphone was placed on a rooftop and connected by cable to the noise analyzer located indoors at each of the three school sites in the study.
- Graphic Level Stripchart Recorder Type 2306 - a unit connected to the noise analyzer for graphically portraying the peaks and valleys in sound levels over time. Each discrete event (individual flyover) was graphically displayed on a tape.

By combining the four units of equipment into an integrated system, two separate data outputs were recorded and collected. A strip-chart graphic for each twenty-four hour sample provided a visual portrayal of the frequency and intensity of each individual flyover. These graphics were useful in the ongoing public dialogue about the nature of JANI. They provided a visual conceptualization of aircraft noise intrusion that was not as apparent in the published statistical summary descriptors.

The second noise analyzer output, hourly Leg values, provided the raw data for statistically contrasting Sites I, II and III. The Leq measures the equivalent continuous equal energy level. It can be applied to any fluctuating noise level. The literature indicates that Leq "provides quite a good measure of intensiveness in that it lays more emphasis on high noise levels which can be quite distracting" (Bruel and Kjaar, n.d.). Since speech communication interference in schools was the focus of this study, Leq was a more appropriate noise descriptor value than Ldn because the latter includes a 10 dB night-time penalty (U.S. EPA, 550/79, p. 4). This research was narrowed to the school-day time span between 8:00 A.M. and 4:00 P.M. and was not concerned with the level of night-time noise.

Published noise level descriptors are based upon data collected over time using computerized models and processes (Chicago, Department of Aviation, April, 1983, pp. IV. 1-20). The available public documentation did not coincide with the time-span during which the amplification experiment was being conducted, i.e., the second semester of the 1982-1983 school year. Hence, to enhance the validity of the experimental design, noise quantification data were gathered separate from the available public reports.

Documentation of the locally collected data is shown in appendix E. A mean noise level value (expressed in Leq's) is displayed for the sample data collected at each school site I, II, III. Ninety-six hourly samples were collected at Site I; 136 at Site II and 104 at Site III. Each sample represented a one-hour mean value based upon statistical summaries of the frequency, intensity and duration of individual aircraft overflights.

These data provide the necessary statistical input for addressing research hypotheses 1 A and 1 B. Rejection decision for the two hypotheses were tested by a two-way analysis of variance with school site and school hour being the independent variables and Leq values being the dependent variable. As previously indicated, the output from the descriptive research anteceded the experimental design and MANOVA statistics employed in the Hypothesis 2 group.

Experimental Design Components

The experimental design includes two variables represented by constructs. Speech communication interference from JANI is one construct. It is an independent variable. The other construct, linguistic task performance, is the dependent variable. These two construct variables, along with the treatment condition (an independent variable) represent the variables of major interest in the JANI analysis. Each is discussed below.

Speech Communication Interference from JANI Construct

As indicated by authorities on noise problems, "... it is not practicable to predict effects by relying only on information concerning the physical parameters of the noise" (Goldstein and Dejoy, 1978, p. 371). In the present analysis there is interest in predicting the effects of noise in classroom settings. Hence, there is a need to include more than noise in the analysis. The federal level authority responsible for regulating aircraft noise is the U.S. Department of Transportation and Federal Aviation Administration. This authority has indicated that speech communication interference is the principal, school related, adverse effect of aircraft noise (U.S. DOT-FAA, 1977, p.2-2). Speech communication interference is a construct, and as such, may be used as an "intervening variable" in a research effort (Kerlinger, 1973, p. 41). Construct validity is particularly relevant to the kind of applied research in this investigation.[2] The speech communication interference construct is defined below. Other pertinent constructs are defined when introduced.

The speech communication interference from JANI construct is more

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[2] Authorities emphasize the need for a high level of construct validity in applied research, particularly in policy research where the focus is on impact (Cook and Campbell, 1979, p.63). There is a need for a high degree of specificity about the nature of the problem, including identifying causal constructs and effect constructs. Construct validity refers to the congruence between cause and effect research operations and referent constructs. Referent constructs represent the researcher's attempt to describe variables in a way that corresponds closely with public dialogue on the topic. Referent constructs become the basis for naming samples, whether the samples are subjects or phenomena (Isaac and Michael, 1971, p.160; Kerlinger, 1973, pp. 461-64; Cook and Campbell, 1979, p.59).

readily perceived in contrast with its opposite, speech intelligibility. Speech intelligibility is a measure of a listener's ability to comprehend speech. Speech communication interference is a measure of the listener's inability to comprehend speech. In controlled laboratory settings, articulation and intelligibility instrumentation are employed to measure both speech intelligibility and speech interference (Webster, 1978, p.198). In field settings, the articulation index has been employed to estimate speech reception in noisy environments and to establish the noise threshold level for the onset of speech communication interference (U.S. DOT-FAA, 1977, p.23).

Noise level criteria applicable to indoor communication have been specified by several sources : (U.S. EPA, 1981; Houtgast, 1978; Acoustical Society of America, 1977; and The International Organization for Standardization, 1974). In all cases the criteria are three dimensional. Separation distance between speaker and listener is one criteria; noise level is a second criteria and voice signal intensity is a third criteria (Houtgast, 1978, p. 173). Taken together, speech interference criteria indicate that as distance between speaker and listener increases, tolerable ambient noise decreases or speech signal intensity must be increased (Figure 3).

In the experimental design of this analysis, speech communication interference is operationalized by quantification of the exterior noise level (step 1) and experimental manipulation of separation distance and speech signal distribution (step 2). Speech communication interference is viewed at the molar level; noise, separation distance, and speech signal distribution are viewed at the micromediation level. Statistical relationships and any attendant causal inferences are based on molar level referent constructs. Experimental operations involve measuring and controlling the underlying micromediating constructs, i.e., noise level, separation distance, and voice signal intensity distribution. The known and suspected cognate constructs of speech communication interference by noise intrusion are now specified.

a. Exterior noise levels - (Described above)

b. Separation distance - The linear distance, expressed in feet or meters, between speaker and listener is one of the classical determinants of a listener's ability to comprehend speech communication in noise (Figure 3). For this analysis, separation distance is mediated by manipulating the classroom acoustical environment so that all experimental subjects are physically closer to the source of the teacher's voice signal.

c. Physical measures of speech - the intensity level of spoken communication is another of the classical components for predicting speech discrimination in noise (Webster, 1978, p.223). In the experimental classrooms, the amplified teacher's voice signal is uniformly distributed at a common intensity level established by auditory consultants from Project Marrs and monitored weekly by this researcher.

d. Annoyance/distractability - An internal disruption at the linguistic level in both speakers and listeners is a documented effect of noise (Goldstein and Dejoy, 1980, p.370). Attitudinal reactions to noise are not isolated in this analysis. They are assumed to contribute to the molar level referent construct, speech communication interference. Gulian (1978) has referred to the relationship between annoyance and speech communication interference as the "interference-distraction theory" (p. 694).

e. Time on task - Recent research on learning has demonstrated the need for "concentrated effort and sustained engagement" (Rubin, 1982, p.170). Time-on-task is currently viewed by many as an acceptable referent construct of cause in evaluating student performance (Fisher, Berliner et al., 1978). The effects of noise on learning could be evaluated by isolating the time-on-task dimension from differential noise level populations and comparing linguistic task performance. However, in this analysis, time-on-task is viewed as a cognate construct of speech communication interference.

Linguistic Task Performance Construct

Based upon public policy documentation, one can assume that speech communication interference in schools (and sleep in hospitals) are identified people activities most sensitive to noise intrusion (U.S. DOT-FAA, 1977, p. 2-2). Connecting speech communication interference to learning degradation, however, has been an elusive task for interested researchers (Chicago, Department of Aviation, July, 1983, IV, 1-7G). Authorities agree that in the relationship between noise and performance, the nature of the cognitive task is important (Goldstein and DeJoy, 1978, p. 370; Mills, 1975). An expanding body of evidence shows that the linguistic task of auditory discrimination is adversely affected by exterior noise intruding into classrooms (Goldstein and DeJoy, 1978, p. 370).

The cognitive task of salient interest in this investigation is linguistic task performance, as differentiated, for example, from motor task performance. This choice is based on the speech chain theoretical paradigm (Figure 1), wherein, oral communication is completed at the linguistic level when the listener recognizes and understands the words and sentences transmitted by the speaker. The major speech communication activity occurring in the research setting population sample classrooms is beginning reading instruction. The Open Court (1979) basal reading program is used. This program employs the phonetic approach in learning to read. Emphasis is placed on whole-group, direct instruction methodology. For approximately two hours each morning students are listening and reacting to the teacher's voice signal. Through a variety of chalkboard activities, students sound and blend consonants and vowels into words, and words into sentences. Reading sub-skills emphasized include phonetic analysis, auditory discrimination, auditory vocabulary, sight vocabulary, word reading, sentence reading, and reading comprehension.

The postulate tested in this analysis incorporates the constructs discussed above, i.e., the noise dimension, the speech communication interference from JANI construct, and the linguistic task performance construct. It is suspected that excessive noise causes speech communication interference, which in turn, causes degradation in linguistic task performance. In the experimental design, the constructs are operationalized as intervening variables and analyzed for their interrelationships.

Treatment Dimension

Teacher voice signal amplification treatment has been successfully employed to reduce speech communication interference problems experienced by subjects with minimal hearing acuity deficits. In this analysis, the treatment is applied to tests its utility in reducing suspected speech communication interference problems from a different source, i.e., jet aircraft noise intrusion.

In the experimental design, the treatment condition is a classificatory variable randomly assigned to intact first and second grade classroom group. Observations are recorded for experimental cases receiving treatment and for control cases not receiving treatment. Of the three components, i.e., ambient noise level, separation distance and voice signal intensity, specified in the current speech interference theoretical models (Houtgast, 1978, p. 172; U.S. DOT-FAA, 1984, p. 449), teacher voice signal amplification provides a strategy for systematically manipulating the latter two, i.e., separation distance and signal intensity. The other component, ambient noise level, has been assigned a measured value, and in this sense, is controlled (but not manipulated).

The amplification equipment provides for uniform voice signal distribution throughout a classroom (soundfield) and unencumbered teacher movement (freefield). The teacher's voice signal is intensified and evenly distributed through the use of a cordless microphone and transmitter channeled to two 12 inch speakers positioned in opposite corners in the rear of a classroom. Intervening between the wireless microphone and the remote speaker is a model M-72 receiver and a Raymer 10-watt amplifier.[3] All components of the system were inspected by a Project MARRS consultant and conform with the National Diffusion Network, USOE standards for use in classrooms.

Subject Selection and Experimental Design

The nature of the behavior under study influenced the subject selection for the analysis. Researchers have reasoned that speech communication interference has an age-dependent effect on learning resulting in greater problems for younger students lacking experience in auditory processing (U.S.DOT-FAA, June 1977, p. 21; Mills, 1978, p. 233; Skinner, 1978, pp. 638-43; and Downs, 1981, p. 179). The nature of skills taught and instructional methodology also influenced subject selection. Because first and second grade students are unable to read independently, much of their time is spent listening to the teacher's voice signal. This is particularly true in the research setting classrooms, where phonetic content and large-group methodology are emphasized.

For the above reasons, the three schools housing primary level students in the district were chosen as the population sample. The availability of ten sets of voice signal amplification equipment for manipulating the classroom acoustical environment complimented the decision to narrow the analysis to first and second grade population samples. With a research setting population of 396 subjects in eighteen first and second grade classrooms and ten sets of equipment, the essen-

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[3] The equipment was acquired from Com-Tek, Salt Lake City, Utah, through Project MARRS consultants.

tial components for experimental research were present including random assignment, treatment manipulation, and multiple comparison groups. Ten intact classrooms were randomly assigned to receive experimental treatment. The remaining eight intact classrooms served as controls for the purpose of comparing between-group, growth or change. Initial, between-group, non-equivalency among sites was known to exist. Archival records indicated that subjects from one of the three school populations, i.e., Site II, had repeatedly demonstrated lower performance on annual measures of both aptitude and achievement compared with subject populations from Sites I and III. These differences could not be controlled experimentally since random assignment of neither individuals nor intact classes to school sites was an available assignment option. Differences were statistically controlled by utilizing a non-equivalent group design to differentiate between treatment differences and selection differences, i.e., two concomitant variables were included in the statistical analysis to control for aptitude and achievement differences between school site comparison groups.

The multivariate analysis of variance (MANOVA) statistical procedure was chosen to analyze the data so that multiple questions of interest could be answered within one experiment (Freund and Littell, 1981, p. 220). This statistical methodology provides a means for analyzing qualitative (non-metric) and quantitative (metric) variables simultaneously, a requirement of the design. The non-metric variables (factors) and their corresponding levels were: treatment-nontreatment, two levels; the speech communication interference construct (represented by school site, three levels; and grade level, two levels. Values from the linguistic task performance posttests observations constituted the metric variable. The MANOVA procedures also allows for analysis of interaction between covariates and factors, another requirement of the design. The covariates were represented by the subject aptitude values and the pretests of linguistic task performance values. Multivariate analysis of covariance procedures are also particularly suited for addressing the aforementioned, initial, between-group non-equivalency problem (by providing posttest scores adjusted for differences in ability and in pretest scores).

As shown on Table 4, the MANOVA matrix provides a means to compare two levels of the treatment variable across three levels of the noise variable. This is the comparison of major interest in evaluating the treatment's utility in mediating speech communication interference from jet aircraft noise intrusion. Of additional interest are the first and second grade level comparisons within each cell, 1 through 6. These comparisons provide values for studying relationships and answering questions about the age-dependent effect.

The observation schedule on Table 4 specifies the dates when data on all subjects were collected and treatment was imposed. O^1 represents the collection of observations for the concomitant variable, student aptitude. In the MANOVA procedures these observations provide statistical control for the between-site population group differences by adjusting individual posttest values for initial aptitude differences. The inclusion of subject aptitude values also allows for an a posteriori analysis of the aptitude-dependent effect posited by Maser (1978) and by Schomer (1981).

O^2 represents the collection of values for another concomitant variable, pretest observations of linguistic task performance. Values

