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## Prevalence of Middle Ear Effusion in Auditory-Learning-Disabled Children and Its Association with Reduced Auditory Learning

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PREVALENCE OF MIDDLE EAR EFFUSION IN AUDITORY-LEARNING-  
DISABLED CHILDREN AND ITS ASSOCIATION WITH  
REDUCED AUDITORY LEARNING

by

Rita Denk-Glass

A Dissertation Submitted to the Faculty of the Graduate School  
of Education of Loyola University in partial fulfillment  
of the Requirements for the Degree of  
Doctor of Education

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1980

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Prevalence of Middle Ear Effusion in  
Auditory-Learning-Disabled Children and Its Association  
With Reduced Auditory Learning

The purpose of this research was to compare the prevalence of middle ear effusion (fluid in the middle ear space) in a group of school-age children educationally classified as auditory-learning-disabled with the prevalence in a comparison group with no apparent learning problems.

This study defined an approach to assessing middle ear effusion and hearing loss in school-age children. Sixty school-age children ranging in ages from seven years to ten years, three months were used in this study.

Thirty children were randomly selected for the experimental group from the children diagnosed as auditory-learning-disabled during 1979 by the Department of Communicative Disorders at Holy Cross Hospital, Chicago. The comparison group was made up of thirty children randomly selected from the children evaluated by the Department of Communicative Disorders and found not to be auditory-learning-disabled.

Children in the experimental and comparison groups had average or above-average intelligence and were matched for social class level. The ratio of boys to girls was seven to one in the experi-

mental group and six to one boys to girls in the comparison group.

The suggested prevalence of middle ear effusion in the auditory-learning-disabled group of school-age children was found to be seventy percent. In the comparison group of school-age children, suggested prevalence of middle ear effusion was seventeen percent.

This study demonstrated a significant relationship between middle ear effusion and reduced auditory learning. A negative correlation was computed between measures of auditory learning and middle ear effusion. The higher the prevalence of middle ear effusion, the lower the scores on measures of auditory learning. The reverse was also found: the lower the prevalence of middle ear effusion, the higher the scores on measures of auditory learning. This study also demonstrated a relationship between a history of middle ear effusion and auditory learning disability in school-age children. Eighty percent of the school-age children diagnosed as auditory-learning-disabled had a history of middle ear effusion; while fifty percent of the school-age children in the comparison group were found to have a history of middle ear effusion. Recommendations for clinical practice and improving present and future research were made from the data gathered in this study.

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## VITA

Rita Mae Denk-Glass was born in Chicago, Illinois on August 27, 1943.

She received her elementary education at St. Richards and Hurley grammar schools in Chicago. Her secondary education was completed at Lourdes High School in Chicago, Illinois, from which she graduated in 1961.

In June 1964, she graduated from Northern Illinois University, receiving a bachelor's degree in Education and Speech Correction. Upon graduation, she worked with autistic and psychotic children at Chicago State Hospital.

In February 1966, Rita Denk-Glass received her Master of Arts degree from DePaul University, Chicago, Illinois. In September of 1966 she was employed by St. Joseph's Hospital, Chicago, to develop speech pathology services.

Retiring in 1970 to raise a family, she moved to Virginia with her husband. She returned to Chicago in 1973 and was employed by Holy Cross Hospital to develop the Department of Communicative Disorders, where she remains as director today. Rita Glass serves as a consultant to the Special Needs Team, Handicapped Effort, for the Department of Human Services of Chicago and is on the professional advisory board of several special and nursery schools as well as Home Health Services in Chicago. She is also presently the chairman of the University of Chicago Laboratory School Council.

Since 1966, she has presented numerous papers and workshops, participating and chairing panels and workshops at state and national conventions including those of The American Association on Mental Deficiency, American Psychological Association, American Association for Children with Learning Disabilities, Illinois Speech and Hearing Association, Illinois Association for Children with Learning Disabilities, and the Illinois Association for the Education of Young Children.

Rita Denk-Glass speaks regularly to parent groups. Working with parents and staffs of Head Start Centers, she conducts workshops and inservice programs to assist them in meeting the communication needs of handicapped preschoolers.

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## CHAPTER I

### INTRODUCTION

The purpose in this study was to compare the prevalence of middle ear effusion (fluid in the middle ear space) in a group of school-age children educationally classified as auditory learning-disabled with the prevalence in a comparison group of children who had no apparent learning problems. Three areas of controversy were dealt with in this study: first, inconsistent use of terminology to describe fluid in the middle ear space; second, inadequate and inconclusive studies regarding the prevalence of middle ear effusion in the normal and learning-disabled school-age population; and third, the lack of agreement among physicians, audiologists, and educators as to the degree of hearing loss that results in reduced cognitive, language, and learning skills.

#### Terminology

Members of the medical profession, aware of the inconsistent use of terminology by physicians recording observations of the middle ear, have begun to address themselves to this issue (Mawson, 1976). Committees have been appointed by the American Academy of Ophthalmology and Otolaryngology for the purpose of simplifying and standardizing terminology. According to Bluestone (1978), otitis media (inflammation in the middle ear space) is the most frequently used term to describe disorders of the middle ear (p. 17). Other terms used inter-

changeably in the literature include middle ear "pathology," "infection," "disease," "disorder," "dysfunction," "ache," and "effusion." For clarity, this study was concerned only with middle ear effusion as defined by Paparella (1976, p. 8). Paparella (1976), as chairperson of the Committee on Terminology at the International Symposium on Middle Ear Effusion held in Ohio in 1975, reported middle ear effusion to be the only term general enough to encompass the various terms used to describe the presence of fluid in the middle ear space. The Committee on Terminology recognized the frequent use of "otitis media" to describe fluid in the middle ear space, but cautioned fellow otolaryngologists not to misuse this term, which means inflammation of the middle ear. Unless a fluid sample is withdrawn from the middle ear space and examined, one cannot be sure that infection is present. Routine otologic examination of the middle ear space, however, is non-invasive, thus precluding direct evidence for inflammatory changes (Paparella, 1976, p. 9). The physician examines the middle ear only indirectly via the outer ear, with the use of light, through the opaque ear drum (otoscopic examination). Middle ear effusion, when mild, is not always apparent to the examining physician and may go undetected unless tympanometric testing is used in addition.

#### Prevalence and Incidence of Middle Ear Effusion

It is known that middle ear effusion frequently occurs in isolation as well as before and after otitis media (Shurin, Pelton, Donner, & Klein, 1979, p. 1121). The effusion is often mild, with no observable symptoms, and therefore goes undetected. Yet persistent middle ear effusions in childhood are of major concern since they may impair



hearing and, as a result, cognition and learning (Zinkus, Gottlieb, & Shapiro, 1978, p. 1100).

Reports on the prevalence (number of cases at one time) and incidence (number of new cases occurring over a period of time) of middle ear effusion have only recently begun to be published (Bluestone, 1978, Klein, 1978, MD, 1979, Shurin et al., 1979). Middle ear effusions in children, which had previously gone undetected, are now receiving attention (Brooks, 1978, Lamberg, 1979, MD, 1979, p. 41). The National Center for Health Statistics, Survey on Medical Care Rendered in Pediatricians' Offices, reports that middle ear effusion is the most common diagnosis made by pediatricians on out-patients in the United States (Koch & Dennison, 1974). Today, it is believed that more than 50 percent of all children have at least one episode of middle ear effusion before they are three years old (Lamberg, 1979, p. 132).

Recent advances in equipment available for audiologic testing by the method of impedance audiometry or tympanometry have made the detection of middle ear effusion simple, objective, and accurate (Brooks, 1974, Bess, Bluestone, Harford & Klein, 1978). The increased awareness of middle ear effusion on the part of audiologists and physicians has noticeably increased the recorded prevalence and incidence in the past five years (Brooks, 1976, Paradise, 1976a). The recurrence of middle ear effusion has only recently been followed in American children (Paradise, 1976a, Shurin et al., 1979). No consistent

statistical analyses on prevalence or incidence have been reported.

In the school-age population, the estimated prevalence of middle ear effusion is between 5 (Johnson, 1950) and 20 percent (Brooks, 1976, p. 224, Feldman & Wilber, 1976, p. 177), and the reported incidence of middle ear effusion in children of all ages varies between 30 (Brooks, 1976, p. 223, Paradise, 1976a) and 50 percent (Jaffe, 1977). Statistical variance in prevalence and incidence appears to be related to two factors: the age of the child, or earlier studies were less accurate than later ones. First, it is now established that middle ear effusion is more common in younger (under 5 years old) than in older (over 10 years old) children (Brooks, 1969, p. 563, Howie, Ploussard & Sloyer, 1975, p. 677, Brooks, 1976, p. 223). Second, recent studies reflect a higher prevalence and incidence of middle ear effusion than described in earlier reports (Howie, Ploussard & Sloyer, 1976, p. 18, Paradise, 1979, p. 63). About 5 percent of diagnosed middle ear effusion persists throughout childhood and into adulthood (Brooks, 1976, p. 227). Jaffe (1977) believes that increased awareness of the prevalence and incidence of middle ear effusion in the pediatric population has fostered more complete and careful examination of the middle ear by physicians. With recent developments in impedance testing equipment, evaluation for middle ear effusion has become so simple that "if you look for middle ear effusion in children, you're going to find it" (Clark, 1976, p. 97). Thus, it appears that the later the research was done, the higher the prevalence and incidence recorded.

### Hearing Loss and Reduced Learning

Middle ear effusion dampens and/or blocks sound from reaching the brain for processing. In medical terms, middle ear effusion causes a conductive hearing loss (Brooks, 1976, p. 223). Brooks noted that the 5 percent of school-age children who have persistent middle ear effusion will go into adult life with permanently impaired middle ear function and reduced hearing (p. 563). Ling (1959) was the first to establish a causal relationship between conductive hearing loss and educational retardation. Subsequent studies have confirmed his initial conclusions (Holm & Kunze, 1969, Quigley & Thomure, 1970, Cooper, 1975, McCall, 1976, Zinkus, Gottlieb & Shapiro, 1978, Freeman in press).

The relationship between hearing loss and impairment in cognition and linguistic development of children has been established (Blue-stone, 1978, p. 18). Medical, educational, and hearing specialists agree on the auditory areas of learning most affected by reduced hearing acuity: auditory reception, association, comprehension, and memory (Kirk, 1962, Johnson & Myklebust, 1967, Chalfant & Scheffelin, 1969, Masters, 1978, Zinkus, Gottlieb & Shapiro, 1978). Even a slight degree of conductive hearing loss impairs auditory learning. It is now believed that a reduction in hearing level of only 15 decibels (American National Standards Institute, 1969), the level at which whispered speech can be heard, is sufficient to impair speech and language acquisition and may lead to generalized educational retardation (Ling, 1962, Holm & Kunze, 1969, Cooper, 1975).

Even a mild or fluctuating hearing loss may have an adverse effect on learning (Paradise, 1976a, p. 20). The length of time during which the hearing loss persists and the degree of hearing loss that will retard learning have not been firmly established (Paradise, 1979, p. 57).

Nor do we know enough about the natural history of middle ear effusion to know how often untreated effusions result in permanent damage to the ear or hearing mechanism...so that the burden of proof lies with those who feel — and we are among them — that it is worthwhile to detect middle ear effusion even in children whose learning thresholds are within accepted definitions of normal (Paradise, 1979, p. 58).

It is necessary to clarify three areas of controversy in the study of middle ear effusion and learning disability: (1) inconsistent terminology, (2) lack of agreement as to the prevalence of middle ear effusion, and (3) uncertainty as to the level of hearing loss and/or degree of middle ear effusion which will adversely affect learning. This investigation decided to study one of these areas, namely, the prevalence of middle ear effusion in auditory-learning-disabled children and its association with reduced auditory learning.