TABLE 4

2x2x3 MANOVA Matrix and Observation Schedule

Speech Communication Interference From Jet Aircraft Noise Intrusion Factor

		Level 1 Site 1		Level 2 Site 2		Level 3 Site 3		
Teacher Voice Signal Amplification Treatment Factor	Level 1 Treatment	cell 1		cell 2		cell 3		
		1	2	1	2	1	2	
		n=17	n=18	n=57	n=59	n=16	n=20	187
	Level 2 Control	cell 4		cell 5		cell 6		
		1	2	1	2	1	2	
		n=17	n=22	n=27	n=40	n=19	n=24	149
		34	40	84	99	35	44	336

```
September 82        January 83 (treatment imposition  90 days) June 83
  O1                   O2                                        O3
---|------//////--------|-----------------------------------------|----
pretest             pretest                                   posttest
aptitude                     linguistc task performance
assessment                          assessment
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Observation Schedule - 1982-83 School Year were collected from all subjects on measures of phonetic analysis, phonics-consonants, auditory discrimination, auditory vocabulary, sight vocabulary, word reading, sentence reading and reading comprehension.

O^3 represents the collection of values for the dependent variable, linguistic task performance. Observations were collected for all subjects on parallel forms of the linguistic task performance pretest instrument.

Statistical Hypotheses

Operational statements of the research hypotheses in null form are now given. The hypotheses are grouped according to their relationship with the research hypotheses presented in Chapter I.

Jet Aircraft Noise Intrusion Hypotheses

1 A There is no difference in the average level of noise(Leq) from jet aircraft overflights between school sites I, II and III.

1 B There is no difference in the average hourly noise level(Leq) across the school day from 8:00 a.m. to 4:00 p.m. at school sites I, II and III combined.

2 A Among first and second grade subjects, there is no difference in linguistic task performance between amplification treatment subjects and non-amplification subjects.

2 B There is no difference in the effect of amplification treatment

between first grade subjects and second grade subjects.

2 C Among first and second grade subjects, there is no difference in the effect of teacher voice signal amplification treatment on linguistic task performance of subjects stratified by aptitude levels, high, middle and low.

2 D Among first and second grade subjects, there is no statistical relationship between teacher voice signal amplification treatment, speech communication interference (from either JANI or from MHL) and linguistic task performance.

Hypotheses 1 A and 1B are addressed by the descriptive statistical procedures discussed above in the noise dimension section. Rejections decisions for Hypotheses 2 A, 2B, 2C and 2D are based on the results of a 2x2x3 combined-group MANOVA analysis. Referring to the MANOVA matrix, Table 4, Hypothesis 2 A represents a comparison of treatment cells (1,2,3) with the non-treatment cells (4,5,6) on the dependent variable, after adjusting all dependent variable values by the concomitant variables, i.e., aptitude and pretest values. Hypothesis 2 B compares treatment effects within the first grade stratum and treatment effects within the second grade stratum. Hypothesis 2 C is based upon an a posteriori comparison of treatment groups with control groups after having stratified the data into high, middle and low strata based upon subjects' aptitude values. Hypothesis 2 D is based upon comparisons within each school site, i.e., cell 1 with cell 4; 2 with 5; and 3 with 6.

Treatment Assignment and Monitoring

Teacher voice signal amplification equipment was randomly assigned to a sample of five intact first grade classrooms and five intact second grade classrooms from the district population of eighteen first and second grade classrooms. Four control groups were utilized at each grade resulting in a study population of eighteen intact classrooms. Classroom selections were determined randomly by a table of random numbers at a grade level meeting on January 6, 1983 with sixteen of the eighteen teachers present as well as the three building principals from Sites I, II and III.

Amplification equipment was installed in the randomly assigned classrooms on January 15, 1983, and operated for the remainder of the school year until June 11, 1983. The amplification system was employed whenever the class was organized for whole-group instruction. During small-group instruction the equipment was disengaged for two reasons. First, teacher-to-student separation distance during small-group instruction negates the need for voice signal amplification. Second, an amplified teacher's voice signal, received by individuals and small groups not involved with the teacher directed group, masks peer-group speech intelligibility. The masking occurs because of multiple, competing voice signals in the communication environment.

Signal intensity level for each of the ten sets of classroom equipment was established by Project Marrs consultants upon installation. Batteries were replaced in the equipment each Monday by this researcher and the school district's audio-visual specialist. Each experimental classroom was monitored no less than once each week by this researcher to assure uniform treatment implementation throughout the experiment. A spare amplification unit was used to temporarily replace original units being repaired.

Data Collection and Analysis

Aptitude Assessment: Values for the concomitant variable, student aptitude, were derived from the results of the Cognitive Abilities Test (Houghton Mifflin, 1980). This instrument is part of the district's testing program administered annually during September to the first and second grade population. Its purpose is to obtain an early assessment of cognitive abilities. The tests were administered in group settings by classroom teachers following uniform procedures coordinated at the district level by this researcher. The tests were machine scored by the Riverside Publishing Company. Test reliability information provided by the publisher indicates an internal consistency reliability correlation of .894 over 7,693 cases at grade one and .893 over 7,686 cases at grade two (Riverside Publishing Co., 1982, p.24).

Linguistic Task Performance Assessment: Based on the nature of speech communication occurring in the research setting classrooms, linguistic task performance assessment instruments were chosen. Emphasis was given to selecting test instruments congruent with the prevailing classroom instructional content. In consultation with speech therapists, classroom teachers, university specialists and publishers' consultants, two commercially published test instruments were selected, i.e., The Stanford Diagnostic Reading Test and The Metropolitan Reading Test. Subtest components include, phonetic analysis, phonics-consonants, auditory discrimination, auditory vocabulary, sight vocabulary, word reading, sentence reading, and reading comprehension. In appendix G, information is provided about the instrumentation including publishers, copyrights, reliability coefficients and content objectives.

An attempt was also made to establish congruence between classroom oral communication process and test administration process. Both pretest and posttest content were administered to experimental subjects via the amplification process. This procedure was followed to maximize the systematic variance between experimental and control subjects on the dependant variable.

Uniform test administration procedures were developed in a grade level meeting on January 6, 1983. Sixteen of eighteen teacher participants and all building principals were involved. Instructions were given by this researcher. Both pretests and posttests were administered by classroom teachers. This procedure was followed because of subjects' ages, requiring that all instructions and much of the test content be read to the class. There is no known reason to suspect systematic, extraneous test administration variance. Item responses were entered by subjects on commercially printed, individual response booklets. Upon completion, all response booklets were hand scored by three school district curriculum personnel with selected spot checks for test scoring accuracy by this researcher. Upon completion of each classroom set, 25% were randomly re-evaluated by an alternate evaluator. All data collected in this investigation were coded and processed by this examiner and one district level curriculum staff member. All data were scanned for entry errors and irregularities and were entered on general coded forms and processed utilizing the on-line facilities of an IBM 3033 computer from the Loyola University Academic Computing Services.

Minimal Hearing Loss Design and Methodology

The MHL analysis is divided into three subsections. The first subsection presents a discussion of initial research efforts by the school district to collect hearing acuity data and to test the value of teacher voice signal amplification treatment. The second subsection presents the non-experimental design components of the analysis including the descriptive, correlational and developmental research data collection and analysis procedures. The third subsection describes the experimental procedures used to test the treatment condition and compare performance growth differences between experimental and to control groups.

Pilot Study

The subjects and technology included in this component of the investigation evolved over a two year period beginning in the fall of 1981 at Mohawk Elementary School (subsequently identified as Site I).

Utilizing subject identification procedures required by the Illinois, Title IVc, Project MARRS Program, trained audiometric technicians initiated pure tone, air conduction, audiometry. The objective was to identify students with minimal hearing acuity deficits.

Due to the level of aircraft noise in the testing environment at Site I, the data collected were assessed as invalid by cooperating Project MARRS consultants (Sarff, 1981). Upon the recommendation of the consultants, the school district purchased a portable, soundproof hearing testing booth to insure valid pure tone, air conduction, audiometry results. In March, 1982, the entire Site I student population was retested utilizing the soundproof booth in conjunction with all Project MARRS procedures required to insure valid data.

Simultaneous with the MHL identification process, the recommended Project MARRS intervention strategy was initiated. Ten sets of teacher voice signal amplification equipment were purchased and installed in classrooms at two separate attendance centers in the elementary district. A unit was installed at each grade level at Site I resulting in six experimental and six control groups across grade levels 1-6. Four sets were installed in classrooms at the district's junior high school. The community's high school also acquired four sets to participate in the experiment. At the time, it was suspected by school officials that JANI caused MHL, resulting in depressed student performance. The experience of school officials suggested that Mohawk Elementary School was the site in greatest need of technological intervention because of its close proximity to O'Hare Airport. Numerous public documentation supported and substantiated the empirical observations of school officials, e.g. (Illinois Pollution Control Board, 1980, Exhibit 18). Assuming an interaction of JANI and MHL, school officials reasoned that intervention across grade levels 1-12 would impact most favorably on students originating from Site I. Basic skills classrooms at levels 7-12 were targeted for teacher voice signal amplification treatment in addition to the six elementary classes at Mohawk Elementary School. At grades 7-12 the intervention strategy was one of longitudinal remediation. Performance by treatment students was to be compared with performance by control students with particular attention to comparisons between subjects originating from Mohawk Elementary School.

Inadequate monitoring procedures at the program implementation stage of the inquiry resulted in insufficient data collection. Audiometric identification procedures were implemented at Mohawk school only. Without MHL baseline data from the secondary school sites, longitudinal comparisons of treatment subjects and control subjects were not possible. Also, the original audiometric observations from Mohawk school were adjudged invalid because of excessive ambient noise in the testing environment.

Salvaged from the preliminary research effort, however, were two sources of important information upon which to build the current investigation. First, valid baseline data from the March, 1982, follow-up audiometric screening program at Mohawk Elementary School were available. Refinement of technology and procedures were additional related benefits. Second, feedback about the amplification technology from participating students, staff and equipment technicians was valuable. From the exploratory efforts pursued during 1981-82 the foundation for the current study began.

Non-experimental Design Components

There is no treatment involved here. The independent variable is the speech communication interference from MHL construct. It differs from speech communication from JANI in terms of the source of the suspected interference. The dependent variable is the same linguistic task performance construct addressed above. Following are pertinent construct definitions and a research procedure summary.

Speech Communication Interference from MHL Construct

The three dimensional theoretical models for predicting speech communication interference from noise, specify that signal reception is a function of the interaction between noise level, signal intensity and separation distance (Figure 3). Soundfield amplification intervention was introduced by Sarff et al. (1977) in classroom environments where noise interference was not an intervening variable of interest. The MHL analysis of this investigation replicates and extends Sarff's research in the MHL context, not in the JANI context. Therefore, speech communication interference, or its reciprocal, speech communication intelligibility, becomes a function of signal intensity and separation distance between speaker and listener. This postulate is consistent with Skinner's analogy (1978, p.645) of turning down the volume of a radio by the equivalent of the hearing loss. "As the volume of the radio decreases, speech discrimination becomes more difficult. Conversely, as the volume is amplified, speech discrimination is enhanced" (p.645). In this sense, MHL is viewed as the major referent construct of the analysis. It is seen as a construct of cause at the physiological level of the listener on the speech chain and suspected of depressing linguistic task performance. The descriptive research procedures summarized below represent an attempt to quantify the prevalence of MHL in the research setting population. The correlational and developmental procedures may be viewed as variations of the quantification process enabling an extensive examination of the available collected data.

Linguistic Task Performance Construct

This is the second major referent construct of the MHL analysis. Task performance is viewed as a construct of effect at the linguistic level on the speech chain. In classroom settings with emphasis on whole-group, direct-instruction, teaching methodology and phonetic reading skills and content, it is important that the listener hear the sounds, words and sentences transmitted by the speaker (Skinner, 1978, p. 638; Downs, 1981. p. 179). Table 5 summarizes the research methodologies and statistical procedures applicable to all non-experimental components in the MHL analysis.

Experimental Design Components

Subject Selection and Experimental Design

Subjects selected for the experimental design represent the same 396 first and second grade population sample used for the JANI analysis. Researchers on auditory problems in school-children have postulated the same age-dependent effect that influenced subject selection rationale for the JANI analysis (Skinner, 1978, pp.638-43; Downs, 1981, p.179). Teacher voice signal amplification equipment was installed in the ten randomly assigned intact classrooms on January 15, 1983 and operated for the remainder of the school year, i.e., ninety days.

As in the JANI analysis, a multivariate analysis of variance (MANOVA) statistical procedure is used to analyze the data collected. The MANOVA matrix is shown on Table 6. The observation schedule is the same as displayed on Table 4. The independent variable of major inter-

TABLE 5

MHL Non-experimental Design Components

Null hypothesis 3 A There is no difference in the proportion of MHL between the local population and the comparable exterior data set.

A. Methodology - descriptive research to define proportions and compare parameters from two populations.

B. Population sample Exterior data set - grades 3-6, n = 1,019
Local data set - grades 1-6, n = 764

C. Statistical procedure - Z score based on number of trials and population proportion given in null hypothesis.

Null hypothesis 3 B There is no difference in the proportion of MHL between school sites I, II and III.

A. Methodology - descriptive research to define and compare parameters from three local populations.

B. Population sample - Site I, 1982-83, grade 1-6, n = 285
Site II, 1982-83, grade 1-2, n = 209
Site III, 1982-83, grade 1-6, n = 270

C. Statistical procedure - Z score based on number of trials and population proportion given in null hypothesis.

Null hypothesis 3 C There is no difference in the proportion of MHL subjects across four hearing threshold classes.

A. Methodology - descriptive research to define and compare hearing acuity variance among four threshold parameters.

B. Hearing acuity parameters - MHL at 15 dB HL n = 103
MHL at 20 dB HL, n = 147
MHL at 25 dB HL, n = 94
MHL > 25 dB HL, n = 95

C. Statistical procedure - 1 x 4 chi-square to test hypothesis about variance.

Null hypothesis 3 D There is no relationship between MHL prevalence (by proportions) and grade level.

A. Methodology - correlational research to investigate extent to which variations in one factor correspond with variations in another factor. Also descriptive research to define and compare parameters from the combined first and second grade sample with the combined fifth and sixth grade sample.

B. Grade level parameters - Grade 1, n = 66.8
Grade 2, n = 65.1
Grade 3, n = 51
Grade 2, n = 51.1
Grade 2, n = 52.7
Grade 2, n = 37.4

C. Statistical procedure - Spearman's rank order correlation coefficient to test strength and direction of relationship; Z score to compare proportions.

Null hypothesis 3 E The probability that any subject will repeat positive identification for MHL on repeated observations is one-half.

A. Methodology - developmental research to trace patterns of change as a function of time.

B. Population sample - 217 hearing acuity values collected at Site I on repeated observations of same subjects over two years.

C. Statistical procedure - McNamar test of correlated proportions

Null hypothesis 3 F Before treatment, linguistic task performance of first and second grade subjects with MHL is no different from linguistic task performance of first and second grade subjects without MHL.

A. Methodology - causal comparative to investigate pretest differences between groups prior to treatment.

B. Population sample - observations with no missing values were available on 362 first and second grade subjects.

C. Statistical procedure - Multivariate analysis of covariance on pretest.

est is the treatment variable, represented by two levels, amplification (cell 1) and non-amplification (cell 2). These cells are further divided into grade levels, one and two; and into aptitude levels, high, middle and low.

Treatment Dimension

Amplification intervention was introduced into research setting experimental classrooms to improve the reception of spoken communication. Research indicates that the majority of minimal hearing acuity deficits are classified as conductive hearing loss (Illinois Department of Public Health, 1982; Aniansson, 1978, p.192). Manifestation of conductive hearing loss is directly related to signal intensity, i.e., as signal intensity increases, reception increases (Skinner, 1978, p.645).

As shown on Table 3, there is a two-step research design component in this analysis similar to the JANI analysis. The experimental design for both analyses is based upon the same treatment (teacher voice signal amplification) and the identical subject sample, i.e., 396 first and second grade students from school sites I, II and III.[4] The two analysis differ in scope and size. The MHL component includes extended data collection and research methodologies beyond the experimental design.

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[4] Two separate MANOVA analyses of the data were conducted because of suspected differences in the distribution curves of the speech communication variables, i.e., JANI and MHL. It was suspected that the MHL factor was evenly distributed among Sites I, II, and III while the JANI factor was not.

TABLE 6

2x2x3 MANOVA Matrix

Speech Communication Interference
From Minimal Hearing Loss

		Grade Level Factor		
Teacher Voice Signal Amplification Treatment Factor	Treatment Group	cell 1 (grade) Level 1 (grade) level 2		
		High	Middle	Low
	Control Group	cell 2 (grade) Level 1 (grade) Level 2		
		High	Middle	Low

Statistical Hypotheses

The six null hypotheses included in the non-experimental MHL research were presented above in Table 5. Following are the remaining four null hypotheses of the analysis. All ten MHL null hypotheses correspond to their research counterparts presented in Chapter I.

4 A Among first and second grade subjects with MHL, there is no difference in linguistic task performance of amplification treatment subjects and non-amplification subjects.

4 B Among subjects with MHL, there is no difference in the effect of teacher voice signal amplification treatment between first and second grade subjects.

4 C Among first and second subjects with MHL, there is no difference in the effect of teacher voice signal amplification treatment on linguistic performance of subjects stratified by aptitude levels, high, middle and low.

4 D Among first and second grade subjects with MHL, there is no difference in the effect of teacher voice signal amplification treatment across four different hearing level threshold classes.

Rejection decisions for null hypotheses 4 A, 4 B, 4 C, and 4 D are based on the 2x2x3 MANOVA matrix displayed in Table 6. Hypothesis 4 A compares treatment cell 1 with non-treatment cell 2 on the dependent variable, after adjusting all posttests scores with the concomitant variables, i.e., subject aptitude and pretests observations.

Hypothesis 4 B compares cell 1.1 with cell 2.1 and cell 1.2 with cell 2.2. Hypothesis 4 C compares amplification and non-amplification groups, i.e., cells 1 and 2, after further stratifying each cell into three aptitude levels, high, middle and low. Hypothesis 4 D compares cells 1 and 2, after stratifying each cell into four hearing level threshold classes, 15, 20, 25 and > 25 dB HL.

Data Collection and Analysis

All identification audiometry procedures required by the National Dissemination Network Project MARRS were followed. Three Project MARRS consultants conducted on-site training before and consultation throughout the audiometry data collection.

Hearing acuity thresholds were defined for each subject using a standard school-type audiometer, Maico Model MA-19, ANSI 1969. The audiometer is a portable electronic device that generates pure tone signals used to assess hearing acuity. The equipment operates off an AC voltage line. Two standard earphones and cushions were used for subject reception of discrete frequency pure tone signals at 500, 1000, 2000, 4000, 6000 and 8000 Hz. Intensity levels tested ranged in 5 decibel increments from 0 to 35 dB. The audiometer is provided with a silent switch for intensity adjustment to prevent subject-test interaction. The equipment conforms with the latest standards, 1969, ANSI.

Because an audiometer is a delicate electronic device, procedures for its handling and care in school settings are specified by the State of Illinois, Department of Public Health (1974, p.66). All procedures were followed including both electronic and biological calibration checks. An extra electronic calibration check occurred at mid-point in the identification audiometry procedures, November, 1982.

Invalid hearing acuity threshold data from the Site I pilot study during the fall of 1981 prompted the district to purchase a portable soundproof testing booth of the type used in Project MARRS to obtain the original baseline data on MHL in southern Illinois schools. The booth is a 750 lb., portable unit labeled Controlled Acoustical Environments by Industrial Acoustic Company, Inc., New York. The unit conforms with 1969, ANSI standards.

Using the audiometer and sound-proof booth as an integrated unit, a district contracted audiometric technician administered individual pure tone air conduction hearing tests to the study population as follows:

Site I - Grade 1-6 population, March, 1982, n=273

Site I - Grade 1-6 population, November, 1982, n=285

Site III - Grade 1-6 population, January, 1983, n=270

Site II - Grade 1-2 population, March, 1983, n=209

The screening procedures developed in conjunction with Project MARRS consultants involved an initial sweep check at 10 db HL. If a subject responded to the signal presented at this intensity, across all frequencies 500 through 8000 Hz in both ears, the subject passed the test and was not identified as having MHL. If the subject failed to respond to any of the 12 separate frequency/intensity/ear combinations, a complete audiogram was obtained across all frequencies at each intensity level 0 dB through 35 dB. Subjects failing the State of Illinois criteria were referred for medical evaluation in accordance with Department of Public Health procedures. All subjects were tested in both ears at six individual frequencies, i.e., 500, 1000, 2000, 4000, 6000 and 8000 Hz. Observations were recorded across all frequencies at each intensity level including 0, 5, 10, 15, 20, 25, 30 and 35 decibels. The subject response values were recorded on data collection forms developed and recommended by the project Marrs consultants. Table 7 provides three hypothetical cases of the data recording scheme used in the investigation and in the continuing project Marrs research.

Case 1 represents a 15 db HL (15 decibel hearing level); case 2 represents a 20 dB HL, and case 3, a 25 dB HL. Hearing levels were calculated by deriving a pure tone average (PTA) on the speech range frequencies of 500, 1000, and 2000 Hz. These frequencies are commonly classified as the low frequencies. High frequency values were also calculated from observations at 4000, 6000, and 8000 Hz. In keeping with project MARRS procedures, values from the weaker ear were used as the basis for the PTA calculations. In Table 7, the PTA for cases 1 and 3 are based on right ear observations while for case 2 the PTA is based on left ear observations, since in each instance, these were the weaker of the two ears observed.

TABLE 7

Pure Tone Air Conduction Audiometry Data Recording Scheme

	Right ear						Left ear						
	500	1000	2000	4000	6000	8000	500	1000	2000	4000	6000	8000	Hz
case 1	15	15	15	10	05	10	10	10	10	10	10	10	dB
case 2	05	10	05	05	05	05	20	25	15	10	10	10	
case 3	25	30	20	10	15	20	15	15	15	15	15	15	

The principle of multi-definitionalism (Cook and Campbell, 1979, p. 63) was utilized in the analysis of the MHL data collected. Incremental levels of MHL were related to linguistic task performance outcomes in search of optimal combinations for auditory learning environment decision-making. The distribution of hearing level threshold classes ranged from 15 dB HL to > 25 dB HL. The classification procedures were developed in consultation with Project Marrs researchers so as to maintain valid comparability between this data set and exterior data accumulated by Project Marrs researchers (Sarff, November, 1983). All data processing and analyses was undertaken by this researcher using the Loyola University Academic Computing Services.

Summary