#### Statement of the Problem

To determine the prevalence of middle ear effusion and its implications for learning by school-age children, one must use accurate detection methods. The physician using otoscopic examination can determine the presence or absence of middle ear effusion. In the last five years, many physicians have included a detailed examination for middle ear effusion in routine pediatric care. Equipment for impedance

audiometry, often referred to as tympanometry, has only been available for clinical use by audiologists in the United States since 1972 (Brooks, 1974, Paradise, 1976a). This specialized equipment has not been in wide use since it is primarily limited to hearing and hospital centers. Educators, for the most part, still do not recognize the high prevalence of middle ear effusion and the implications for learning in the school-age population. School systems, to date, are screening only for sensorineural hearing loss (hearing loss due to an abnormality or damage to the sense organ of the ear or its nerve) and remain unaware of the higher prevalent conductive hearing loss in school-age children.

Eagles, Doerfler, and Wishick (1967) found the prevalence of sensorineural hearing loss in the school-age population to be 4.1 percent and that of conductive hearing loss (loss caused by blocked sound conduction to the inner ear) to be 15 percent. However, it is suspected that the incidence of conductive hearing loss today is as high as 30 percent, accounting for 80 to 90 percent of all hearing loss found in children (Brooks, 1974, p. 140). According to Lescouflair (1975), based on the kind of screening for hearing loss being done in most schools, present-day hearing programs in schools are a failure (p. 469).

We do not have adequate screening programs to detect conductive hearing loss in children. Programs that do exist are inadequate for detection of conductive hearing loss in school-age children with normal hearing and in those who are auditory-learning-disabled.

Adequate hearing is necessary in all children for the development of language, cognition, and learning. Therefore, it appears important

to determine the implications of middle ear effusion on learning by means of studies on the prevalence of middle ear effusion in the learning-disabled school-age population. Researchers today believe the prevalence of middle ear effusion to be higher in learning-disabled than in normal school-age children (Masters, 1978, Zinkus, Gottlieb & Shapiro, 1978, Freeman, in press), but little research has been done in this area. If middle ear effusion is more common in learning-disabled school-age children in general, is it also greater in auditory-learning-disabled school-age children? To date, no study has satisfactorily established an association between higher prevalence of middle ear effusion in school-age children and reduced auditory learning (Rapin, 1979, p. 3).

In this study, an attempt was made to establish the prevalence of middle ear effusion in auditory-learning-disabled school-age children.

#### Purpose of the Study

The purpose in this study was first to determine whether the prevalence of middle ear effusion was higher in a group of auditory-learning-disabled school-age children than in a comparison group of school-age children. Furthermore, an attempt was made to determine whether there was a correlation between scores on auditory measures of learning and the prevalence of middle ear effusion. In addition, the investigation sought to determine whether there is a correlation between a past history of middle ear effusion and auditory learning disability in school-age children. As a point of interest, the

prevalence of middle ear effusion in auditory-learning-disabled school-age children was compared with the prevalence reported in generally learning-disabled school-age children.

The data gathered in this study are intended to help future classroom teachers, learning disability specialists, and educators to develop adequate evaluation procedures for assessing suspected auditory learning disabilities in children. It is hoped that, as a result of this study, screening for middle ear effusion will be included in all future learning disability evaluations.

## Definition of Terms

For the purpose of this study, the following terms are operationally defined:

1. Air-Bone Gap

The difference, in decibels, between the hearing levels for a particular frequency as determined by air conduction and by bone conduction.

2. Air Conduction

The process by which sound is conducted to the inner ear through the air in the outer ear canal.

3. Audiogram

The graphic representation of hearing levels for pure tones.

4. Audiometry

Measurement of hearing.

5. Auditory Learning Disability (reduced auditory learning)

Difficulties exhibited by a child with average or above-average intelligence in one or more basic auditory learning processes involved in reception, understanding, organization, memory, or expression of language (as measured by the Wechsler Intelligence Scale for Children, the Peabody Picture Vocabulary Test, and the Auditory Subtests of the Illinois Test of Psycholinguistic Abilities).

6. Auditory Memory

Ability to recall or reproduce sequentially what one has heard.

7. Auditory Processing

The action or operation of receiving and associating auditory stimuli to make them meaningful.

8. Auditory Reception

Ability to receive and derive meaning from auditory stimuli.



9. Auditory-Vocal Association  
Ability to relate, organize, and manipulate auditory symbols in a meaningful way.
10. Bone Conduction  
Transmission of sound waves directly through the bones of the skull.
11. Conductive Hearing Loss  
Poor conduction of sound from the outer to the inner ear.
12. Decibel  
A unit of relative intensity of sounds on a scale from 0 to 130; 0 dB corresponds to  $0.002 \text{ dynes/cm}^2$ .
13. Epidemiology  
A branch of medicine that deals with incidence, distribution, and control of disease in a population. The sum of factors controlling presence or absence of disease.
14. Eustachian Tube  
Tube that establishes communication between the nasopharynx and the tympanic cavity, serving to adjust the pressure of air in the cavity to the external pressure.
15. Histology  
Study of tissue structure and organization.
16. Histopathology  
Study of structure and organization of diseased tissue.
17. Impedance Audiometry (tympanometry)  
An objective measurement of mobility of the eardrum during artificially induced air pressure changes in the external ear canal.
18. Learning Disability  
Difficulty in one or more learning processes involved in reception, understanding, organization, memory, or expression of language, in a child with average or above average intelligence.

19. Middle Ear

The region between the outer ear canal and the inner ear.

20. Middle Ear Effusion

Presence of fluid in the middle ear space.

21. Myringotomy

Cutting of an opening in the eardrum.

22. Otitis Media

Inflammation of the middle ear space.

23. Otoscopic Examination

Observation of the eardrum with an otoscope.

24. Pure Tone

A sound of a single frequency.

25. Sensorineural Hearing Loss

Hearing loss due to abnormality or damage of the auditory sense organ or its nerve.

26. Tympanic Membrane

Eardrum.

27. Tympanogram

Graphic representation of the mobility of the tympanic membrane.

## Hypotheses

Four null hypotheses were tested in this study:

- Hypothesis I     There is no statistically significant difference between the prevalence of middle ear effusion in auditory-learning-disabled school-age children and that in school-age children who have no apparent learning disability.
- Hypothesis II    There is no correlation between middle ear effusion and auditory learning disability.
- Hypothesis III   There is no predictability of auditory memory based on knowledge of the following variables in school-age children: Middle ear effusion, auditory reception, auditory-vocal association, Peabody Picture Vocabulary Test intelligence quotient, Wechsler verbal scale score, and Wechsler performance scale score.
- Hypothesis IV    There is no correlation between a history of middle ear effusion and auditory learning disability in school-age children.

## Limitations of the Study

This study has several limitations:

First, this study was only a prevalence study. Testing for middle ear effusion in auditory-learning-disabled school-age children and in the comparison group was done only once as part of an initial learning disability evaluation. The course of middle ear effusion was not followed. The cost, limited time of the professional staff for testing, and lack of availability of several subjects after the completion of the learning disability evaluation made audiologic follow-up testing unrealistic at this time. Thus, incidence was not determined in this study. Suggestion of middle ear effusion was made from the audiology test results.

Second, history of middle ear effusion was determined solely on parents' response to the question, "Does your child have a history of middle ear effusion?"

Third, children used in this study for both the experimental and comparison groups ranged in age from 7 years to 10 years 3 months. The upper age limit for the Illinois Test of Psycholinguistic Abilities varies between 10 years 3 months and 10 years 6 months on the different auditory subtests. Children 10 years old may reach ceilings on the administered auditory subtests.

Fourth, the experimental and comparison groups were matched for social class position by the Hollingshead Two-Factor Index of Social Class. The limitation of this matching was that the social class position of the comparison and auditory-learning-disabled school-age children was based exclusively on the father's education and occupation level. Mother's education and occupation were not considered. The Hollingshead Two-Factor Index of Social Class was normed on an all-white population. This study included black as well as white children, however.

Fifth, this study did not control for race or ethnicity.

Sixth, data were gathered on all subjects at a low statistical level (non-parametric), reducing the level of statistical analyses that could be applied.

#### Significance of the Study

It was intended that this study would provide experimental data on the prevalence of middle ear effusion in auditory-learning-disabled school-age children.

This study was significant to the extent that:

1. It describes an approach to the assessment of hearing and middle ear effusion in school-age children.
2. It determined a significantly higher prevalence of middle ear effusion in auditory-learning-disabled school-age children than in a comparison group of school-age children.
3. It showed a higher prevalence of middle ear effusion in auditory-learning-disabled school-age children than in generally learning-disabled school-age children.
4. It demonstrated a relationship between middle ear effusion and reduced auditory learning.
5. It suggested that the prevalence of middle ear effusion in school-age children is a key factor in predicting auditory learning disabilities.
6. It demonstrated a relationship between a history of middle ear effusion and auditory learning disability in school-age children.

### Procedure and Overview

Chapter II, Review of the Literature, contains six major divisions. The first reviews the literature concerning the historical development of middle ear effusion. The second section discusses middle ear effusion and hearing loss. The third section provides a discussion of the history of screening procedures for hearing loss. The fourth section reviews the development of impedance audiometry. The fifth section reports on the studies done on conductive hearing loss in learning-disabled children. The sixth and final section reviews the educational implications for children with middle ear effusion and conductive hearing loss.

Chapter III consists of a description of the research methodology and research design. It discusses the statistical hypotheses, selection of the sample, the tests used, and the rationale, as well as the procedure and data collection.

In Chapter IV, the data collected are presented and analyzed.

Chapter V includes the interpretation, discussion, and a brief summary of the study, as well as the conclusions and recommendations based on the study.

## CHAPTER II

### REVIEW OF THE LITERATURE

The historical development of the understanding of middle ear effusion will be reviewed first. A discussion of middle ear effusion and the accompanying conductive hearing loss will show the relationship between the two. The third area reviewed, screening procedures for assessing hearing loss, acquaints the reader with the present inadequacies in testing the hearing of children. Impedance audiometry, its history and development, is considered next in an attempt to establish credibility for this newest audiometric screening procedure. The research on prevalence and incidence of middle ear effusion in the normal and learning-disabled school-age child is the fifth area discussed. This provides the reader with the background data necessary to understand the need for the present study. The sixth and final section considers the educational implications of middle ear effusion and hearing loss on learning.

#### Historical Development of the Study of Middle Ear Effusion

The study of middle ear function began in the 16th century. According to Békésy and Rosenblith (1948), Capivacci (ca 1580) was the first to differentiate between conductive and labyrinthine (sensorineural) deafness. He had his patients bite on a 25-inch-long iron bar that was attached to a zither; if the zither could not be heard, the deafness was thought to be in the labyrinth (Békésy and Rosenblith, 1948, p. 745).

During the 17th century, Duvérney (ca 1683) wrote a book that described the basic functions of the middle ear with remarkable accuracy. He realized the involvement of the middle ear in apparent cases of conductive hearing loss and described the effects of positive and negative air pressure (Duvérney, 1973, p. 127).

During the 18th century, the understanding of the anatomy of the ear and of middle ear functions was advanced considerably by Scarpa (ca 1772) (Feldman, 1970, p. 10). Valsalva (ca 1707) was credited with developing a maneuver to create positive pressure in the middle ear (Valsalva maneuver). Valsalva also distinguished the three major divisions of the ear as we know them today, and he was one of the first physicians to demonstrate a clear understanding of middle ear function (Lindsey, 1959, p. 123).

Surgeons of the 18th and 19th centuries are credited with developing the myringotomy procedure (perforation of the eardrum for ventilation and/or drainage), which was first performed by Busson, in 1748, and later by Cooper, in 1800 (Alberti, 1974, p. 805). Cooper (1800) was aware that air could enter the middle ear through the eustachian tube. In his first presentation to the Royal Society of London in 1800, he showed that perforating the eardrum did not result in deafness, contrary to what was, until that time, a commonly held view (pp. 151-53).

In 1801, again before the Royal Society, Cooper presented what is now considered a classical paper, which earned him, at the age of 34, the Society's highest honor, the Copley Medal (Brock, 1952, p. 24).



Here Cooper clearly described the essential role of air in the functioning of the middle ear (p. 439). He asserted that the drum will produce very little sound unless air is admitted by the eustachian tube; if air does not have free access to the middle ear because the eustachian tube becomes obstructed, the eardrum ceases to vibrate and thus sound is no longer conveyed to the inner ear. The result of this air obstruction is known today as conductive hearing loss (Brock, 1952).

Although Cooper published only two papers on the function of the middle ear, he was the first to document an understanding of air pressure as an essential component in the correct functioning of the middle ear.

Müller (ca 1837) continued Cooper's work and developed new and correct concepts regarding the functions of the middle ear (Hemholtz, 1954). Politzer (1869), a 19th century Austrian otologic surgeon, also elaborated on Cooper's work. Recognizing the importance of air pressure in the middle ear, he (1869) studied retraction of the eardrum and negative middle ear pressure by injecting air into the middle ear during a voluntary swallow (p. 96). This procedure, used even today, is called "Politzerizing" (Politzer, 1869, p. 97).

Toynbee (1865), another leading otologic surgeon of the 1860s, differentiated mechanical dysfunction (middle ear effusion) from sensorineural dysfunction (p. 197). He was also credited with developing and naming the first otoscope (Toynbee, 1865, p. 220).

By the last quarter of the 19th century, physicians and otologic surgeons had made several observations on middle ear function, includ-

ing the following principles:

1. The basic principles of sound transmission through the middle ear had been described.
2. Pressure in the external ear canal was known to reduce hearing primarily in the low frequencies.
3. The basic principles of impedance (although not named as such) of the ear had been studied.
4. It was known that sound should be heard better by air conduction.
5. It was observed that occlusion of one ear caused referral of bone conduction sounds to the occluded ear.
6. Knowledge of the principles of correct pressure and sound transmission resulted in successful treatment of conductive hearing loss.

During the 20th century, knowledge of middle ear function advanced further. Much has been written on the cause, treatment, and management of middle ear effusion, with little consistency among physicians and related specialists (Tschopp, Senturia, Black, Huss1, Mawson, Paradise, Pulec & Ranney, 1975, p. 11). Knowledge gaps exist in cause, treatment, and management of middle ear effusion.

Although middle ear effusion is the most common of the chronic conditions encountered in pediatric practice, it frequently goes unrecognized, and relatively little is known about its epidemiology or its natural history. More importantly, the impact of middle ear effusion on the overall well-being of children, and on their cognitive and language development, remains essentially unexplored. In part because of these gaps in our knowledge, and also because prospective, controlled treatment trials have not been reported, uncertainty and controversy exist concerning: 1) the necessity, in many instances, of treating middle ear effusion; 2) the choice of various treatment methods; and 3) the timing of those treatments that are undertaken. Finally, the widespread use of adenoidectomy to prevent middle ear inflammation is seriously lacking in supporting

evidence. A few reported studies bear on some of these questions, but both their scope and the information they provide are limited. In order to resolve important prognostic and treatment issues concerning middle ear effusion during infancy and childhood, carefully designed epidemiologic and clinical studies of types not hitherto reported are urgently needed (Paradise, 1976a, p. 20).

In a review of the literature on the epidemiology of middle ear effusion, McEldoney and Kessner (1972) also reported that the work done thus far was inconclusive. Like Paradise, they found that no longitudinal studies had been performed which adequately reflected the incidence of middle ear effusion in the normal population.

Major national and international workshops, meetings, and conferences have been held during the past ten years in which attempts at defining and clarifying the epidemiology, natural history, treatment, and prevention of middle ear effusion were continued. The National Otitis Media Conference held in Dallas in 1972, and similar conferences held regularly, including the Second International Symposium on Recent Advances in Middle Ear Effusion held in May 1979, at Ohio State University (in press), continue to foster awareness of the gaps of knowledge in the field of middle ear effusion and otitis media.

There is a continuing lack of adequate research and information on the history, development, and prevention of middle ear effusion. There is also a lack of standards and rigor in reports and research being conducted on the prevalence, incidence, and persistence of middle ear effusion in the pediatric population (Rapin, 1979, p. 3). There continues to be a need for prospective multidisciplinary studies on the effect of middle ear effusion on learning. Finally, no concrete

data are available on the duration and frequency of middle ear effusion which retard learning.

Nevertheless, new information has been gathered in the 1970s. Howie (1975a), at the First International Symposium on Middle Ear Effusion at Ohio State University, reported that bacterial pathogens cause otitis media and middle ear effusion. Howie, Ploussard, and Sloyer (1977) confirmed the bacterial etiology of otitis media and reported that *Diplococcus pneumoniae* and *Haemophilus influenzae* cause 75 percent of all episodes (p. 13). Howie believes that the immediate goal of researchers should be the development of a suitable vaccine against common types of *Diplococcus pneumoniae* (Howie, Ploussard, and Sloyer, 1977, p. 19). To date, however, such a vaccine has not been developed.

Bernstein (1972, 1977) describes the highly complex relationship between inflammation and middle ear effusion. He considers it impossible to select any one aspect of middle ear inflammation as being of prime importance in middle ear effusions, as Howie et al. did in the key role they assigned to bacteria. One difficulty in studies of the history and development of middle ear effusion is that "histologic and histopathologic material can only be taken from a patient at the time the diagnosis is made, making documentation of the exact stages and progression of the disease in humans difficult" (Bernstein, 1977, p. 418). Such documentation can be obtained only in the animal model. However, as mentioned in the Tos and Bak-Pederson Study (1975), already in very early life, changes in the mucosa of the mid-

dle ear can be demonstrated in the presence of middle ear effusion. It therefore should be emphasized that aggressive clinical treatment of middle ear effusion must be given early (Tos & Bak-Pederson, 1975, p. 128).

The composition of the effusion has now been well established (Bernstein, 1977). The effusion consists of local secretions from submucosal cysts or glands in the middle ear. Eustachian tube dysfunction is associated with effusion (Bluestone, Beery, and Andrus, 1974, p. 32). Secretion of mucus by the cells of the middle ear is believed to occur when there is a lack of air in the middle ear system (eustachian tube blockage), resulting in a negative middle ear pressure (Bluestone, Beery & Andrus, 1974, Bluestone & Shurin, 1974).

#### Middle Ear Effusion and Hearing Loss

Physicians and educators are concerned with the reduction in hearing that usually accompanies middle ear effusion. Brooks (1978b) believes that middle ear effusion is the most common cause of conductive hearing loss, accounting for over 90 percent of all hearing loss in children (p. 173). Middle ear effusion is most frequent among children under 10 years of age (Howie, 1975a, p. 67, Cooper, 1975, p. 260, Brooks, 1979, p. 31, Shurin et al., 1979, p. 1123).

Although middle ear effusion is widely prevalent among school-age children, it often escapes detection (Reed, Struve & Maynard, 1967, Eagles et al., 1967, Paradise, 1976a). Paradise, Smith & Bluestone (1976) give several plausible explanations for this: symptoms are often absent or not readily apparent, otoscopic examination by

physicians is often difficult to accomplish satisfactorily, and tympanic membrane abnormalities are difficult to recognize (p. 198). Published reports on the degree of hearing loss associated with middle ear effusion are inconsistent and make objective, controlled, and quantifiable studies of middle ear effusion and hearing loss difficult. Thus, to date, no conclusive level of hearing loss related to middle ear effusion has been established.

A summary of a recent workshop on middle ear effusion and child development explained the difficulty of determining the correlation between degree of hearing loss and specific middle ear findings.

It is apparent that there may be a significant and fluctuating range of severity in the effect that middle ear disease may have on hearing. It is clear that correlations of the degree of hearing loss with particular physical findings of middle ear disease are not reliably predictable. Thus, for research purposes, better techniques for quantifying hearing ability in infants and young children are required. While we now have some objective means of measuring hearing [tympanometry] we do not have the necessary data on normative hearing levels in young children (Ruben & Hanson, 1979, p. 107).

It thus becomes important to identify middle ear effusion and the degree of accompanying conductive hearing loss in children because these factors are related to reduced learning and educational development. Rapin (1979), in a review of the literature on middle ear effusion and scholastic performance, confirmed that middle ear effusion and conductive hearing loss have an adverse effect on verbal skills and scholastic performance of school-age children, in particular their reading ability (p. 11).

## Screening Procedures for Hearing Loss

Screening of children for hearing loss is necessary so that data can be obtained on normative hearing levels in young children. By means of such screening, one can assess the need for early detection and for medical treatment of middle ear effusion and conductive hearing loss.

The World Health Organization advocates the use of screening tests which sort out apparently well persons who probably do not have a disease from those who probably do have the disease (Wilson & Junger, 1968). Screening tests are not intended to be diagnostic, but are aimed at early recognition and treatment of a disease process at a time when treatment will either reverse it or slow its rate of progression. Screening is therefore a type of secondary prevention. Frankenburg (1974) states that diseases to be screened for should fulfill nine criteria. The disease or condition should be:

1. Serious or potentially serious.
2. Prevalent.
3. Characterized by an acceptable criterion for diagnosis.
4. Treatable.
5. Controllable.
6. Lessened by early treatment.
7. Screened in a reasonable time.
8. Diagnosed and treated with available resources.
9. Significant enough to justify the costs and results of screening (p. 612-16).

It appears that middle ear effusion and conductive hearing loss in the school-age population meet Frankenburg's criteria for a disease that needs to be recognized early and treated.

Jaffe's findings also support the need for large-scale screen-

ing for middle ear effusion and hearing loss. He points out that undetected and untreated middle ear effusion can lead to progression of disease, which can create irreversible changes in the conductive mechanism of the ear and, in addition, may result in educational barriers (Clark, 1976, p. 97). If middle ear effusion and conductive hearing loss meet criteria as a disease to be screened, we must next determine how to accomplish this screening adequately.

### History of Hearing Screening

Until World War II, screening of hearing was primarily the job of the physician. Tuning forks, ticking watches and sound resonators were among the devices employed. Results were not specific, but significant conductive and sensorineural loss could be detected. Approximately 56,000 veterans of World War II had service-connected hearing impairment or diseases of the ear (Anderman, 1962, p. 477). Following World War II, hearing screening and detection of middle ear effusion in large adult populations began to be used. The United States Army provided the primary impetus for the screening of large numbers of people, with criteria for compensation based on the severity of service-connected hearing impairment. The Veterans Administration is credited with establishing the first audiology clinic in New York in 1946.

When electric audiometers based on pure-tone air conduction were introduced in the early 1930s, manufacturers designed their own models with features that they considered best. This initially led to confusion and uncertainty as to what values were taken as the reference



intensity levels to represent normal hearing. Here again, the Army could supply data that led to standards for audiometers. In 1951, the first standards were set by the American Standards Association (Davis, 1962). In 1964, these were replaced by international standards (International Standards Organization). In 1969, American National Standards Institute (ANSI) standards were adopted which are still employed today (see Appendix A). All large-scale hearing screenings conducted before 1969 were performed with pure-tone air and bone conduction audiometry and/or otoscopic examination by physicians. Brooks (1969) performed the first large-scale hearing screening in England by using the new impedance audiometry technique. The theory of impedance audiometry and tympanometry had been developed in the early 1900s.