This investigation examined the utility of amplification intervention for mediating suspected speech communication interference from two sources, i.e. JANI and MHL. To accommodate the duel foci of the study, a theoretical paradigm was employed. The Speech Chain (Figure 1) portrays oral communication as a chain of events between speaker and listener connected at three discrete levels, i.e., acoustic, physiological and linguistic (Denes and Pinson,1963). In the investigation, JANI was positioned as speech communication interference at the acoustic level on the speech chain. MHL was positioned at the physiological level.

Although emanating from different sources and intervening at different levels on the speech chain, both forms of speech communication interference were represented by a common, molar level, referent construct of cause, i.e., speech communication interference. Linguistic task performance was positioned as a molar level, referent construct of effect on the speech chain. The treatment condition, teacher voice signal amplification, was imposed between the suspected cause construct and the suspected effect construct to evaluate its worth in mediating speech communication interference. The cause and effect constructs and treatment manipulation were operationalized in two separate experimental designs, both of which included randomly assigned, multiple comparison groups. A MANOVA statistical procedure was employed in both analyses to provide answers to the multiple research hypotheses formulated.

Beyond the experimental research focus of the investigation, correlational and longitudinal research was employed to accumulate and analyze an expanded data set for the MHL construct.

In the next chapter the results of the statistical analysis of the data are presented.

CHAPTER IV

RESULTS

Overview

In this chapter the results of the statistical analysis of the data are presented. The investigation was conducted to determine if speech communication interference within the auditory environment of elementary school classrooms was an alterable variable.

Two forms of speech communication interference data were collected and are analyzed in the two major sections of this chapter. In the first section, the derived statistics summarizing the noise level dimension of the problem are presented. In the second section, statistics summarizing the hearing acuity threshold values are presented.

Incorporated into both the JANI and MHL sections is an analysis of the data collected from an experimental design. In the experimental design, linguistic task performance comparisons are made between experimental subjects provided with a treatment condition (teacher voice signal amplification intervention) and control subjects not exposed to the treatment. Multivariate analysis of covariance statistical procedures are employed to enable the simultaneous analysis of multiple response variables, covariates and metric and non-metric factors. Post-hoc orthogonal means comparisons are used, where appropriate, to evaluate overall and subskill treatment effects.

Within the JANI section, the data analysis explores linguistic task performance effects between comparison groups (amplification and non-amplification) in relationship with speech communication interference from jet aircraft overflights, a suspected causal construct, represented by levels of exterior noise at school sites I, II and III.

Within the MHL section, the data analysis explores linguistic task performance effects between comparison groups (amplification and non-amplification) in relationship with speech communication interference from minimal hearing acuity deficits, another form of the suspected causal construct, represented by subjects' hearing acuity threshold values.

Jet Aircraft Noise Intrusion Analysis

Results of the JANI analysis are presented in two subsections corresponding to the descriptive research on the physical level of the problem and the experimental research on the task performance dimension.

Results of noise quantification analysis at each of three school sites are summarized and compared in the first subsection. Findings from the experimental design, which involves task performance comparisons between experimental and control groups differing in treatment condition levels, are presented in the second subsection.

Quantification Of The Noise Level Dimension

Hypotheses 1 Group

Two hypotheses comprise this group. Hourly noise level comparisons are made across school sites and school hours based upon a sample of 336 Leq values collected from atop three school sites throughout the experiment.

Hypothesis 1 A

There is no difference in the average level of noise(Leq) from jet aircraft overflights between school sites I, II and III.

Results of a 2x2 ANOVA indicated that school sites differed in noise levels as indicated by the p value of 0.0001 displayed in Table 8. Post hoc analysis of least squares mean noise levels generated by the ANOVA procedure indicated no difference in mean noise levels between Sites I and II. Both sites, however, manifested different (higher) average noise levels than Site III, $p = 0.0001$.

TABLE 8

ANOVA - Noise Level by School Site and School Hour

Source	DF	Sum of Squares	Mean Square	F Value	PR > F	R-Square
Model	23	4209.7	183.0	3.43	0.0001	0.20
Error	312	16657.3	53.4			
Corrected Total	335	20867.0				

Source	DF	Type III Sum of Squares	F Value	PR > F
School	2	2085.5	19.53	0.0001
Time	7	817.4	2.19	0.0350
School*time	14	1269.6	1.70	0.0548

A visual comparison of the mean noise levels by school site is shown on Figure 5. Based on statistically significant p values from the two-way analysis of variance, Hypothesis 1 A is rejected in favor of the alternative that Sites I, II and III do differ in average noise lev-

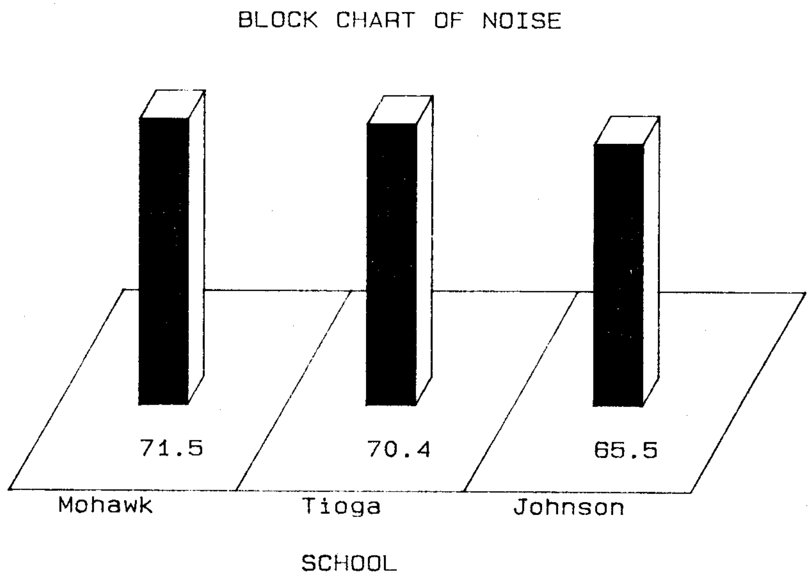

Figure 5: Mean Noise Level (Leq) by School Site

els(Leq) from jet aircraft overflights.

Hypothesis 1 B

There is no difference in the average hourly noise level (Leq) across the school day from 8:00 a.m. to 4:00 p.m. at school sites I, II and III combined.

At Site I, 96 Leq samples were collected between 8:00 a.m. and 4:00 p.m. over 12 days. At Site II, 136 samples were collected over 17 days and at Site III, 104 samples were collected over 13 days. As shown on Figure 6, noise ranged in severity from 66.20 dB at 8:00 a.m. to 71.88 dB at 10:00 a.m.

Pair-wise comparisons of least squares means generated by the ANOVA procedure revealed that the highest one-hour noise level, i.e., 10:00 a.m. to 11:00 a.m., was significantly different from the noise levels recorded at 8:00 a.m., 1:00 p.m. and 3:00 p.m. Conversely, the lowest noise level (8:00 a.m.) was significantly different from all other intervals except 3:00 p.m. to 4:00 p.m.

Based upon results obtained, $p = 0.0350$, Hypothesis 1 B was rejected. Significant differences were found in levels of noise across the school day.

Experimental Design Hypotheses

Of major interest in this investigation is the effect of amplification intervention on the linguistic task performance of subjects as compared with the performance of subjects not exposed to the treatment. The Hypothesis 2 group addresses this comparison. Because the relationship between amplification treatment and task performance is central to

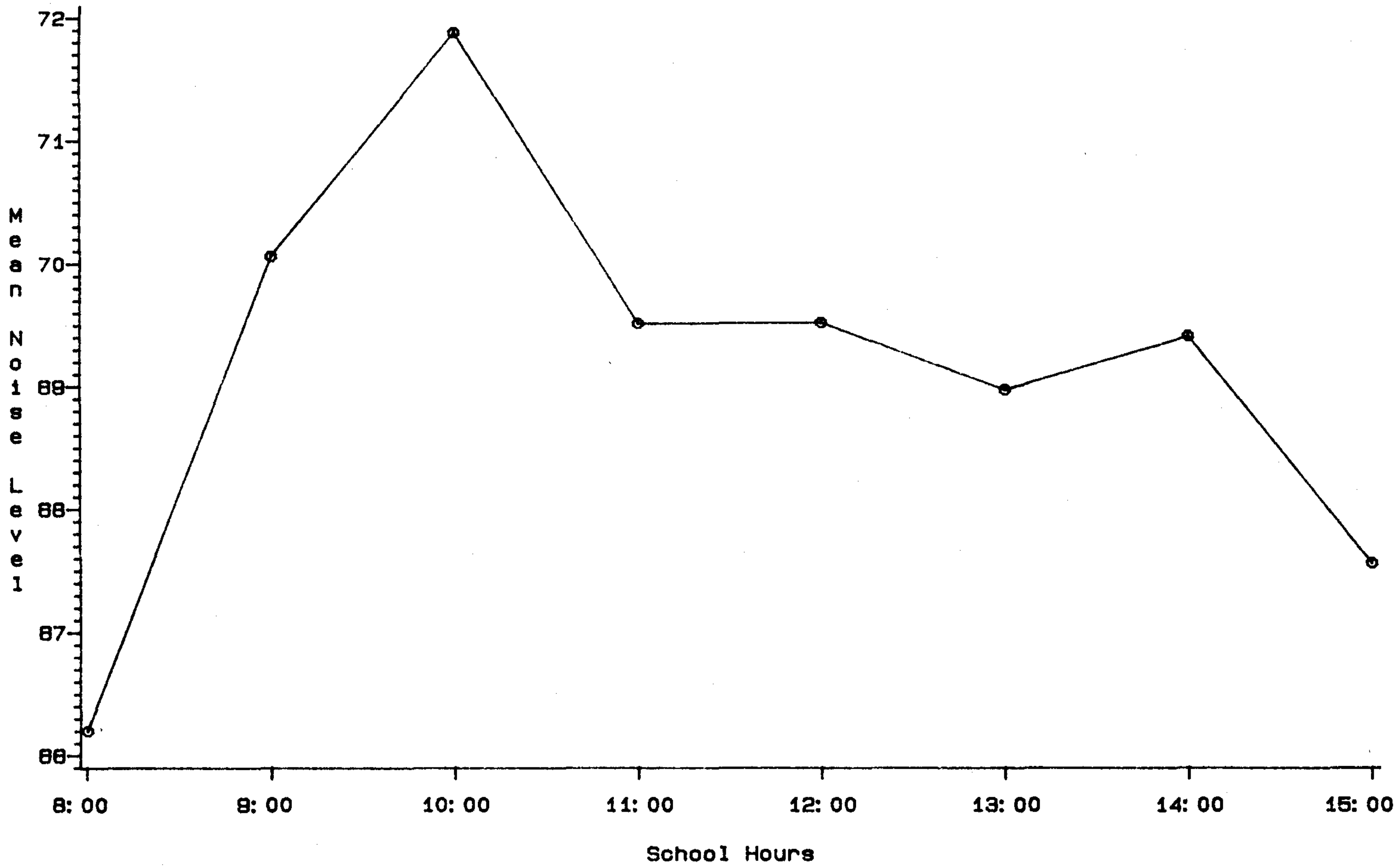

Figure 8: Mean Noise Level (Leq) By School Hour

both the jet aircraft noise intrusion (JANI) and minimal hearing loss (MHL) experiments in the overall investigation, an expanded analysis was employed and is described. Statistical procedures applied to the data include MANOVA, ANCOVA and gain score analysis. The description of the evaluation of each hypothesis after 2 A is more concise.

Hypothesis 2 Group

Four hypotheses are included in this grouping. The effect of amplification treatment on linguistic task performance of all subjects is evaluated in Hypothesis 2 A. Effects by grade level and effects by aptitude level are evaluated in hypotheses 2 B and 2 C. In Hypothesis 2 D, the treatment condition is evaluated for its affect on speech communication interference, first from MHL and then from JANI.

Hypothesis 2 A

Among first and second grade subjects, there is no difference in linguistic task performance between amplification treatment subjects and non-amplification treatment subjects.

As discussed in Chapter III, multivariate analysis of covariance is an appropriate statistical data analysis procedure for the simultaneous analysis of multiple, qualitative independent variables and multiple, quantitative covariates and dependent variables. The applicability of the procedure, however, is dependent upon meeting the assumption of homogeneity-of-slopes. Covariance analysis tests for differences in intercepts assuming a constant regression relationship between groups. The test for homogeneity-of-slopes is the test for the validity of this assumption.

Table 9 summarizes the results of the multivariate homogeneity of slopes test for the four qualitative factors across the six response variables common to 339 subjects with no missing observations. The procedure tests for interaction between each separate factor and covariate. A nonsignificant interaction between a covariate and factor (i.e., $P > .05$) satisfies the assumption of homogeneity-of-slopes. In Table 9, the value of .29 for the I.Q. covariate by treatment factor satisfies the homogeneity assumption; the value of .002 for the sight vocabulary covariate by school factor does not. Inspection of Table 9 indicates that both the pretest covariate and the I.Q. covariate met the assumption of homogeneity criterion on 27 of 28 individual tests. According to Kirk, tests for significance in analysis of covariance are robust, but.. "Little is known concerning the effect of violation of the assumption of homogeneity of within-group regression coefficients" (1968, p. 469). Since the sight vocabulary covariate met the assumptions across three of the four factors, it was included in the subsequent MANOVA.

A 2x2x3x2 factorial design was incorporated into the multivariate analysis of covariance to make comparisons between the levels of each factor across six response variables common to all subjects in the experimental design. Of 396 observations in the data set, 339 had no missing values (see Limitations, Chapter V). Observations included values obtained on the I.Q. test (covariate), six pretests (covariates) and six parallel forms of the pretests, which are subsequently identified as the posttests, dependent variables or response variables, depending upon context. Random assignment of 18 intact classrooms resulted in observations being distributed across two grade levels, three school sites, and

TABLE 9

Homogeneity-of-Slopes Test Results

	Prob > F			
Covariate	Covariate * Treatment	Covariate * MHL	Covariate * School	Covariate * Grade
IQ Test(C)	.29	.15	.59	.17
Sight Vocabulary(M)	.38	.23	.002	.19
Phonics-Consonant(M)	.25	.42	.15	.61
Auditory Discrimination(S)	.80	.19	.24	.18
Phonetic Analysis(S)	.68	.07	.50	.13
Auditory Vocabulary(S)	.38	.18	.58	.33
Comprehension(S)	.28	.17	.32	.28

NOTE: (C) = Cognitive Abilities Test; (M) = Metropolitan Reading Test; (S) = Stanford Reading Test.

two levels of the treatment condition. Observations for the MHL factor were dichotomously classified by presence or absence of the measured attribute.

Table 10 displays the univariate output for one of the six common response variables included in the 2x2x3x2 MANOVA.[1] The output in Table 10 provides essential information for assessing the fit of the general linear statistical procedure to the data. The dependent variable, linguistic task performance, represented by posttests, has been modeled as a linear function of the qualitative factors plus the quantitative covariates, pretests and IQ tests. Having met the homogeneity of between-group slopes assumption, the regression parameters reveal the strength of the linear relationship between the effects (i.e., treatment condition, MHL, school and grade) and the response variable, in this example, phonetic analysis (Hays, 1973, p. 655).

Univariate results displayed in Table 10 are:

(1) A test of the hypothesis that the true slope for the population denoted by the regression parameter is significantly different from 0. The hypothesis of a regression parameter with 0 value is rejected at the $p = 0.0001$ level of significance for the phonetic analysis model in Table 10 and for the other five response variables. One can assume that there is a linear relationship, i.e., a predictor, within the model, and that the linear relationship is significantly better than just using the overall mean to predict linguistic task performance (Marks, 1982, p. 151).

(2) R-square, the coefficient of determination, identifies the percent of variation in the response variable measurements which can be

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[1] One table was included for the purpose of illustration. Inclusion of all response variables would have required six tables. Treatment effects for each of the remaining five response variables are displayed in Figure 7 and in scatterplots displayed in appendix B.

TABLE 10

MANOVA - Phonetic Analysis Response Variable Illustration

Source	DF	Sum of Squares	Mean Square	F Value	(1) PR > F	(2) R-Square
Model	19	1167722.1	61459.0	39.46	0.0001	0.70
Error	319	496837.8	1557.4			
Corrected Total	338	1664559.9				

Source	DF	(3) Type III SS	F Value	(4) PR > F
Treatment	1	27335.7	17.55	0.0001
MHL	1	1096.0	0.70	0.4000
School	1	19169.3	6.15	0.0024
Grade	1	4346.2	2.79	0.0958
Pre-Sight Vocabulary	1	11128.0	7.14	0.0079
Pre-Phonics-Consonants	1	945.0	5.74	0.0171
Pre-Auditory Discrimination	1	7490.9	4.81	0.0290
Pre-Phonetic Analysis	1	74380.6	47.76	0.0001
Pre-Auditory Vocabulary	1	4183.0	2.69	0.1022
Pre-Comprehension	1	13932.5	8.95	0.0030
IQ-test	1	342.1	0.22	0.6396
Treatment*MHL	1	18889.6	6.06	0.0026
Treatment*school	1	394.5	0.25	0.6151
MHL*school	1	1393.0	0.45	0.6398
MHL*grade	1	1477.2	0.95	0.3308

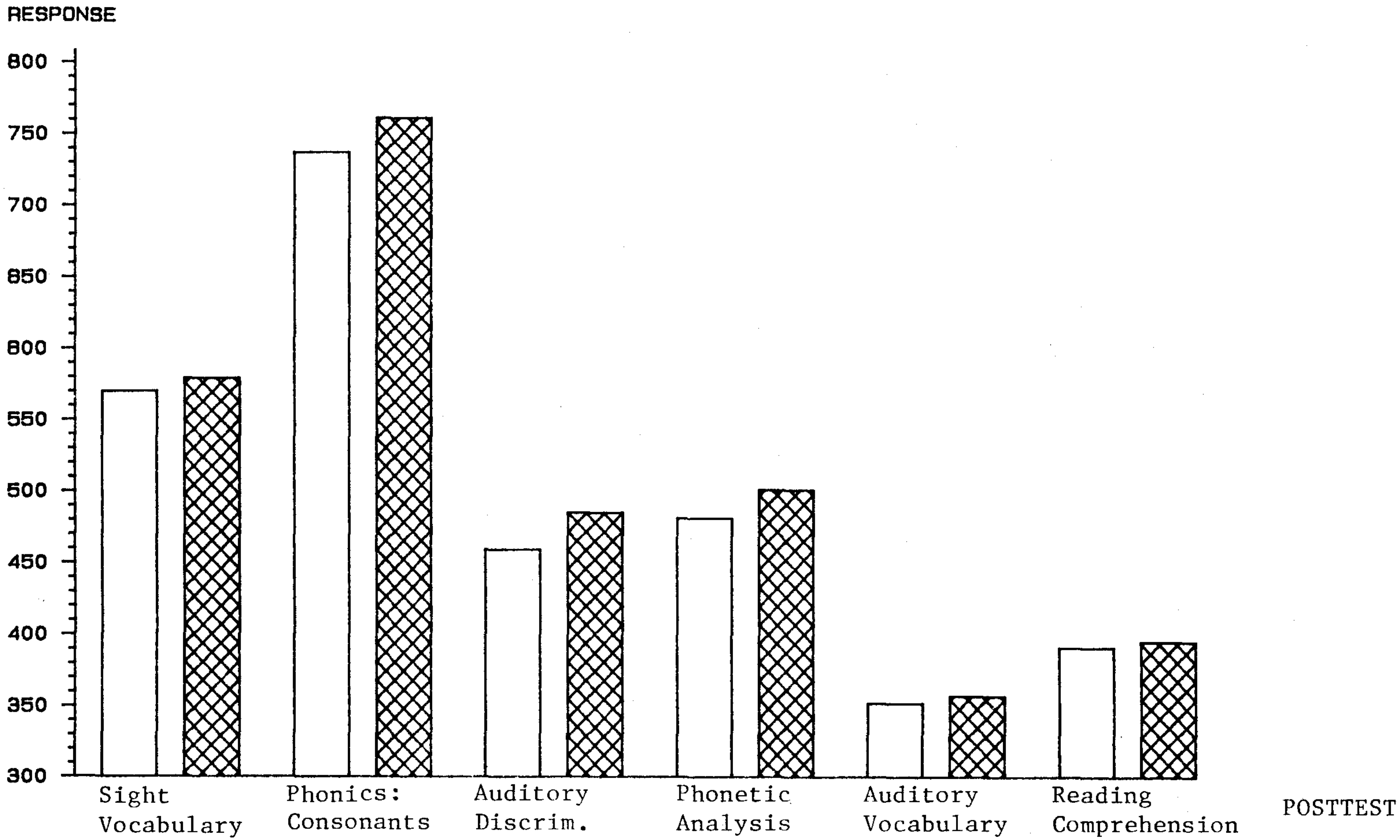
explained by the fitted regression model. The values for the coefficients of determination range across the six dependent variables from .61 to .85. As shown, the coefficient of determination for the phonetic analysis response variables is .70. This indicates that 70% of the variance in the response variable, phonetic analysis, is accounted for by the measured effects.

(3) Type III SS for treatment factor represent sum of squares adjusted for covariates. (Note: Type III SS are appropriate for unbalanced designs while Type I SS are appropriate for balanced designs)

(4) Reports statistical significance of measured effect.

Figure 7 displays the results of adjusted group means comparisons for each response variable (with homogeneous slopes) common to all subjects in the analysis. In the general linear model of the SAS (1982) procedure, adjusted means are represented by least squares means (LSM). In the least squares means procedure all covariates are held to their mean value within a class or group. The hypothesis of no difference between treatment and control groups is rejected for three dependent variables, i.e., phonics-consonants, $p = 0.0331$; auditory discrimination, $p = 0.0134$; and phonetic analysis, $p = 0.0001$. The hypothesis is not rejected for the other three dependent variables. Post hoc least squares means analyzed reveals that in each of the six pair-wise comparisons, the adjusted posttest value for the treatment group exceeds the adjusted posttest value for the control group.

Based on the results of the univariate analysis displayed in Figure 7 and the regression parameters displayed in Table 10, a statistical probability statement can be advanced about each pair of adjusted means. Using the phonetic analysis response variable as an example, the following effect statement is appropriate: Among treatment groups, having been identified with homogenous pretest and IQ test values, one may predict a higher value on the phonetic analysis response measure for subjects in the experimental group than for subjects in the



LEGEND: TYPE Plain Bar = Control group; Crossed Bar = Experimental group

Figure 7: Comparison of Experimental and Control Group Means

control group at the 0.0001 level of significance. In other words, prior knowledge of group membership adds to the predictability of performance measurement.

As a visual aid to the reader, a scatterplot[2] of the auditory discrimination response variable is displayed in Figure 8. In the auditory discrimination scatterplot, the experimental group mean is 485 while the control group mean is 459. The difference between the two levels of the treatment condition is statistically significant, $\underline{p}$ = 0.0134.

While the above discussion addresses itself to the univariate output from the MANOVA analysis, multivariate findings are of equal or greater interest. Table 11 displays the findings of the statistical hypothesis of no <u>overall</u> effect for four factors and four interaction combinations across the six common response variables.

Results indicate a significant difference between levels for three overall main effects, i.e., treatment, $\underline{p}$ = 0.0012; school, $\underline{p}$ = 0.0001; and grade level, $\underline{p}$ = 0.0001. There were no significant overall interaction effects. Of central interest in this study are the effects of the treatment variable (main effect) and interaction between the treatment condition and the other three factor, i.e., MHL, school and grade level. For decision-making related to Hypothesis 2 A, therefore, the overall treatment effect, P = 0.0012, is applicable while the other main effect results are not.

Continuing with the analysis of Hypothesis 2 A, an alternative,

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[2] A scatterplot for each of the other five response variables is included in appendix B.

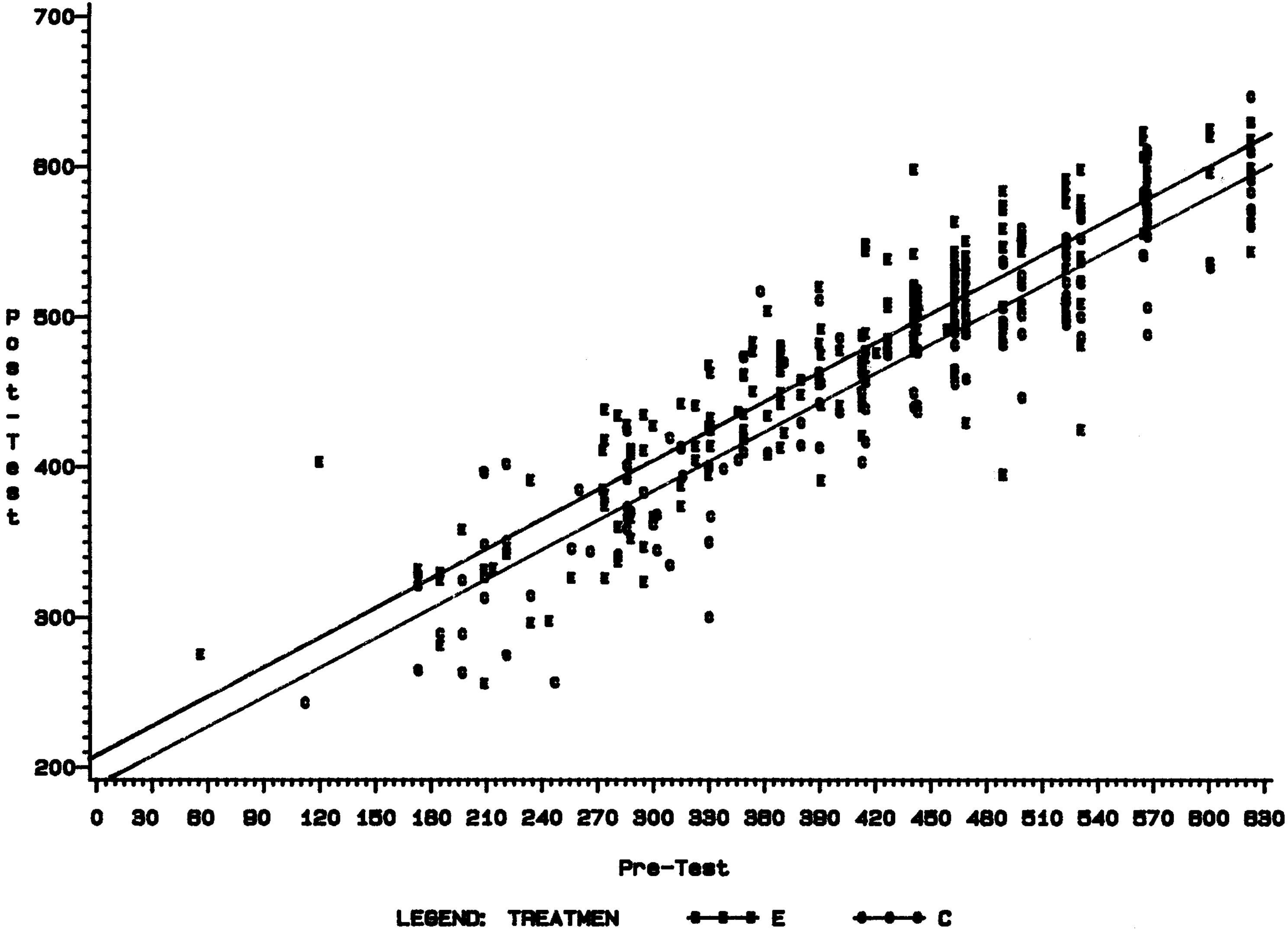


Figure 8: Scatterplot of Auditory
Discrimination Response Variable

TABLE 11

Combined-Group MANOVA Statistics

MANOVA TEST CRITERIA FOR THE HYPOTHESIS OF NO OVERALL TREATMENT EFFECT

H = Type III SS&CP Matrix for: Treatment
E = Error SS&CP Matrix
P = Dep. variables = 5
Q = Hypothesis DF = 1
NE = DF of E = 336
S = Min (P-Q)-1) = 1
M = .5 (ABS (P-Q)-1) = 1.5
N = .5 (NE-P-1) = 165.0

Hotelling-Lawley Trace Prob > F = 0.0012

Pillai's Trace Prob > F = 0.0012

Wilks' Criterion Prob > F = 0.0012

MANOVA TEST FOR THE HYPOTHESIS OF NO OVERALL...

MHL EFFECT: PROB > F = 0.2836
SCHOOL EFFECT: PROB > F = 0.0001
GRADE EFFECT: PROB > F = 0.0001
TREATMENT*MHL EFFECT: PROB > F = 0.5922
TREATMENT*SCHOOL EFFECT: PROB > F = 0.0614
TREATMENT*GRADE EFFECT: PROB > F = 0.4672
MHL*SCHOOL EFFECT: PROB > F = 0.5120

Note: Each of the three multivariate statistics in table 11 are based on a different test criterion. According to authorities, "No one criterion has been demonstrated to be universally superior or inferior" (Freund, R. and Littell, R., 1981, p. 210).

but weaker hypothesis (SAS, 1982, p. 176) is that the treatment condition does not affect the average across the six response variables. Such a test provides a gross indication of performance differences between comparison groups. The output from this one-way analysis of covariance is displayed in Table 12. The coefficient of determination indicates that 82% of the variation in the averaged response variable is accounted for by the model. Results obtained indicated a significant difference in treatment effects, $p = 0.0002$, a result very similar to the MANOVA p value of 0.0012. The implication is that treatment effects are parallel whether measured by the simultaneous analysis of the six response variables in the MANOVA procedure or by the univariate analysis of averaged response variables using ANCOVA procedures.

Gain Score Analysis

To account for differences in the test administration process between the control and experimental groups, as explained in Chapters I and III, a gain score analysis of the data was applied.

Authorities have indicated that gain, or difference scores analysis, is appropriate, if "the concomitant variable is of the same nature as the dependent variable" (Kirk, 1968, p. 487; Cook and Campbell, 1979, p. 182). The 13 response variables included in the study were published with alternative but equivalent forms to enable change comparisons between pretests and posttests (Karlsen, B.; Madden, R.; and Gardener, E., 1976, p. 65; Farr, R.; Prescott, G,; Balow, I.; and Hogan T., 1978, p.39).

Using the two-sample t test procedure recommended by Mark's (1982, p. 73) and by SAS (1982, p. 220), a comparison of the difference or

TABLE 12

ANCOVA - Treatment Effect Across Averaged Responses

Source	DF	Sum of Squares	Mean Square	F Value	PR > F	R-Square
Model	14	49199397.3	35142426	103.0	0.0001	0.82
Error	324	11053406.1	34115			
Corrected Total	338	60252803.4				

Source	DF	Type III SS	F Value	PR > F
Treatment	1	469473.0	13.76	0.0002
Hearloss	1	7260.1	0.21	0.6449
School	2	62104.3	0.91	0.4035
Grade	1	5175.5	0.15	0.6972
Treatment*MHL	1	672.4	0.02	0.8884
Treatment*school	2	120507.8	1.77	0.1726
Treatment*grade	1	57863.5	1.70	0.1937
MHL*school	2	24954.6	0.37	0.6940
MHL*grade	1	19505.8	0.57	0.4501
Sum Pre	1	16048491.5	470.42	0.0001
IQ Test	1	150804.1	4.42	0.0363

gain scores between pre and post tests by treatment groups was made on each of the six common response variables. Between-group homogeneity of population variance test results were included with the SAS printed output. On two response variables, sight vocabulary and auditory discrimination, the variances were unequal; on the other four responses, the variances were equal. The appropriate (equal versus unequal) homogeneity of variance $\underline{t}$ statistic is displayed.

Table 13 provides a comparison between the gain score results and the MANOVA results across the six common response variables. The two procedures yielded similar statistically significant probability results on three response variables, i.e., sight vocabulary, auditory discrimination and phonetic analysis and on one statistically nonsignificant result, comprehension. On the phonics-consonants variable, the gain score procedure was more conservative; on the auditory vocabulary variable, the MANOVA procedure was more conservative.

TABLE 13

Comparison of Gain Score and MANOVA Results

	PROB > |T| HO: LSM CONTROL = LSM EXPERIMENTAL	
Response Variable	Gain Score P Values	MANOVA P Values
Sight Vocabulary(M)	0.0280 (SIG)	0.0398 (SIG)
Phonics-Consonants(M)	0.0992 (NS)	0.0166 (SIG)
Auditory Discrimination(S)	0.0058 (SIG)	0.0067 (SIG)
Phonetic Analysis(S)	0.0002 (SIG)	0.0001 (SIG)
Auditory Vocabulary(S)	0.0033 (SIG)	0.0927 (NS)
Comprehension(S)	0.2538 (NS)	0.1651 (NS)

NOTE: (M) = Metropolitan Reading Test; (S) = Stanford Reading Test.

Based upon both the univariate and multivariate analysis of the treatment effects reported above, linguistic task performance differences between amplification subjects and non-amplification subjects have been demonstrated by the MANOVA result, p = 0.0012 and by the ANCOVA result, p = 0.0002. Results of the separate gain score analysis paralleled the MANOVA and ANCOVA findings. Sufficient evidence is available to support a decision to reject null Hypothesis 2 A, and to accept the alternative hypothesis of linguistic task performances differences between amplification treatment subjects and non-amplification subjects. In Chapter V the discussion of treatment effect differences is expanded to include practical as well as statistical significance of results.

Hypothesis 2 B

There is no difference in the effect of teacher voice signal amplification treatment between first grade subjects and second grade subjects.

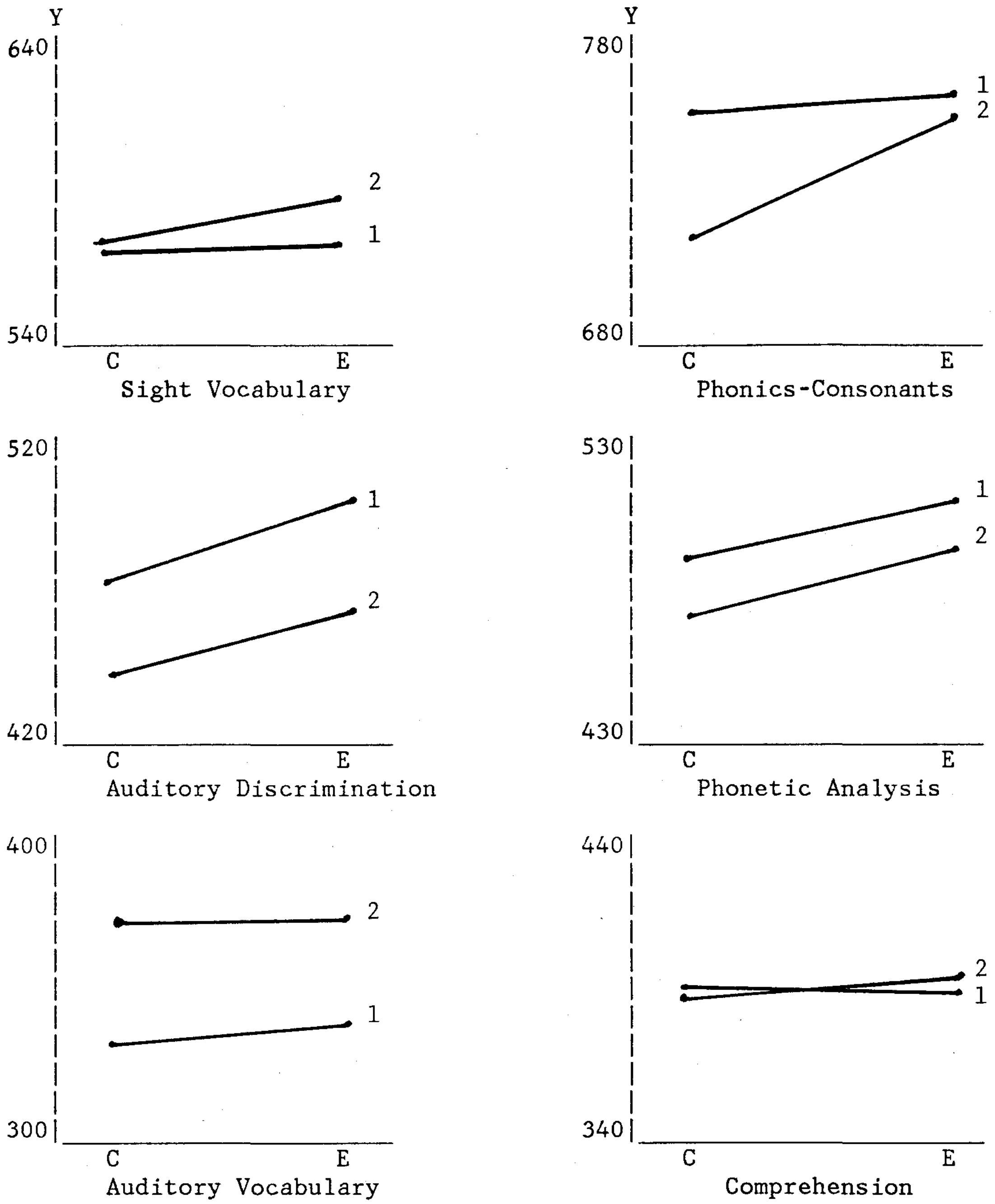
In the alternative to Hypothesis 2 B, a prediction of a more significant treatment effect among first grade comparisons than among second grade comparisons was made. In order to reject Hypothesis 2 B, therefore, evidence of overall interaction between the treatment factor and the grade level factor was needed with subsequent means comparisons verifying differences in treatment effects across grade levels one and two. As shown in Table 11, however, the overall interaction between treatment and grade level, generated by the MANOVA test across 339 observations, was not significant, p = 0.4672; nor did subsequent means comparisons indicate directional differences in treatment effects across grade levels. Based upon the results obtained, therefore, Hypothesis 2

B was not rejected.

The post hoc comparisons of least squares means, however, was revealing. On 11 of 12 possible orthogonal comparisons (six first and six second grade), the experimental group mean exceeded the control group mean. On two response variables, within the first grade group, the treatment effect was statistically significant, i.e., auditory discrimination, $p = 0.0137$ and phonetic analysis, $p = 0.0037$. On five response variables, within the second grade group, the treatment effect was statistically significant, i.e., sight vocabulary, $p = 0.0101$; phonics-consonants, $p = 0.0023$; auditory discrimination, $p = 0.0425$; phonetic analysis, $p = 0.0002$; and comprehension, $p = 0.0400$ (All significant results were derived from the directional alternative hypotheses that the experimental group mean exceeded the control group mean; p values were based upon one-tailed t tests).

Visual inspection of the six reduced sized plots in Figure 9 and their full sized antecedents in appendix C illustrates why there was no overall interaction of treatment effects across grade levels. The two levels of the grade factor reacted similarly to the two levels of the treatment condition, i.e., the experimental group exceeded the control group at both the first and second grade.

Beyond the MANOVA tests over 339 observations, additional post hoc comparisons were made possible by examining all response variables utilized in the study. To this point in the discussion, comparisons and analysis has been limited to six response variables common to all first and second grade subjects. By stratifying the study data on a grade level basis, i.e., grade one and grade two, performance data on more



Legend: C = Control; E = Experimental; Y = Adjusted Posttest;
1 = Grade 1; 2 = Grade 2

Note: Reduced sized plots above are displayed full size in appendix C

FIGURE 9: Treatment by Grade Level Relationship Plots

response variables became available for comparisons.[3] While increasing the response variables analyzed, however, the two separate grade level analyses reduced the number of subjects from 339 overall, to 153 and 183 in the first and second grade strata respectively.

Grade 1 Effects:

Each of the nine first grade response variables satisfied the homogeneity-of-slopes requirement for multivariate analysis of covariance application across factors by covariates. Within the first grade factor, therefore, it may be assumed that there was a within-group regression slope common to each separate level of the factor. Thereafter, the covariance procedure is used to check between-level differences within each factor by comparing least squares means. Differences in least squares means emanate from differences in regression slope intercepts with the grand mean.

Results of the two separate MANOVA tests, displayed in Table 14, indicated an overall treatment effect, within the first grade stratum, which was not significant, $p = 0.1424$. Post hoc analysis of least squares means revealed significant treatment effects on the same two response variables reported above in the combined first and second grade MANOVA test, i.e., auditory discrimination, $p = 0.0075$; and phonetic analysis, $p = 0.0076$. On this test, the auditory vocabulary response was also significant, $p = 0.0298$.

Grade 2 Effects:

Results of the MANOVA test applied to the second grade stratum are

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[3] Three response variables were unique to the first grade sample. Four response variables were unique to the second grade. Six were common to both.

TABLE 14

Treatment Effects By Grade Level - All Subjects

MANOVA TEST FOR THE HYPOTHESIS OF NO OVERALL...

Grade 1	Grade 2
TREATMENT EFFECT > F = 0.1424	TREATMENT EFFECT > F = 0.0045
MHL EFFECT > F = 0.3566	MHL EFFECT > F = 0.3111
SCHOOL EFFECT > F = 0.0217	SCHOOL EFFECT > F = 0.0144
TRT*MHL EFFECT > F = 0.7481	TRT*MHL EFFECT > F = 0.8071
TRT*SCHOOL EFFECT > F = 0.0978	TRT*SCHOOL EFFECT > F = 0.0011
MHL*SCHOOL EFFECT > F = 0.5916	MHL*SCHOOL EFFECT > F = 0.8243
N = 153	N = 183

Note: The MANOVA for grade 1 included observations across nine response variables; the MANOVA for grade 2 included ten response variables. Six response variables were common to both levels of the grade factor.

exhibited in Table 15.