#### History of the Development of Impedance Audiometry

The concept of acoustic impedance was first described and refined by A.G. Webster (1919) for research purposes (Schuster, 1934). Otto Metz (1946) was the first to apply impedance concepts clinically. Admittance and impedance measurements of the middle ear which are now used clinically can be attributed to the work of Metz (1951, 1953). The first commercially available electroacoustic impedance instrument, Madsen Z061, was developed in Denmark in 1957 on the basis of the work of Metz. Impedance was first used for research in England by Denzel Brooks in 1959. Later on, impedance audiometry was introduced in the United States, where it was first used and reported on by Zwislocki (1963). Tympanograms, the graphic illustrations of ear-

drum mobility produced with the electroacoustic meter, were first reported by Terkildsen and Thomas, who used the Madsen Z061, in 1959. From 1960 to 1970, refinements in application of tympanometry developed in England, Denmark, and the United States. It was not until 1970, however, that the first commercial impedance equipment, manufactured by the Grason Stadler Company (Grason, 1972), became available in the United States.

Impedance audiometry provides an objective measure of the mobility of the eardrum under air pressure changes artificially induced in the outer ear canal. The mobility or lack of mobility of the eardrum determines the presence or absence of middle ear effusion, which, if persistent, can dampen or block sound, resulting in a conductive hearing loss. Since middle ear effusion is responsible for 90 percent of all hearing loss in children, screening for this loss is essential (Brooks, 1978, p. 173, Brooks, 1971, 1978, 1979). Bluestone and Shurin (1974) and Howie (1977) consider impedance audiometry to be the preferred method of screening for middle ear effusion in children. Several reasons for this preference are given in the literature. Impedance audiometry has lightened the task of evaluating middle ear effusion and conductive hearing loss compared in the previous audiometric and medical techniques (Brooks, 1971, 1973, 1974, 1976, 1978a, Harford, Bess & Bluestone, 1978). The testing techniques are especially well suited for children; they are objective, accurate, quick, and easy to administer and create little discomfort for the patient (Northern & Downs, 1974). Often, children who will not cooperate with

conventional audiometric and otologic techniques do not object to impedance testing. Large numbers of children have been tested with the impedance audiometric technique. A wide variety of normative impedance test values are becoming available; however, there is little consistency between them (Jerger, 1970, 1974, 1975, Brooks, 1969, 1971, 1976, 1978a, 1978b, 1979, Paradise, 1976a, 1977, 1979). Impedance audiometry is being included as a routine testing technique in almost all otology and audiology clinics (Downs, 1977). The American Speech and Hearing Association recently developed guidelines for the use of impedance audiometry (ASHA, 1979). Adoption of consistent guidelines by persons doing impedance testing should eventually provide consistent data from various institutions.

In the 1970s, impedance audiometry was introduced as the method of choice in screening of children for middle ear effusion and conductive hearing loss. However, impedance measurement cannot as yet provide accurate assessment of sensorineural hearing loss (Brooks, 1979, p. 29), which accounts for 4.1 percent of the hearing loss in children (Hull, Mielke, Timmons & Williford, 1971, p. 501). Therefore, the question arises how one can effectively screen for hearing loss, both conductive and sensorineural, and middle ear effusion in children.

According to Brooks (1971), in the past few years the comparison of hearing screening methods in children has received much attention. He believes that emphasis has to be placed on screening procedures that will identify both hearing loss and middle ear effusion. Various

proposals have been made on the selection of tests for hearing screening (Jerger, 1970, 1972, Eagles, 1961, 1972, Ling, 1972, Renval, Lidden & Jungert, 1973, Harker & Van Wagoner, 1974, Lewis, Barry & Stuart, 1974, Ferrer, 1974, Lilly, 1974, McCandless & Thomas, 1974, Bluestone & Shurin, 1974, Orchick & Herdman, 1974, Cooper, Gates, Owen & Dickson, 1975, Brooks, 1969, 1971, 1973, 1976, 1978a, 1978b, 1979, & Paradise, 1975, 1976a, 1977, 1979). The screening methods recommended in the literature were determined in part by methods available at the time the screening was completed.

Investigators performing longitudinal studies before 1970 recommended screening by pure-tone audiometry in conjunction with otoscopic examination (Eagles, Wishick & Doerfler, 1967). Others during the 1970s advocated impedance audiometry, although they differed in their opinion as to the use of impedance audiometry in isolation or as a substitute for other clinical methods of screening (e.g., otoscopic examination). Most authors now agree that pure-tone audiometry in conjunction with impedance audiometry is adequate for the screening of hearing in children.

The question whether impedance audiometry can replace otoscopic examination has been raised. Bluestone and Cantekin (1979) have compared the findings of tympanometry and otoscopy with myringotomy findings in 239 children. They found that even experienced clinicians had some difficulty in identifying ears with effusion, and that they had even greater difficulty identifying ears without effusion. They concluded that impedance audiometry, when validated with myringotomy

findings, is as accurate as otoscopy performed by experts (p. 13). For identification of middle ear effusion, Bluestone and Cantekin (1979) recommended both otoscopy and tympanometry, suggesting that otoscopists should establish inter-observer reliability and compare their observations with myringotomy findings to insure accuracy (p. 13). This, however, is practical only in a research setting. Paradise, Smith, and Bluestone, in a (1976) study on detection of middle ear effusion, also recommended the use of tympanometry in conjunction with otoscopy for teaching purposes (p. 198). Large-scale otoscopic screenings by physicians combined with audiometric screening, have been limited by cost and available manpower (Paradise, Smith & Bluestone, 1976). In a study conducted by McCandless and Thomas (1974), 93 percent agreement was found between otoscopic examination and impedance audiometry. It thus appears that impedance audiometry (tympanometry) is at least as accurate as otoscopic examination, and it is far less costly.

Several studies have compared the accuracy of pure-tone audiometry with that of otoscopy (Eagles, 1961, Melnick et al., 1964, Brooks, 1971, Roberts, 1976). In all cases, pure-tone audiometry was found to be less accurate than otoscopic examination. McCandless and Thomas (1974) found only 61 percent agreement between the results of the two procedures (p. 102). In the Pittsburgh Study (1967), when the results of audiometric testing were compared with those of otoscopic examination, less than 50 percent of the cases of ear effusion were detected by pure-tone audiometry (Eagles et al., 1967, p. 272). This

observation is of great importance, considering that possibly as much as 90 percent of hearing loss in school-age children results from middle ear effusion rather than from sensorineural abnormalities (Brooks, 1978b, p. 173).

Thus, for hearing screening in children, it appears that impedance audiometry in conjunction with pure-tone audiometry is most effective because impedance tests for ear effusion and not only for hearing loss (Harker & Van Wagoner, 1974, p. 198).

Bluestone, Beery, and Paradise (1973) summarized the screening controversy:

Impedance audiometry cannot detect sensorineural hearing impairment and therefore cannot displace pure-tone audiometry as a screening procedure. For detection of the much more common conductive hearing losses in children, however, impedance audiometry (tympanometry) appears far more sensitive and reliable than air-conduction audiometry and equal or superior in reliability to otoscopic examination as usually carried out. The greater feasibility of impedance audiometry in combination with air conduction audiometry as compared with otoscopic examination by physician for screening large groups of children is self-evident in the cost factor alone. For these reasons, impedance audiometry (tympanometry) in combination with air conduction audiometry appears to constitute the best method presently available for detecting middle ear effusion and conductive hearing loss among populations of children (p. 604).

With pure-tone audiometry and impedance audiometry thus established as the specific tests to be included in hearing screening, we need next to consider the prevalence of hearing loss and middle ear effusion in school children with normal learning ability as well as the learning-disabled school-age child.

Prevalence of Middle Ear Effusion and Hearing Loss in Normal and Learning-Disabled School-Age Children

Studies to date on the prevalence of middle ear effusion are few and limited in scope, making it difficult to determine the prevalence of middle ear effusion (Paradise, 1976a). Few studies describe the population adequately, and few include controls for race and social class (Fay, 1970, Mc Eldoney & Kessner, 1972, Paradise, Smith & Bluestone, 1976). Case-finding methods are of uncertain sensitivity, and the methods of hearing assessment used have lacked standardization in the use of otologic, audiometric, and impedance procedures (Paradise, 1976a, p. 20-21). To date, no credible large-scale prevalence or incidence studies of middle ear effusion, performed with routine impedance testing, have been reported (Brooks, 1978a, 1978b, & Paradise, 1976a, 1979). It is known, however, that the prevalence and incidence of middle ear effusion are higher than had previously been recognized. The prevalence and incidence are higher in young children, especially during the first year of life, than in later years. The prevalence of middle ear effusion decreases after age 10 (Brooks, 1969). The prevalence of middle ear effusion in the general pediatric population is reported to range from 15 percent (Eagles et al., 1967, Paradise, 1976a) to 50 percent (Clark, 1976, Jaffe, 1977). There may be a hereditary tendency toward middle ear effusion (Proctor, 1972), and a history of previous bouts of middle ear effusion is common in children (Howie, 1975b).

Only one large-scale study was conducted in the United States

on the prevalence of hearing loss in the general population of school-age children. Three thousand school-age children were tested by pure-tone air conduction audiometry in conjunction with otoscopic examination. Eagles et al. (1967) found that 15 percent of these children were otologically abnormal (i.e., they had middle ear effusion), and 4.1 percent had sensorineural hearing loss. In a follow-up study of incidence over a five-year period, Eagles (1972) found that 24.4 percent of 1,191 children between the ages 5 and 10 years had middle ear effusion.

Results of impedance audiometry screening are just beginning to appear in the literature. Small-scale studies conducted recently by Brooks (1978a), who used impedance audiometry measurements on school-age children entering school, revealed that 33 percent had a single episode of middle ear effusion during the first year of school, lasting 4 to 6 weeks (p. 178). Only 16 percent had recurrent ear effusions (Brooks, 1978b, p. 178).

Thus, no large-scale prevalence or incidence studies have been reported to date that have employed impedance audiometry of normal school-age children (Paradise, 1976a). Brooks in England and Paradise in the United States, who have done the most extensive testing of school-age children aged 7 to 10 years, found a prevalence of middle ear effusion between 15 and 20 percent. It is possible, then, that the prevalence in learning-disabled children is even higher. Only one pilot study on middle ear effusion as a factor in learning disability by Masters (1978) in the Journal of Learning Disabilities has been



published. Masters (1978) used a combination of pure-tone and impedance audiometry to assess hearing and middle ear effusion in children classified as learning-disabled. He found a 25 percent prevalence of middle ear effusion in the learning-disabled population, compared to only 12.8 percent in his control group of normal school-age children (1978, p. 56). Freeman (in press) compared 50 children classified as learning-disabled with 32 children who had no apparent learning deficits. He found the prevalence of middle ear effusion to be almost three times greater in the learning-disabled children (p. 4). Freeman suggests that the higher prevalence of middle ear disease in children classified as learning-disabled warrants close initial screening and follow-up monitoring of their auditory function. "The correction of conductive hearing loss in these learning-disabled children, through proper medical management, may actually improve their learning disability by improving their ability to hear" (Freeman, in press, p. 6).

The two above studies suggest that the prevalence of middle ear effusion and the accompanying conductive hearing loss is greater in learning-disabled than in normal school-age children. Before the difference can be determined, more research is needed.

In view of the implications of middle ear effusion for learning, the question of whether middle ear effusion can be prevented needs to be considered. No study to date has adequately answered this question. In separate studies, sulfonamides (Ensign, Urbanick & Morgan, 1960, Perrin, Charney, MacWhinney, 1974) and ampicillin

(Maynard, Fleshman & Tschopp, 1972) administered prophylactically have been found to reduce but not prevent the number of ear infections in children who are at high risk for ear effusions. Bacterial vaccines currently under consideration offer the possibility of preventing middle ear effusion, but they are not yet available (Paradise, 1976, Howie, 1977a, 1977b). Prophylactic adenoidectomy and tonsillectomy have been suggested, but to date no conclusive results of the effectiveness of these procedures has been published. Four studies have been carried out, three in England by McKee (1963a, 1963b) and Mawson (1967), and one in New Zealand by Roydhouse (1970). In all but the second study by McKee (1963b), adenoidectomy, tonsillectomy, and adeno-tonsillectomy were considered together. A problem in all of the studies was the exclusion of seriously ill children who needed immediate surgery (Paradise, 1975). McKee (1963a, 1963b) found adenoidectomy to be effective in prevention of recurring middle ear effusion, but Mawson (1967) and Roydhouse (1970) did not. Paradise (1975) found major problems in the execution, design, diagnostic criteria, and procedures in all four of these studies.

The results of studies aimed at preventing the recurrence of middle ear effusion have been equally inconclusive. Howie (1975b) believes that aggressive drug treatment, followed, if necessary, by surgical intervention, can prevent the development of the "otitis prone condition" (p. 676), but he admits (1977) that "we do not have a vaccine, medication or surgical procedure available that can prevent the recurrence of middle ear effusion" (p. 19). Recent research

on adenoidectomy by Roukanen, Sandelin, and Makinen (1979) has suggested that early removal of adenoids (before the age of 3 years) is successful in preventing the recurrence of middle ear effusion and the "otitis prone condition" (p. 170).

Myringotomy has also been suggested as a means of preventing recurrence (Bluestone & Shurin, 1974, p. 379). Paradise (1977b) concluded that myringotomy with tube insertion is valuable in preventing the recurrence of middle ear effusion. In recommending myringotomy, he cautions that the efficacy of this procedure has not been compared systematically with prophylactic antibacterial treatment, adenoidectomy, or no treatment at all (p. 89). The criteria for undertaking an operation must therefore be individualized and should include consideration of the frequency, severity, and duration of past episodes of middle ear effusion (Roddy, Earle & Haggerty, 1966, Bluestone & Shurin, 1974). The medical reasons for doing a myringotomy in the hope of preventing recurrence of middle ear effusion must be considered carefully. Myringotomy is justified only after a trial regimen of antibacterial prophylaxis has failed and a child has had several documented bouts of middle ear effusion (Paradise, 1977b, p. 89, Matz, 1979).

Since it appears that middle ear effusion is not yet preventable, the question of whether acute middle ear effusion with or without otitis is treatable should be considered. Physicians today believe that most cases of acute middle ear effusion with or without otitis media can be treated successfully (Baron, 1972, Matz, 1979); however,

several areas of controversy exist. According to Paradise (1976b), there is disagreement as to (1) whether middle ear effusion or otitis should be treated at all, (2) the use of drugs or surgery, and (3) the timing of treatment. Little preference for any one form of treatment over the others has been reported (McKee, 1963a, 1963b, Mawson, Adlington & Evans, 1967, Roydhouse, 1970, Paradise, 1975, Mawson, 1977).

The concern for prevention, reducing occurrence, and treatment of middle ear effusion stems from the suspected relationships between hearing impairment and cognitive, language, and learning development in children (Paradise, 1977b, p. 88).

The level of hearing loss that is considered developmentally significant has been considered previously. Beasley (1940), in the first large-scale study done on the extent of hearing loss that is educationally significant, arrived at a decrease in hearing level of 35 dB (RE: ANSI, 1969). Eagles (1964) defined hearing loss that leads to an educationally handicapping problem as a 25 dB decrease in hearing (RE:ANSI, 1969) at all frequencies. Recent evidence indicates that the above reports grossly underestimate the impact of minor hearing loss on communication and learning (Holm & Kunze, 1969, Quigley & Thomure, 1970, Ling, 1972, Omer, 1972, Kaplan, Fleshman & Bender, 1973, Baum & Clark, 1973, Merluzzi & Hinchcliff, 1973, Brooks, 1974, 1976). A hearing level as slight as 15 dB in the speech frequencies (RE: ANSI, 1969) may be sufficient to lead to generalized educational retardation (Clark, 1976, p. 98, Freeman, in press, p. 4). A hearing

loss of only 15 dB (RE: ANSI, 1969), which is considered acceptable in school hearing screenings, is enough to cause language and learning problems (Northern & Downs, 1974, Needleman, 1977). It has been confirmed that severe chronic middle ear effusion and accompanying conductive hearing loss affect learning (Paradise, 1976a, 1977, Young, 1977), but language, educational, and learning concerns about children with mild hearing loss remain. Ruben (1979), summarizing the proceedings of a recent workshop on middle ear effusion and child development, states:

While the literature is not definitely clear, the participants in this workshop conclude that temporary, fluctuating, mild hearing loss (15 dB) in the developing child, most usually associated with recurrent middle ear effusion, may well have a significant effect on the child's development. The primary effect is probably on early acquisition of language skills. Indirect effects on cognition, school performance, and academic achievement which are suggested by some studies could be related to delay in the child's development. How significant a delay and the degree to which that affects a child's development probably depends on the complex interaction of compensatory mechanisms which are associated with the complex phenomena of learning.

It is apparent that the effects of temporary middle ear effusion and conductive hearing loss in the developing child are, at most, likely to be subtle. The contribution of recurrent illness, pain and discomfort to the developmental pathology is unknown. Nevertheless even subtle effects on language acquisition particularly if ultimately reflected in delayed reading skills, can contribute to a chain of delays in the education process from which he or she may never recover (p. 111).

It is thus important to determine whether middle ear effusion with accompanying mild conductive hearing loss is related to learning. Next, the educational implications of middle ear effusion need to

be considered.

#### Association Between Middle Ear Effusion and Learning Disability

Ling (1959) was the first to establish a relationship between middle ear effusion and educational retardation, and Masters (1978) was the first to find that a disproportionately high number of learning-disabled school-age children had middle ear effusion. Zinkus, Gottlieb, and Shapiro (1978) and Rapin (1979) believe that educational retardation in some school-age children is a residual complication of middle ear effusion and conductive hearing loss incurred during early childhood. According to Brooks (1976) and Bluestone (1978), the relationship between middle ear effusion and educational retardation has been well established. Paradise (1976), Harford (1977), Freeman (1977), Masters (1978), and others agree, but feel that the association is not substantial or well documented in past research.

Zinkus, Gottlieb, and Shapiro (1978) found that children with histories of middle ear effusion and otitis media appear to be more prone than other children to educational retardation. No study to date has determined the specific relationship of middle ear effusion to auditory learning disability or learning disability in general.

#### Educational Implications of Middle Ear Effusion and Conductive Hearing Loss

It has been established that receptive and expressive linguistic capabilities develop concurrently with maturation of the auditory mechanism (Lennenberg, 1967, Menyuk, 1969, Eimas, Sequel, Juszyck & Vigorito, 1972, Kavanaugh & Mattingly, 1972, Irwin, 1974, Menyuk &

Looney, 1976, Menyuk, 1979). Associated with the developmental and maturational process is the acquisition of cognitive and linguistic skills (Savin & Perchonoch, 1965, Mattingly, 1972). This relationship among hearing, language, and learning supports the contention that children with hearing loss may be delayed in the linguistic and cognitive development that is related to adequate hearing (Freeman, in press, p. 2). Bond (1935) reported a 15 percent higher incidence of reading impairment in children with histories of chronic middle ear effusion than in children with normal hearing.

Auditory processing deficits, including reduction in auditory attention, vigilance, memory, discrimination, sound blending, and closure, have been associated with the presence of conductive hearing loss in children (Chalfant & Scheffelin, 1969, Chalfant & Flat-house, 1972, Barr, 1972, Katz, 1972, Lewis, 1975).

Zinkus, Gottlieb, and Schapiro (1978) point out, in support of this suggested association, that, in children with middle ear effusion and conductive hearing loss, the processing of auditory input is deficient even though the cognitive functions remain intact (p. 1100). Disturbances in auditory reception, memory, and processing appear to interfere with the school-age child's ability to develop reading, spelling, and mathematical proficiency despite average or above-average intelligence (Myklebust, 1954, 1967, Johnson & Myklebust, 1967, Haring & Ridgeway, 1969, Zigmund, 1969, Chalfant & Flat-house, 1971).

The reason for the effect of middle ear effusion on learning and

language development needs to be considered so that the full impact of middle ear effusion on the development of auditory skills needed for language and learning can be determined. "It seems reasonable to speculate that there may exist in early life 'critical' or 'sensitive' periods during which both auditory stimuli and auditory perception must be at optimal levels if there is to be full realization of the potential for the development of language, learning and the intellectual process" (Paradise, 1977b, p. 88). If this is correct, children who develop middle ear effusion during the first few years of life may indeed fail to develop the auditory skills necessary for language and learning to occur (Lennenberg, 1967, Dale, 1972, Downs, 1975). Three of the auditory components considered necessary for language learning during the first two years of life are auditory reception, auditory association, and auditory memory (Karlin, Karlin & Gursen, 1965, Dale, 1972, Lewis, 1976).

The first two years of life are also critical for the development and maturation of the central nervous system. Freeman (in press) has hypothesized that even minor degrees of hearing loss during this period can affect the linkage of sound, as well as language development and learning. A theory of sensory deprivation proposed by Katz and Epstein (1962) and elaborated by Katz and Illmer (1972) appears to lend credence to this concept of a critical period of auditory learning (Katz, 1978, p. 879). The absence of normal auditory stimulation, due to middle ear effusion and accompanying conductive hearing loss, is likely to have an adverse effect on the anatomic develop-



ment of auditory nerve cells (Riesen, 1975, Webster & Webster, 1977, Katz, 1978). Animal studies demonstrate that the nature and amount of sensory stimulation during early life can, under certain conditions of auditory deprivation, significantly affect brain cell development and later cortical function (Greenough, 1975, p. 37, Silverman, Cloptan & Flameno, 1975, p. 554, Webster & Webster, 1977, p. 392). In 1964, Myklebust pointed out that auditory sensory deprivation could distort the integration of mental abilities, and that certain middle ear disorders do not encourage development of the mechanisms in the brain necessary for efficient listening strategies. According to Jaffe (1977), the development of linguistic centers of the brain is affected by conductive hearing loss. Jaffe was quoted in a recent interview in Newsweek as saying "if a child suffers even a minor degree of hearing loss during the critical auditory development time of the nervous system, the nerve pathways that link sound to language and learning will fail to form normally and some permanent linguistic impairment resulting in an auditory learning disability may occur" (Clark, 1976, p. 97). Holm and Kunze (1974) suggest that "the lack of stimulation (auditory), during a critical period of development [first two years] results in reduced function of the developing sensory organ, not only at the time of deprivation but throughout the life of the organism" (p. 839).

The hypothesis of a critical period in auditory development is supported by available data on children which suggest that even relatively mild conductive hearing losses (15 dB RE: ANSI, 1969) result-

ing from middle ear effusion in early childhood may cause learning disabilities during school age (Fry, 1966, Holm & Kunze, 1969, Fry, Dillane, Jones, Kalton & Andrew, 1969, Hamilton & Orwick, 1974, Lewis, 1976, Jaffe, 1977, Rapin, 1979).

### Summary

In the review of the literature, six areas relevant to the understanding of this study have been examined by the researcher. An understanding of the development of the study of middle ear effusion laid the groundwork for associating it with conductive hearing loss. The history of the development of impedance audiometry, a method used in this study, was developed in relationship to its use in detecting middle ear effusion. The credibility for impedance audiometry as the testing method of choice in the school-age child was suggested.

Published reports are inconsistent and inconclusive regarding the prevalence and incidence as well as the persistence of middle ear effusion in normal as well as learning-disabled school-age children. The prevalence of middle ear effusion, however, is considered in a limited number of studies to be higher in learning-disabled school-age children than in normal children.

The level of hearing loss that is educationally significant has not been clearly established in the literature. It does appear to be less than was previously expected and may be as low as 15 dB (RE: ANSI, 1969).

An association between middle ear effusion and learning disability has been suggested by Masters, Zinkus et al. and Freeman; the

research to date, however, is not considered adequate to substantiate this. Middle ear effusion is more closely linked with children who have auditory learning disabilities than with children who have learning disabilities in general. Specific areas of auditory reception, processing, and memory are known to be reduced in school-age children with middle ear effusion. The occurrence of middle ear effusion during the first two years of life appears to be especially significant in affecting later auditory development necessary for learning.