Whereas the treatment effect within the first grade stratum was not significant, the treatment effect within the second grade stratum was significant, $p = 0.0045$. This result, however, is related to and dependent upon the interaction effect between the treatment factor and school factor, which was also significant, $p = 0.0011$. Interaction between these two factors indicates that treatment effects varied depending upon where experimental and control group comparisons were

TABLE 15

Second Grade Treatment Effects by School Site Levels

Response Variable	Treatment Group	Site I		Site II		Site III	
		PROB > |T| HO: LSM C = LSM E		PROB > |T| HO: LSM C = LSM E		PROB > |T| HO: LSM C = LSM E	
Phonics- (M)	C	573	0.2878	551	0.6084	559	0.0035
Vowels	E	596		540		645	
Structural(S)	C	425	0.0446	425	0.3529	426	0.0014
Analysis	E	443		428		459	
Inferential(S)	C	453	0.8193	448	0.2850	442	0.1080
Comprehension	E	450		452		455	
Sight(M)	C	602	0.4611	584	0.0269	595	0.0209
Vocabulary	E	603		601		622	
Auditory(S)	C	466	0.1820	470	0.1166	469	0.1227
Discrimination	E	488		489		497	
Phonetic(S)	C	514	0.0001	512	0.8493	514	0.0963
Analysis	E	576		510		531	
Compre- (S)	C	440	0.3958	442	0.6966	434	0.0372
hension	E	443		439		452	

N = 183

NOTE: (M) = Metropolitan Reading Test; (S) = Stanford Reading Test.

made, i.e., Site I, Site II or Site III. Numerically, there were four significant treatment effect comparisons at Site III; two at Site I; and one at Site II. At Site III the experimental group's adjusted mean exceeded the control group's adjusted mean at a statistically significant level on the following response variables: phonics-consonants, $p = 0.0035$; structural analysis, $p = 0.0014$; sight vocabulary, $p = 0.0209$; and comprehension, $p = 0.0372$. At Site I, treatment effects were significant as follows: structural analysis, $p = 0.0446$; and phonetic analysis, $p = 0.0001$. At Site II the treatment was significant on the sight vocabulary response, $p = 0.0269$.

Hypothesis 2 C

Among first and second grade subjects, there is no difference in the effect of teacher voice signal amplification treatment on linguistic task performance of subjects stratified by aptitude levels, high, middle and low.

Based upon the aptitude-dependent relationship between learning and noise, reviewed in chapter II, an analysis of the data set stratified by three aptitude groups was undertaken.[4] Researchers Maser(1978) and Schoemer(1981) have reported that aircraft noise intrusion has a more degrading effect upon the attention span and task performance of low aptitude students than upon middle and upper ability students. To determine if amplification intervention would aid in mediating speech communication disruptions for low ability students, the data were ana-

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[4] Aptitude stratification was based upon converting subjects' aptitude test scores from scaled scores to stanine equivalents using the publisher's table. Stanines 1, 2 and 3 formed the low aptitude stratum; stanines 4, 5 and 6 formed the middle stratum; and stanines 7, 8 and 9 formed the high stratum (Thorndike and Hagan, 1980, p. 44).

lyzed by aptitude strata, high, middle, and low. The alternative to Hypothesis 2 C was that a more significant treatment effect would be evidenced among low aptitude comparisons than among middle or high aptitude comparisons. Two separate MANOVA procedures were employed. In the first MANOVA test, 339 observations were analyzed simultaneously. In the second test, the data were stratified into three groups, high, middle and low, and a separate MANOVA test was applied to each. Prior to applying either the combined test or separate tests, a homogeneity-of-slopes test indicated that the sight vocabulary response variable did not fulfill the assumptions for analysis of covariance and could not be included in the analysis. The MANOVA tests were then conducted on five remaining response variables, i. e., phonics-consonants, auditory discrimination, phonetic analysis, auditory vocabulary and comprehension.

Results of the MANOVA test across two levels of the treatment condition and three levels of the aptitude factor were as follows. The overall treatment effect was significant, $\underline{p} = 0.0008$; the overall aptitude effect was significant, $\underline{p} = 0.0067$; and the interaction was nonsignificant, $\underline{p} = 0.0767$. Because the question of interest in Hypothesis 2 C was the relationship between treatment levels and aptitude levels, no statistical evidence resulted from the combined MANOVA (since the interaction effect was not significant).

Subsequent MANOVA analysis of each separate aptitude stratum, did, however, generate statistically significant results that had been negated in the nonsignificant interaction result of $\underline{p} = 0.4672$. Examination of Table 16 indicates that the overall treatment effect was statistically significant <u>within</u> the high aptitude stratum, $\underline{p} = 0.0119$, and within the middle aptitude stratum, $\underline{p} = 0.0226$. Only within the low stratum was the treatment effect nonsignificant, $p = 0.3787$.

Examination of least squares means displayed in Table 16 reveals that on the phonetic analysis and auditory discrimination response variables, the treatment condition manifested more benefit than on the other response variables. On the phonetic analysis response, there were significant effects across two aptitude strata, i.e., high aptitude stratum, $p = 0.0018$; and middle aptitude stratum, $p = 0.0012$. On the auditory discrimination response, there were significant treatment effects across two aptitude strata, i.e., middle, $p = 0.0126$; and low, $p = 0.0389$. Discussion of the practical significance of these results is included in Chapter V.

Hypothesis 2 D

Among first and second grade subjects, there is no statistical relationship between teacher voice signal amplification treatment, speech communication interference (from either JANI or from MHL) and linguistic task performance.

Analysis of the data revealed that the speech communication interference construct was more clearly discernible in the MHL factor than in the noise factor. Therefore, the discussion begins with the variable most readily isolated, i.e., MHL.[5] In the second step of this hypothesis analysis, the MHL stratum is controlled while the examination focuses on the non-MHL stratum and its relationship with the school (noise) factor.

Relationship of Treatment Factor and MHL Factor:

In order to substantiate a statistical relationship between the

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[5] An extended analysis of the MHL variable follows in the second section of this chapter.

TABLE 16

Treatment Effect By Aptitude Group

Response Variable	Treatment Group	High Aptitude LSM	High Aptitude Prob C=E	Middle Aptitude LSM	Middle Aptitude Prob C=E	Low Aptitude LSM	Low Aptitude Prob C=E
Phonics- (M) Consonants	Control	801	0.5248	741	0.0110	662	0.2976
	Exp.	789		769		676	
Auditory(S) Discrim.	C	547	0.6233	466	0.0176	364	0.0389
	E	539		492		405	
Phonetic(S) analysis	C	518	0.0018	477	0.0012	454	0.4931
	E	551		494		446	
Auditory(S) Vocabulary	C	394	0.0031	355	0.2932	319	0.1939
	E	416		358		326	
Compre- (S) hension	C	442	0.1570	387	0.3750	353	0.7366
	E	451		389		350	
		N = 65		N = 206		N = 68	
MANOVA Test for Hypothesis of no Overall Treatment Effect: Prob > F =		0.0119		0.0226		0.3787	

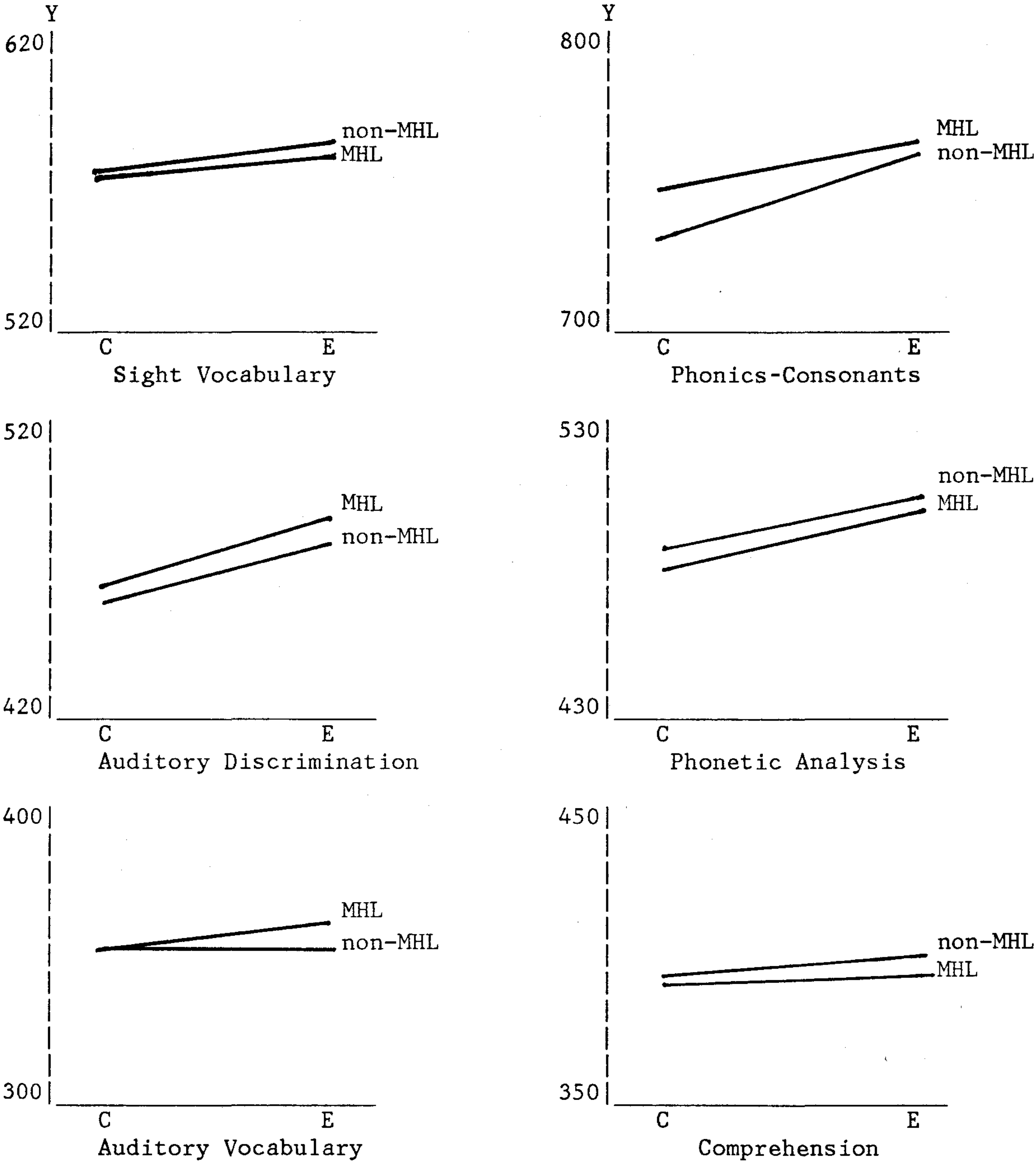
NOTE: (M) = Metropolitan Reading Test; (S) = Stanford Reading Test.

two levels of the treatment factor (amplification and non-amplification) and the two levels of the MHL factor (presence and absence), a statistically significant p value was needed on the MANOVA test for the hypothesis of no overall interaction between the treatment factor and the MHL factor. On the 339 observation MANOVA test displayed in Table 11 above, however, the resulting p value for the overall interaction effect was 0.5922. Post hoc analysis of least squares means revealed the reason for the nonsignificant interaction effect.

The six response variable plots displayed in Figure 10 portray the relationship between the two levels of the treatment condition and the two levels of the MHL factor on each response variable. Taken together, the six plots illustrate that the experimental group means exceeded the control group means on both levels of the MHL factor. Stated another way, the two levels of the MHL factor (presence and absence) did not react differently to the treatment condition, resulting in an interaction; the two levels, in fact, reacted similarly. Higher posttest scores were evidenced by both levels of the MHL factor on the experimental level of the treatment condition. Only on the auditory vocabulary response variable was there a visually apparent interaction effect and that effect was not statistically significant, $p = 0.0678$.

To examine further the relationship of the treatment factor and the MHL factor, the data were sorted by MHL levels into two groups, i.e., a MHL stratum and a non-MHL stratum. Results from the hearing acuity screening were used to identify 124 first and second grade subjects in the non-MHL classification and 221 subjects in the MHL class. As discussed in Chapter III, a threshold demarcation of 15 dB HL was utilized for assigning subjects to the MHL level of the factor. Any value lower than 15 dB HL resulted in the subject's being classified as non-MHL.

Homogeneity-of-slopes tests for each of the two MHL levels were



Legend: C = Control; E = Experimental; Y = Adjusted Posttest
MHL = presence of MHL; Non-MHL = absence of MHL

Note: Reduced sized plots above are displayed full size in appendix D

FIGURE 10: Treatment by MHL Relationship Plots

administered to assure comparability of comparisons. Within the group of students with MHL, there was no interaction between the treatment factor and the six common pretests. Nor was there an interaction between treatment groups and aptitude. Within the group free of MHL, heterogeneous slopes were indicated on two covariates, i.e., sight vocabulary and phonics-consonants. Therefore, subsequent MANOVA procedures included all available response variables and covariates within the MHL stratum and four of six response variables within the non-MHL stratum. Having accounted for homogenous slopes, differences in adjusted posttests means, generated by the MANOVA procedure, were attributable to treatment effects since differences due to the linear relationship between performance and covariates were effectively removed from consideration (Hays, 1973, p. 655).

MHL Stratum:

Examination of adjusted pair-wise means, within the MHL stratum, revealed that on all six response variables, the experimental group demonstrated higher posttest scores than its control group counterpart. On three variables the differences were statistically significant, i.e., auditory discrimination, $p = 0.0351$; phonetic analysis, $p = 0.0047$; and auditory vocabulary, $p = 0.0112$. Conversely, there were no significant differences between the adjusted posttest results of the experimental group and the control group within the non-MHL stratum. Worth noting, however, on each of the four paired comparisons, adjusted posttest means were higher for the experimental group than for the control group.

MANOVA statistics for the hypothesis of no overall treatment effect resulted in a statistically significant difference within the MHL group, $p = 0.0071$; and a nonsignificant result, $p = 0.3866$, within the

TABLE 17

Treatment Effect by MHL Group

Response Variable	Treatment Group	NON_MHL GROUP LSM	NON_MHL GROUP Prob C=E		MHL GROUP LSM	MHL GROUP Prob C=E
Sight (M)	Control	Heterogeneous			566	0.0544
Vocabulary	Exp.	Slopes			575	
Phonics (M)	C	Heterogeneous			740	0.1615
Consonants	E	Slopes			751	
Auditory(S)	C	470	0.2116		461	0.0176
Discrimin	E	483			483	
Phonetic(S)	C	491	0.0565		476	0.0024
Analysis	E	502			493	
Auditory(S)	C	359	0.4957		355	0.0056
Vocabulary	E	359			366	
Compre- (S)	C (n = 61)	398	0.3301	(n = 92)	389	0.3882
hension	E (n = 63)	401		(n = 129)	390	
MANOVA Test for Hypothesis of no Overall Treatment Effect: Prob > F =		0.3866			0.0071	

NOTE: (M) = Metropolitan Reading Test; (S) = Stanford Reading Test.

non-MHL group.

Taken together, the MANOVA test results seem to support the following statements.

The treatment condition, amplification intervention, did not affect MHL subjects and non-MHL subjects differently, as evidenced by the interaction effect test, $p = 0.5922$. Support for this statement is fortified by the six response variable plots displayed in Figure 9, which portray the higher posttest responses of the experimental group across both levels of the MHL factor, i.e., presence and absence.

However, even though both MHL subjects and non-MHL were affected similarly by amplification intervention, the effect <u>within</u> each distinct group was more pronounced within the MHL level than within the non-MHL level. Support for this statement is provided by separate MANOVA tests of MHL strata. Within the MHL stratum, the treatment effect was statistically significant, $p = 0.0071$; within the non-MHL stratum, the effect was not statistically significant, $p = 0.3866$.

Based upon the MANOVA results presented, there is evidence to support rejecting a hypothesis of no relationship between amplification treatment, speech communication interference (from MHL) and linguistic task performance.

<u>Non-MHL stratum</u>:

Having isolated the MHL factor, an attempt was made to isolate the JANI dimension also. One way to explore the relationship of interest was to stratify the data by the two levels of the MHL factor. Then, by examining treatment effects within the non-MHL stratum only, a competing source of speech communication interference was functionally removed as a factor of influence on linguistic task performance. What remained was a group of 134 subjects, 124 of whom had no missing observations over all possible independent and dependent variables.

By further stratifying this data set on the basis of school sites, which were quantified earlier by noise levels, treatment effects at school sites with differential noise levels were examined.

For this post hoc analysis, three of the six common response variables fulfilled the homogeneity assumption for covariance analysis.

As shown on Table 18, a significant difference for the multivariate hypothesis of no overall treatment effect was demonstrated at Site I only, where each of the three pair-wise comparisons favored the experimental group. Among Site I comparisons, the overall treatment effect was significant, $p = 0.0242$, and significant treatment effects were demonstrated on both the phonetic analysis response, $p = 0.0135$ and the auditory vocabulary response, $p = 0.0124$. At Sites II and III, overall treatment effect comparisons were not significant

At this point in the analysis, there appears to be insufficient evidence to reject a hypothesis of no relationship between amplification treatment, noise level (represented by school site) and linguistic task performance. If the task performance results at site II had paralleled the task performance results at Site I, as the noise level results had paralleled each other, a rejection decision would have been evident.

JANI Summary

Results of statistical analysis applied to four null hypotheses have been presented. Findings are now summarized in terms of the alternative hypotheses, which are the equivalent of the research hypotheses.

TABLE 18

Treatment Effect by School Site For Non-MHL Group

NON-MHL Group

Response Variable	Treatment Group	Site I Adjusted Mean	Site I Prob C=E	Site II Adjusted Mean	Site II Prob C=E	Site III Adjusted Mean	Site III Prob C=E
Phonetic(S) Analysis	Control	524	0.0068	460	0.1126	508	0.0958
	Epx.	566		473		483	
Auditory(S) Vocabulary	C	369	0.0062	357	0.0362	354	0.6879
	E	392		345		343	
Compre- (S) hension	C	427	0.2137	373	0.4479	419	0.2165
	E	437		375		402	
		n = 32		n = 60		n = 32	
MANOVA Test for Hypothesis of no Overall Treatment Effect: Prob > F =		0.0242		0.1162		0.3447	

NOTE: (M) = Metropolitan Reading Test; (S) = Stanford Reading Test.

- There was statistical evidence to support the hypotheses of differences in noise levels between school sites and differences in noise levels across school hours.
- There was statistical evidence to support the hypothesis of an overall treatment effect on linguistic task performance. However,

the treatment effect was not more evident among first grade subjects or low aptitude subjects, as predicted.

- A difference between treatment effects by MHL levels was demonstrated. However, treatment effects by noise levels, ranging from 65.5 dB to 71.5 dB were indistinguishable.

Minimal Hearing Loss Analysis

Results of the MHL analysis are presented in two subsections. In the first subsection, descriptive research to quantify MHL prevalence in the district's grade 1-6 population is presented. Beyond prevalence identification, the nature of MHL is more fully explored by expanding the data analysis through correlational and developmental techniques.

In the second subsection, data pertinent to the experimental design component of the MHL analysis is presented. Statistical evidence to support decision-making on two experimental design hypotheses is provided.

Nonexperimental Design Hypotheses

Hypotheses 3 Group

Six related hypotheses comprise this group. Nonparametric statistical analysis was applied to the ordinal level data, which consisted of hearing acuity observations collected over two school years on subjects in grades 1-6.

Hypothesis 3 A

There is no difference in the proportion of MHL between the local population and the comparable exterior data set.

As discussed in Chapter III, specific criteria for defining the boundaries of MHL classification were not available. To assure validity of population comparisons, therefore, the identification criteria used in this analysis were identical with those from the available exterior data source, i.e., "audiometric thresholds in excess of 10 dB HL but less than 40 dB HL" (Project Marrs, 1983, p.2).

Of the 764 subjects in grades 1-6 at school sites I, II, and III, tested for hearing acuity thresholds during the 1982-83 school year, 439 (57%) were identified with MHL. Table 19 summarizes the results of the local hearing screening and provides a comparative analysis with the exterior data set.

Probability values reported in Table 19 are based on tests of proportions procedures described by Triola (1980, p. 215). The data met the required assumptions for using the binomial distribution approximation, i.e., np > 5 and nq > 5 (p. 216). In each of the four paired-comparisons between grades 3-6 of the local data set and the exterior data set, there was a statistically significant result indicating that local MHL prevalence was greater.

Based upon the p values reported, there is evidence to support rejecting null Hypothesis 1 A in favor of the alternative hypothesis, i.e., that local MHL exceeded MHL from the exterior comparison group.

TABLE 19

Comparison of Exterior and Local MHL Prevalence

Exterior Data Set			Local Data Set		Comparison	
Grade	N	Prevalence Proportion	N	Prevalence Proportion	Z Value	P Value
1	NA		184	66.8		
2	NA		212	65.6		
3	270	30.3	94	51	4.38	< 0.0007
4	246	38.2	90	51.1	2.52	< 0.0059
5	252	27.7	93	52.7	5.17	< 0.0007
6	251	22.7	91	37.4	3.34	< 0.0007

Hypothesis 3 B

There is no difference in the proportion of MHL between school Sites I, II and III.

While the Hypothesis 3 A descriptive statistics provided answers to the amount of MHL, additional statistical analysis was applied to the collected data to determine the location of MHL within the research setting. On Table 20, local grade level MHL proportions by school site are displayed.

Inspection of Table 20 reveals that the noisiest school, Site I, had a smaller proportion of MHL prevalence than the least noisy school, Site III. Both sites included indentical grade level data i.e., 1-6, whereas Site II included grade one and two data only and therefore was

TABLE 20

MHL Prevalence by School Site

	Site I Frequency/Percent		Site II Frequency/Percent		Site III Frequency/Percent	
NON-MHL	137	48.1	65	31.1	123	45.6
MHL	148	51.9	144	68.9	147	54.4

NOTE: Frequencies at Sites I and II include grade 1-6 distributions; frequencies at Site II include grades 1-2 only.

not included in this analysis.

Using test procedures for comparing two proportions (Triola, 1980, p. 291), a p value of 0.4801 was obtained. As a result, the null hypothesis of equal proportions was not rejected. The prevalence of MHL at Sites I and III were statistically similar, even though Site I had a higher level of noise.

Hypothesis 3 C

There is no difference in the proportion of MHL subjects across four hearing level threshold classes.

In addition to the dichotomous classification of hearing screening results by presence or absence of MHL, the data were analyzed by multiple classificatory distributions. Table 21 displays the frequencies obtained in the analysis. Beginning with a 15 dB HL (least severe) classification, subjects were identified in four distinct categories, i.e., 15, 20, 25 and > 25 dB HL.

TABLE 21

MHL Prevalence by Hearing Level Threshold Class

Hearing Level	Frequency	Percent
NON-MHL	325	42.5
MHL at 15 dB HL	103	13.5
MHL at 20 dB HL	147	19.2
MHL at 25 dB HL	94	12.3
MHL > 25 dB HL	95	12.4

Results indicated that the highest proportion occurred at 20 dB HL and the lowest occurred at 25 dB HL.

To test this hypothesis, a 1 x 4 chi-square procedure was used. The statistic obtained, 17.29, with three degrees of freedom, resulted in a p value statistically significant, < 0.005. Accordingly, Hypothesis 3 C was rejected. MHL in the study population was not equally distributed by hearing level threshold classes.

Hypothesis 3 D

There is no relationship between MHL prevalence (by proportions) and grade level.

By summarizing the 764 subject hearing acuity values as grade level proportions, the data were ranked in two ordered series, i.e., one series corresponding to grade level proportions and one series corresponding to grade level numbers. Using nonparametric procedures recommended by Siegel (1956, p. 202) for small samples, the two ordered series were measured for the strength and direction of their correlation. The resultant Spearman's rho statistic was -0.7714, indicating an inverse relationship between MHL prevalence and grade level, with a p value of 0.0724. However, since the inverse relationship was not significant at the .05 level, the alternative hypothesis was not supported by statistical evidence and the null hypothesis was not rejected. Figure 11 portrays the relationship between MHL prevalence and grade level resulting from the analysis.

An earlier analysis of hearing acuity data collected from 273 subjects at Site I during 1981-82 revealed a greater inverse relationship than the results of the larger sample collected in 1982-83. A Spearman's correlation coefficient of -0.9429 resulted from the 1981-82 data with a corresponding p value of 0.0048.

Although Hypothesis 3 D was not rejected, as stated, subsequent tests comparing the combined first and second grade prevalence with the combined fifth and sixth grade prevalence did demonstrate a statistically significant difference in proportions. The combined first and second grade proportion was 66.2%; the combined fifth and sixth grade proportion was 45.1%. Using Triola's (1980, p. 295) procedure for testing the equality of proportions, a z statistic of 4.5 was obtained, indicating a significant difference in the two proportions, $p \doteq 0.0001$. This finding leads to an interpretation that first and second grade subjects evidenced a higher proportion of MHL prevalence than fifth and sixth grade subjects.

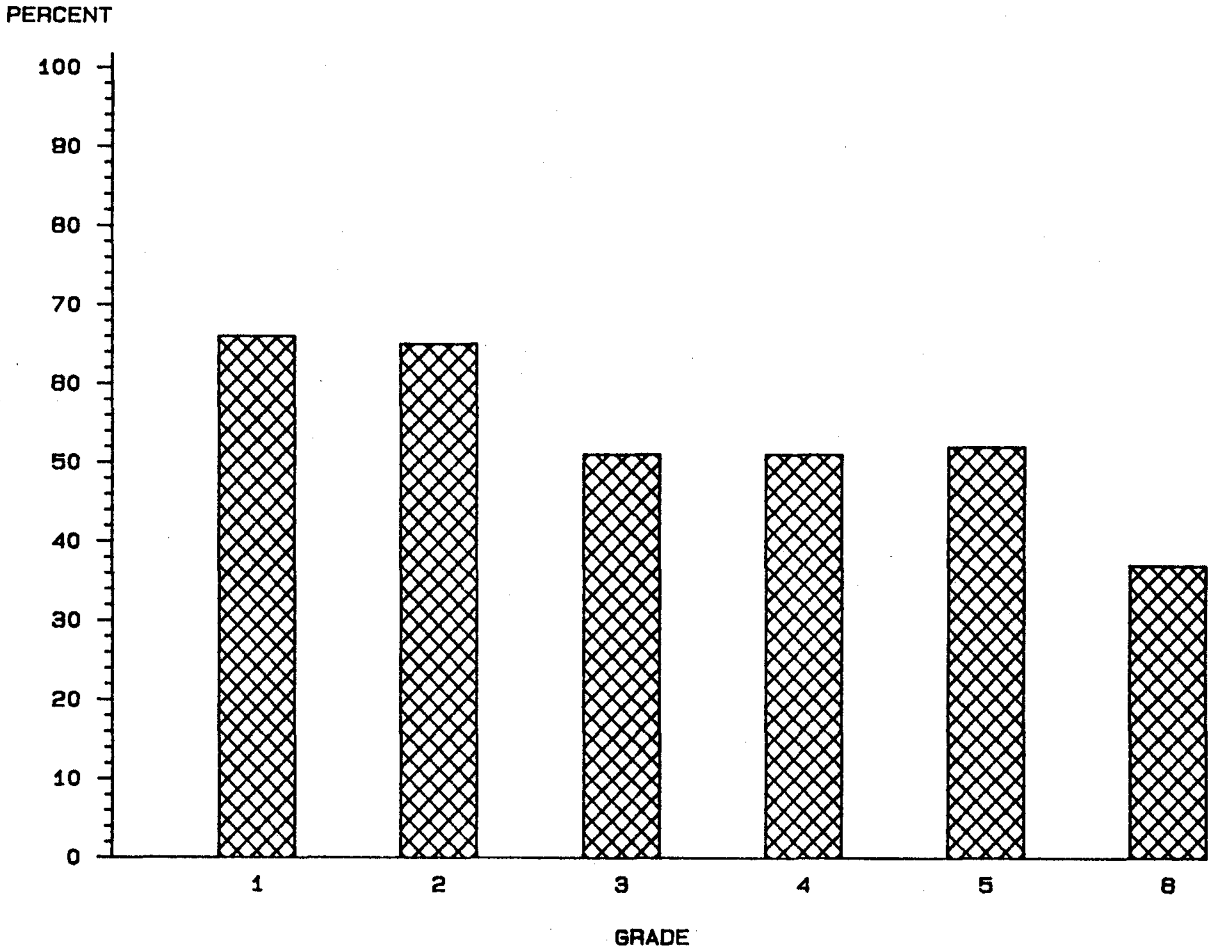


Figure 11: MHL Prevalence by Grade Level

Hypothesis 3 E

The probability that any subject will repeat positive identification for MHL on repeated observations is one half.

Table 22 displays the results of a McNemar test of equality of proportions based upon hearing acuity data collected over a two year period from the Site I population.

TABLE 22

McNemar Test Of Correlated Proportions For MHL Prevalence

FREQUENCY PERCENT ROW PCT COL PCT	No MHL	Some MHL	TOTAL
No MHL	82 37.79 73.87 74.55 (A)	29 13.36 26.13 27.10 (B)	111 51.15
Some MHL	28 12.90 26.42 25.45 (C)	78 35.94 73.58 72.90 (D)	106 48.85
TOTAL	110 50.69	107 49.31	217 100.00

STATISTIC FOR 2-WAY TABLE

CONTINUITY ADJUSTED CHI-SQUARE DF = 1 PROB (D) > (C)= < 0.0001

This analysis represents a problem in correlated proportions since each of the two sample proportions is based on the same individuals. On the fourfold table of frequencies displayed on Table 22, each cell contains the first and second set of responses from repeated hearing acuity tests for each individual.

Of the 217 subjects with paired responses, interest is focused on the proportion who repeat positive identification as compared with the proportion who change from positive to negative on repeated observations. The null hypothesis is: For those subjects identified with MHL on both tests (cell D), the probability that any child will remain positively identified (that is, P of D) is equal to the probability that he or she will be negatively identified (that is, P of C) is equal to one half. The alternative hypothesis is that P of D > P of C. The implication of the probability result of 0.0001 is that a significant difference was demonstrated by the repeated observations, i.e., that there is a greater proportion of positive identifications upon repeated observations than changes to negative identifications.

As recommended by Siegel (1956,p. 64), a continuity adjustment was applied to the statistical calculation because a continuous distribution (chi square) was used to approximate a discrete distribution.

Based on the McNemar test results, Hypothesis 1 E was rejected in favor of the alternative hypothesis of inequality of proportions.

<u>Hypothesis 3 F</u>

Before treatment, there is no difference in the linguistic task performance between subjects with MHL and subjects without MHL.

For this hypothesis, parametric procedures were used to make pretreatment task performance comparisons between population subsets with and without MHL. Observations with no missing values were available on 362 first and second grade subjects. Six common pretests constituted the dependent variable. The MHL factor was the independent variable and aptitude values were used as the covariate. No significant differences in least squares means between MHL levels (presence or absence) resulted from the six pair-wise comparisons generated from the MANOVA test. Accordingly, Hypothesis 2 was not rejected. No pretest differences were evident in the linguistic task performance of subjects dichotomously classified by MHL levels. Table 23 provides the supporting evidence for the decision.

Experimental Design Hypotheses

Hypothesis 4 Group

The Hypotheses in this group were evaluated by a post hoc analysis of the MHL stratum, which contained 221 observations with no missing observations.

Hypothesis 4 A

Among first and second grade subjects with MHL, there is no difference in linguistic task performance between amplification treatment subjects and non-amplification treatment subjects.

The results of a combined-group 2x3x2 MANOVA test, displayed in Table 24, indicate a significant overall treatment effect, $p = 0.0017$. There were no significant interaction effects between the two levels of the treatment factor and the three levels of the school factor or the two levels of the grade factor. As in Hypothesis 2 A, there was no

TABLE 23

Linguistic Task Performance By MHL Level Before treatment

RESPONSE VARIABLE	MHL GROUP	LSM	STD ERR LSM		PROB > |T| HO: LSM NO-MHL = LSM-MHL
Sight (M)	NO-MHL	534	7.4		0.6923
Vocabulary	MHL	531	5.5		
Phonics- (M)	NO-MHL	685	12.4		0.4876
Consonants	MHL	686	9.2		
Auditory(S)	NO-MHL	426	8.7		0.2397
Discrimination	MHL	413	6.4		
Phonetic(S)	NO-MHL	437	6.0		0.7786
Analysis	MHL	435	4.4		
Auditory(S)	NO-MHL	338	5.8		0.9729
Vocabulary	MHL	338	4.3		
(S) Comprehension	NO-MHL	349	6.7	(n = 128)	0.5780
	MHL	345	5.0	(n = 234)	

MANOVA TEST FOR THE HYPOTHESIS OF NO OVERALL...

TREATMENT EFFECT: PROB > F = 0.7808

NOTE: (M) = Metropolitan Reading Test; (S) = Stanford Reading Test.

interest in the grade effect unless the grade factor had interacted with the treatment factor.

Examination of least squares means revealed that in each of the six orthogonal comparisons, the experimental group mean exceeded the control group mean. In three comparisons, differences were statistically significant, i.e., auditory discrimination, $p = 0.0307$; phonetic analysis, $p = 0.0001$; and auditory vocabulary, $p = 0.0076$.

TABLE 24

Combined-Group MANOVA Statistics - MHL Subjects