In the next chapter, the design and procedures used for closer evaluation of the relationship between suggested middle ear effusion and several measures of auditory learning disability in school-age children are developed. In this research, the investigator hoped to establish an association between the two. The study design and procedure were, in part, selected and developed from the six areas examined in the literature review.

## CHAPTER III

### DESIGN AND PROCEDURE

#### Statement of Purpose

This study was designed as an investigation of the relationship between the suggestion of middle ear effusion and several measures of auditory learning disability in an auditory learning-disabled group and a comparison group of school-age children with average or above-average intelligence.

#### Working Definitions

Middle ear effusion is defined as fluid in the middle ear space (Paparella, 1976, p. 8). This fluid results in reduced conduction of sound to the sense organ (inner ear). Effusion in the middle ear is the most common cause of conductive hearing loss (Brooks, 1976, p. 223, Feldman & Wilbur, 1976, p. 177). The presence of effusion can be suggested and substantiated through clinical evaluation with four audiometric procedures: air conduction audiometry, bone conduction audiometry, impedance audiometry, and acoustic reflex testing (Bluestone, Beery & Paradise, 1973, p. 604, McCandless & Thomas, 1974, p. 102, ASHA Guidelines, 1979, p. 283). These four procedures must be used in combination since no one procedure enables one to rule out hearing loss (Brooks, 1976, p. 223-24, Feldman & Wilbur, 1976, p. 345, Paradise, Smith & Bluestone, 1976, p. 210).

Air conduction audiometry measures sound waves transmitted through

the outer ear via the ear canal to the middle ear, then to the inner ear and to the brain. Sounds at various calibrated intensities and frequencies are introduced through ear phones from an audiometer. The patient's responses to these sounds are recorded as an audiogram. An air conduction loss of 15 dB or more was considered significant for this study.

In bone conduction audiometry, sound waves are transmitted through the bones of the skull directly to the inner ear and to the brain. For recording of sound vibration a bone oscillator is placed behind the ear, and various calibrated sound levels and frequencies from an audiometer are introduced.

The difference, measured in decibels (sound volume), between a child's hearing via air conduction and that via bone conduction is significant in determining the presence or absence of a conductive hearing loss. This difference is clinically referred to as an air-bone gap. An air-bone gap of 10 dB or more in combination with other positive auditory test results is considered clinically significant; i.e., if a child hears better by 10 dB through bone than through air conduction, something is blocking sound conduction by air. Middle ear effusion is the probable cause of the observable sound blockage, which is apparent on the audiogram as the air-bone gap (Sweitzer, 1977). An air-bone gap of 10 or more dB was considered significant for this study.

Impedance audiometry, or tympanometry, is a procedure for objec-

tive measurement of eardrum mobility under air pressure changes artificially induced in the external ear canal. In the presence of middle ear effusion, the eardrum either is unable to move or moves less than under normal conditions. In order to measure impedance, a plug is placed in the child's ear canal, producing a seal by creating a negative pressure. A probe which contains three holes provides (a) a 220 Hz tone from an oscillator, (b) air pressure from a pump and manometer, and (c) a pick-up microphone for comparison of the sound pressure level in the cavity between the eardrum and probe tip at the reference voltage of the impedance bridge. The mobility of the eardrum is then recorded on a tympanogram. A tympanometric configuration with a pressure peak of  $\pm 150\text{mm H}_2\text{O}$  or greater was considered the cut-off point for possible failure (see Figure 1 for a diagram of the impedance set-up).

Another diagnostic procedure in the diagnosis of middle ear effusion is acoustic reflex testing. Acoustic reflexes are the changes in the stiffness of the eardrum that occur as a result of the contraction of the stapedius muscle. The sound pressure level at which the eardrum contracts, as well as the presence or absence of contraction, provide information on middle ear effusion and conductive hearing loss. Absent tympanic reflexes at frequencies of 500-4000 Hz with contralateral stimulus presentation were considered significant for this study. The combination of results from these four audiometric procedures provides diagnostic data that suggest the presence

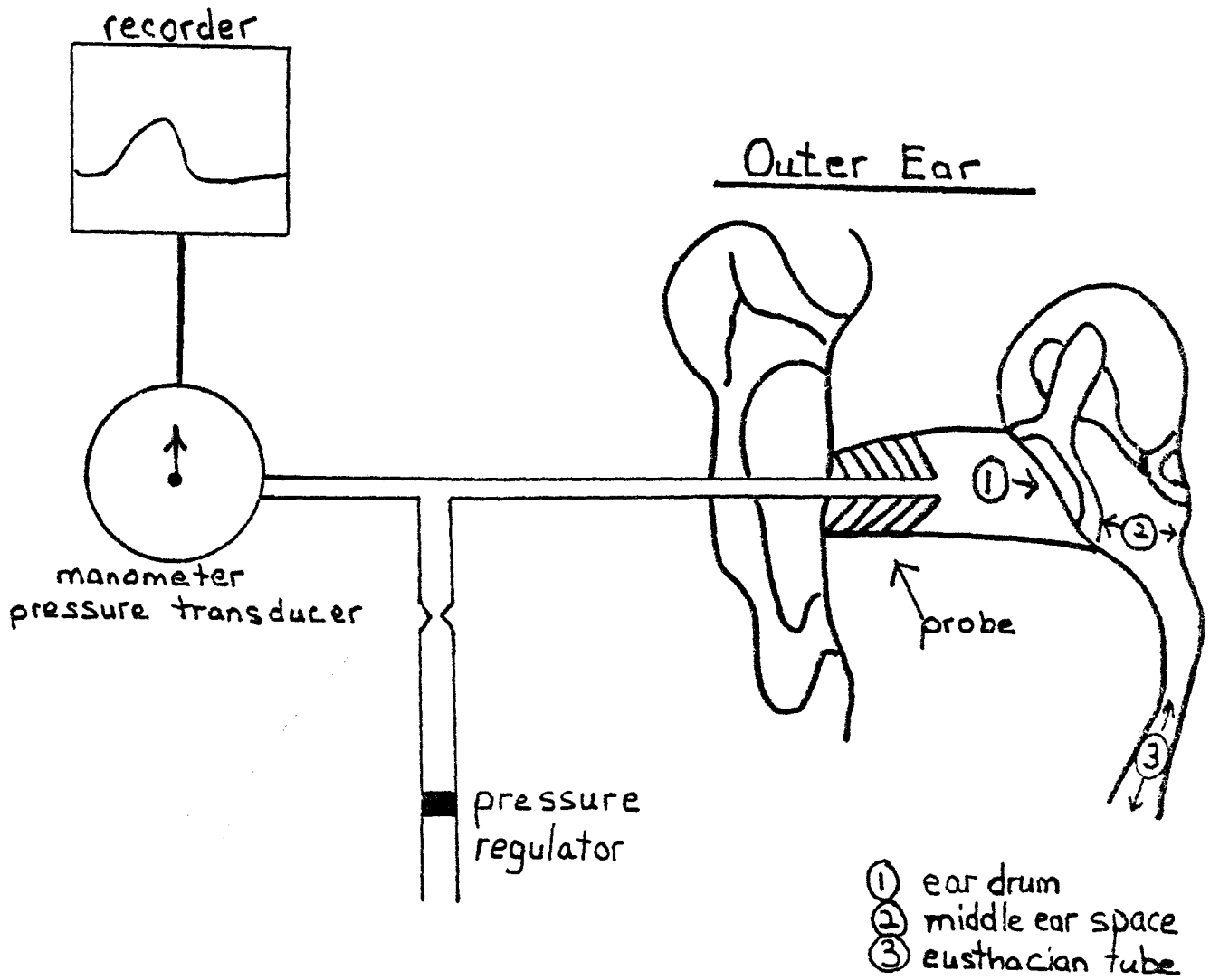


Figure 1. Diagram of experimental set up for impedance audiometry.

or absence of middle ear effusion. Middle ear effusion is well defined clinically. The results of the four audiometric procedures are such that any trained, certified audiologist would reach the same diagnostic conclusion as to the presence or absence of middle ear effusion.

#### Reliability of Audiometric Testing Procedures

In support of the above statement, the 16 possible combinations of test results from administration of the four audiometric procedures were scored independently by two audiologists for suggestion of middle ear effusion. The conclusions of the two audiologists were in agreement (see Appendix A).

#### Auditory Learning Disability

Auditory learning disability is defined as a deficiency in learning through the auditory channel in spite of average or above-average intelligence, in the absence of gross sensory (end organ) deficits or severe emotional problems (Johnson & Myklebust, 1967). For the purpose of this study, auditory learning disability was determined by scores on the auditory subtests of the Illinois Test of Psycholinguistic Abilities (ITPA) and the Peabody Picture Vocabulary Test. According to Kirk (1962) and Kirk, McCarthy, and Kirk (1968), auditory learning breakdown can occur at three levels: receptive, associative, or expressive. Three measures of auditory learning disability are auditory reception, auditory-vocal association, and auditory-sequential memory. These are assessed by standard scores on the auditory subtests of the Illinois Test of Psycholinguistic Abili-



ties (see Test Manual).

### Reliability and Validity of the Illinois Test of Psycholinguistic Abilities

The validity and reliability of the three auditory subtests used in this study, auditory reception, auditory-vocal association, and auditory-sequential memory, are discussed below.

Auditory Reception Subtest. Reliability and validity studies show high internal consistency in the auditory reception subtest. The median coefficient is .95 for all age groups (Paraskevopoulos & Kirk, 1969, p. 31). Test-retest reliability coefficients over a five-month period are .63 for eight-year-olds. Difference scores between auditory reception and other subtest scores on the Illinois Test of Psycholinguistic Abilities show median reliabilities ranging from .77 to .91 (Paraskevopoulos et al., 1969, p. 32). The median correlations of the auditory reception subtest with other subtests ranged from .12 to .50. The highest intercorrelations are with tests at the representational level, particularly with the auditory-vocal association subtest (Paraskevopoulos et al., 1969, Table 11-1, p. 186).

Auditory-Vocal Association Subtest. Internal consistency in the auditory-vocal association subtest has a range from .86 to .94 among eight age groups. The five-month test-retest reliability is the highest for this subtest, .83 for eight-year-olds. Difference scores between auditory-vocal association and other subtests of the ITPA show median reliabilities of .67 to .88. The median intercorrelations of the auditory-vocal association subtest range from .22 to .54

(Paraskevopoulos et al., 1969, p. 35). Intercorrelation between auditory-vocal association and auditory reception is high, .52 (Paraskevopoulos et al., 1969, Table 11-1, p. 186).

Auditory-Sequential Memory Subtest. The median internal consistency coefficient for this subtest was .90 for eight age groups (Paraskevopoulos et al., 1969, Table 7-3, p. 103). Five-month test-retest reliability for eight-year-olds is .89 (Paraskevopoulos et al., 1969, p. 45). Difference scores between auditory-sequential memory and other subtests have median reliabilities ranging from .83 to .91 (Paraskevopoulos et al., Table 7-6, p. 111). Intercorrelations of auditory-sequential memory with other subtests range from .06 to .28. It appears that this test emerges as an independent factor of the battery, since its correlation with the other tests is negligible (Paraskevopoulos et al., 1969, p. 45, Table 11-1, p. 186).

The population and norms of the ITPA make it an appropriate test for the subjects in this study. The Illinois Test of Psycholinguistic Abilities was normed on 962 English-speaking children from 17 Illinois schools and one Wisconsin school. The mean I.Q. of the children was 100. The male-to-female ratio was one to one, and 4 percent of the study population were black. The socioeconomic status of the children was middle-class (see ITPA Test manual).

Auditory reception, auditory-vocal association, and auditory-sequential memory are measured as follows according to the test manual of the Illinois Test of Psycholinguistic Abilities (Kirk et al., pp. 8-10):

### Auditory Reception

The child's ability to derive meaning from verbally presented material is measured by requiring the subject to answer yes or no questions (i.e., Do boys play? Do dogs fly? etc.).