MANOVA TEST CRITERIA FOR THE HYPOTHESIS OF NO OVERALL TREATMENT EFFECT

H = Type III SS&CP Matrix for: Treatment
E = Error SS&CP Matrix

P = Dep. variables	=	6
Q = Hypothesis DF	=	1
NE = DF of E	=	202
S = Min (P-Q)-1)	=	1
M = .5 (ABS (P-Q)-1)	=	2.0
N = .5 (NE-P-1)	=	97.5

Hotelling-Lawley Trace Prob > F = 0.0017

Pillai's Trace Prob > F = 0.0017

Wilks' Criterion Prob > F = 0.0017

MANOVA TEST FOR THE HYPOTHESIS OF NO OVERALL...

SCHOOL EFFECT: PROB > F = 0.1498
GRADE EFFECT: PROB > F = 0.0001
TREATMENT*SCHOOL EFFECT: PROB > F = 0.2614
TREATMENT*GRADE EFFECT: PROB > F = 0.1439
TRT*SCHOOL*GRADE EFFECT: PROB > F = 0.3240

Based upon results obtained, Hypothesis 4 A was rejected in favor of the alternative of a demonstrated relationship between amplification treatment, MHL and linguistic task performance.

Hypothesis 4 B

Among subjects with MHL, there is no difference in the effect of teacher voice signal amplification treatment between first and second grade subjects.

Results of the combined-group 2x3x2 MANOVA test, displayed in Table 24, were used for the evaluation of Hypothesis 4 B. In this analysis, interest is focused on differences in treatment effects between grade levels one and two within the MHL stratum. As shown in Table 24, the interaction between the two levels of the treatment factor and the two levels of the grade factor was not significant, $p = 0.1439$.

As in the earlier grade level analysis of all subjects, Hypothesis 2 B, post hoc examination of least squares means was revealing. Again, on 11 of 12 possible orthogonal comparisons, the experimental group mean exceeded the control group mean. Among six first grade comparisons, the difference was statistically significant on one response variable, i.e., phonetic analysis, $p = 0.0493$. Among second grade comparisons, the experimental group mean exceeded the control group mean, at a statistically significant level, on five of six response variables, i.e., sight vocabulary, $p = 0.0127$; phonics-consonants, 0.0030; auditory discrimination, $p = 0.0398$; phonetic analysis, $p = .0001$; and auditory vocabulary, $p = 0.0068$.

Based upon results obtained, Hypothesis 4 B was not rejected. In the alternative to Hypothesis 4 B, a prediction of a more significant treatment effect among first grade comparisons than among second grade comparisons had been made. The obtained results did not support the prediction.

Again, as in the grade level analysis of all subjects, separate MANOVA tests were applied, in this case, to the MHL stratum rather than to all subjects. Results of these tests are exhibited in Table 25. The number of observations was reduced to 100 within the first grade stratum and 119 within the second grade stratum. First grade results indicated a nonsignificant overall treatment effect, p = 0.3173 and a nonsignificant interaction effect between the treatment factor and the grade level factor, p = 0.3002. Within the second grade stratum, all main effects and interaction effects were significant, i.e., treatment, p = 0.0051; school, p = 0.0245; and treatment by school, p = 0.0496.

TABLE 25

Treatment Effects By Grade Level - MHL Subjects

MANOVA TEST FOR THE HYPOTHESIS OF NO OVERALL...

Grade 1	Grade 2
TREATMENT EFFECT > F = 0.3173	TREATMENT EFFECT > F = 0.0051
SCHOOL EFFECT > F = 0.2857	SCHOOL EFFECT > F = 0.0245
TRT*SCHOOL EFFECT > F = 0.3002	TRT*SCHOOL EFFECT > F = 0.0496
N = 100	N = 119

Since the overall interaction between the treatment factor and school factor was significant, examination of the relationship between treatment levels at school sites was appropriate. On the nine response variables with homogenous slopes, within the second grade stratum, three orthogonal comparisons of treatment levels by school site were significant at both Site I and Site III. There were no significant treatment effects at Site II.

As shown in Table 26, there appears to be no discernible pattern in treatment effects across school sites except that that all six significant comparisons occurred within two school sites, i.e., Site I and Site III. Overall, on 24 of 27 comparisons, the experimental group mean evidenced a higher value than the control group mean.

Hypothesis 4 C

Among first and second grade subjects with MHL, there is no difference in the effect of teacher voice signal amplification treatment on linguistic task performance of subjects stratified by aptitude levels, high, middle and low.

The alternative to Hypothesis 4 C was that a more significant treatment effect would be evidenced among low aptitude comparisons than among high aptitude or middle aptitude comparisons. For this 2x3 MANOVA test (two treatment levels and three aptitude levels) 221 observations were available. All six response variables common to the experimental population fulfilled the assumptions of homogenous slopes for analysis of covariance (In the parallel analysis above, i.e., Hypothesis 2 B, the sight vocabulary response variable had not manifested homogeneity). Again, a MANOVA test was applied to all observations simultaneously followed by a separate MANOVA test applied to each aptitude stratum.

Results of the combined-group MANOVA test were as follows. The

TABLE 26

Grade 2 Treatment Effects by Site Level - MHL Subjects

Response Variable	Treatment Group	Site I	PROB > |T| HO: LSM C = LSM E	Site II	PROB > |T| HO: LSM C = LSM E	Site III	PROB > |T| HO: LSM C = LSM E
Phonics- (M)	C	527	0.0806	524	0.9775	535	0.0152
Vowels	E	588		523		628	
Structural(S)	C	407	0.0024	416	0.0952	425	0.0699
Analysis	E	448		428		446	
Literal(S)	C	422	0.2589	428	0.8735	425	0.2569
Comprehension	E	429		427		432	
Inferential(S)	C	452	0.6216	448	0.2024	439	0.2020
Comprehension	E	445		455		451	
Phonics(M)	C	763	0.1002	754	0.0766	751	0.0365
Consonants	E	816		791		823	
Auditory(S)	C	454	0.0397	467	0.0982	444	0.3125
Discrimination	E	510		493		459	
Phonetic(S)	C	502	0.0001	506	0.4342	503	0.1355
Analysis	E	581		508		522	
Auditory(S)	C	409	0.1298	412	0.3240	392	0.0320
Vocabulary	E	423		415		415	
Compre- (S)	C	435	0.4317	442	0.4792	431	0.1764
hension	E	438		443		443	
Effect: Prob > F =		0.0034		0.1538		0.3332	

NOTE: (M) = Metropolitan Reading Test; (S) = Stanford Reading Test.

overall treatment effect was significant, p = 0.0009; the overall aptitude effect was significant, p = 0.0235; and the interaction between the two main effects was significant, p = 0.0054. Post hoc analysis of least squares means corresponding to the interaction effect revealed the following. Among high aptitude comparisons, significant treatment effects were evidenced on three response variables, i.e., sight vocabulary, p = 0.0443; phonetic analysis, p = 0.0056; and auditory vocabulary, p = 0.0018. Among middle aptitude comparisons, significant treatment effects were evidenced on two responses, i.e., phonics-consonants, p = 0.0421; and phonetic analysis, p = 0.0044. Among low aptitude comparisons, significant treatment effects occurred on three responses, i.e., sight vocabulary, p = 0.0262; auditory discrimination, p = 0.0136; and auditory vocabulary, p = 0.0336.

Results of separate MANOVA tests on each aptitude stratum are exhibited in Table 27. The overall treatment effect effect was significant among high aptitude comparisons only, p = 0.0034. Comparing the present results with the parallel test (over 339 observations), displayed in Table 14 above, suggests the following. In both tests, the high aptitude group demonstrated a significant amplification treatment effect while the low aptitude group did not. In the former test, the middle aptitude group also manifested a significant result. In the present test, the middle aptitude group did not.

Based upon results obtained, Hypothesis 4 C was not rejected. A more significant treatment effect among lower aptitude comparisons was not evidenced, as predicted.

TABLE 27

Treatment Effect By Aptitude Group - MHL Subjects

Response Variable	Treatment Group	High Ability		Middle Ability		Low Ability	
		LSM	Prob C=E	LSM	Prob C=E	LSM	Prob C=E
Sight(M) Vocabulary	Control	585	.0092	574	.4849	521	.0556
	Exp.	609		575		542	
Phonics- (M) Consonants	C	803	.2202	735	.0466	690	.4862
	E	774		762		691	
Auditory(S) Discrim.	C	538	.4269	466	.0509	366	.0482
	E	542		488		409	
Phonetic(S) analysis	C	502	.0020	471	.0058	469	.2982
	E	541		490		455	
Auditory(S) Vocabulary	C	384	.0024	357	.2282	324	.0842
	E	411		360		340	
Compre-(S) hension	C	434	.2399	383	.4973	358	.4186
	E	440		383		360	
		N = 45		N = 131		N = 45	
MANOVA Test for Hypothesis of no Overall Treatment Effect: Prob > F =		0.0034		0.1538		0.3332	

NOTE: (M) = Metropolitan Reading Test; (S) = Stanford Reading Test.

Hypothesis 4 D

Among first and second grade subjects with MHL, there is no difference in the effect of teacher voice signal amplification treatment across four different hearing level threshold classes.

In the nonexperimental MHL data analysis, summarized in Table 21, the population subset spanned grades 1-6. In the present analysis, identical classification was applied to first and second grades subjects included in the experimental design to enable task performance comparisons by treatment levels across each of the four MHL intensity groups. Table 28 summarizes MANOVA test results generated by the data.

To evaluate the utility of the treatment condition across levels of MHL, an ANCOVA was applied to the averaged response from the six dependent variables common to all subjects. As shown in Table 28, the coefficients of determination (R-Square), ranged from .80 to .91, indicating that a high percentage of variation had been accounted for by the fitted regression model. Results of the ANCOVA tests indicated a statistically significant difference between treatment levels for the 75 subjects identified with MHL at 20 decibels. The second largest performance difference occurred at 25 dB, but was not significant. As expected, the least impact of amplification treatment occurred within the group of students with the least MHL, i.e., 15 dB. In each of the four pair-wise comparisons (treatment level by MHL intensity level) the experimental group, with amplification, attained a higher averaged response than the control group, without amplification.

The graphic representation of the ANCOVA test, Figure 12, portrays a comparison of linguistic task performance by treatment levels for each of four discrete MHL hearing threshold classes and for the class of

TABLE 28

Treatment Effects by MHL Threshold Class

ANCOVA: Averaged Response Across 6 Common Dependent Variables

HEARING LEVEL	TREATMENT GROUP		LSM SUMS	STD ERR LSM	PROB > |T| C = E	R SQUARE
MHL @ 15 dB	C	(n = 18)	3150	28.4	0.2629	.91
	E	(n = 27)	3173	23.2		
MHL @ 20 dB	C	(n = 30)	2987	28.9	0.0114	.80
	E	(n = 45)	3075	23.6		
MHL @ 25 dB	C	(n = 20)	2946	40.7	0.0568	.81
	E	(n = 26)	3035	35.5		
MHL @ >25 dB	C	(n = 24)	2890	46.4	0.1334	.80
	E	(n = 31)	2960	40.8		

MANOVA TEST FOR THE HYPOTHESIS OF NO OVERALL TREATMENT EFFECT BY MHL THRESHOLD CLASS

MHL @ 15 dB (n=75) TREATMENT EFFECT > F = 0.293
MHL @ 20 dB (n=75) TREATMENT EFFECT > F = 0.078
MHL @ 25 dB (n=46) TREATMENT EFFECT > F = 0.451
MHL > 25 dB n=55) TREATMENT EFFECT > F = 0.465

MANOVA TEST FOR THE HYPOTHESIS OF NO OVERALL TREATMENT EFFECT....

PROB > F = 0.0225

n = 221

observations without MHL. Within each class, experimental subjects attained a higher mean score than their control counterpart.The highest scores were attained within the 15 dB HL class. The most significant treatment effect was evidenced within the 20 dB HL class. As hearing levels decreased toward the > 25 dB class, performance results decreased at a parallel rate between treatment levels.

In the middle of Table 28, treatment effect comparison results are displayed for a MANOVA test applied to each separate MHL strata across the six common response variables. Results of this analysis demonstrate again that comparisons among MHL 20 dB observations yielded the lowest p value, but this time it was not significant, $p = 0.0775$.

At the bottom of Table 28, results of a combined-group MANOVA test over all 221 observations, four hearing threshold classes, and six common response variables yielded a probability value of 0.0225. Prior to calculation of all ANCOVA and MANOVA tests, a homogeneity-of-slopes test indicated that adjusted posttest means were free of interaction between pretests, IQ, and treatment condition levels.

Based upon the combined-group MANOVA test results obtained, Hypothesis 4 D was rejected in favor of the alternative hypothesis, i.e., the effect of teacher voice signal amplification treatment on posttest results was not similar across the five different hearing level classes.

MHL Summary

MHL analysis findings are summarized below in terms of the research hypothesis advanced.

- MHL prevalence was quantified in greater proportions locally than

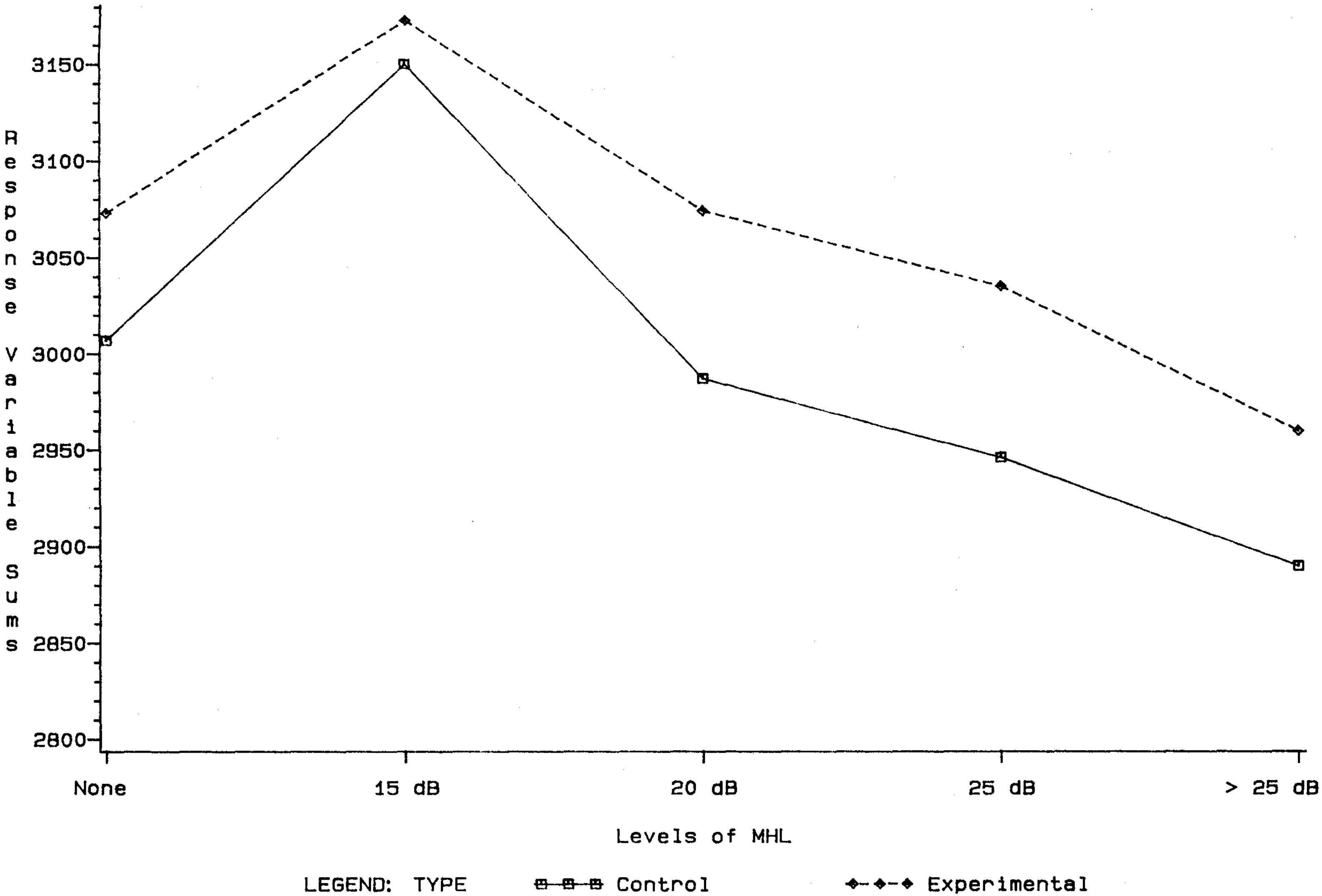


Figure 12: Comparison of Averaged Responses
Across Hearing Thresholds

in the comparative data set from exterior sources.

- MHL was not aligned with noise levels, within the 65.5 dB to 71.5 dB range, nor was it distributed proportionately across grade levels.
- Greater MHL prevalence occurred at the 20 dB HL class than at the other three hearing level classes.
- Subjects positively identified for MHL in an initial screening demonstrated a propensity to repeat positive identification.
- Results of the experimental design indicated that subjects with MHL benefited from an amplified teacher voice signal. As MHL intensified, linguistic task performance decreased but experimental subjects continued to evidence a higher level of performance than their control subject counterparts.
- Amplified teacher voice signals contributed more aid to second grade subjects than to first grade subjects and more aid to high aptitude subjects than to low aptitude subjects.

CHAPTER V

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

Overview

This investigation examined the utility of teacher voice signal amplification treatment for mediating speech communication interference from two sources, i.e., jet aircraft noise intrusion and minimal hearing loss. A theoretical paradigm, The Speech Chain (Figure 1), was used to portray oral communication as a chain of events between speaker and listener, connected at three discrete levels, i.e., acoustic, physiological and linguistic. Speech communication interference was represented as a molar level referent construct of cause on the speech chain; linguistic task performance was represented as a molar level referent construct of effect on the Speech Chain. The treatment condition, teacher voice signal amplification, was incorporated into an experimental design as an intervening or enabling treatment to offset interference between speaker and listener. Linguistic task performance comparisons were made between experimental subjects, who received the treatment, and control subjects, who did not. Multivariate analysis of covariance statistical procedures were employed to enable the simultaneous analysis of multiple response variables, covariates and factors.

Just as speech communication interference (the suspected causal variable) precedes linguistic task performance (the suspected effect variable) on the speech chain paradigm, quantification of speech communication interference anteceded experimentation in the research design.

Descriptive statistics were derived to summarize speech communication interference data collected from both noise level quantification and hearing acuity screening.

Following is a discussion of the results reported in Chapter IV. All hypotheses are presented in their null form. Interpretative information is provided about the statistical procedures and the relative importance of the findings. Each hypothesis group includes a separate set of preliminary conclusions which are integrated into overall conclusions following the separate JANI and MHL analyses.

JANI Analysis

Quantification of the Noise Level Dimension

Hypothesis 1 Group

Hypothesis 1 A

There is no difference in the average level of noise(Leq) from jet aircraft overflights between school sites, I, II and III.

Results of a two-way analysis of variance on 336 Leq measurements indicated that the school sites differed in noise levels, $p = 0.0001$. Based upon the statistical analysis, Hypothesis 1 A was rejected. While noise level quantification findings were statistically similar at Sites I and II, both were statistically dissimilar to Site III.

Hypothesis 1 B

There is no difference in the average hourly noise level(Leq) across the school day from 8:00 a.m. to 4:00 p.m. at school sites I, II and III combined.

Results of a two-way analysis of variance indicated that differences in noise levels did occur across the school day with 10.00 a.m. beginning the noisiest one-hour interval. Based upon results obtained, $p = 0.0350$, Hypothesis 1 B was rejected.

Preliminary Conclusions

- It appears that exterior noise levels from jet aircraft overflights are measurable on the local level. As predicted, findings differed by school site, depending upon site location in proximity to the noise source. Site I, located on the windward side of O'Hare Airport (west), directly below departure and arrival overflights from the busiest runway (27 L), yielded the highest noise-level, hourly averages during the school day, 71.5 Leq. Site II was nearly parallel at 70.4 Leq, followed by Site III at 65.5 Leq.

  Supporting evidence that noise levels at school sites I, II and III are high and different from one another has been provided by the FAA during the course of this investigation. Noise level descriptors reported by the FAA (March,1984) identify Site I with the highest noise level of 102 schools surrounding O'Hare International Airport. Site I and two elementary schools from neighboring communities are currently in the process of being soundproofed through federal funding. Site II, along with 20 other schools, has been identified in the 70 Ldn classification and recommended for soundproofing treatment in the near future.[1] Site III was identified by the FAA in the 65 Ldn contour and not recommended for soundproofing.

- In this analysis, differential noise levels prevailed at different times during the course of the school day. The noisiest one-hour interval occurred between 10:00 a.m. and 11:00 a.m.

  Awareness that peak noise levels during the school day adhere to a repetitious pattern may be of some value to local educators in planning daily instruction, particularly in scheduling large-group, direct-instruction activities.

Treatment Effect on Task Performance - All Subjects

Having quantified the prevailing noise level, the next step was to examine the effect of amplification intervention on student task performance at three school sites within the quantified noise level environment. Subject selection for the experimental design was based upon research reports of age-dependent and task-dependent relationships between noisy environments and learning. Hence, the youngest available subjects, i.e., first and second grade, and linguistically related response variable tasks, including auditory vocabulary, sight vocabulary, phonics-consonants, auditory discrimination, phonetic analysis and reading comprehension, were selected.

Four separate hypotheses were advanced and tested on the observa-

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[1] See FAA soundproofing documentation in appendix F.

tions collected from 396 subjects in the experimental design. Each hypothesis is discussed below.

Hypothesis 2 Group

Hypothesis 2 A

Among first and second grade subjects, there is no difference in linguistic task performance between amplification treatment subjects and non-amplification subjects.

Results of a combined-group 2x2x3x2 multivariate analysis of covariance, displayed in Table 11, indicated a significant overall treatment effect, $p = 0.0012$. Post hoc analysis of least squares means revealed that the experimental group attained higher adjusted posttest means than the control group and that the differences were statistically significant on the following response variables: phonics-consonants, $p = 0.031$; auditory discrimination, $p = 0.0134$; and phonetic analysis, $p = 0.0001$. On each of the remaining three responses, i.e., sight vocabulary, auditory vocabulary and reading comprehension, the experimental group achieved a higher mean score but the difference was not statistically significant.

In addition to the MANOVA procedure, other statistical data analysis was undertaken to evaluate the effect of amplification treatment on linguistic task performance. Results of an analysis of covariance (using pretest and aptitude values as concomitant variables), shown on Table 12, indicated that amplification intervention did affect the average across the six responses. Although a weaker hypothesis, the result,

$p = 0.0002$, compared closely with the combined-group MANOVA test result, $p = 0.0012$.

Gain score analysis, reported in Table 13, yielded treatment effect results similar to results obtained from the MANOVA analysis. Rationale for the extra statistical analysis procedure, i.e., gain score comparisons, follows.

In the experimental design, ten intact classrooms were randomly assigned to receive amplification treatment for ninety days while eight intact classrooms were randomly assigned as controls and did not receive treatment. Experimental subjects were administered both the pretest and posttest linguistic task performance instruments with amplification treatment. Control subjects were administered both tests without amplification. Testing procedures differed so as to "maximize the systematic variance under study" (Kerlinger, 1974, p. 307).

It could be posited that differences in treatment effects were attributable to difference in testing conditions rather than to differences in performance growth over the ninety-day period between pretest and posttest. The gain score analysis provided a means for isolating task performance growth from pretest to posttest and revealed that treatment subjects evidenced significantly higher performance growth than their control counterparts.

Based upon results reported in Tables 10, 11, 12, and 13, the hypothesis of no treatment effect differences between experimental and control groups was rejected. An overall treatment effect was evidenced, with significant differences occurring in the linguistic subskill tasks of phonics-consonants, auditory discrimination and phonetic analysis. In Table 29, a representation of the relationship between statistical significance and practical significance is displayed for those response variables with significant results.

TABLE 29

Practical Significance of Treatment Effects - All Subjects

RESPONSE VARIABLE	TEST	TREATMENT GROUP	ADJ. POSTTEST	P VALUE	GRADE LEVEL EQUIVALENT	DIFFERENCE
Phonics-Consonants	Metro-politan	Control Exp.	737 761	0.0331	Not Available	
Auditory Discrim.	Stanford	Control Exp.	459 486	0.0134	3.9 5.0	+ 1 year 1 month
Phonetic Analysis	Stanford	Control Exp.	481 502	0.0001	3.0 3.5	+ 5 Months

NOTE: Corresponding descriptive statistics are displayed in appendix A

In summary, it appears that the magnitude of the treatment effect was substantial. On the auditory discrimination response variable the experimental group posttest scores exceeded the control group posttest scores comparable to one year and one month in grade level equivalents.[2] On the phonetic analysis response, the grade equivalent difference was comparable to five months. Given that the treatment intervention spanned

[2] After having used scaled scores for all statistical analysis, conversion to grade equivalents on the Stanford test and to percentiles on the Metropolitan test was undertaken to enable discussion of the practical significance of the results. Note further that percentile conversion on the Metropolitan test does not apply uniformly <u>across</u> grade levels and is only applicable and used for comparisons <u>within</u> a grade level stratum.

a ninety-day period only, the resulting grade level equivalent differences seem to provide strong support for the utility of teacher voice signal amplification treatment.

The results appear to be consistent with research and theories of authorities on language acquisition, particularly Skinner(1978) and Downs(1981), reviewed in chapter II. Skinner(p. 638) has indicated that the spoken sounds in the American English language span a 25 to 30 decibel range from faintest to loudest, making speech intelligibility a demanding task for young, inexperienced listeners. The task of the listener becomes even more difficult if hearing acuity deficits exist and interfering noise masks speech signals (Downs, p.179).

The setting and context for evaluating teacher voice signal amplification treatment appears to have contained a multitude of pertinent micromediating influences, the synergetic effect of which were partially overcome by amplification intervention.

Hypothesis 2 B

There is no difference in the effect of teacher voice signal amplification treatment between first and second grade subjects.

Based upon the age-dependent effect suggested in the literature, a directional alternative was advanced for this hypothesis, i.e., that there would be more evidence of treatment effect differences among first grade comparisons than among second grade comparisons.

Results of the combined-group MANOVA test, which analyzed 339 first and second grade observations across six common variables, did not support the alternative hypothesis. The interaction test between treatment levels and grade levels was not significant, $p = 0.4672$. Accordingly, Hypothesis 2 B was not rejected. Interaction plots, exhibited in Figure 9 and in appendix C, did however, illustrate that at both the first and second level, experimental group means exceeded control group means. Post hoc comparisons revealed significant treatment effects on more response variables among second grade comparisons than among first grade comparisons. On two of six response variables, there were significant treatment effects among first grade comparisons, i.e., auditory discrimination and phonetic analysis. On five of six responses, there were significant treatment effects among second grade comparisons, i.e., sight vocabulary, phonics-consonants, auditory discrimination, phonetic analysis, and comprehension.

Subsequent MANOVA analysis of treatment effects by grade level strata revealed a nonsignificant treatment effect within the first grade stratum, $p = 0.1424$ and a significant treatment effect within the second grade stratum, $p = 0.0045$. The second grade main effect, however, was negated by interaction effects between treatment levels and school (site) levels, meaning that treatment effects were related to school sites, within the second grade stratum. Examination of treatment effects by school site, displayed in Table 15, revealed no discernible pattern other than location. There was a significant treatment effect between comparison groups on four response variables at Site III, two at site I, and one at site II.

Viewed together, the one combined and two separate MANOVA analyses suggest that amplification intervention resulted in more benefit to second grade subjects than to first grade subjects.

Retrospective analysis of the experimental design environment suggests a reason for the finding. Separation distance between speaker and listener has been identified as a determinant of speech intelligibility in communication interference paradigms (Figure 3). While monitoring treatment implementation throughout the experiment, this investigator observed that separation distance within first grade classrooms was different from separation distance within second grade classrooms. While conducting whole-class instruction, within a typical first grade classroom environment, subjects were grouped on a carpet immediately in front of their teacher. Separation distance between speaker and listener was approximately 12 feet. Conversely, whole-class instruction within second grade classrooms, with traditional seating arrangements, resulted in separation distances of 30 to 40 feet between subjects in the rear of a classroom and their teacher. In second grade treatment classrooms, therefore, with a speaker box in either corner of the rear of the room and a teacher front and center, separation distance (from the teacher's amplified voice signal) was considerably fewer feet than in second grade classrooms without speaker boxes. Conversely, separation distance between experimental and control groups within first grade was slight, since all subjects (both treatment and controls) were similarly located near the teacher's direct voice signal. Stated alternatively, research indicates that whole-group instructional settings create a more noise sensitive environment than small-group instructional settings create (Crook and Langdon, 1974, p. 227). Second grade classrooms in the present research setting were organized in whole-groups while first grade classrooms were organized in small-groups.