### Auditory-Vocal Association

The child's ability to relate, organize and manipulate auditory symbols in a meaningful way is measured by a sentence completion technique (i.e., I pound with a \_\_\_\_\_. A dog has hair. A fish has \_\_\_\_\_. etc.).

### Auditory-Sequential Memory

This test evaluates the child's ability to reproduce a sequence of auditory stimuli from memory. Auditory memory is measured by having the child repeat a series of numbers after the examiner (i.e., 3-1-6, 3-4-6-2, 6-3-2-8-1, etc. increasing in length).

Scores obtained in the above subtests are translated into scaled scores for interpretation. Kirk et al. (1968) determines the significance of scaled scores on the auditory subtests of the ITPA according to how they deviate from the average mean (36). A difference of  $\pm 7$ ,  $\pm 8$ , or  $\pm 9$  points between the average mean of the scaled scores and the subtest scaled scores is considered a borderline discrepancy. A plus or minus difference of 10 or more points between the average mean of the scaled scores and the subtest scaled scores is considered a significant discrepancy. For the purpose of this study, borderline as well as significant discrepancies in auditory subtests were considered to be indicators of auditory learning disabilities.

The Illinois Test of Psycholinguistic Abilities was administered as part of a Learning Disabilities evaluation at Holy Cross Hospital in Chicago. The above-mentioned auditory subtests were administered

to both the experimental and the comparison group. All testing was done by three experienced clinicians with master's degrees who were certified in learning disabilities. All were on the staff of the Department of Communicative Disorders at Holy Cross Hospital.

The Peabody Picture Vocabulary Test was also administered to both experimental and comparison groups, as part of the work-up for auditory learning disabilities, by the learning disability specialists at Holy Cross Hospital. The Peabody Picture Vocabulary Test was "designed to provide an estimate of a subject's verbal intelligence through measuring the client's hearing vocabulary" (Dunn, 1965, p. 25). It was included in the test battery for auditory learning disabilities because it measures an auditory skill (hearing vocabulary) and is highly correlated with the Wechsler Intelligence Scale for Children, the test used to assess the intelligence level of both the experimental and the comparison groups in this study (Dunn, 1965, p. 41).

#### Reliability and Validity of the Peabody Picture Vocabulary Test

The Peabody Picture Vocabulary Test was standardized on 4,012 children attending Nashville Tennessee schools. Reliability coefficients for raw scores of children aged 7 through 10 years range from .74 to .79 (Dunn, 1965, p. 30).

The reliability of information on the Peabody Picture Vocabulary Test was reported by Dunn (1965, Table 7, p. 31). Coefficients of equivalence and temporal stability were found to be satisfactory both for average children and for those who have physical, mental and emotional

disabilities (Dunn, 1965, p. 32).

Validity data for the Peabody Picture Vocabulary Test for individual test items, as well as for the total test, are given in the test manual. Content validity was built into the test through use of the Webster New Collegiate Dictionary. Only those words that could be illustrated by picture were chosen (Dunn, 1965, p. 32). Item validity was established by selection of individual words where the percentage of subjects passing increased from one age group to the next (Dunn, 1965, p. 33). The median congruent validity of the Peabody Picture Vocabulary Test when compared with the Binet intelligence test was .71. The congruent validity of the test compared acceptably with the Peabody Picture Vocabulary Test. The congruent validity between the verbal and full scale scores of the Wechsler Intelligence Scale for Children (WISC) was significantly higher than the performance scores when compared with the Peabody Picture Vocabulary Test intelligence scores. The median congruent validity for the Wechsler verbal score was .67, for the full scale, .61, and for the performance, .39, as compared with the Peabody Picture Vocabulary Test intelligence scores (Dunn, 1965, p. 33). The Peabody Picture Vocabulary Test intelligence score appears similar to the Wechsler intelligence scores (Kimbrell, 1960, p. 502, Himelstein & Herndon, 1962, p. 82). According to Dunn (1965), the Peabody Picture Vocabulary Test intelligence scores correlate better with the Wechsler than with the Binet intelligence scores (p. 41).

## Intelligence

In this study, intelligence is an important variable for school-age children. School-age children are defined in this study as children between the ages of 7 years and 10 years 3 months inclusively. Average or above-average intelligence of a child was determined in this study by scores on the Wechsler Intelligence Scale for Children-Revised (WISC-R). Verbal and performance scores were computed from subtests administered to each child. The full-scale score is the sum of the verbal and performance scores on the WISC-R. A full-scale score falling within one standard deviation of the mean is considered average. Any score above one standard deviation from the mean (average mean is 100) is considered above-average. Any children with average or above-average (a score of 90 or above) intelligence on the WISC-R were considered acceptable for this study in that they met the criteria of learning-disabled as well as normal school-age children having average or above-average intelligence. The WISC-R was administered to all children in the experimental and comparison groups and the verbal and performance as well as full-scale scores were recorded.

## Reliability and Validity of the Wechsler Intelligence Scale for Children

The WISC-R was administered by two Ph.D.-trained, licensed, experienced clinical psychologists, employed by the Department of Communicative Disorders of Holy Cross Hospital. Intelligence testing for both the experimental and comparison groups was done by the same examiners.

The examiners were not aware, prior to testing, whether the children being evaluated were in the experimental or the comparison group. The WISC-R was standardized by David Wechsler on 11 age groups of normal children, with 200 children in each of the groups. An equal number of boys and girls were included in each group, as were whites and non-whites from four geographic regions as specified in the 1970 U.S. Census report (Wechsler, 1974, p. 17). The groups of children used in the standardization of the WISC-R were also matched for socioeconomic status; they included five groups based on the educational and occupational level of the father. All children tested had to speak and understand English (Wechsler, 1974, pp. 18-19).

Reliability coefficients of the WISC-R ranged from .91 to .94 on the verbal I.Q. subtest, from .89 to .91 on the performance subtest, and from .95 to .96 on the full-scale score (Wechsler, p. 27). Another aspect of the reliability of a test is its stability over time. The stability coefficient for the verbal I.Q. was .90, that for the performance I.Q., .90, and that for the full-scale I.Q., .94 (Wechsler, p. 29). Coefficients of correlation of I.Q. scores on the WISC-R with I.Q. scores on the Stanford-Binet test (Form L-M, 1972 norms) were computed. The average coefficients of correlation of the WISC-R verbal, performance, and full scale I.Q.'s with the Stanford-Binet I.Q. are .71, .60, and .73, respectively (Wechsler, p. 51). These values are similar to those obtained in several studies involving the Stanford-Binet and the 1949 WISC (Zimmerman & Woo-Sam, 1972, pp. 14-17).

## Method and Procedures

Data for this study were collected by this researcher from the case records of children who received learning disability evaluations in the Communicative Disorders Department at Holy Cross Hospital. The clients were evaluated between January 1, 1979, and December 31, 1979. This examiner recorded data on each subject from individual case records. Case records were coded to assure only group identity of subjects and to allow a later recheck of the data. A permission/information release form was signed by the parents of all children who participated in this study. Each subject was tested for two mornings by three testers; the psychologist and audiologist tested one morning and the learning disability specialist, the second morning. The examiners felt that the children would become fatigued if all testing were conducted in one sitting. The average time for psychological evaluation was from 1 to 1½ hours. Audiologic testing required 20 to 30 minutes. The learning disability evaluation, which included the auditory subtests of the Illinois Test of Psycholinguistic Abilities and Intelligence quotient of the Peabody Picture Vocabulary Test, took about 2 hours. Testing of each subject was completed within seven days. All testing was done at Holy Cross Hospital to insure that the environmental and noise conditions were the same for all subjects. The same test procedures and equipment were used for all subjects. The learning status of a child was not known to the evaluators prior to testing. All audiologic equipment was calibrated daily and checked to meet the American Speech and Hearing Association (ASHA)



standards.

Tests were administered as follows to both experimental and comparison groups:

1. The audiologists carried out four audiometric procedures: air conduction audiometry, bone conduction audiometry (to determine the air-bone gap), impedance audiometry (tympanometry), and acoustic reflex testing.
2. The psychologists administered the Wechsler Intelligence Scale for Children-Revised, obtaining verbal, performance and full scale scores.
3. The learning disability specialists administered the Peabody Picture Vocabulary Test and three auditory subtests from the Illinois Test of Psycholinguistic Abilities (auditory reception, auditory-vocal association, and auditory-sequential memory).
4. This researcher used the Hollingshead Two-Factor Index of Social Position to determine the social class level of all subjects in the experimental and comparison group. (Information pertaining to the father's occupational and educational level was taken from case history forms in the subject's folder.)

It was determined by these test procedures which school-age children were included in the experimental and comparison groups.

### Subject Selection

The experimental group in this study consisted of 30 children randomly selected from 32 children evaluated between January 1, 1979, and December 31, 1979 and diagnosed as auditory-learning-disabled. Diagnosis of auditory learning disability was based on the results of the administered test battery described. All subjects received the entire ITPA although the auditory subtest scores were used exclusively in this study. Children found to have visual and/or motor learning disabilities based on reduced visual and motor subtest scores of the ITPA were eliminated from this study. All subjects in the ex-

perimental group had average or above-average intelligence as measured in this study; they were between 7 years and 10 years 3 months old. The experimental group had a sex ratio of seven boys to every girl. This preponderance of males in the learning disability population has been reported previously (Lerner, 1976, p. 12) (see Table 1). The average and median social class position of the experimental group was IV (lower middle class) as determined by the Hollingshead Two-Factor Index of Social Position (1957) (see Appendix B). (For a complete listing of social class position of the families of children in the experimental group, see Table 2.)

This study was not controlled for race or ethnicity; however, the experimental group in this study consisted of black as well as white children of varied ethnic backgrounds. The majority of the subjects in the experimental group were white. The predominant ethnicity of the white children was Polish and Lithuanian. All subjects in the experimental group were second-generation English-speaking Americans. (For a complete breakdown of the racial and ethnic make-up of the experimental group see Table 3.)

The children in the experimental group were referred for a learning disability evaluation by physicians, teachers, parents, and various agencies. All children in the experimental group were seen as out-patients except for those referred by psychiatrists. The two children in the experimental group admitted to Holy Cross Hospital for a three-day period had learning and psychological testing as part of a medical work-up so that possible brain dysfunction could be eval-

TABLE 1

The Sex Ratio of Auditory-Learning-Disabled Group and  
a Comparison Group of School-Age Children

	Auditory-Learning- Disabled Group	Comparison Group
Boys	26 (87%)	25 (83%)
Girls	4 (13%)	5 (17%)
Column Total	30	30

\* The literature substantiates a higher ratio of boys to girls  
in the learning-disabled population.

TABLE 2

Listing of Social Class Position of Auditory-Learning-Disabled Group and a Comparison Group of School-Age Children

Social Position	Auditory-Learning-Disabled Group	Comparison Group
Class I	3	2
Class II	1	2
Class III	3	4
Class IV	18	17
Class V	5	5
Total	30	30

TABLE 3

Racial and Ethnic Background of Auditory-Learning-Disabled Group  
and Comparison Group of School-Age Children

Racial and Ethnic Background	Auditory-Learning-Disabled Group	Comparison Group
White*	18	17
Black	6	8
Spanish	2	3
Other:		
Indian (American)	1	
Japanese (American)	1	
Filipino (American)	1	1
Arabian (American)	1	1
Column Total	30	30

\*A breakdown of the major ethnicity of the white subjects in the auditory-learning-disabled group and comparison group of school-age children.

	<u>Auditory-Learning-Disabled Group</u>	<u>Comparison Group</u>
White	18	17
Polish (American)	6	5
Lithuanian (American)	4	6
Irish (American)	4	3
Italian (American)	1	1
Croatian (American)		1
Serbian (American)	1	
Hungarian (American)	1	
Undetermined	1	

uated. (For a complete listing of referral sources of children in the experimental group, see Table 4.)