A competing hypothesis for treatment effect differences between first and second grade comparison groups could be advanced. When the data were stratified and a MANOVA was applied to each stratum, significant performance differences between experimental and control subjects was demonstrated on two second grade response variables, i.e., phonics-vowels and structural analysis, that were not administered to first grade subjects. Hence, performance differences between grade levels could have been attributable to test content differences. This contention, however, seems to have been countervailed by the combined-group MANOVA test over six variables common to all 339 observations in the analysis.

In Table 30, the practical significance of second grade treatment effects by school site are displayed. Percentile equivalents are provided for Metropolitan test results and grade level equivalents for Stanford test results on each response variable with significant treatment effects.

Hypothesis 2 C

Among first and second grade subjects, there is no difference in the effect of teacher voice signal amplification treatment on linguistic task performance of subjects stratified by aptitude levels, high, middle and low.

Statistical support for rejecting Hypothesis 2 C was not evidenced by results obtained. A combined-group MANOVA test of the overall interaction between two treatment levels and three aptitude levels across five response variables with homogenous slopes was not quite significant, $p = 0.0767$. However, a separate MANOVA test applied to each aptitude stratum, high, middle and low, did demonstrate statistically significant treatment effects among comparisons within the high-stratum, $p = 0.0119$ and within the middle-stratum, $p = 0.0226$. The treatment

TABLE 30

Practical Significance - Second Grade Subjects

RESPONSE VARIABLE	TEST	TREATMENT GROUP	ADJ. POSTTEST	P VALUE	GRADE LEVEL/ PERCENTILE EQUIVALENT	DIFFERENCE
		(Site I)				
Structural Analysis	Stanford	Control	425	0.0446	3.2	
		Exp.	443		3.7	+ 5 months
Phonetic Analysis	Stanford	Control	514	0.0001	4.0	
		Exp.	576		9.0	+ 5 years
		(Site II)				
Sight Vocabulary	Metro-politan	Control	584	0.0269	32 %ile	
		Exp.	601		44	+ 12 points
		(Site III)				
Phonics-Vowels	Metro-politan	Control	559	0.0035	50 %ile	
		Exp.	645		68	+ 18 points
Structural Analysis	Stanford	Control	426	0.0014	3.3	
		Exp.	459		4.2	+ 9 months
Sight Vocabulary	Metro-politan	Control	595	0.0209	40 %ile	
		Exp.	622		92	+ 52 points
Compre-hension	Stanford	Control	434	0.0372	3.5	
		Exp.	452		3.9	+ 4 months

NOTE: Significant effects derived from Table 15 effect within the low-stratum was not significant, $p = 0.3787$. Based upon results obtained, Hypothesis 2 C was not rejected. Comparisons within the low aptitude stratum did not manifest a more significant treatment effect than comparisons within the high and middle aptitude strata, as predicted.

As discussed in Chapter IV, this a posteriori data analysis was undertaken to evaluate the aptitude-dependent relationship, posited in the literature about the effects of noise on learning. The logic underlying the alternative to Hypothesis 2 A was...since noise adversely affects low aptitude students more than other students, amplification intervention should help low aptitude students more than others.

As Shown in Table 31, however, benefit from amplification intervention was distributed across all levels of aptitude strata with three significant comparisons occurring within the middle stratum, two within the high stratum, and one within the low stratum.

The results suggest that perhaps there was a flaw in the logic of the alternative hypothesis posited for this analysis. Cook and Campbell have discussed a possible explanation for finding such a "fan-spread" pattern in treatment effects, i.e., it is possible that selection-maturation bias accounted for the distribution of treatment effects across aptitude strata (1979, p. 53).

Test content also may have affected the results across aptitude strata. Examination of Table 31 reveals that on two response variables, significant treatment effects overlapped multiple aptitude strata. The treatment effect was significant on the phonetic analysis response across both the high and middle aptitude strata. The treatment effect was significant on the auditory discrimination response across both the

TABLE 31

Practical Significance by Aptitude Strata - All Subjects

RESPONSE VARIABLE	TEST	TREATMENT GROUP	ADJ. POSTTEST	P VALUE	GRADE LEVEL EQUIVALENT	DIFFERENCE
		(High Aptitude Stratum)				
Phonetic Analysis	Stanford	Control	518	0.0018	4.1	
		Exp.	551		6.2	+ 2 years 1 month
Auditory Vocabulary	Stanford	Control	391	0.0032	3.3	
		Exp.	416		3.6	+ 3 months
		(Middle Aptitude Stratum)				
Phonics-Consonants	Metro-politan	Control	741	0.0110	Not available	
		Exp.	769			
Phonetic Analysis	Stanford	Control	477	0.0012	4.7	
		Exp.	494		5.4	+ 7 months
Auditory Discrim.	Stanford	Control	466	0.0126	4.2	
		Exp.	492		5.3	+ 9 months
		(Low Aptitude Stratum)				
Auditory Discrim.	Stanford	Control	364	0.0389	4.2	
		Exp.	405		5.3	+ 4 months

middle and low aptitude strata. According to the test publisher (Harcourt Brace Jovanovich, 1976) the phonetic analysis test measures relationships between sounds and letters (phoneme-grapheme relationships) while the auditory discrimination test measures the ability to hear similarities and differences among sounds in words. A competing hypothesis for the treatment effect distribution is that test performance on the phonetic analysis response required more prerequisite skills than test performance on the auditory discrimination response and that the upper aptitude stratum possessed more prerequisite skills than the low aptitude stratum. Differences between treatment effects by aptitude strata resulting from test content differences would be treatment-selection-instrumentation interaction (Cook and Campbell, 1979, p. 53). The nature of the linguistic task and its relationship to subject aptitude appears to be an area in need of further research in future amplification treatment studies.

Hypothesis 2 D

Among first and second grade subjects, there is no statistical relationship between teacher voice signal amplification treatment, speech communication interference (from either JANI or from MHL) and linguistic task performance.

Having found a relationship between teacher voice signal amplification treatment and linguistic task performance, an attempt was made to link the treatment effect with the suspected interference causes, i.e., JANI and MHL.

From the combined-group 2x2x3x2 MANOVA test, displayed in Table 11, interaction effects were evaluated to assess relationships between the treatment factor and other factors, i.e., MHL, school site, and grade level.

Results of the test for interaction between the two levels of the treatment factor (experimental and control) and the two levels of the MHL factor (presence and absence) revealed a nonsignificant effect,

$p = 0.5922$. Post hoc analysis of least squares means revealed that both levels of the MHL factor had evidenced higher posttest means within the experimental group than within the control group. Plots of treatment/MHL relationships are exhibited in Figure 10 and in appendix D. Examination of orthogonal means comparisons indicated significant treatment effects among MHL comparisons on three response variables, i.e., auditory discrimination, phonetic analysis and auditory vocabulary. Among non-MHL comparisons there was a significant treatment effect on one response, phonetic analysis.

In order to make within-group comparisons of treatment effects between the two levels of the MHL factor (presence and absence), a separate MANOVA test on each stratum was applied. Results of these tests, displayed in Table 17, indicated that the overall treatment effect, within the MHL stratum, was significant, $p = 0.0071$, whereas the overall treatment effect, within the non-MHL stratum, was nonsignificant, $p = 0.3866$. These results were used as statistical evidence for rejecting part of Hypothesis 2 D. That is, based upon the MANOVA results for the hypothesis of no overall treatment effect on the MHL stratum, $p = 0.0071$, one may reject the null hypothesis and accept the alternative hypothesis of a demonstrated relationship between teacher voice signal amplification treatment and linguistic task performance, within the group of 221 subjects with MHL. This finding suggests that amplification treatment <u>does</u> mediate speech communication interference from slight physiological deficits in subjects' hearing acuity (MHL) and that the effect is demonstrable in linguistic task performance.

The utility of the treatment condition for mediating speech communication interference, attributable solely to JANI, was not easily discernible. Examination of Table 17 reveals that subjects without hearing acuity deficits (N = 124) manifested no significant treatment effect differences across four common response variables with homogeneous pretreatment regression slopes. Examination of the same 124 subjects, further stratified on the noise level dimension (school site), failed to solidify the necessary evidence for statistical decision-making. As shown in Table 18, the noisiest school site, i.e. Site I, produced the most significant amplification effects, $p = 0.0242$, as anticipated. But the effect was not paralleled at Site II, where the measured noise level was statistically similar. Also, post hoc stratification of the data reduced sample size at Site I and Site III to 32 subjects each, thus decreasing the power of the test.

Based upon the findings reported, Hypothesis 2 D was rejected with respect to a demonstrated statistical relationship between amplification treatment, MHL and linguistic task performance. A conclusion on the relationship between amplification treatment, JANI and linguistic task performance cannot be made. The available statistical evidence was inconclusive and inconsistent.

Preliminary Conclusions

On the basis of statistical analysis of the Hypothesis 2 group, the following conclusions were drawn.

- First and second grade subjects, provided with amplification treatment, evidenced higher posttest scores than their control group counterparts. The effect was statistically significant on three response variables, i.e., phonics-consonants, auditory discrimination, and phonetic analysis.

This finding supports a hypothesis that linguistic task performance (the molar level referent construct of effect in this investigation) was enhanced by the intervening variable, teacher voice signal amplification intervention. Decomposition of the effect construct (linguistic task performance) into six subskill components revealed significant performance results on three of the six responses, i.e., phonics-consonants, auditory discrimination and phonetic analysis.

The results of this analysis fortify earlier research by Sarff et al.(1977-1983) and expands the data base to grade levels, i.e., first and second, previously unexamined.

• The attempt to link speech communication interference, the suspected causal factor, with linguistic task performance, the suspected effect, and to evaluate the treatment condition as a mediator, was partially successful. Using the Speech Chain paradigm (Figure 1) for construct identification, MHL was positioned at the physiological level in the chain of events between speaker and listener. Results demonstrated that MHL subjects, provided with amplification intervention, attained significant overall linguistic task performance benefit as well as significant subskill benefit on three response variables common to all subjects in the analysis.

The attempt to isolate treatment effects which counteracted speech communication interference attributable solely to JANI was inconclusive. Treatment effect differences by school site did not parallel noise level differences by school site. However, the following two generalizations appear to be consistent with the data analysis and findings.

- •• Within the noise level range quantified in this analysis, i.e., 65.5 Leq to 71.5 Leq, across school sites I, II and III, students provided teacher voice signal amplification intervention manifested higher posttest results than students not provided amplification intervention and the differences were statistically significant.
- •• A large proportion of the first and second grade sample population, i.e., > 66%, evidenced minimal hearing acuity deficits. This subset of the first and second grade, when provided amplification intervention, demonstrated significantly higher posttest results than students not provided with intervention. Therefore, it may be generalized that speech communication interference from MHL is partially mediated by teacher voice signal amplification intervention, and that the results occurred within a research setting with noise levels ranging from 65.5 Leq to 71.5 Leq. Whether different treatment effects for MHL subjects would occur within a more noisy or less noisy learning environment could only be determined in a subsequent investigation.

- The hypothesis of no treatment effect differences between grade levels was not rejected because results of comparisons within grade level strata indicated significant treatment effects among second grade comparisons and nonsignificant treatment effects among first grade comparisons, a finding opposite of the directional alternative hypothesis advanced.

Post hoc examination of the least squares means revealed significant treatment effects, within the second grade stratum, on the following response variables: phonics-consonants, structural analysis, sight vocabulary, auditory discrimination and phonetic analysis. The overall linguistic task performance treatment effect within the first grade stratum was not significant.

An explanation for finding significant treatment effects within the second grade group and not within the first grade group may be found in the speech communication interference paradigm displayed in Figure 3. Separation distance between speaker and listener has been identified as a determinant of speech communication interference and its reciprocal, speech intelligibility. Separation distance within the nine second grade research setting classrooms was greater than within the nine first grade classrooms. Therefore, the treatment intervention, which reduced separation distance, should have and did have more effect within the second grade stratum.

• Regarding aptitude comparisons, significant treatment effects were found among comparisons within the high aptitude and middle aptitude strata. Significant treatment effects were not found within the low aptitude stratum, contrary to prediction. Two explanations were advanced for these results. It is possible that there was treatment-selection-maturation interaction resulting in high and middle aptitude experimental subjects growing at a faster rate than low aptitude experimental subjects. It is also possible that there was selection-instrumentation interaction resulting in the more able subjects performing better than their less able classmates on the phonetic analysis subskill test because the test required prerequisite learnings not possessed by less able students, even though all experimental groups had received an amplified voice signal.

Minimal Hearing Loss Analysis

Nonexperimental Design Hypotheses

Hypothesis 3 Group

Six hypotheses were grouped to provide information about the nature of MHL prevalence in the investigation setting.

Hypothesis 3 A

There is no difference in the proportion of MHL between the local population and the comparable exterior data set.

Table 19 reveals more MHL locally than in the exterior data set, (Project Marrs, 1983, p. 2). The differences were statistically significant in each of four paired-comparisons. Accordingly, Hypothesis 3 A was rejected. Local MHL prevalence was identified in greater proportions than in the comparable exterior data set.

No interpretation is being advanced about the higher proportion of MHL identified locally. What does seem important is the large proportion of grade 1-6 elementary schoolchildren, in general, and the larger proportion of first and second grade schoolchildren, in particular, who were identified with minimal hearing acuity deficits. This group, which exceeds 66% in the first and second grade, is not accounted for in the present State of Illinois Hearing Conservation program.

Hypothesis 3 B

There is no difference in the proportion of MHL between School Sites I, II and III.

Results in Table 20 indicate no statistical relationship between MHL prevalance and noise levels (represented by school site). Accordingly, Hypothesis 3 B was not rejected. Differences in MHL prevalence by school site were not parallel with differences in noise levels by school site. The noisiest school did not have the most MHL nor did the least noisy school have the smallest proportion of MHL. In other words, aircraft noise was not identified as a contributor to MHL. This finding is consistent with the literature (U.S. DOT-FAA, 1977).

Hypothesis 3 C

There is no difference in the proportion of subjects across four hearing level threshold classes.

Findings reported in Table 21 demonstrate that MHL prevalence was not similarly distributed across four different hearing threshold classes. Thus, Hypothesis 3 C was rejected. Greater prevalence occurred at the 20 dB HL threshold class than at the other three thresholds. This finding, coupled with the results displayed in Figure 12, is important. As shown in Figure 12, task performance degradation slopes downward for cases identified with hearing acuity levels higher than 15 dB. In the present analysis, 147 subjects, or 19.2% of the study population, were identified in the 20 dB HL threshold class. As discussed above, in Hypothesis 3 A, the 20 dB HL class demonstrates a hearing acuity level which passes the State of Illinois Hearing Conservation program.

Hypothesis 3 D

There is no relationship between MHL prevalence (by proportions) and grade level.

Hypothesis 3 D was not rejected. Results of a nonparametric test of the strength and direction of the correlation between grade level and MHL proportions yielded a Spearman's rho statistic of -0.7714, indicating an inverse relationship with a p value of 0.0724. The result did not fall within the critical region for rejecting the null hypothesis. This test included 764 hearing level thresholds, which were collapsed into six grade level proportions. A year earlier, a similar test over 273 hearing observations from Site I only, yielded a Spearman's correlation coefficient of -0.9429, indicating a significant inverse relationship, $p = 0.0048$.

Taken together, the results of the two tests imply that MHL and grade level are inversely related and that lower grade children exhibit a higher proportion of MHL than upper grade children. Support for this inference was verified by a separate comparison of first and second grade MHL prevalence with fifth and sixth grade prevalence. The combined proportion of MHL among 396 first and second grade subjects was 66.2%. The corresponding proportion for 184 fifth and sixth grade subjects was 45.1%. A test comparing the two proportions indicated they were significantly different.

This finding may be important to educators in terms of organizational implications. If two thirds of all first and second grade schoolchildren have minimal hearing acuity deficits, then appropriate identification programs and intervention strategies need to be planned.

Hypothesis 3 E

The probability that any subject will repeat positive identification for MHL on repeated observations is one-half.

Results of a McNemar Test of Correlated Proportions, Table 22, indicated a systematic trend among subjects for positive identification over repeated screenings for MHL. Subjects identified positively on an initial observation were more likely to repeat a positive identification than to change to a negative identification. Hypothesis 3 E was rejected.

This finding suggests a propensity for students to repeat positive identification and fortifies the argument for appropriate intervention. Further, intervention strategies of a long term duration may be necessary because of the likelihood of minimal hearing acuity deficits reoccurring among diagnosed cases.

Hypothesis 3 F

Before treatment, there is no difference in the linguistic task performance between subjects with MHL and subjects without MHL.

Results shown in Table 23 were contrary to expectations. The predicted effect was that subjects with MHL would not perform as well on pretest task performance instruments as subjects without MHL. Hypothesis 3 F was not rejected. There were no significant task performance differences evidenced by posttest comparisons between the MHL group and the non-MHL group. The comparisons were made across six response variables common to both groups.

A possible explanation for finding no pretest task performance differences between MHL and non-MHL subjects is the cumulative effect theory posited by Sarff (1981. p. 268). In previous studies, involving middle and upper grade MHL students, academic deficiencies heightened with successive grade levels. Perhaps insufficient time in school had passed by midyear of the first and second grade for MHL subjects to have accumulated academic deficiencies.

Preliminary Conclusions

- Differential hearing acuity values are observable within an elementary school population. More than one half of the population sampled in the present analysis manifested hearing acuity threshold levels 15 dB or greater.
- MHL prevalence was not associated with noise levels, at school sites ranging from 65.5 Leq to 71.5 Leq.
- MHL prevalence was greatest within the 20 dB HL intensity category.
- MHL prevalence demonstrated an age-dependent relationship, i.e., greater proportions at first and second grades than at fifth and sixth grades.
- MHL prevalence demonstrated a tendency towards repeated identification, i.e., once identified within the first five grades of elementary school, the probability was greater than one-half of reidentification on a subsequent audiometric screening.

Treatment Effects on Task Performance - MHL Subjects

Hypothesis 4 Group

To evaluate the treatment effect on MHL cases only, an a posteriori analysis of the MHL stratum within the experimental population was conducted. There were 221 observations with no missing values available for the analysis and evaluation of the Hypothesis 4 group.

Hypothesis 4 A

Among first and second grade subjects with MHL, there is no difference in linguistic task performance of amplification treatment subjects and non-amplification treatment subjects.

Results of a combined-group 2x3x2 MANOVA test, displayed in Table 24, indicated a significant overall treatment effect, $p = 0.0017$. The treatment did not demonstrate an interaction with either the school factor or the grade factor. Post hoc analysis of least squares means revealed that the experimental group attained higher posttest means than the control group and that the difference was statistically significant on three response variables, i.e., auditory discrimination, phonetic analysis and auditory vocabulary. On each of the remaining three response variables, i.e., sight vocabulary, phonics-consonants and reading comprehension, the treatment group evidenced a higher mean score but the difference was not statistically significant.

Attention to similarities between Hypothesis 4 A results and Hypothesis 2 A results is directed. Both hypotheses address the same analysis, i.e., overall and subskill treatment effect comparisons. But Hypothesis 4 A is based upon a subset of the total experimental population, i.e., MHL subjects, while Hypothesis 2 A included all subjects.

Results of overall treatment effects from both analyses were similar, i.e., p = 0.0012 for the combined-group MANOVA over all 339 observations, and p = 0.0071 for the combined-group MANOVA over 221 MHL observations. Within both groups, significant treatment effects were evidenced on the auditory discrimination and phonetic analysis response variables. The groups differed in that the auditory vocabulary response was significant within the MHL subset while the phonics-consonants response was significant within the set of all observations.

As in the discussion of Hypothesis 2 A above, a representation of the relationship between statistical significance and practical significance is displayed for those response variables with significant results. In Table 32 it is shown that the experimental group mean exceeded the control group mean at a level comparable to nine months in grade level equivalents on the auditory discrimination response variable; four months on the phonetic analysis response; and one month on the auditory vocabulary response. Again, the results appear to provide strong support for the utility of teacher voice signal amplification intervention. The findings seem to support an inference that MHL is a alterable variable and that amplification intervention is a productive mediator of speech communication interference resulting from MHL.

Whether amplification treatment mediated speech communication interference emanating solely from JANI is not clear and can be discussed only in terms of associating performance results with prevaling noise levels across three school sites in the research setting. Conversely, however, the results do indicate that amplification treatment does mediate speech communication interference emanating solely from MHL and that the mediation enables demonstrable increases in student productivity.

TABLE 32

Practical Significance of Treatment Effects - MHL Subjects

RESPONSE VARIABLE	TEST	TREATMENT GROUP	ADJ. POSTTEST	P VALUE	GRADE LEVEL EQUIVALENT	DIFFERENCE
Auditory Vocabulary	Stanford	Control	355	0.0112	2.9	
		Exp.	366		3.0	+ 1 month
AUDITORY DISCRIM.	Stanford	Control	461	0.0351	4.0	
		Exp.	483		4.9	+ 9 months
PHONETIC ANALYSIS	Stanford	Control	476	0.0001	2.9	
		Exp.	493		3.3	+ 4 Months

NOTE: Corresponding descriptive statistics are displayed in appendix D

<u>Hypothesis 4 B</u>

<u>Among subjects with MHL, there is no difference in the effect of teacher voice signal amplification treatment between first and second grade subjects</u>.

Results of a combined-group 2x3x2 MANOVA test over 221 observations indicated a significant overall treatment effect, $p = 0.0111$ and a significant overall grade effect, $p = 0.1439$. Post hoc examination of least squares means revealed no significant treatment effects among first grade comparisons across six common response variables. Among second grade comparisons, significant treatment effects were evidenced on four of the six common responses, i.e., sight vocabulary, phonics-consonants, phonetic analysis and auditory vocabulary.

To evaluate within-group treatment effects, a separate MANOVA test was applied to each grade level strata. Results of the two tests, displayed in Table 25, indicate a significant treatment effect among second grade comparisons, $p = 0.0051$ and a nonsignificant treatment effect among first grade comparisons, $p = 0.3173$. Significant interaction between the treatment factor and the school factor, within the second grade stratum, required that test results be interpreted in terms of site location. As in the general population, the second grade MHL stratum demonstrated significant treatment effects at Sites I and III.

Viewed together, the one combined and two separate MANOVA analyses, suggest that amplification intervention resulted in more benefit to second grade subjects than to first grade subjects. Accordingly, Hypothesis 4 B was not rejected. The statistical evidence did not support the predicted directional alternative hypothesis.

Similar to Hypothesis 2 B, an interpretation is being advanced by this researcher that treatment effect differences between first and second grade strata are attributable to separation distance differences, with significant overall treatment effects occurring within the second grade stratum only, where separation distance between speaker and listener was greatest and amplification intervention had more opportunity to reduce separation distance and to mediate speech communication interference.

Hypothesis 4 C

Among first and second grade subjects with MHL, there is no difference in the effect of teacher voice signal amplification treatment on linguistic task performance of subjects stratified by aptitude levels, high, middle and low.

Results of a combined-group MANOVA test of the MHL stratum indicated significant interaction between treatment levels and aptitude levels, $p = 0.0054$. Inspection of least squares means revealed significant treatment effects in both the high and middle aptitude groups on the phonetic analysis response variable. In addition, the high aptitude group demonstrated significant treatment effects on the auditory vocabulary response variable while the low aptitude group evidenced significant effects on the auditory discrimination response.

Subsequent stratification of the MHL observations by aptitude levels revealed a significant overall treatment effect within the high aptitude stratum only, $p = 0.0034$. Accordingly, Hypothesis 4 C was not rejected. The low aptitude stratum did not demonstrate a more significant treatment effect than the high or middle aptitude stratum, as predicted.

Comparison of results from the evaluation of Hypothesis 2 C and 4 C suggest some unresolved questions, particularly for high aptitude subjects. Analysis of all subjects (Hypothesis 2 C) resulted in significant treatment effects occurring in both the high and middle strata. Analysis of MHL observations only (Hypothesis 4 C) resulted in significant treatment effects within the high-stratum only. Across 65 high-stratum observations in Hypothesis 2 C, a significant treatment effect was obtained, $p = 0.0119$. Across 45 high-stratum observations in Hypothesis 4 C, a significant treatment effect was obtained, p = 0.0034. Based upon results obtained from the two separate high-strata comparisons, it appears that amplification treatment is more effective for bright students, with MHL, than for bright students for the overall experimental population. The data analysis seems to imply that minimal hearing acuity deficits hinder language acquisition for some bright students and that the obstruction is mediated by amplification intervention.

Hypothesis 4 D

Among subjects with MHL, there is no difference in the effect of teacher voice signal amplification treatment across four different hearing level threshold classes.

This hypothesis is a cognate of Hypothesis 4 A above. In Hypothesis 4 A, the independent variable, hearing level threshold, was dichotomously divided. In the present hypothesis, the same independent variable was divided into four levels.[3]

Based on the findings presented in Table 28 and graphically represented in Figure 12, Hypothesis 4 D was rejected. There were differences found in treatment effects across four different hearing level threshold classes. Further inspection of treatment comparisons across the four hearing level classes, plus the non-MHL class, reveals a systematic trend that may be a unique outcome of this analysis. As displayed in Figure 12, incremental increases in hearing degradation are paralleled by corresponding decreases in task performance. The trend appears to be both constant and systematic. Additionally, amplification

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[3] In the literature there was no comparable exterior data set that was stratified by hearing threshold categories.

intervention consistently appears to reduce but not to eliminate performance degradation.

Preliminary Conclusions

On the basis of statistical analysis of the Hypothesis 4 group, the following conclusions were drawn.

- Communication interference along the speech chain resulting from physiological deficits in subjects' hearing acuity was partially mediated by teacher voice signal amplification intervention. Mediation effects were demonstrable in overall linguistic task performance evaluation. Subskill effects were also demonstrable on specific response variables including auditory discrimination, phonetic analysis and auditory vocabulary.
- Post hoc data analysis indicated that second grade subjects evidenced more subskill benefit than first grade subjects. An interpretation is advanced that this unanticipated result occurred because separation distance between speaker and listener was reduced more within the second grade group than within the first grade group.
- Post hoc data analysis also suggested that high aptitude subjects benefited more from the treatment than low aptitude subjects benefited.
- Most importantly, amplification intervention consistently and systematically appears to have reduced but not to have eliminated performance degradation resulting from minimal hearing acuity deficits.

Investigation Conclusions

In the following critique, the findings of the two separate but related analyses, i.e., jet aircraft noise intrusion and minimal hearing loss, are integrated and prioritized in terms of relative importance from the perspective of this investigator.

A number of micromediating influences on language acquisition were identified for their contribution to the treatment effects in this experiment. From the literature review, it was shown that spoken sounds in American English span an intensity range of 25 to 30 decibels from faintest to loudest, making speech intelligibility a demanding task for inexperienced listeners. The 339 first and second grade subjects involved in the research comparisons in this investigation, were typical of students at their grade levels, i.e., they were highly dependent upon hearing their teacher's voice signal because of their inability to read. Instructional content in the research setting classrooms emphasized the acquisition of phonics related subskills through teacher-directed, whole-group instructional methodology. The students spent a large proportion of each day listening to and responding to their teacher's voice signal. Sixty-six percent of the experimental population manifested minimal hearing acuity deficits. Two of the three school sites evidenced publicly documented exterior noise levels within the 70 Ldn noise level contours.

Experimental subjects, provided teacher voice signal amplification treatment over a ninety-day period, demonstrated significantly higher posttest results than their control subject counterparts on tests which were congruent with the ongoing phonetically oriented prereading curriculum. On the linguistic subskill of auditory discrimination, the treatment effect was comparable to one year and one month in grade level equivalents. On the subskill task of phonetic analysis, the treatment effect was comparable to five months. Overall, it appears that the magnitude and practical significance of amplification intervention was substantial.

In the experimental design, the treatment condition was manipulated while several other factors of interest were not. An a posteriori data analysis enabled further assessment of amplification effects in relationship with the following factors: subjects' hearing acuity thresholds, subjects' grade level, subjects' aptitude level, and the quantified exterior noise level at three school sites.

Treatment effects among comparison groups, with minimal hearing acuity deficits were significant, as predicted. Additionally, incremental hearing acuity threshold identification enabled treatment comparisons across four specific hearing level threshold classes, i.e., 15, 20, 25 and > 25 dB HL. Results demonstrated that amplification intervention systematically reduced but did not eliminate task performance degradation as hearing acuity deficits intensified.

Treatment effects among grade level comparison groups were significant within the second grade stratum and nonsignificant within the first grade stratum, contrary to prediction. Treatment effects among aptitude level comparison groups were significant within the high and middle aptitude strata and nonsignificant within the low stratum aptitude, another result contrary to prediction.

An interpretation for finding results contrary to expectation on both the treatment/grade level relationship and the treatment/aptitude relationship was advanced. The strength of the treatment effect at the second grade is attributed by this investigator to separation distance reduction, between speaker and listener, inherent in amplification intervention. Since second grade subjects were further removed from their teacher than first grade subjects, amplification intervention had more opportunity to reduce separation distance.

In the treatment/aptitude relationship, selection-maturation interaction and selection-instrumentation interaction may have accounted for high and middle aptitude comparisons demonstrating significant treatment effects while low aptitude comparisons did not.

Treatment effects among comparison groups from different school sites (which represented the noise level factor) were inconclusive. An interpretation was advanced that amplification intervention benefited all subjects within the identified noise level range of 65.5 Leq to 71.5 Leq. Treatment effect differences between school sites were indistinguishable.

The following inferences about the nature of minimal hearing acuity deficits appear to have been demonstrated by the nonparametric tests of hearing screening data collected over two school years

Minimal hearing acuity deficits, at 15 dB HL or greater, were prevalent within the elementary school population in large numbers. Within the first and second grade sample, the proportion of MHL exceeded 66%. MHL prevalence demonstrated an age-dependant tendency with first and second subjects evidencing a larger proportion than fifth and sixth grade subjects. MHL also demonstrated a tendency toward reidentification over time. Additionally, contrary to public perception, MHL prevalence did not align itself with exterior noise levels among the three school sites.

Regarding the noise quantification data collected, exterior noise levels at two of the three school were high, i.e., > 70 Leq. The collected data compared closely with the publicly documented noise descriptors exhibited in appendix E.

Limitations of the Study

- The data for the experimental design included observations collected from 396 subjects on numerous variables including hearing acuity, aptitude, and pre and posttest linguistic subskills across a nine month time span. Due to subject absenteeism and/or enrollment changes during data collection in a public school setting, missing values occurred. The MANOVA statistical procedure employed only those 339 observations with no missing values.
- Amplification intervention was limited to a one semester application covering approximately ninety school days. Additionally, temporary interruptions in treatment continuity were caused by equipment adjustments and repairs to remediate signal interference from competing frequencies such as taxi cab dispatchers.
- Application of amplification intervention across treatment levels was not uniform during pre and posttest administration. Gain score statistical methodology (see Hypothesis 2 B, Chapter V) was employed to control for treatment level test administration differences.
- In the experimental design, between-site selection differences were controlled statistically with convenience sampling of eighteen intact classrooms. Random assignment of individuals or intact groups to neighborhood schools (with suspected differential noise

levels) was not an available assignment option.

- Procedures prescribed by Project MARRS for identifying hearing acuity deficits focused on the weaker of the subjects' two ears. Clinical audioligists focus on the better of the subjects' two ears.
- This analysis did not address the causes of MHL nor did it attempt to provide a low-fence demarcation recommendation.

Recommendations

Recommendations are presented as follows: recommendations for application of the findings to school organizational practice, recommendations for replicating and extending this research, and recommendations for future research.

Application Of Findings To School organizational Practice

- Speech communication interference from both jet aircraft noise intrusion (where appropriate) and from minimal hearing loss should be evaluated systematically, preferably on an annual basis. Removing obstructions to the reception of spoken communication is particularly important in lower primary grade levels, where students cannot yet read and are highly dependent upon hearing their teacher's voice signal. For this reason particularly, first and second grade instructional classrooms are likely to be more noise sensitive than classrooms of older students. First and second grade students are also more likely to manifest continuous or intermittent hearing acuity deficits than older students. Amplification intervention appears to be a productive mediator of speech communication interference from minimal hearing loss or from jet aircraft noise intrusion (within the noise level range of 65.5 to 71.5 Leq). Amplification intervention would also seem appropriate for older students, particularly whenever they are in a large-group, teacher-directed instructional setting.

- Noise level contour maps for public buildings surrounding O'Hare International Airport are available from public sources including the FAA and the City of Chicago. A local school district may rely on publicly documented noise levels, may undertake its own noise quantification analysis, or may combine the two monitoring procedures.
  - For the 102 schools around O'Hare International Airport, current noise level documentation from the FAA includes projections through 1995. These resources will enable an investigator to determine the level of exterior noise prevailing at school sites near O'Hare Airport. For schools located near other airports, noise contour information should be available from the FAA.
  - Noise levels across time differed during the course of the school day in this analysis. Local educators may choose to schedule activities accordingly. One possible adjustment would be to avoid teacher-directed, whole-group instruction during the noisiest one-hour period.
- Current hearing conservation practice in the State of Illinois does not require identification audiometry at threshold levels below 25 dB HL. In this analysis, large numbers of students were identified with hearing threshold levels below 25 dB (Table 21).

Amplification intervention benefited students in this study (particularly, those subjects identified at 20 dB HL) as in the original research conducted by Project MARRS investigators.

For practitioners interested in screening for hearing acuity levels similar to those employed in this analysis, it is suggested that Project Marrs consultants be contacted.

- The principle of "separation distance" (Figure 3) between speaker and listener is an important determinant of speech intelligibility in a classroom environment where speech communication interference is suspected.
  - Separation distance may be shortened by seating arrangements, which place the speaker and listener in closer proximity, or by using technology, such as classroom amplification equipment, which has a similar effect.

Replication And Extension Of This Research

Based upon the experiences and problems encountered in this investigation, the following methodological adjustments are recommended.

- Uniform application of amplification intervention across treatment levels during pre and posttest administration is recommended. It is suggested that both treatment levels be tested in an amplified environment (rather than in a non-amplified environment) so as not to confound treatment effects with minimal hearing acuity deficits, i.e., subject selection.
- Treatment intervention should be extended to one or more school years to examine the cumulative effect, particularly in reading comprehension performance. In the present ninety-day study, the

greatest gains were on topics that could be learned in isolation, such as phonetic analysis and auditory discrimination. Given more time, gains in isolated reading subcomponent skills may converge and impact upon reading comprehension more than evidenced in the present study.

- To investigate the age-dependent effect, birth dates would provide more specificity than grade level. Also, collection of performance data across more than two grade levels would be more discriminating in examining the age-dependent effect.
- Depending upon the availability of classroom amplification equipment, random assignment of intact classes may be planned to result in an overall balanced rather than unbalanced design.
- Depending upon the availability of noise monitoring equipment, by simultaneously monitoring exterior noise and interior classroom noise, an investigator may:
  - Evaluate exterior noise attenuation.
  - Identify sources of speech communication interference within a classroom, other than interference from JANI or MHL, using the appropriate analytical paradigm, i.e., signal-to-noise ratio.

Future Research

- Separation distance should be included as an independent variable in future studies about speech communication interference, regardless of the source of the interference. Multiple levels of the variable would allow for an analysis of optimal treatment effects on a separation distance/treatment effect curve.
- Data sets of hearing acuity levels, ranging from 15 dB HL through

40 dB HL are now available for statistical comparisons from two sources, i.e. Project MARRS and this investigation.

- Amplification technology needs to be evaluated in a variety of educational environments with differential noise levels, grade levels, and academic tasks.

REFERENCES

Aircraft Noise

American Speech-Language-Hearing Association. Noise as a Public Health Problem: Proceedings of the Third International Congress, Freiburg, West Germany, September 25-29, 1978. Edited by Jerry V. Tobias, Gerd Jansen and W. Dixon Ward. Rockville, Md.: American Speech-Language-Hearing Association, 1980.

Aniansson, Gunnar. "Traffic Noise Speech Interference Levels for Normal and Hearing-Impaired Listeners." In Noise as a Public Health Problem: Proceedings of the Third International Congress, Freiburg, West Germany, September 25-29, 1978. pp.192-202. Edited by Jerry Tobias, Gerd Jansen and W. Dixon Ward. Rockville, Md.: American Speech-Language-Hearing Association, 1980.

Broch, Jens Trampe. Application of B and K Equipment to Acoustic Noise Measurements. 2nd ed. Denmark: K. Larsen and Son, 1971.

Bruel & Kjaer Instruments, Inc. Measuring Sound. Denmark: K. Larsen & Son, n.d.

Chicago, Department of Aviation. Airport Master Plan Study Chicago O'Hare International Airport Volume XIX Technical Working Group. by Landrum and Brown, Inc., May, 1982.

Chicago, Department of Aviation. Addendum-Draft Environmental Impact Statement (DEIS) Master Plan Development (1984-1995). by Landrum and Brown, Inc., July, 1983. (mimeographed.)

Chicago, Department of Aviation. Draft Environment Impact Statement for the Chicago O'Hare International Airport (1984-1995) Master Plan Development. by Landrum and Brown, Inc., April, 1983. (mimeographed.)

Chicago, Department of Law. Exhibits Testimony of the City of Chicago Before the Illinois Pollution Control Board Airport Noise Regulation (R77-4). June 16-20, 1980. (mimeographed.)

Cohen, Sheldon; Evans, G.W.; Krantz, D.S.; and Stokols, D. "Physiological, Motivational, and Cognitive Effects of Aircraft Noise on Children." American Psychologist 35 (March 1980): 231-43.

Cohen, Sheldon; Evans, G. W.; Krantz, D. S.; Stokols, D.; and Kelly, S. "Aircraft Noise and Children: Longitudinal and Cross-sectional Evidence on Adaptation to Noise and the Effectiveness of Noise Abatement." Journal of Personality and Social Psychology 40 (1981): 331-45.

Cohen, Sheldon; Krantz, D.S.; Evans, G.W.; Stokols, D. "Cardiovascular and Behavioral Effects of Community Noise." American Scientist 69 (September/October 1981): 528-35.

Cohen, Sheldon. "Sound Effects on Behavior." Psychology Today (October 1981): 38-49.

Denes, Peter B.and Penson, Elliot N. The Speech Chain. Bell Telephone Laboratories., 1963: Doubleday, Anchor Books, 1973.

Goldstein, Jeffrey, and Dejoy, David M. "Behavioral and Performance Effects of Noise: Perspectives for Research." In Noise as a Public Health Problem: Proceedings of the Third International Congress, Freiburg, West Germany, September 25-29, 1978. pp.369-74. Edited by Jerry Tobias, Gerd Jansen and W. Dixon Ward. Rockville, Md.: American Speech-Language-Hearing Association, 1980.

Goldstein, Jeffrey. "Fundamental Concepts in Sound Measurement." In Noise and Audiology, pp.3-58. Edited by David M. Lipscomb. Baltimore: University Park Press, 1978.

Green, Kendall B. "The Effects of Community Noise Exposure on the Reading and Hearing Ability of Brooklyn and Queens School Children." Ph.D. dissertation, New York University, 1980.

Gulian, Edith. "Team IV: Influence of Noise on Performance and Behavior." In Noise as a Public Health Problem: Proceedings of the Third International Congress, Freiburg, West Germany, September 25-29, 1978 pp. 692-94. Edited by Jerry Tobias, Gerd Jansen and W. Dixon Ward. Rockville, Md.: American Speech-Language-Hearing Association, 1980.

Houtgast, Tammo. "Indoor Speech Intelligibility and Indoor Noise Level Criteria." In Noise as a Public Health Problem: Proceedings of The Third International Congress, Freiburg, West Germany, September 25-29, 1978. pp.172-83. Edited by Jerry Tobias, Gerd Jansen and W. Dixon Ward, Rockville, Md. American Speech-Language-Hearing Association, 1980.

Hassall, J. R., and Zaveri, M. Phil. Acoustic Noise Measurements. Denmark: Bruel & Kjaer. 1979.

Hyatt, Carole L. "The Effect of Jet Aircraft Noise on Student Achievement and Attitude Toward Classroom Environment." Ed.D. dissertation, Seattle University, 1982.

Illinois Department of Energy and Natural Resources. Economic Impact Study of Proposed Airport Noise Regulations, R77-4, Volume III:Technical Study of Public Airports in Chicago by Paul Schomer. Document No. 81/38.(Nov. 1981).

Illinois Institute of Natural Resources. Issues Related to Airport Noise in Illinois. by Robert G. Ducharme, Inc. Document No. 81/16. (April, 1981).

International Organization for Standardization. "Assessment of Noise with Respect to its Effect on the Intelligibility of Speech." Ref. No. ISO/TR 3352-1974(E).

Jansen, Gerd. "Noise Pollution Standards and the Effects of Noise on Health." In Noise as a Public Health Problem: Proceedings of the Third International Congress, Freiburg, West Germany, September 25-29. 1978 pp. 54-59. Edited by Jerry Tobias, Gerd Jansen and W. Dixon Ward. Rockville, Md.: American Speech-Language- Hearing Association, 1980.

Jensen, Paul. "Community Noise." In Noise and Audiology, pp.245-73. Edited by David M. Lipscomb. Baltimore: University Park Press, 1978.

Lewin, Renee Z. "An Investigation of the Effectiveness of Amplification as a Viable Method for Improvement of Language and Academic Achievement in a Noisy Environment." Ed.D. dissertation, Loyola University of Chicago, 1983.

Lipscomb, David M. Noise and Audiology. Baltimore: University Park Press, 1978.

Loeb, Michael. "Noise and Performance: Do We Know More Now?" In Noise as a Public Health Problem: Proceedings of the Third International Congress, Freiburg, West Germany 1978, pp. 303-21. Edited by Jerry V. Tobias, Gerd Jansen and W. Dixon Ward. Rockville, Md.: American Speech-Language-Hearing Association, 1980.

Maser, A.L.; Sorensen, P.H.; and Kryter, K.D. "Effects of Intrusive Sound on Classroom Behavior", paper presented at annual meeting of the Western Psychological Association, San Francisco, Ca., 19-22 April, 1978.

Mills, John H. "Effects of Noise on Young and Old People." In Noise and Audiology, pp. 229-41. Edited by David M. Lipscomb. Baltimore: University Park Press, 1978.

Rose, Michael. FAA, interview, Des Plaines, Illinois, March 1983.

Suburban O'Hare Commission. O'Hare International Airport Master Plan. by Ralph Burke Associates and Bolt Bernack and Newman Inc., June, 1981.

Suter, Alice H. "Hearing Level and Speech Discrimination in Noise." In _Noise as a Public Health Problem: Proceedings of the Third International Congress, Freiburg, West Germany, September 25-29, 1978_. pp. 203-17. Edited by Jerry Tobias, Gerd Jansen and W. Dixon Ward. Rockville, Md.: American Speech-Language-Hearing Association, 1980.

U.S. Congress. House. _Aviation Safety and Noise Abatement Act of 1979_. Pub.L. 96-193, 96th Cong., Feb. 18, 1980, H.R. 2440.

U.S. Congress. House. _Tax Equity and Fiscal Responsibility Act of 1982_. Pub. L. 97-248, 97th Cong., Sept. 3, 1982, H.R. 4961.

U.S. Department of Transportation, Federal Aviation Administration and Office of Environmental Quality. _Calculations of Maximum A-weighted Sound, Levels (dBA) Resulting from Civil Aircraft Operations_. June, 1978.

U.S. Department of Transportation, Federal Aviation Administration and Office of Environmental Quality. _Impact of Noise on People_. May, 1977.

U.S. Department of Transportation and Federal Aviation Administration. _Draft Environmental Impact Statement: Chicago O'Hare International Airport, Chicago, Illinois_. (_mimeographed_.) December, 1983. (mimeographed.)

U.S. Department of Transportation and Federal Aviation Administration. _Final Environmental Impact Statement: Chicago O'Hare International Airport, Chicago, Illinois_. 2 vols. May, 1984. (mimeographed).

U.S. Department of Transportation and Federal Aviation Administration. _Report to Congress Study - The Feasibility, Practicability and Cost of the Sound-proofing of Schools, Hospitals, and Public Health Facilities Located Near Airports_. (_mimeographed_.) July, 1977

U.S. Department of Transportation, Federal Aviation Administration and Office of Environmental Quality. _Study of Sound-proofing Public Buildings Near Airports_. by Trans Systems Inc. and Wyle Lab., April, 1977. (mimeographed.)

U.S. Environmental Protection Agency. _Protective Noise Levels Condensed Version of EPA Levels Document_. Report No. EPA 550/9-79-100. November, 1978. (mimeographed.)

U.S. Environmental Protection Agency. Office of Noise Abatement and Control. _About Sound_. Washington, D.C.: Government Printing Office, 1976.

Webster, John C. "Speech Interference Aspects of Noise." In Noise and Audiology, pp. 193-228. Edited by David M. Lipscombe. Baltimore: University Park Press, 1978.

Minimal Hearing Loss

Boyd, Sharon F. "Hearing Loss: Its Educationally Measurable Effects on Achievement." M.S. Thesis, Southern Illinois University, 1974.

Brown, Marie Scott, and Collar, Maureen. "Effects of Prior Preparation on the Preschooler's Vision and Hearing Screening." Maternal Child Nursing, September/October 1982, pp. 323-28.

Burgener, Gerald W. "Voice Amplification and its Effect on Test Taking Performance." Ph.D. dissertation, Southern Illinois University, 1980.

Cass, Richard, and Kaplan, Phillis. "Middle Ear Disease and Learning Problems: A School System's Approach to Early Detection." Journal of School Health (December 1979): 557-60.

Dale, D.M.C. Applied Audiology for Children. Springfield, Il.: Charles C. Thomas, 1962.

Denk-Glass, Rita. "Prevalence of Middle Ear Effusion in Auditory - Learning - Disabled Children and its Association With Reduced Auditory Learning." Ed.D. dissertation, Loyola University of Chicago, 1980.

Downs, Marion P. "Contribution of Mild Hearing Loss to Auditory Language Learning Problems." In Auditory Disorders in School Children: The Law. Identification. Remediation. pp. 177-89. Edited by Ross J. Roeser and Marion P. Downs. New York. Thieme-Stratton Inc., 1981.

Downs, M.P. "Hearing Loss Definition, Epidemiology and Prevention." Public Health Reviews. Vol. IV, No. 3 and 4 (July-December 1975): 225-77.

Finitzo-Hieber, Terese. "Classroom Acoustics." In Auditory Disorders in School Children: The Law. Identification. Remediation. pp. 250-62. Edited by Ross J. Roeser and Marion P. Downs. New York: Thieme-Stratton Inc., 1981.

Fisher, Lee I. "Efficiency and Effectiveness of Using a Portable Audiometric Booth in School Hearing Conservation Programs." Language, Speech, and Hearing Services in Schools 7 (1976): 242-49.

Jaffe, Burton F. Hearing Loss in Children. Baltimore: University Park Press, 1977.

Howie, Virgil M.; Ploussard, John H.; and Sloyer, John. "The Otitis-Prone Condition." American Journal of Diseases of Children 129 (June 1975): 676-78.

Illinois Department of Public Health and Office of the Superintendent of Public Instruction. Rules and Regulations of the Child Hearing Test Act. November, 1972.

Illinois Department of Public Health. A Manual for Audiometrists. Springfield, Il.: 1974.

Illinois State Board of Education. Department of Specialized Educational Services. Hearing Impaired Manual: Recommended Procedures and Practices. Springfield, Il.: July, 1980.

Katz, Jack. ed. Handbook of Clinical Audiology. 2nd ed. Baltimore: Williams and Wilkens, Co., 1978.

Keith, Robert W. "Tests of Central Auditory Function." In Auditory Disorders in School Children: The Law. Identification. Remediation. pp.159-73. Edited by Ross J. Roeser and Marion P. Downs. New York: Thieme-Stratton Inc., 1981.

Lewis, Neil. "Otitis Media and Linguistic Incompetence." Arch Otolaryngol 102 (July 1976): 387-90.

Martin, Fredrick N. Introduction to Audiology. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1975.

Needleman, Harriet. "Effect of Hearing Loss from Early Recurrent Otitis Media on Speech and Language Development." In Hearing Loss in Children. pp.640-649. Edited by Burton F. Jaffe. Baltimore: University Park Press,1977.

Northern, Jerry L., and Downs, Marion P. Hearing in Children. 2nd ed. Baltimore: Williams and Wilkens, Co. 1978.

Roeser, Ross J., and Downs, Marion P. eds. Auditory Disorders in School Children: The Law. Identification. Remediation. New York: Thieme-Stratton Inc., 1981.

Roeser, Ross J., and Northern, Jerry L. "Screening for Hearing Loss and Middle Ear Disorders." In Auditory Disorders in School Children: The Law. Identification. Remediation. pp. 120-50. Edited by Ross J. Roeser and Marion P. Downs. New York: Thieme-Stratton Inc., 1981.

Roeser, Ross J., and Price, Deborah R. "Audiometric and Impedance Measures: Principles and Interpretation. In Auditory Disorders in School Children: The Law. Identification. Remediation. pp. 71-101. Edited by Ross J. Roeser and Marion P. Downs. New York: Thieme-Stratton Inc., 1981.

Sarff, Lewis S. "An Innovative Use of Free Field Amplification in Regular Classrooms." In Auditory Disorders in School Children: The Law. Identification. Remediation. pp. 263-72. Edited by Ross J. Roeser and Marion P. Downs. New York: Thieme-Stratton Inc., 1981.

Sarff, Lewis S. interview, Bensenville, Illinois, May, 1983.

Sarff, Lewis S. interview, Bensenville, Illinois, November, 1983.

Sarff, Lewis S.; Ray, Helen R.; and Bagwell, Cynthia L. "Why Not Amplification in Every Classroom?" Hearing Aid Journal (October 1981): 44-52

Skinner, Margaret Walker. "The Hearing of Speech During Language Acquisition." Otolaryngologic Clinics of North America 11 (October 1978): 631-50.

Woodford, Charles, and O'Farrell, Mary Lynn. "High-Frequency Loss of Hearing in Secondary School Students: An Investigation of Possible Etiologic Factors." Language, Speech, and Hearing Services in Schools 14 (January, 1983): 24-28.

General Resources

Carus, Marianne; Anderson, Thomas R.; and Webber, Howard R. eds. The Headway Program. LaSalle, Il.: Open Court Publishing Co., 1979.

Cook, Thomas D., and Campbell, Donald T. Quasi-Experimentation Design & Analysis Issues for Field Settings. Chicago: Rand McNally College Publishing Co., 1979.

Freund, Rudolf J., and Littell, Ramon c. SAS for Linear Models: A Guide to the ANOVA and GLM Procedures. Cary, NC.: SAS Institute Inc., 1981.

Hays, William L. Statistics for the Social Sciences. 2nd ed. New York: Holt, Rinehart & Winston, Inc., 1973.

Helwig, Jane T. SAS Introductory Guide. Cary NC.: SAS Institute Inc., 1978.

Hull, C. Hadlai, and Nie, Norman H. SPSS Update 7-9. New York: McGraw-Hill Book Co., 1981.

Isaac, Stephen, and Michael, William B. Handbook in Research and Evaluation. San Diego: Edits Publishers, 1971.

Kerlinger, Fred N. Foundations of Behavioral Research. 2nd ed. New York: Holt, Rinehart & Winston, Inc., 1973.

Kirk, Roger E. *Experimental Design: Procedures for the Behavioral Sciences*. Belmont, Ca.: Brooks/Cole Publishing Co., Inc., 1968.

Marks, Ronald G. *Analyzing Research Data: The Basics of Biomedical Research Methodology*. Lifetime Learning Publications. Belmont, Ca.: Wadsworth, Inc.,1982.

Minium, Edward W. *Statistical Reasoning in Psychology and Education*. New York: John Wiley & Sons. 1978.

Nie, Norman H.; Hull, C.H.; Jenkins, J.G.; Steinbrenner, K.; and Bent, D.H. *Statistical Package for the Social Sciences*. 2nd ed. New York: McGraw-Hill Book Co., 1975.

O'Fallon, O.K., and Young, L. Douglas. "Discussion." In *Improving Educational Standards and Productivity: The Research Base for Policy*, pp. 281-87. Edited by Herbert J. Walberg. Berkeley:McCutchan Corp., 1982.

Ray, Alice A., ed. *SAS User's Guide: Statistics, 1982 Edition*. Cary, NC.: SAS Institute Inc., 1982. Corp., 1982.

Riverside Publishing company. *Technical Manual Cognitive Abilities Test*. Chicago: Riverside Publishing Company, 1982.

Rubin, Louis. "Instructional Strategies." In *Improving Educational Standards and Productivity*. pp. 161-76. Edited by Herbert J. Walberg. Berkeley: McCutchan Publishing Corp., 1982.

Siegel, Sidney. *Nonparametric Statistics for the Behavioral Sciences*. New York: McGraw-Hill Book Company, Inc., 1956.

Thorndike, Robert L., and Hagan, Elizabeth. *Cognitive Abilities Test, Form 3, Level 1 and Level 2*. Iowa City: Houghton Mifflin, 1980.

Triola, Mario F. *Elementary Statistics*. Menlo Park, Ca.: Benjamin/Cummings Publishing Co. 1980.

Tyler, Ralph W. "Dynamic Response in a Time of Decline." *Phi Delta Kappan* 63 (June 1982): 655-58.

Walberg, Herbert J., ed. *Educational Environments and Effects Evaluation, Policy,and Productivity*. Berkeley: McCutchan Publishing Corp., 1979.

APPENDIX A

DESCRIPTIVE STATISTICS

NOTE: The descriptive statistics, displayed in Table 33, are applicable to the major hypothesis of this investigation, i.e., experimental and control group comparisons on each of the six response variables common to all 339 observations (Hypothesis 2 A). Charts and plots, displayed in Figure 7 and 8 and in Appendix B are based upon adjusted posttest scores contained in Table 33.

TABLE 33

Descriptive statistics-Treatment Comparisons - All Subjects

RESPONSE VARIABLE	TREATMENT GROUP	N	IQ TEST	(UNADJUSTED) PRETEST	POSTTEST	ADJUSTED POSTTEST	STD ERR	P VALUE
Sight(M)	C	151	100	540	572	570	3.7	0.0393
Vocabulary	E	188	98	526	574	580	3.9	
Phonics- (M)	C	151	100	697	744	737	7.7	0.0166
Consonants	E	188	98	682	749	761	8.1	
Auditory(S)	C	151	100	426	465	459	7.0	0.0067
Discrimin.	E	188	98	417	480	485	7.4	
Phonetic(S)	C	151	100	442	485	481	3.4	0.0001
Analysis	E	188	98	430	490	502	3.6	
Auditory(S)	C	151	100	350	364	352	2.6	0.0927
Vocabulary	E	188	98	330	356	357	2.8	
Compre- (S)	C	151	100	354	398	391	2.6	0.1513
hension	E	188	98	341	387	395	2.8	

NOTE:

TESTS : (M) = Metropolitan Reading Test;(S) = Stanford Reading Test

TREATMENT GROUP : C = control group; E = experimental group

UNADJUSTED TESTS: Not adjusted for covariates

ADJUSTED POSTTEST : In the SAS General Linear Model adjusted posttests are represented by least squares means, which are adjusted for covariates, i.e., pretests and IQ tests

STD.ERR : Standard error of least squares means

P VALUE : Probability of obtaining a T score >, by chance, for hypothesis: least squares mean of control group = least squares mean of experimental group

APPENDIX B

SCATTERPLOTS OF RESPONSE VARIABLES

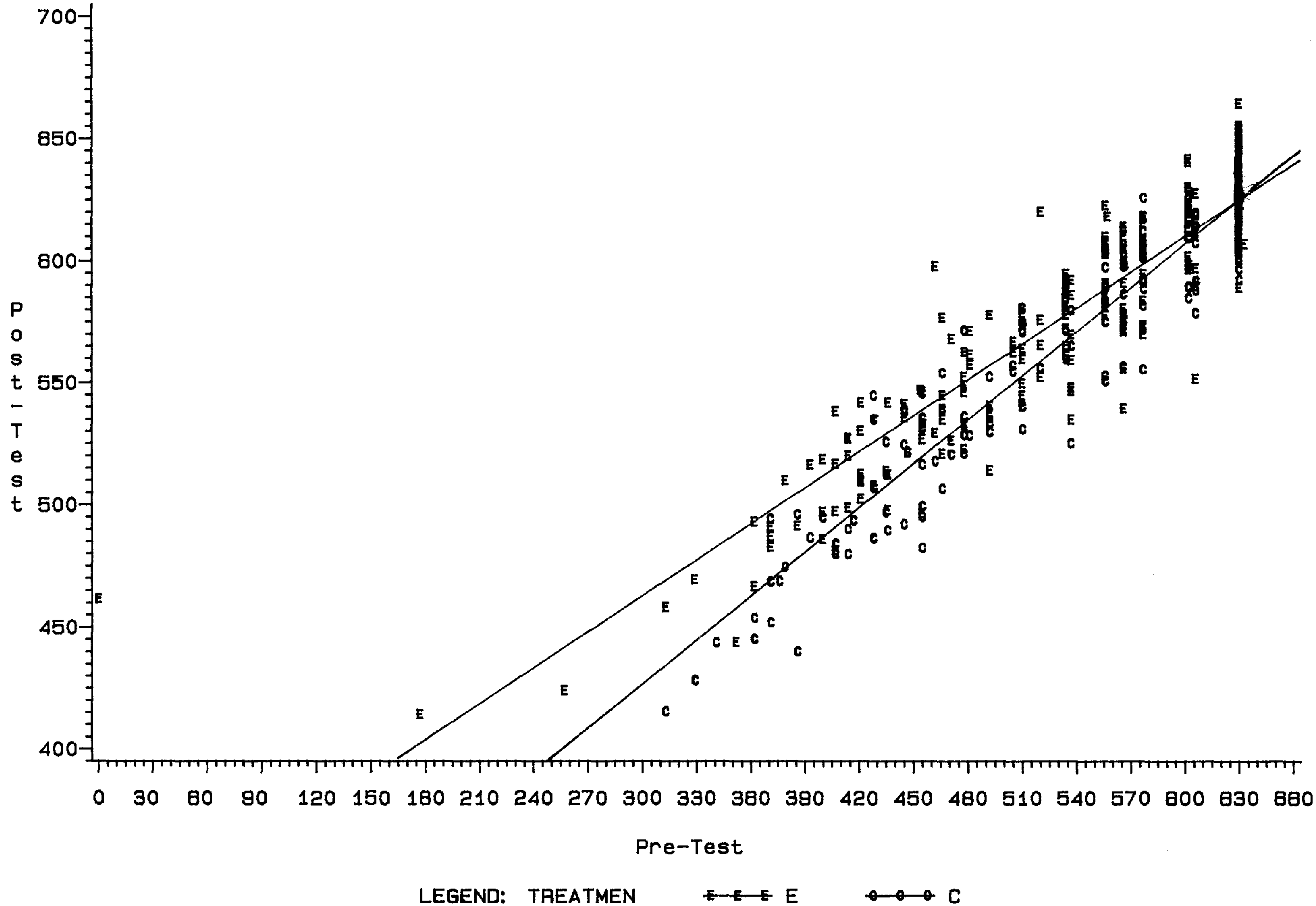
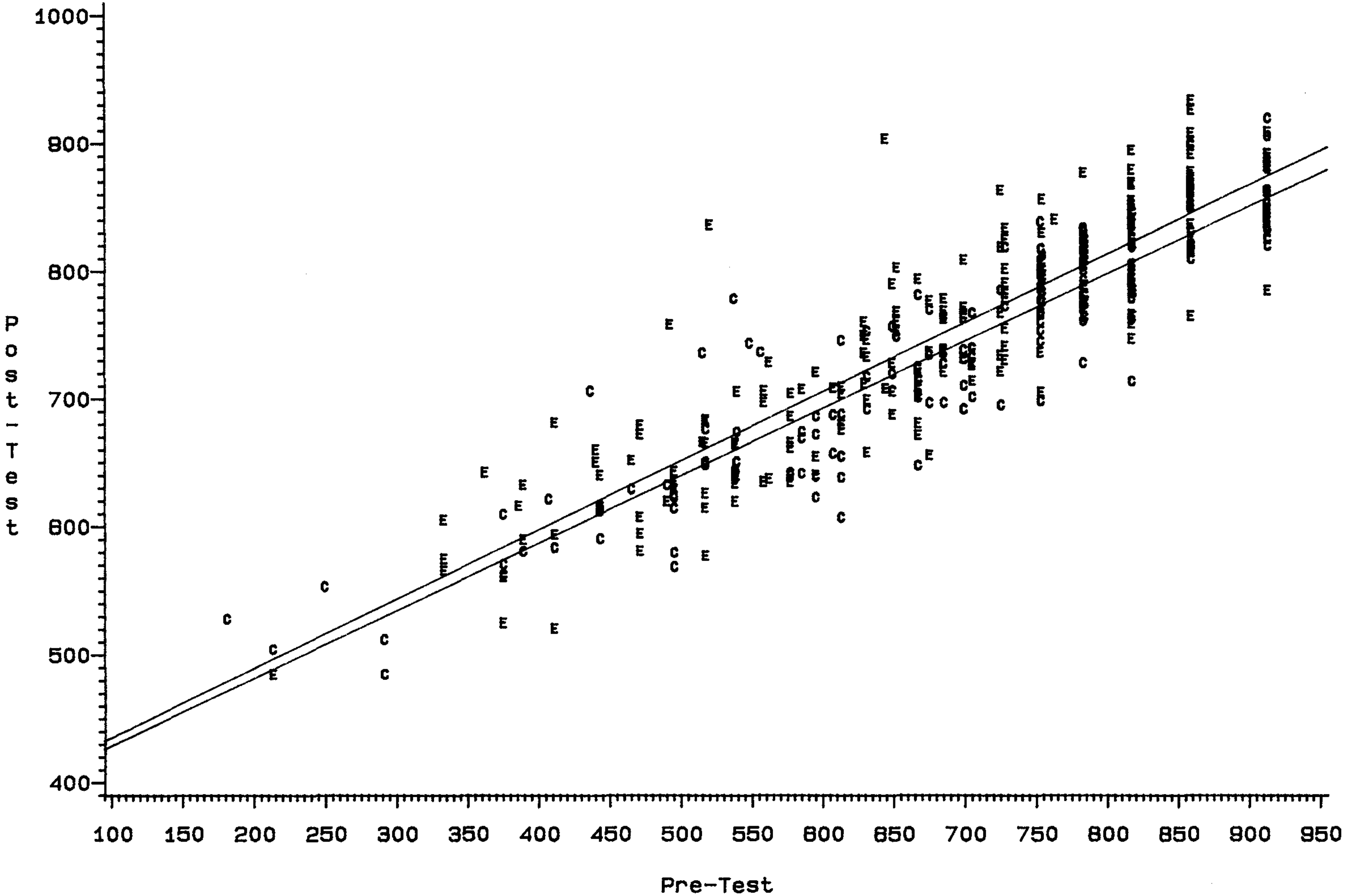


Figure 13: Scatterplot of Sight
Vocabulary Response Variable



LEGEND: TREATMEN E C

Figure 14: Scatterplot of Phonics-consonant Response Variable

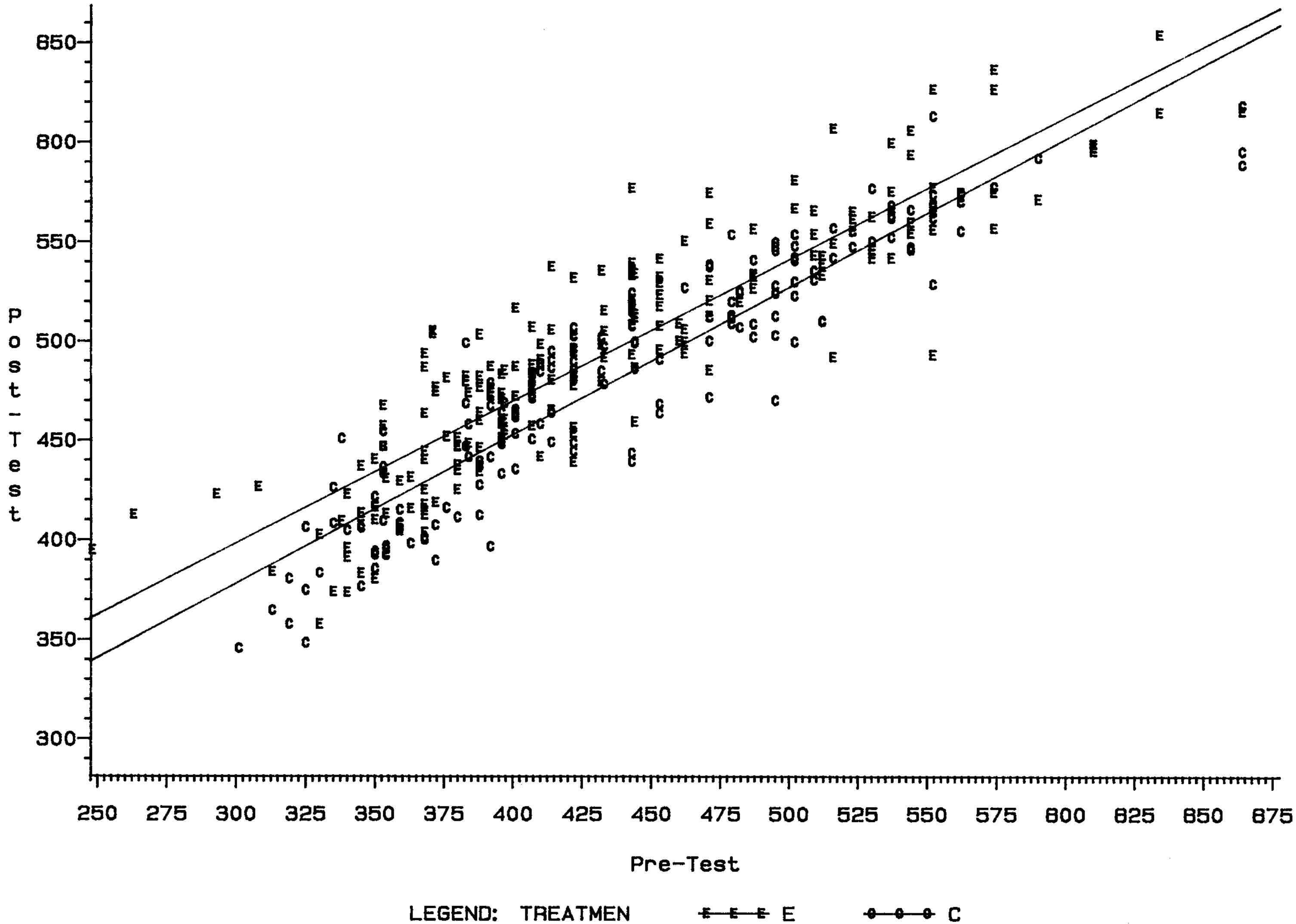


Figure 15: Scatterplot of Phonetic
Analysis Variable

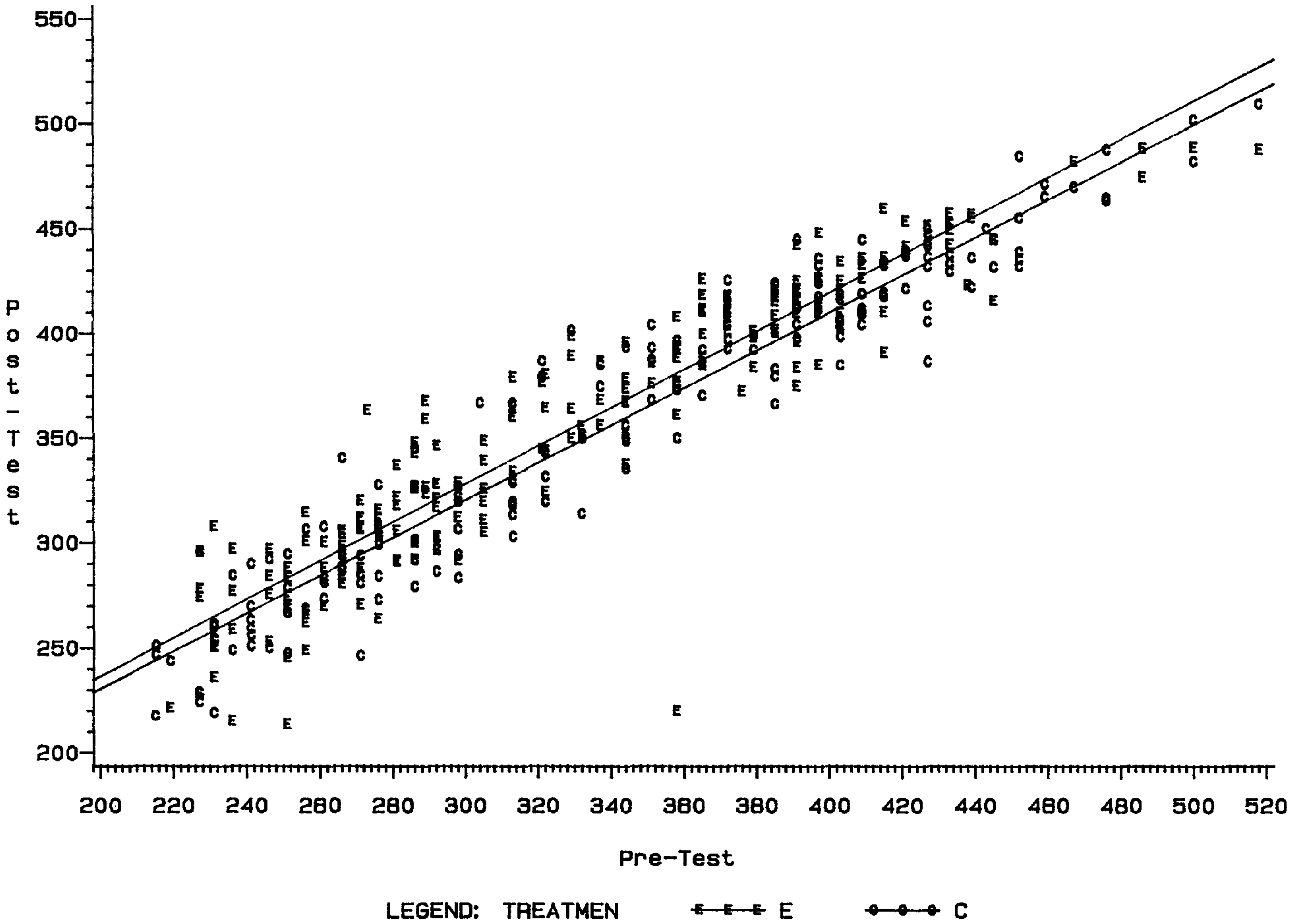


Figure 18: Scatterplot of Auditory Vocabulary Variable

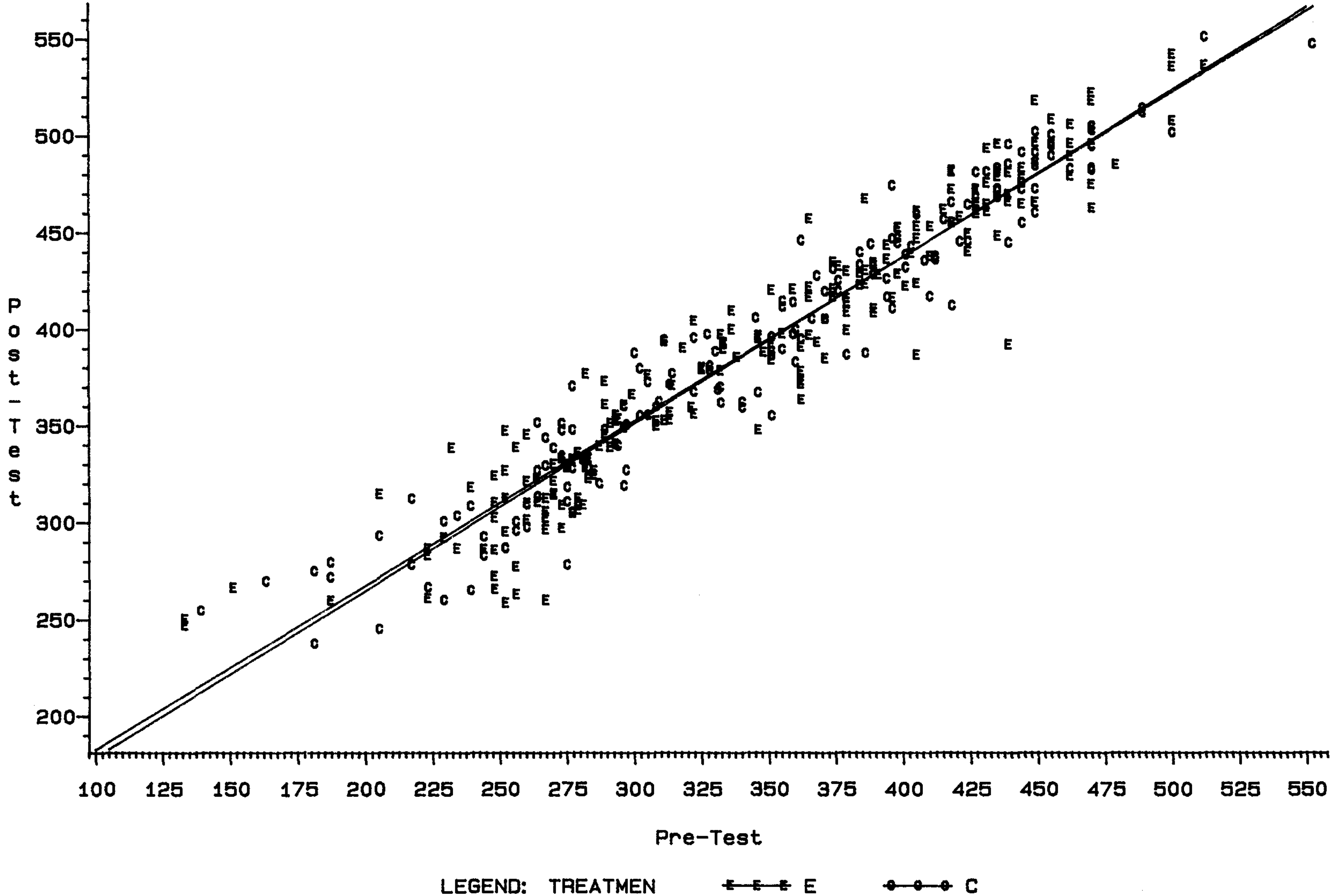


Figure 17: Scatterplot of Comprehension Response Variable

APPENDIX C

TREATMENT BY GRADE LEVEL RELATIONSHIP PLOTS

NOTE: The relationship plots are preceded by Table 34, which displays the corresponding least squares means from which the data were plotted.

TABLE 34

LSM'S and P Values For Treatment by Grade Relationships

RESPONSE	TRT/ GRADE	LSMEAN	STD ERR	PROB > |T| HO: LSMEAN(I) = LSMEAN(J) I/J	1	2	3	4
	C 1	569	7.4	1	.	0.7741	0.6922	0.0976
Sight	C 2	572	7.0	2	0.7741	.	0.9634	0.0201
Vocabulary	E 1	572	7.6	3	0.6922	0.9634	.	0.1578
	E 2	588	6.5	4	0.0976	0.0201	0.1578	.
	C 1	757	15.4	1	.	0.1179	0.6513	0.9846
Phonics-	C 2	716	14.7	2	0.1179	.	0.0766	0.0045
Consonants	E 1	764	16.0	3	0.6513	0.0766	.	0.7879
	E 2	758	13.5	4	0.9846	0.0045	0.7879	.
	C 1	475	14.0	1	.	0.1847	0.0474	0.6965
Auditory	C 2	443	13.4	2	0.1847	.	0.0151	0.0849
Discrimination	E 1	503	14.5	3	0.0474	0.0151	.	0.0975
	E 2	466	12.3	4	0.6965	0.0849	0.0975	.
	C 1	491	6.9	1	.	0.0922	0.0075	0.7332
Phonetic	C 2	471	6.6	2	0.0922	.	0.0015	0.0003
Analysis	E 1	510	7.1	3	0.0075	0.0015	.	0.1705
	E 2	494	6.0	4	0.7332	0.0003	0.1705	.
	C 1	332	5.3	1	.	0.0001	0.1617	0.0001
Auditory	C 2	372	5.0	2	0.0001	.	0.0004	0.5825
Vocabulary	E 1	339	5.4	3	0.1617	0.0004	.	0.0001
	E 2	375	4.6	4	0.0001	0.5825	0.0001	.
	C 1	392	5.3	1	.	0.7466	0.8990	0.4952
Compre-	C 2	389	5.0	2	0.7466	.	0.8116	0.0800
hension	E 1	392	5.4	3	0.8999	0.8116	.	0.4442
	E 2	398	4.6	4	0.4952	0.0800	0.4442	.

NOTE: P values displayed represent SAS output for two-tailed t tests. One half displayed value is appropriate for directional alternative, when displayed experimental group LSM > control group LSM

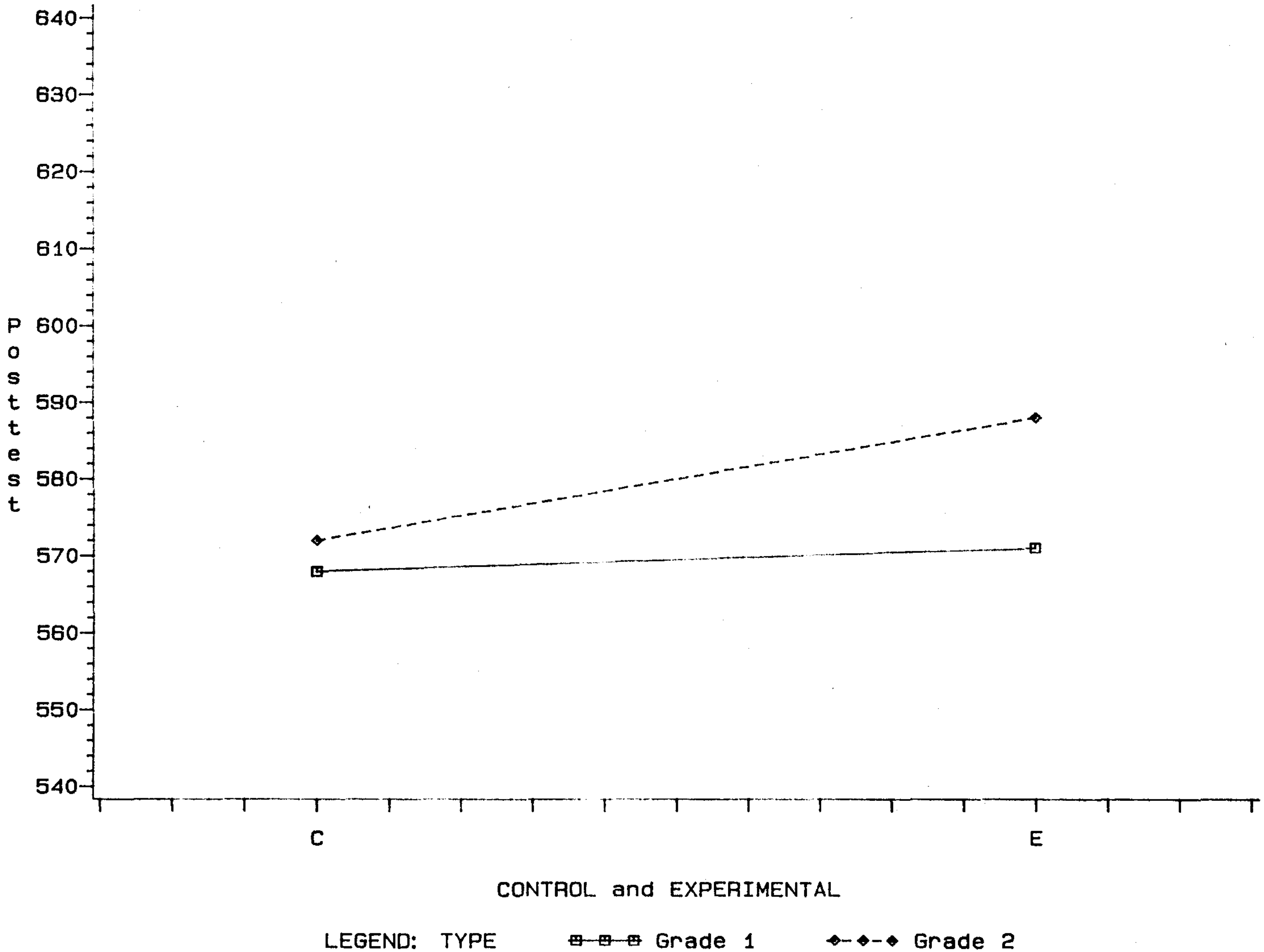


Figure 18: Treatment Level by Grade Level
on Sight Vocabulary Response Variable

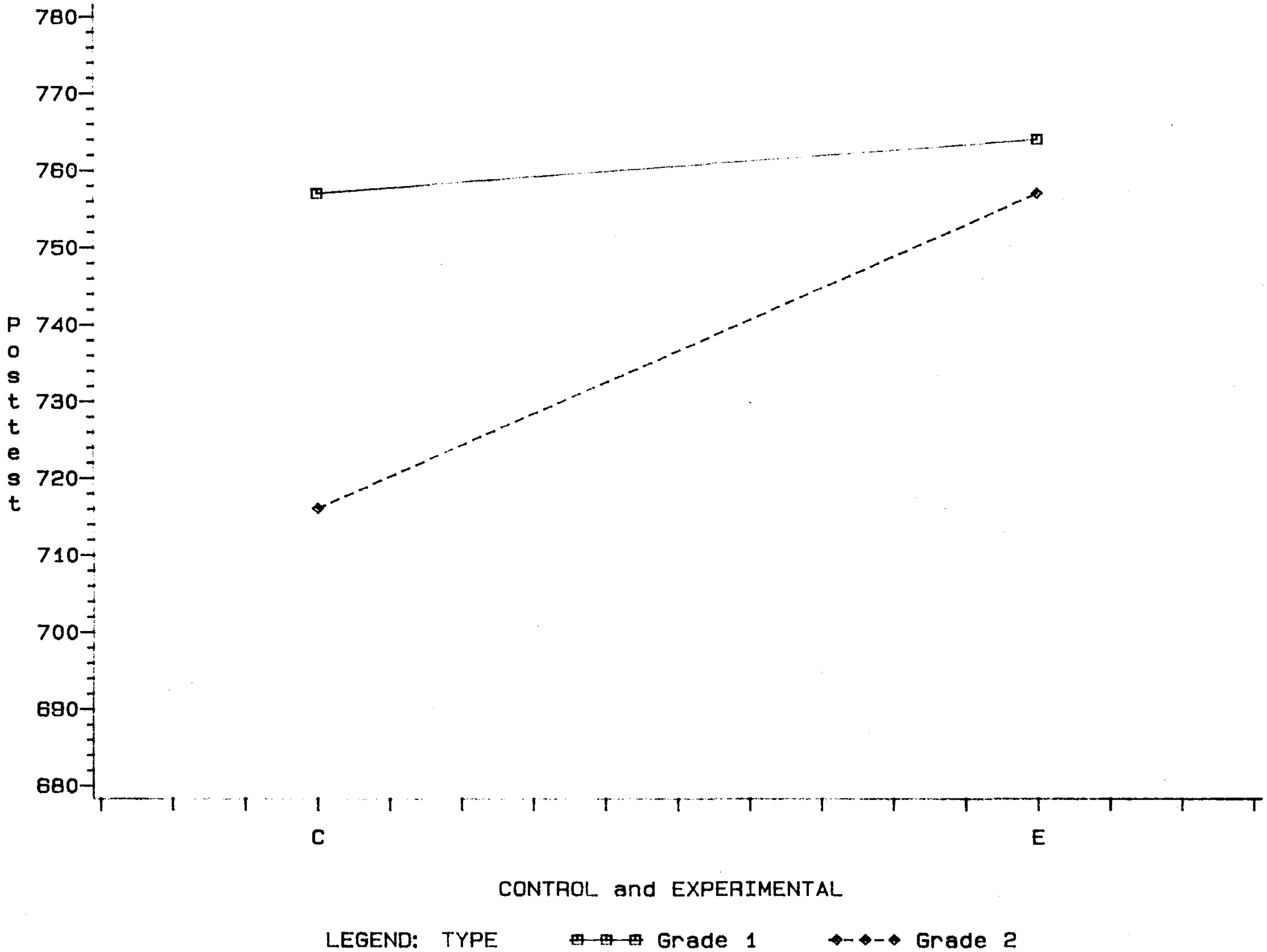


Figure 19: Treatment Levels by Grade Levels
on Phonics: Consonant Response Variable

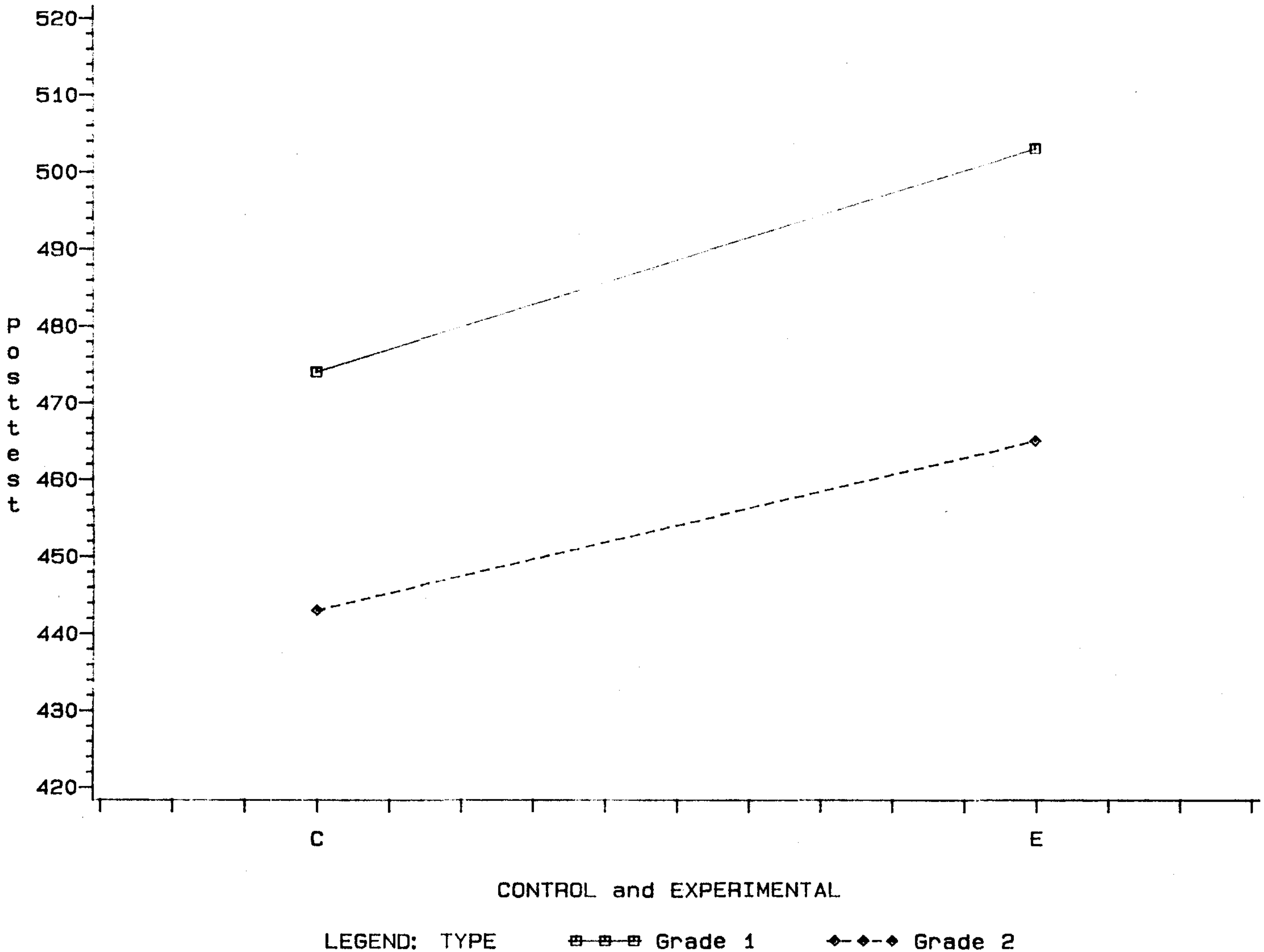


Figure 20: Treatment Level by Grade Level on Auditory Discrimination Response Variable

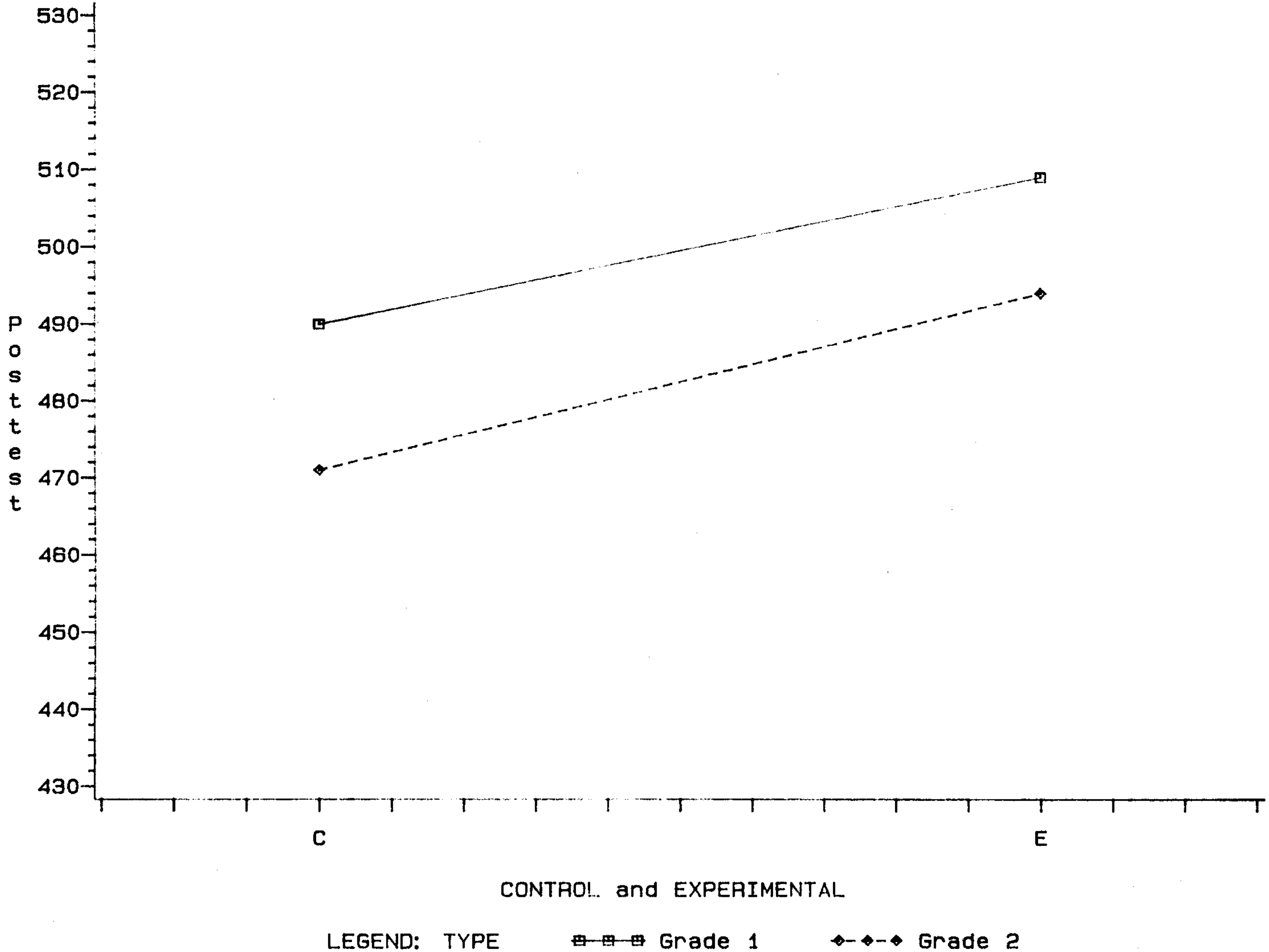


Figure 21: Treatment Level by Grade Level
on Phonetic Analysis Response Variable

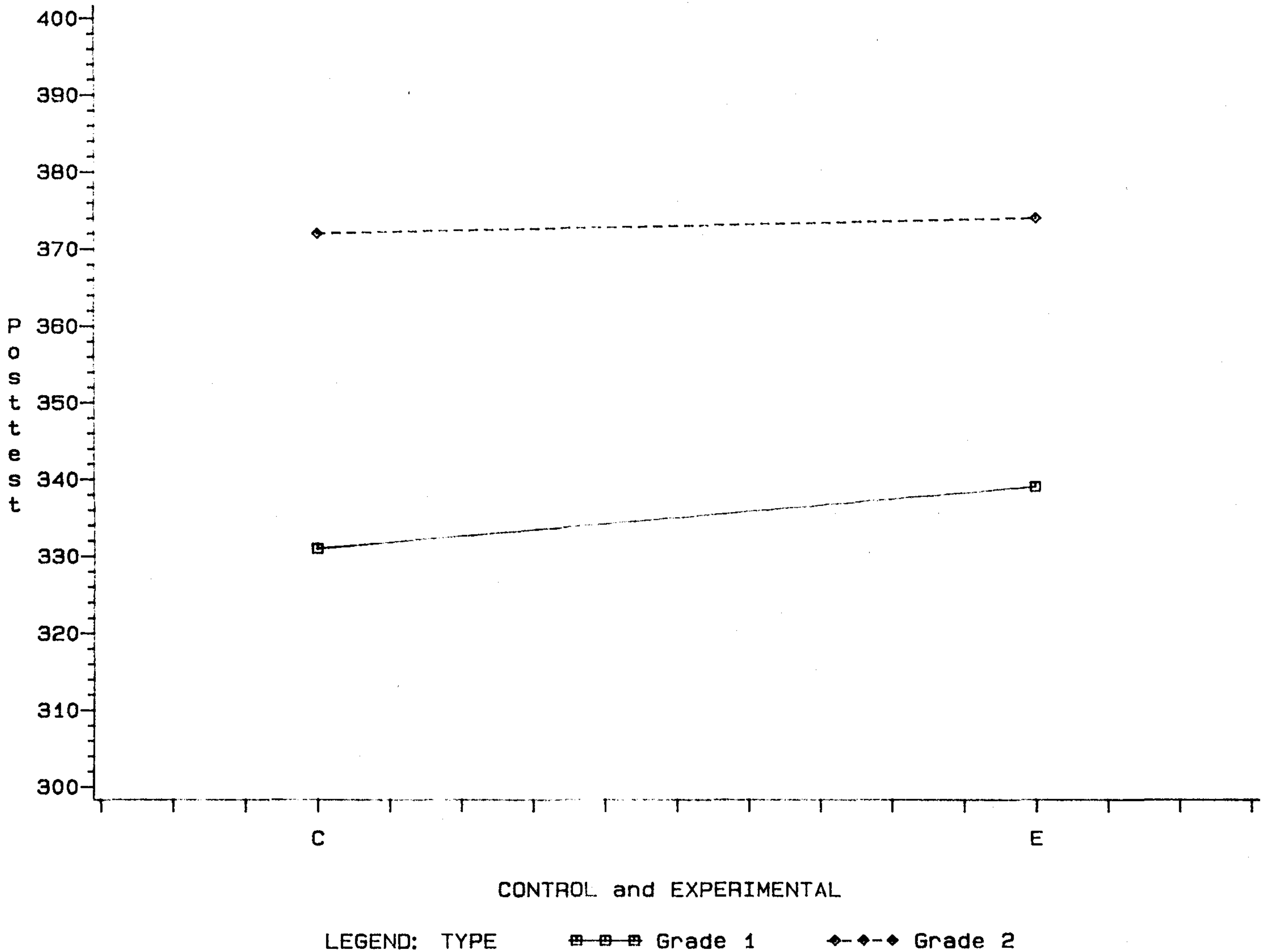


Figure 22: Treatment Level by Grade Level on Auditory Vocabulary Response Variable

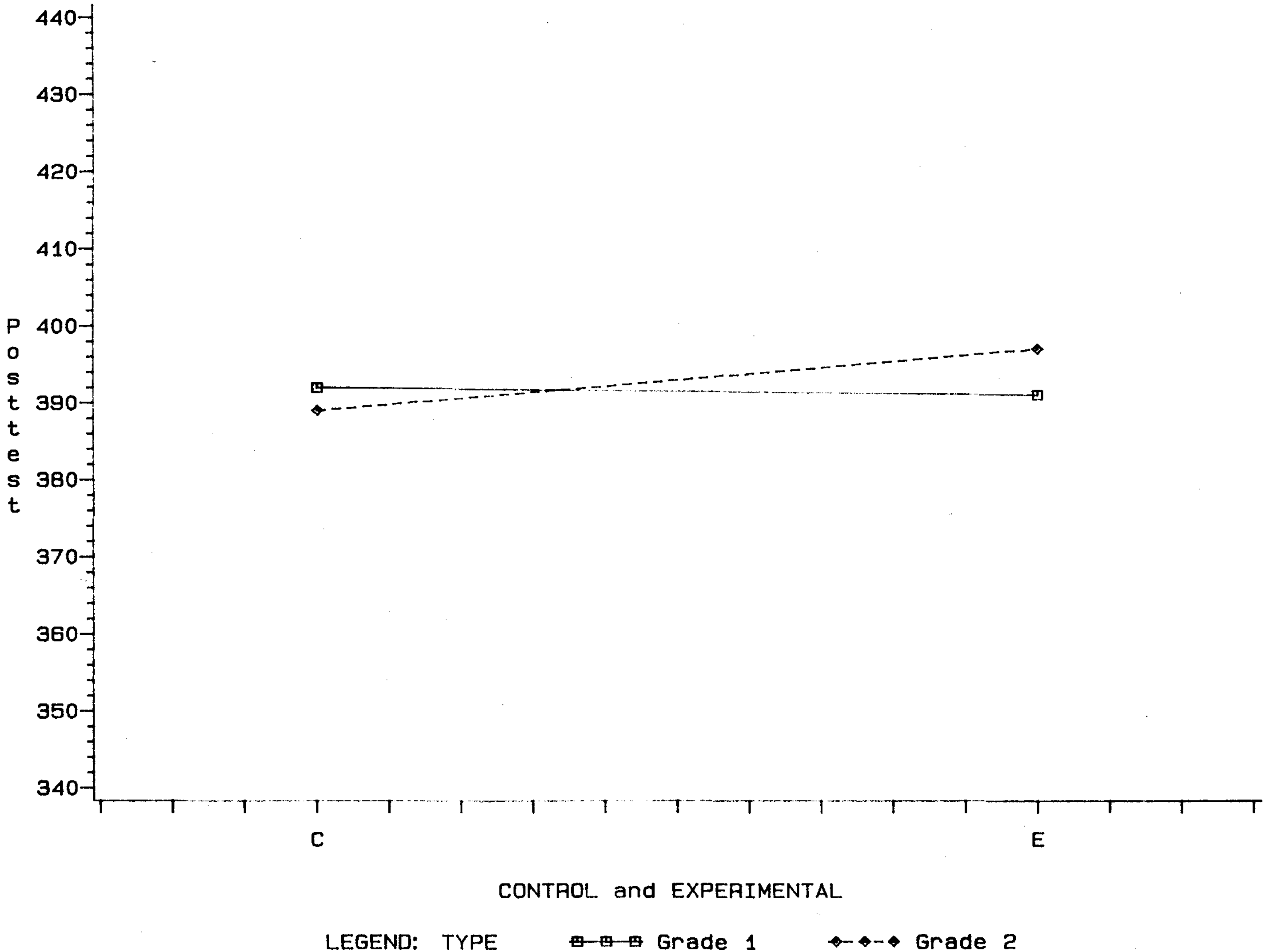


Figure 23: Treatment Level by Grade Level
on Comprehension Response Variable

APPENDIX D

TREATMENT BY MHL RELATIONSHIP PLOTS

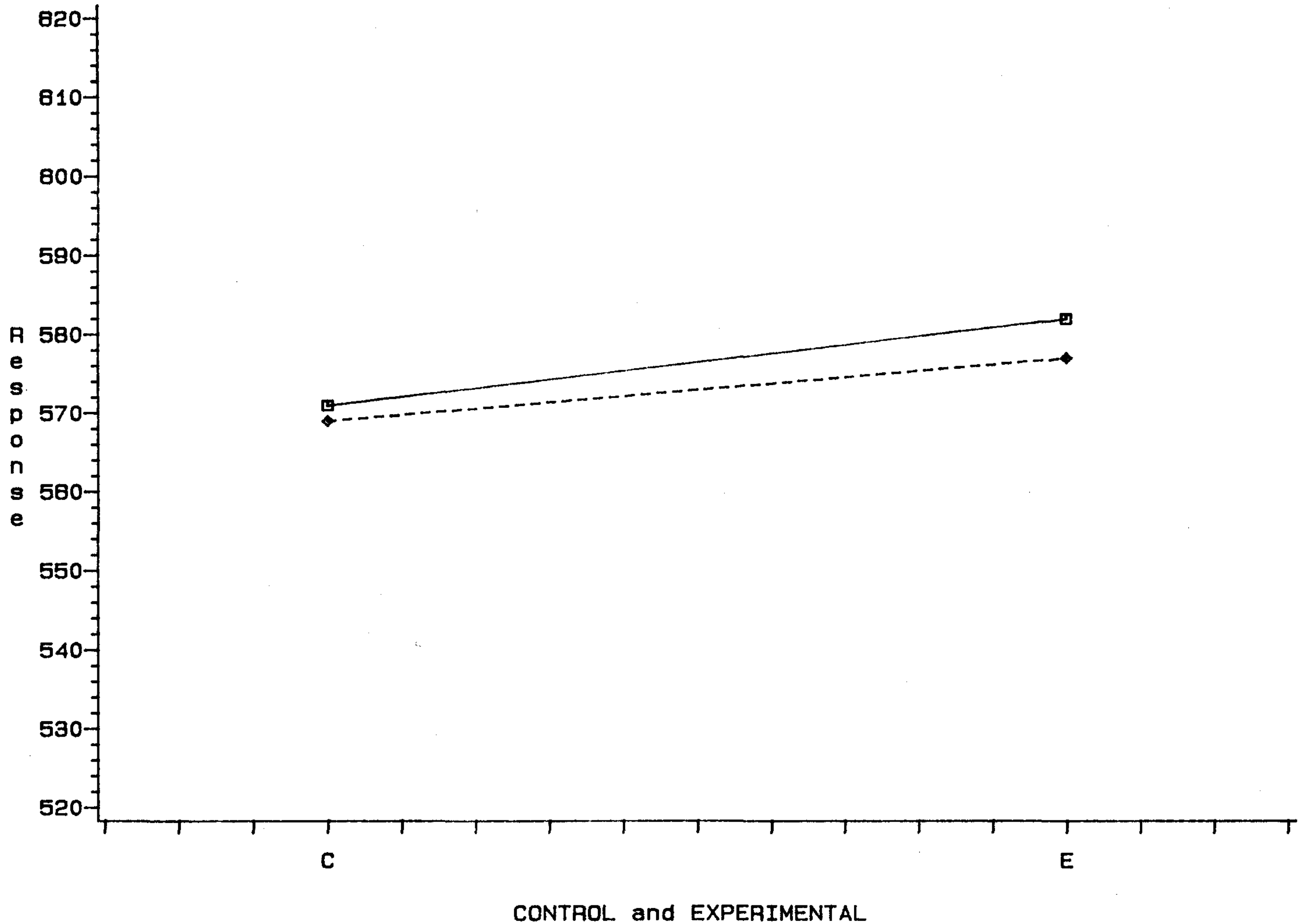
NOTE: The relationship plots are preceded by Table 35, which displays the corresponding least squares means from which the data were plotted.

TABLE 35

LSM'S and P Values For Treatment by MHL Relationships

RESPONSE	TRT/ MHL	LSMEAN	STD ERR	PROB > |T| HO: LSMEAN(I) = LSMEAN(J) I/J	1	2	3	4
Sight Vocab.	C No MHL	571	6.6	1	.	0.8218	0.1823	0.3798
	C Some MHL	570	4.6	2	0.8218	.	0.1086	0.2046
	E No MHL	582	6.2	3	0.1823	0.1086	.	0.2046
	E Some MHL	578	4.3	4	0.3798	0.2046	0.5185	.
Phonics-Consonants	C No MHL	729	11.8	1	.	0.2674	0.1721	0.0254
	C Some MHL	745	9.7	2	0.2674	.	0.3828	0.1950
	E No MHL	760	13.0	3	0.0721	0.3828	.	0.8645
	E Some MHL	763	9.1	4	0.0254	0.1950	0.8645	.
Auditory Discrim.	C No MHL	456	10.7	1	.	0.6653	0.1400	0.0146
	C Some MHL	462	8.8	2	0.6653	.	0.2490	0.0207
	E No MHL	479	11.8	3	0.1400	0.2490	.	0.4552
	E Some MHL	490	8.3	4	0.0146	0.0207	0.4552	.
Phonetic Analysis	C No MHL	484	5.3	1	.	0.3553	0.0146	0.0123
	C Some MHL	478	4.3	2	0.3553	.	0.0007	0.0001
	E No MHL	503	5.8	3	0.0146	0.0007	.	0.7652
	E Some MHL	501	4.0	4	0.0123	0.0001	0.7652	.
Auditory Vocab.	C No MHL	352	4.0	1	.	0.8661	0.8112	0.0373
	C Some MHL	352	3.3	2	0.8661	.	0.9235	0.0098
	E No MHL	351	4.4	3	0.8112	0.9235	.	0.0203
	E Some MHL	363	3.1	4	0.0373	0.0098	0.0203	.
Compre-hension	C No MHL	392	4.0	1	.	0.5920	0.3221	0.8944
	C Some MHL	389	3.3	2	0.5920	.	0.1264	0.6412
	E No MHL	398	4.4	3	0.3221	0.1264	.	0.2106
	E Some MHL	392	3.1	4	0.8944	0.6412	0.2106	.

NOTE: P values displayed represent SAS output for two-tailed t tests. One half displayed value is appropriate for directional alternative, when displayed experimental group LSM > control group LSM



LEGEND: TYPE ⊟—⊟—⊟ No MHL ◆-◆-◆ Some MHL

Figure 24: Treatment by MHL Level
on Sight Vocabulary Response

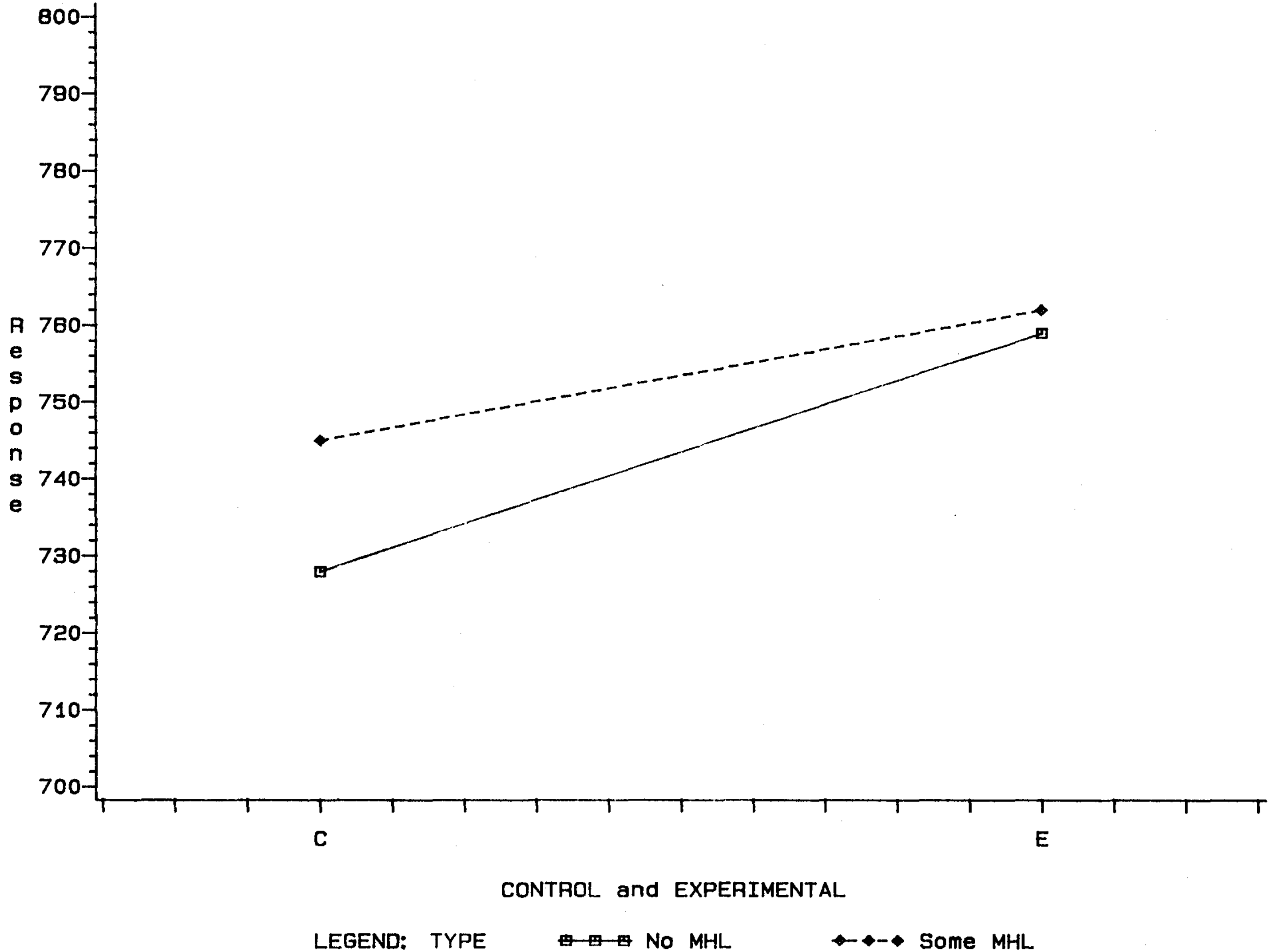


Figure 25: Treatment by MHL Level
on Phonics-Consonant Response

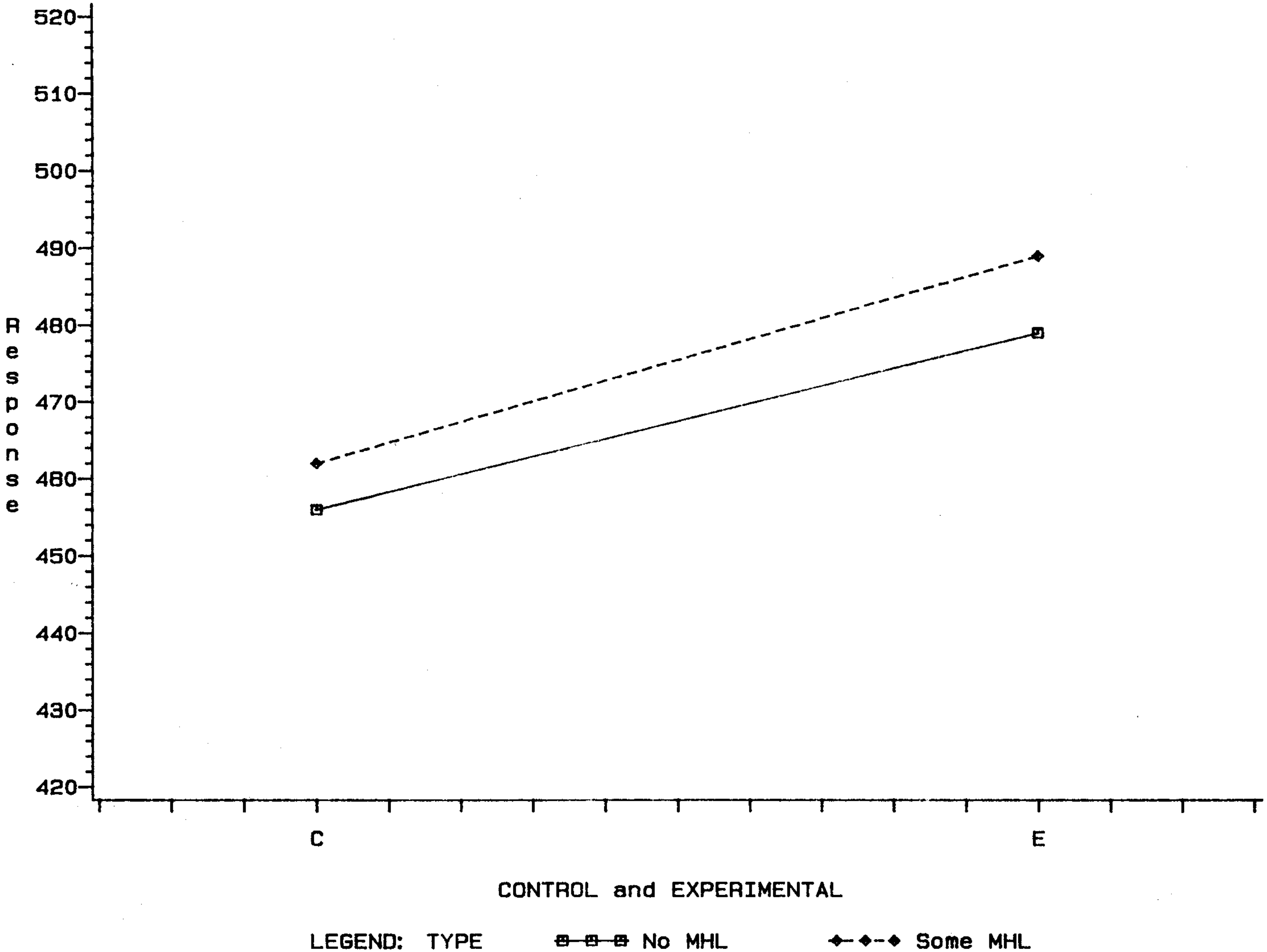


Figure 28: Treatment by MHL Level
on Auditory Discrimination Response

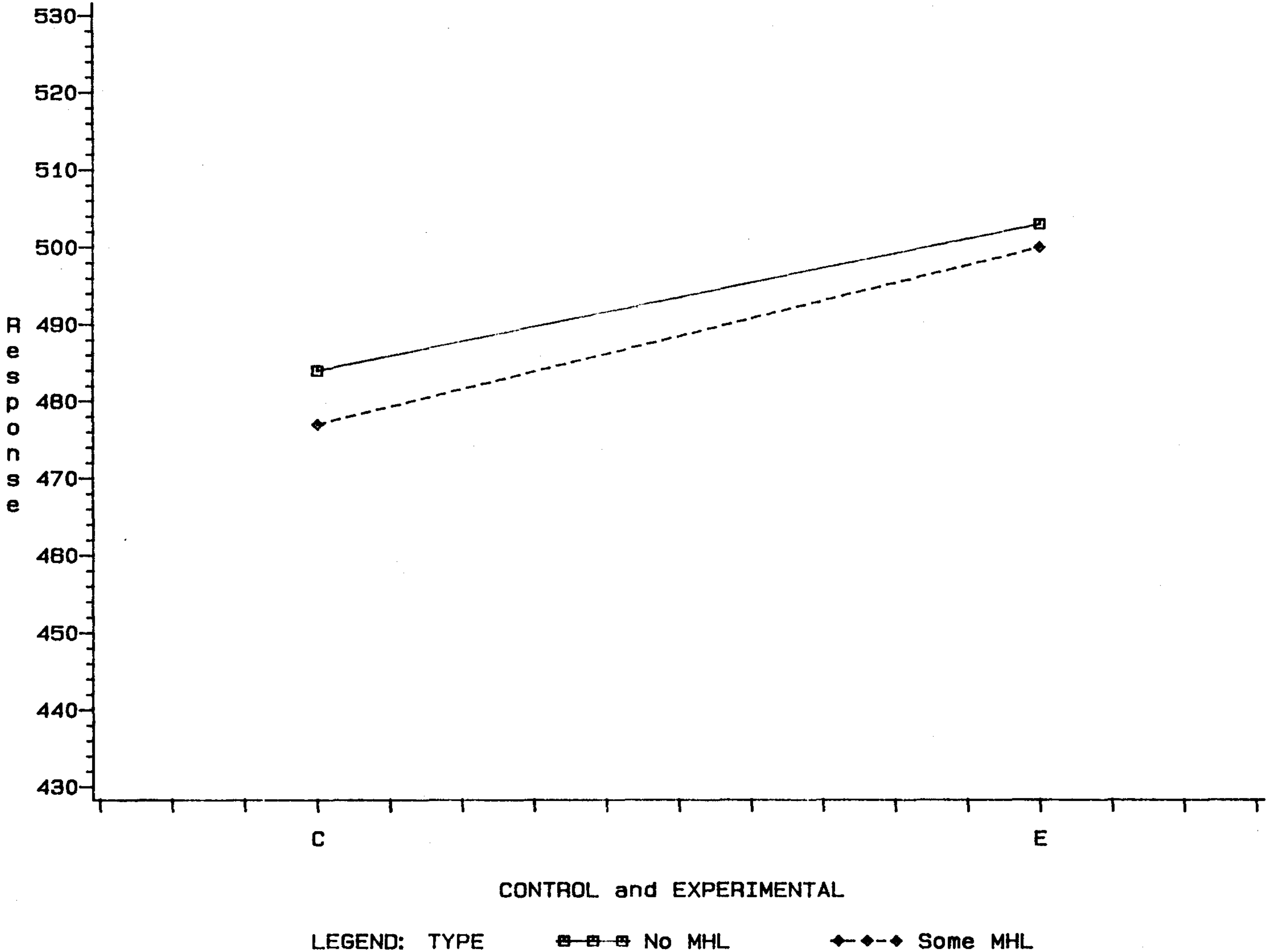


Figure 27: Treatment by MHL Level on Phonetic Analysis Response

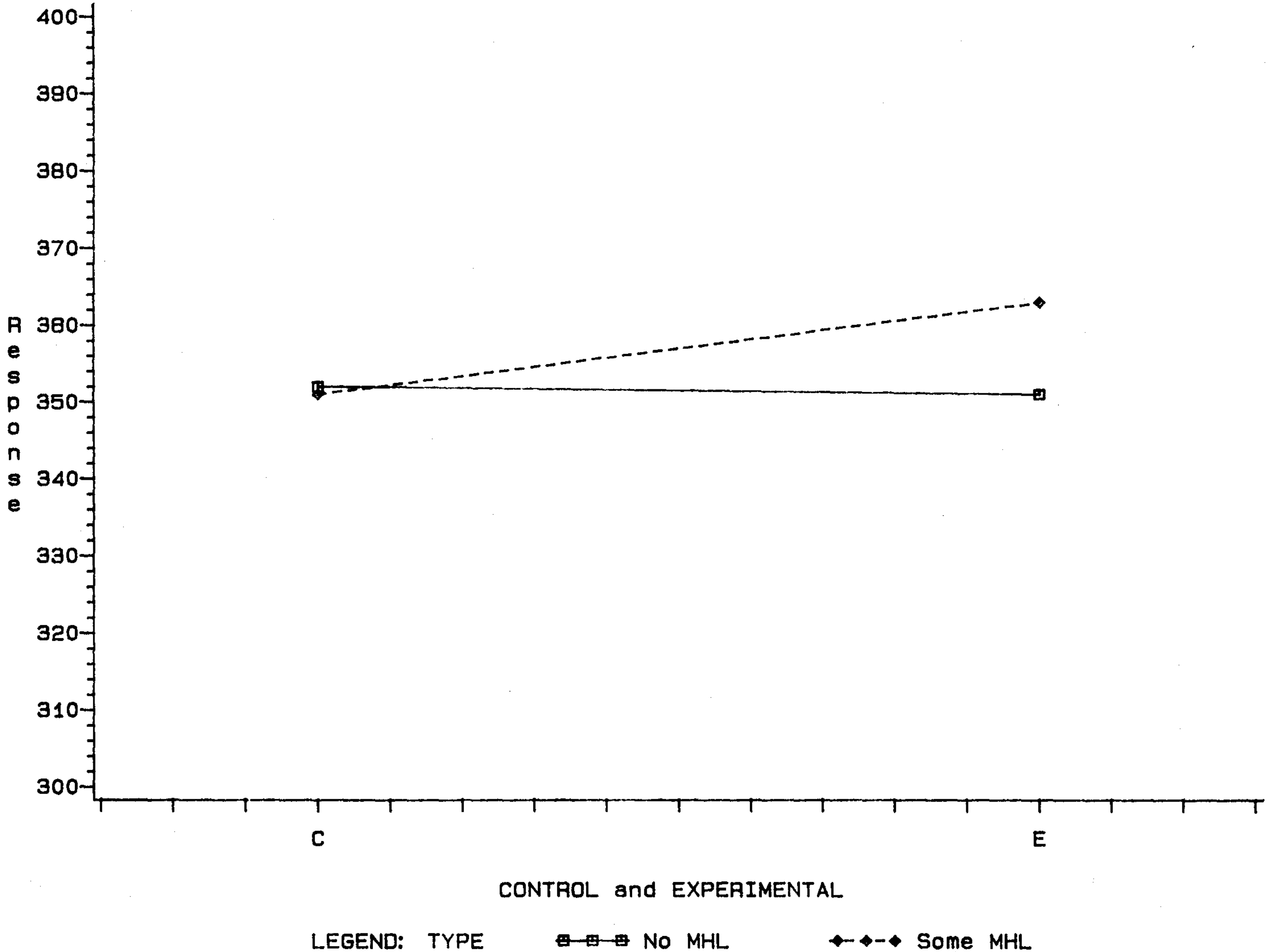


Figure 28: Treatment by MHL Level
on Auditory Vocabulary Response

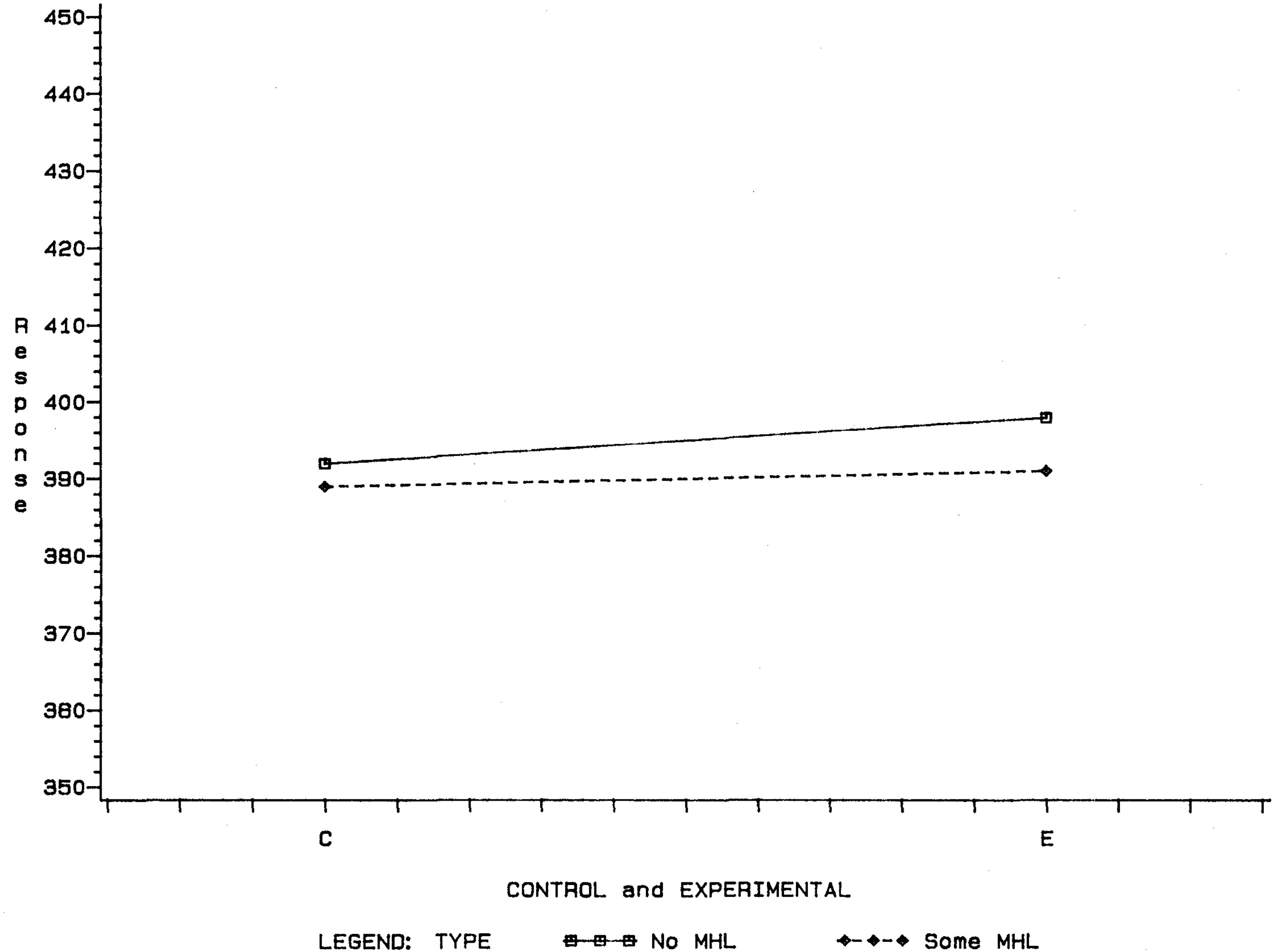


Figure 29: Treatment by MHL Level
on Comprehension Response

APPENDIX E

NOISE LEVEL DOCUMENTATION

Published Noise Descriptors of Sites I, II and III

The noise level descriptors displayed below have been extracted from Tables F-1 through F-7 reported by the City of Chicago, Department of Aviation (July, 1983). In the Chicago document Ldn descriptors were reported for 102 school in the vicinity of O'Hare Airport while TA and meq descriptors were limited to a sample of 24 schools.

Shown below are the available descriptors for Sites I, II and III for 1979, 1985, 1990, and 1995, both with and without the proposed airport expansion project.

TABLE F-1

1979 Daytime (7:00 a.m. - 7:00 p.m.)

Time (minutes) above indicated dBA level

	65 dBA	75 dBA	85 DBA	95 dBA	105 dBA	Ldn	Leq
Site I	425.0	111.6	29.7	0.3	0.0	79.7	75.2
Site II	344.0	40.2	1.7	0.0	0.0	70.1	67.1
Site III	NA	NA	NA	NA	NA	(65-70 Ldn)	

TABLE F-2

1985 "without Project" Daytime (7:00 a.m. - 7:00 p.m.)

Time (minutes) above indicated dBA level

	65 dBA	75 dBA	85 DBA	95 dBA	105 dBA	Ldn	Leq
Site I	360.2	96.5	23.9	0.7	0.0	80.3	75.3
Site II	308.1	33.9	1.6	0.0	0.0	69.7	66.6
Site III	NA	NA	NA	NA	NA	(65-70 Ldn)	

TABLE F-3

1985 "with Project" Daytime (7:00 a.m. - 7:00 p.m.)

Time (minutes) above indicated dBA level

	65 dBA	75 dBA	85 DBA	95 dBA	105 dBA	Ldn	Leq
Site I	368.6	103.9	25.8	0.8	0.0	79.4	75.3
Site II	308.7	35.6	1.8	0.0	0.0	69.1	66.6
Site III	NA	NA	NA	NA	NA	(65-70 Ldn)	

TABLE F-4

1990 "without Project" Daytime (7:00 a.m. - 7:00 p.m.)

Time (minutes) above indicated dBA level

	65 dBA	75 dBA	85 DBA	95 dBA	105 dBA	Ldn	Leq
Site I	377.4	92.5	24.9	0.8	0.0	81.2	75.7
Site II	298.1	40.1	1.3	0.0	0.0	70.2	66.6
Site III	NA	NA	NA	NA	NA	(65-70 Ldn)	

TABLE F-5

1990 "with Project" Daytime (7:00 a.m. - 7:00 p.m.)

Time (minutes) above indicated dBA level

	65 dBA	75 dBA	85 DBA	95 dBA	105 dBA	Ldn	Leq
Site I	376.2	97.6	26.6	0.8	0.0	80.3	75.6
Site II	291.6	41.4	1.4	0.0	0.0	69.5	66.5
Site III	NA	NA	NA	NA	NA	(65-70 Ldn)	

TABLE F-6

1995 "without Project" Daytime (7:00 a.m. - 7:00 p.m.)

Time (minutes) above indicated dBA level

	65 dBA	75 dBA	85 DBA	95 dBA	105 dBA	Ldn	Leq
Site I	377.4	92.5	24.9	0.8	0.0	81.2	75.7
Site II	298.1	40.1	1.3	0.0	0.0	70.2	66.6
Site III	NA	NA	NA	NA	NA	(65-70 Ldn)	

TABLE F-7

1995 "without Project" Daytime (7:00 a.m. - 7:00 p.m.)

Time (minutes) above indicated dBA level

	65 dBA	75 dBA	85 DBA	95 dBA	105 dBA	Ldn	Leq
Site I	373.9	100.0	24.0	1.2	0.0	78.8	75.0
Site II	257.6	30.7	0.0	0.0	0.0	67.8	64.3
Site III	NA	NA	NA	NA	NA	(65-70 Ldn)	

Source: City of Chicago, Department of Aviation, <u>Addendum Draft Environmental Impact Statement</u>, by Landrom and Brown Inc., July, 1983.

Leq Noise descriptors Collected at Sites I, II and III

by Phillip Lindahl, Professional Engineer

Site I Mohawk Elementary School

TIME/DATE	11/22/82	12/6/82	12/7/82	12/8/82	12/9/82	3/1/83
8:00	64.0	60.0	65.4	71.3	71.9	60.7
9:00	58.8	59.7	65.2	69.4	71.1	65.1
10:00	57.4	66.2	66.9	71.7	74.4	76.7
11:00	57.8	63.3	70.5	63.8	64.5	81.4
12:00	57.4	75.3	65.3	78.7	77.6	79.8
13:00	63.3	59.6	67.7	69.9	71.6	79.5
14:00	66.0	70.2	69.3	76.6	77.5	77.7
15:00	68.3	64.4	68.8	66.9	69.1	74.4

TIME/DATE	3/2/83	3/3/83	3/4/83	3/5/83	3/6/83	3/7/83
8:00	73.0	62.3	58.0	76.8	63.7	62.4
9:00	73.1	68.4	73.9	73.0	70.7	73.1
10:00	78.6	76.3	83.8	70.5	80.2	80.1
11:00	81.0	75.6	79.3	69.0	80.8	80.9
12:00	81.4	78.6	81.6	67.8	79.5	79.5
13:00	76.5	72.3	71.0	65.4	71.2	76.5
14:00	79.8	75.9	82.2	77.8	79.3	80.7
15:00	76.1	70.6	71.2	65.8	70.4	74.9

Site II Tioga Elementary School

TIME/DATE	3/8/83	3/9/83	3/10/83	3/11/83	Sat 3/12/83	Sun 3/13/83	3/14/83
8:00	70.2	64.8	76.7	74.8	61.8	58.4	74.7
9:00	83.0	81.9	80.4	77.7	60.1	71.1	79.3
10:00	80.7	78.1	81.8	81.2	65.9	70.8	80.6
11:00	77.1	75.8	82.6	75.8	63.7	61.2	77.9
12:00	74.7	78.3	77.7	75.5	62.3	62.6	76.8
13:00	77.8	80.3	76.6	77.0	65.0	61.7	78.7
14:00	78.6	75.2	72.6	78.6	59.6	59.0	78.2
15:00	77.3	82.0	84.3	77.5	61.0	62.9	75.7

TIME/DATE	3/15/83	3/16/83	3/17/83	3/18/83	3/19/83	3/20/83	3/21/83
8:00	57.1	57.9	66.1	58.1	80.0	60.7	62.3
9:00	71.8	66.9	69.7	66.9	80.3	63.7	62.0
10:00	66.7	69.8	64.5	62.0	79.7	63.8	72.3
11:00	56.3	65.2	64.4	62.2	77.6	61.8	77.5
12:00	60.4	60.6	61.5	60.9	79.5	68.0	80.2
13:00	71.3	66.7	59.2	68.8	78.7	70.8	74.1
14:00	58.1	57.1	59.2	61.7	79.5	70.5	72.6
15:00	58.7	57.9	61.8	62.4	79.9	57.6	59.2

Site II Tioga Elementary School (continued)

TIME/DATE	3/22/83	3/23/83	3/24/83
8:00	72.1	76.0	61.6
9:00	80.0	80.3	65.1
10:00	79.5	78.4	68.6
11:00	77.1	77.1	66.2
12:00	75.8	78.1	63.0
13:00	78.2	76.4	63.2
14:00	72.3	71.7	56.5
15:00	79.4	79.2	56.9

Site III Johnson Elementary School

TIME/DATE	4/12/83	4/13/83	4/14/83	4/15/83	4/16/83	4/17/83	4/18/83
8:00	57.8	63.5	63.7	69.8	56.4	52.8	67.6
9:00	58.9	64.2	68.4	71.9	68.2	58.7	70.3
10:00	59.2	58.9	73.6	74.1	70.4	54.7	73.1
11:00	58.7	62.2	67.7	75.1	64.8	55.1	75.5
12:00	58.4	61.5	65.1	63.8	70.8	53.6	72.1
13:00	59.2	60.6	72.7	71.0	71.6	55.8	72.9
14:00	63.8	61.5	69.7	71.9	63.2	53.2	74.2
15:00	58.4	64.3	71.7	72.1	71.7	55.6	58.4

TIME/DATE	4/19/83	4/20/83	4/21/83	4/22/83	4/23/83	4/24/83
8:00	71.0	67.6	68.8	72.6	74.7	73.4
9:00	72.5	72.8	67.4	70.8	73.5	76.5
10:00	61.9	74.7	72.0	74.2	73.1	75.5
11:00	67.4	74.2	73.6	61.5	59.1	58.4
12:00	58.0	71.4	72.8	54.5	58.5	58.4
13:00	55.1	71.9	71.9	57.6	58.7	59.5
14:00	53.8	74.9	71.5	54.3	60.2	57.8
15:00	61.8	69.2	69.7	56.4	61.3	55.9

APPENDIX F

SITE I AND SITE II FAA SOUNDPROOFING DOCUMENTATION

NOTE: The first FAA document is a copy of the approved application for federal assistance for soundproofing Mohawk Elementary School (Site I).

The second document is a copy of a letter dated February 9, 1984 from George P. Grote, FAA, to the President of the Bensenville Elementary School District, Ms. Mary Kassmier.

Both documents reproduced with permission from Bensenville Elementary School District.

OMB Approval No. 29-R0218

FEDERAL ASSISTANCE

2. APPLICANT'S APPLICATION a. NUMBER: 3-17-0022-N3 b. DATE: Year month day 1984 9 12

3. STATE APPLICATION IDENTIFIER a. NUMBER: b. DATE ASSIGNED: Year month day 19

1. TYPE OF ACTION (Mark appropriate box)
- ☐ PREAPPLICATION
- ☒ APPLICATION
- ☐ NOTIFICATION OF INTENT (Opt.)
- ☐ REPORT OF FEDERAL ACTION

Leave Blank

SECTION I—APPLICANT/RECIPIENT DATA

4. LEGAL APPLICANT/RECIPIENT
- a. Applicant Name : Village of Bensenville and
- b. Organization Unit : Ill. D.O.T., Division of Aeronautics
- c. Street/P.O. Box : 1 Langhorne Bond Dr., Capital Airport
- d. City : Springfield e. County : Sangamon
- f. State : Illinois g. ZIP Code: 62706
- h. Contact Person (Name & telephone No.) : Roger H. Barcus, Chief Engineer (217) 753-4400

5. FEDERAL EMPLOYER IDENTIFICATION NO.

6. PROGRAM (From Federal Catalog) a. NUMBER: 20.106 b. TITLE: A.I.P.

7. TITLE AND DESCRIPTION OF APPLICANT'S PROJECT

Soundproofing Mohawk School in Bensenville, Illinois

8. TYPE OF APPLICANT/RECIPIENT
A-State; B-Interstate; C-Substate District; D-County; E-City; F-School District; G-Special Purpose District; H-Community Action Agency; I-Higher Educational Institution; J-Indian Tribe; K-Other (Specify):
Enter appropriate letter: E

9. TYPE OF ASSISTANCE
A-Basic Grant; B-Supplemental Grant; C-Loan; D-Insurance; E-Other
Enter appropriate letter(s): A

10. AREA OF PROJECT IMPACT (Names of cities, counties, States, etc.)
Village of Bensenville

11. ESTIMATED NUMBER OF PERSONS BENEFITING
400

12. TYPE OF APPLICATION
A-New; B-Renewal; C-Revision; D-Continuation; E-Augmentation
Enter appropriate letter: A

13. PROPOSED FUNDING

a. FEDERAL	$ 492,880.00
b. APPLICANT	61,610.00
c. STATE	---.00
d. LOCAL	---.00
e. OTHER	61,610.00
f. TOTAL	$ 616,100.00

14. CONGRESSIONAL DISTRICTS OF: a. APPLICANT b. PROJECT

15. TYPE OF CHANGE (For 12c or 12e)
A-Increase Dollars; B-Decrease Dollars; C-Increase Duration; D-Decrease Duration; E-Cancellation; F-Other (Specify):
Enter appropriate letter(s):

16. PROJECT START DATE Year month day 1984 05 11

17. PROJECT DURATION Months

18. ESTIMATED DATE TO BE SUBMITTED TO FEDERAL AGENCY Year month day 19 84 09 12

19. EXISTING FEDERAL IDENTIFICATION NUMBER

20. FEDERAL AGENCY TO RECEIVE REQUEST (Name, City, State, ZIP code)
FAA, CHI-ADO, Des Plaines, Illinois 60018

21. REMARKS ADDED ☐ Yes ☒ No

SECTION II—CERTIFICATION

22. THE APPLICANT CERTIFIES THAT ▶

a. To the best of my knowledge and belief, data in this preapplication/application are true and correct, the document has been duly authorized by the governing body of the applicant and the applicant will comply with the attached assurances if the assistance is approved.

b. If required by OMB Circular A-95 this application was submitted, pursuant to instructions therein, to appropriate clearinghouses and all responses are attached: No response / Response attached
(1)
(2) (See Preapplication)
(3)

23. CERTIFYING REPRESENTATIVE
a. TYPED NAME AND TITLE: Lawrence Bieneman, Village President
b. SIGNATURE: Lawrence Bieneman
c. DATE SIGNED: Year month day 19 84 09 12

SECTION III—FEDERAL AGENCY ACTION

24. AGENCY NAME

25. APPLICATION RECEIVED Year month day 19

26. ORGANIZATIONAL UNIT

27. ADMINISTRATIVE OFFICE

28. FEDERAL APPLICATION IDENTIFICATION

29. ADDRESS

30. FEDERAL GRANT IDENTIFICATION

31. ACTION TAKEN
- ☐ a. AWARDED
- ☐ b. REJECTED
- ☐ c. RETURNED FOR AMENDMENT
- ☐ d. DEFERRED
- ☐ e. WITHDRAWN

32. FUNDING

a. FEDERAL	$ .00
b. APPLICANT	.00
c. STATE	.00
d. LOCAL	.00
e. OTHER	.00
f. TOTAL	$ .00

33. ACTION DATE ▶ Year month day 19

34. STARTING DATE Year month day 19

35. CONTACT FOR ADDITIONAL INFORMATION (Name and telephone number)

36. ENDING DATE Year month day 19

37. REMARKS ADDED ☐ Yes ☐ No

38. FEDERAL AGENCY A-95 ACTION

a. In taking above action, any comments received from clearinghouses were considered. If agency response is due under provisions of Part 1, OMB Circular A-95, it has been or is being made.

b. FEDERAL AGENCY A-95 OFFICIAL (Name and telephone no.)

STANDARD FORM 424 PAGE 1 (10-75)
Prescribed by GSA, Federal Management Circular 74-7

Copy of George P. Grote's letter

February 9, 1984

Ms. Mary Kassmier, President
Board of Education, District 2
Bensenville Elementary Schools
Bensenville, Illinois 60106

Dear Ms. Kassmier:

Thank you for your letter of January 27, 1984, regarding the school soundproofing program proposed by the Federal Aviation Administration (FAA) in our Draft Environmental Impact Statement for the O'Hare Airport Phsae II Development. We appreciate the effort put forth by the school district in documenting evidence to support the inclusion of Tioga School for soundproofing consideration. The information you submitted has been evaluated and we are pleased to inform you that Tioga School, will be included in the list of facilities eligible for soundproofing in our Final Environmental Impact Statement.

It is recognized that the mitigating measures proposed in our draft document are only the first steps in a comprehensive program to reduce the effects of aircraft noise. We hope that the school district will remain actively involved in the Airport Noise Compatibility Planning effort that we are recommending for O'Hare Airport.

Sincerely,

ORIGINAL SIGNED BY

George P. Grote
Manager
Chicago Airports District Office

SOURCE: U.S. Department of Transportation and Federal Aviation Administration, Final Environmental Impact Statement: Chicago O'Hare International Airport, Chicago Illinois, 2 Vols. May, 1984, Vol. 1, p. 145. (mimeographed.)

APPENDIX G

LINGUISTIC TASK PERFORMANCE INSTRUMENTATION

TABLE 36

Reliability Coefficients for Six Common Response Variables

RESPONSE VARIABLE	GRADE LEVEL	PUBLISHER TEST	PRETEST r	POSTTEST r
			(Form A)	(Form B)
Auditory Vocabulary	1	Stanford	.85	.86
Auditory Discrimination	1	Red Level	.84	.84
Phonetic Analysis	1		.94	.95
Comprehension	1		.95	.95
Auditory Vocabulary	2	Stanford	.85	.86
Auditory Discrimination	2	Green Level	.84	.84
Phonetic Analysis	2		.94	.95
Comprehension	2		.95	.95
			(Form J 1)	(Form K 1)
Sight Vocabulary	1	Metropolitan	.92	*
Phonics-Consonants	1	Primary 1	.90	*
Sight Vocabulary	2	Metropolitan	.92	*
Phonics-Consonants	2	Primary 2	.90	*

Note: r values represent Kuder-Richardson formula #20 reliability coefficients derived from national samples by test publisher.

* Publisher indicates that K1 coefficients differ minimally from J1.

Source of technical information for Stanford Tests: B. Karlson et al. Stanford Diagnostic Reading Test, Manual for Administering and Interpreting Reading Tests, (New York: Harcourt Brace Jovanovich, Inc.), 1976.

Source of technical information for Metropolitan tests: R. Farr et al. Metropolitan Reading Test, Teachers' Manual for Administering and Interpreting Reading Tests, (New York: Harcourt Brace Jovanovich, Inc.), 1978.

TABLE 37

Test Content Objectives for Six Common Response Variables

RESPONSE VARIABLE	OBJECTIVE	ITEMS
	(Stanford Red Level - Grade 1)	
Auditory vocabulary	The pupil will demonstrate auditory recognition of the common meanings of words frequently found in reading materials for the primary grades.	36
Auditory discrimination		
Consonant sounds	The pupil will hear similarities and differences among initial and final consonant sounds represented by single consonant letters, consonant clusters and digraphs.	24
Vowel sounds	The pupil will hear similarities and differences among short vowel sounds, long vowel sounds, diphthong vowel sounds, and vowel sounds controlled by certain consonant letters.	16
Phonetic analysis		
Consonants	The pupil will relate beginning and ending consonant sounds represented by a single consonant letter, consonant clusters, and and digraphs to their most common spellings.	24
Vowels	The pupil will relate short and long vowels sounds to their most common spellings.	16
Comprehension		
Word Reading	The pupil will identify words encountered in reading materials for the primary grades.	42
Sentence	The pupil will comprehend kernel sentences and	32

Reading	sentence transformations of various patterns.	
paragraph Compre-hension	The pupil will comprehend explicitly stated meanings and details in short reading passages.	16

(Stanford Green Level - Grade 2)

Auditory vocabulary	The pupil will demonstrate auditory recognition of the common meanings of words frequently found in reading materials for the elementary grades in the areas of reading and literature, mathematics and science, and social studies and the arts.	40
Auditory discrimination		
Consonant sounds	The pupil will discriminate among consonant sounds represented by single consonant letters, consonant clusters, and digraphs.	18
Vowel sounds	The pupil will discriminate among short vowel sounds, long vowel sounds, diphthong vowel sounds, and vowel sounds controlled by certain consonant letters.	18
Phonetic analysis		
Consonant sounds	The pupil will recognize the same consonant sounds represented by the same spelling or two different spellings.	18
Vowel sounds	The pupil will recognize the vowel sounds represented by the same spelling or two different spellings.	18
Comprehension		
Literal	The pupil will comprehend explicitly stated meanings and details in short reading passages.	30
Infer-ential	The pupil will draw conclusions and make inferences and generalizations from explicitly and implicitly stated meanings in short reading passages.	30

(Metropolitan - Grade 1)

Sight vocabulary	Grade Level of Words:	
	Grade 1	6
	Grade 2	15
	Grade 3	6
	Grade 4	3
Phonics-consonants	Objective:	
	Initial single consonants	3
	Initial consonant clusters	6
	Final single consonants	9
	Final consonant clusters	9

(Metropolitan - Grade 2)

Sight vocabulary	Grade Level of Words:	
	Grade 2	5
	Grade 3	12
	Grade 4	9
	Grade 5	4
Phonics-consonants	Objective:	
	Initial single consonants	3
	Initial consonant clusters	3
	Initial consonant digraphs	6
	Final single consonants	6
	Final consonant clusters	6
	Final consonant diagraphs	6

NOTE: Throughout the discussion, the term Phonics-consonants has been used to label a Metropolitan Achievement subskill test fully entitled Phoneme/Grapheme:Consonants.

APPROVAL SHEET

The dissertation submitted by Kenneth L. Kaufman has been read and approved by the following committee:

Dr. Barney M. Berlin, Director
Associate Professor, Curriculum and Instruction, Loyola

Dr. Robert C. Cienkus
Associate Professor, Curriculum and Instruction, Loyola

Dr. Judith W. Irwin
Associate Professor, Curriculum and Instruction, Loyola

Dr. Jack Kavanagh
Associate Dean, College of Education, Loyola

Dr. Lewis S. Sarff
Psychologist, Lincoln Developmental Center, Lincoln, Illinois

The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the dissertation is now given final approval by the Committee with reference to content and form.

The dissertation is therefore accepted in partial fulfillment of the requirements for the degree of Doctor of Education.

Dec 6, 1984
Date

Barney M Berlin
Director's Signature