There were several reasons given for referral of these children: (1) difficulty learning in school, (2) lack of motivation, (3) general interest in the learning and/or psychological potential of the child, and (4) ruling out minimal brain dysfunction.

The comparison group in this study also included 30 subjects randomly selected from a group of 33 children evaluated in the Department of Communicative Disorders at Holy Cross Hospital between January 1, 1979, and December 31, 1979, and found not to have a learning disability. The children in the comparison group were of the same age and intelligence level as the children in the experimental group. The comparison group had a male to female ratio similar to that of the experimental group (see Table 1). The average and median social class position of the comparison group was equal to that of the experimental group. (For a complete listing of social class position of the families of children in the comparison group, see Table 2.)

The comparison group in this study consisted of black as well as white children of varied ethnic backgrounds. The majority of the subjects in the comparison group were also white. The predominant ethnicity of the comparison group was Polish and Lithuanian. All subjects in the comparison group were second-generation English-speaking Americans. (For a complete breakdown of the racial and ethnic make-up of the comparison group, see Table 3.)

TABLE 4

Referral Sources for Auditory-Learning-Disabled Group and a  
Comparison Group of School-Age Children

Referral Source	Auditory-Learning-Disabled Group	Comparison Group
Physicians	15	13
Family (G.P.)	2	4
Neurologist	5	3
Psychiatrist	2	3
Otologist	4	2
Pediatrician	2	1
Teachers	9	4
Parents (foster)	4	8
Others*	2	5
Column Total	30	30

<u>*Others - Auditory-Learning-Disabled</u>	<u>Comparison Group</u>
1 - St. Xavier College	1 - School Speech Therapist
1 - Social Worker-Abraham Lincoln School of Medicine	1 - School Psychologist
	1 - Head Start Social Worker
	1 - Greater Lawn Mental Health
	1 - DePaul University Psycho-Education Clinic

The children in the comparison group were referred from the same sources as were the children in the experimental group. The comparison group children were seen as out-patients except for three admitted by psychiatrists. The three in-patient children used in the comparison group were also admitted to Holy Cross Hospital for a three-day period to have learning and psychological testing as part of a medical work-up so that possible brain dysfunction could be evaluated. (For a complete listing of the comparison group referral sources, see Table 4.)

Reasons for referral in the comparison group remained consistent with those stated in the experimental group.

The data collected in this study were analyzed by computer by means of the Statistical Package for the Social Sciences Programs and SOUPAC. Use of packaged programs insures that the procedure is mathematically correct, that the design is efficient, and that the evaluation is comparable to the way in which social scientists approach data analyses (Nie, Hull, Jenkins, Steinbrenner & Bent, 1970).

### Statistical Hypotheses

Four hypotheses on the relationship between suggested middle ear effusion and auditory learning disability were formulated for testing in this study. The level of significance at which the four hypotheses were accepted or rejected was set at .05.

Hypothesis I Auditory learning disability and the prevalence of middle ear effusion are statistically independent.



Subhypothesis There is no association between auditory learning disability and middle ear effusion.

To test the above hypothesis, this researcher used a chi-square goodness-of-fit test. Chi-square goodness-of-fit, a test of statistical significance, helps determine whether a systematic relationship exists between two variables (Isaac & Michael, 1971, p. 116). The variables of the first hypothesis are auditory learning disability (dependent) and middle ear effusion (independent). For testing of the subhypothesis, a measure of association, phi, was used, which indicates the strength of relationship between the variables of auditory learning disability and middle ear effusion. Phi indicates to what extent prior knowledge of a cases value on one variable (middle ear effusion) enables one to predict the cases value on the other variable (auditory learning disability) (Nie et al., 1970, p. 224). Contingency and uncertainty coefficients were also determined. Contingency coefficients measure predictive association (Hays, 1973, p. 745), whereas the uncertainty coefficient determines the proportion by which "uncertainty" in the dependent variable is reduced by knowledge of the independent variable (Theil, 1967, pp. 33-35, Nie et al., 1970, p. 226).

The population used for the test of Hypothesis I met the requisite of a chi-square goodness-of-fit test that one sample is divided into categories from which a sample is randomly selected. Middle ear effusion was measured on a nominal scale. The categories for suggestion of middle ear effusion are two: present (yes) and absent (no) (see Appendix A for a listing of this division). Auditory reception, audi-

tory-vocal association, and auditory-sequential memory are also divided into two categories; one is greater than or equal to 36 (the average test score); the other is less than 36.

- Group II Hypotheses
- 2A. There is no correlation between middle ear effusion and auditory reception.
  - 2B. There is no correlation between middle ear effusion and auditory-vocal association.
  - 2C. There is no correlation between middle ear effusion and auditory-sequential memory.

For the Group II hypotheses, this researcher used a biserial correlation, which computes a coefficient of correlation between a continuous variable (auditory learning disability) and a variable that is considered dichotomous, that is, one which can be classed in only two categories. In this part of the study, suggestion of middle ear effusion was considered the artificial dichotomy since the cut-off points between present and absent were arbitrarily set. These cut-off points used in combination to suggest middle ear effusion are widely agreed upon in the audiology literature (Feldman & Wilbur, 1976, Feldman, 1976, Brooks, 1978, Harford, Bess, Bluestone & Klein, 1978, Paradise & Smith, 1979). (For an explanation of the cut-off points used in the audiometric test battery carried out in this study, see pages 47 and 48).

The measures of auditory learning disability — auditory reception, auditory-vocal association, and auditory-sequential memory — are continuous, being made up of set scores (between 1 and 60) (Siegel, 1956, p. 213-23, Isaac & Michael, 1971, p. 126). In the Group II hypotheses,

these measures of auditory learning disability are the dependent variables and middle ear effusion is the independent variable.

Hypothesis III There is no linear relationship between auditory-sequential memory and the following independent variables: middle ear effusion, auditory reception, auditory-vocal association, Peabody Picture Vocabulary Test Intelligence quotient, Wechsler verbal scale score, and Wechsler performance scale score.

To assess the relationship in Hypothesis III, this researcher used a multiple-regression technique, the Statistical Package for Social Sciences (SPSS) Multiple Regression Program with a dummy variable. The dependent variable chosen for this hypothesis was auditory-sequential memory; the independent variables were middle ear effusion, auditory reception, auditory-vocal association, Peabody Picture Vocabulary Test Intelligence quotient, Wechsler verbal scale score, and Wechsler performance scale score.

The dependent and independent variables met the criteria for a multiple regression analysis: (1) the variables are normally distributed and (2) have interval level data. Middle ear effusion was used as the dummy variable since it could not meet the criteria for multiple regression, being below interval level data (Nie et al., 1970, pp. 373-76).

Hypothesis IV History of middle ear effusion and auditory learning disability are statistically independent.

Subhypothesis There is no association between a history of middle ear effusion and auditory learning disability.

To test Hypothesis IV, this researcher again used a chi-square goodness-of-fit test to determine whether a systematic relationship exists between auditory learning disability (dependent variable) and a history of middle ear effusion (independent variable). For testing of subhypothesis IV, the phi statistic was used to determine how strongly the two variables, a history of middle ear effusion and auditory learning disability, were associated. Contingency and uncertainty coefficients were also determined.

The limitations of this hypothesis were, first, that the history data given by parents about their children could be inaccurate, and second, that the number of episodes of middle ear effusion was not recorded. For this study, the history of prevalence was determined by having parents answer yes or no to the question "Does your child have a history of middle ear effusion?" Since middle ear effusion is often asymptomatic, parents could not be expected to know when effusion had occurred. Parents responded "yes" to the question of previous middle ear effusion if their child had complained of an earache or if their pediatrician had noted ear effusion on routine medical examinations and related this finding to them. The course of middle ear effusion was not followed regularly by parents or pediatricians once it was detected. Thus, the frequency and/or duration of middle ear effusion of children in this research could not be accurately determined by the set method of data collection. Knowing the incidence and duration of episodes of middle ear effusion has been suggested as important in predicting the degree of auditory learning disability. These data should be collected

later over regular intervals through hearing re-tests of the subjects in this research.

### Summary

This chapter dealt with the statistical hypotheses, subject selection, data collection, research instruments, description of the subjects, and the statistical methods used.

The four hypotheses stated in Chapter I were restated in statistical terms.

Chapter IV consists of the analysis of the data and results.

## CHAPTER IV

### ANALYSIS OF THE DATA AND RESULTS

#### Introduction

This study was designed as an investigation of the relationship between middle ear effusion and several measures of auditory learning disability in school-age children with average or above-average intelligence. The history of middle ear effusion and its relationship to auditory learning disability was also investigated in this study.

#### Hypothesis I

The first statistical hypothesis concerns the relationship between auditory learning disability and the prevalence of middle ear effusion.

Hypothesis I Auditory learning disability and the prevalence of middle ear effusion are statistically independent.

Subhypothesis There is no association between auditory learning disability and middle ear effusion.

The investigation used a chi-square statistic to test the above hypothesis, to determine whether auditory learning disability and middle ear effusion are distributed identically throughout the population. The coefficients in the chi-square statistic assess the strength of association. If the hypothesis of independence can be rejected, then we can say that the attributes of auditory learning disability and middle ear effusion are statistically related or associated (Hays, p. 729). In testing for independence (i.e., the lack of sta-

tistical association) between auditory learning disability and middle ear effusion, the table in which the entire set of data is shown is referred to as a contingency table (see Table 5).

The chi-square statistic is written as:

$$\chi^2 = \sum_j \sum_k \frac{(f_{ojk} - f_{ejk})^2}{f_{ejk}}$$

where:

$f_{ojk}$  = observed frequency  
in cell  $jk$   
 $f_{ejk}$  = expected frequency  
in cell  $jk$

with degrees of freedom =  $(r-1)(c-1)$   
where  $r$  = number of rows  
 $c$  = number of columns

Table 5 illustrates the data for which the chi-square statistic was computed to test hypothesis I for the experimental group and the comparison group. A chi-square value of 15.27148 with one degree of freedom was obtained. This was found to be statistically significant at the .0001 level. Thus, the computed chi-square value statistic showed that auditory learning disability and the prevalence of middle ear effusion are systematically related. The null hypothesis was rejected. Thus, it can be said that auditory learning disability and middle ear effusion are related somehow, although it is not clear from this test how or how strongly. A phi statistic was used to determine the strength of relationship between these two variables.

The formula for  $\phi$  is

$$\phi = \sqrt{\frac{\chi^2}{N}}, \text{ where } N = 60$$

(Hays, p. 743).

TABLE 5

## Contingency Table

The Prevalence of Middle Ear Effusion in Auditory-Learning-Disabled Group and a Comparison Group of School-Age Children

	Middle Ear Effusion	
	No	Yes
Auditory-Learning-Disabled Group	9 (30%)	21 (70%)
Comparison Group	25 (83%)	5 (17%)
Column Total	34	26

$\chi^2 = 15.27148$ . Significant at .0001 level.



Phi can be zero only when two variables are completely independent. However, when there is complete association,  $\phi = 1$ . The computed phi statistic was .53814, indicating a moderate association between auditory learning disability and middle ear effusion. The significance of the phi coefficient was computed at three levels using the following formula:

$$\phi(.05) = \frac{1.96}{N} = .25$$

$$\phi(.01) = \frac{2.58}{N} = .33$$

$$\phi(.001) = \frac{3.20}{N} = .41$$

(Hays, p. 743).

Phi was found to be significant at the .001 level. In other words, there is a one in one thousand chance that the relationship found between middle ear effusion and auditory learning disability is due to chance alone (see Table 6).

The contingency coefficient a measure of predictive association, was also computed. The formula

$$c = \left( \frac{\chi^2}{2 + N} \right)^{\frac{1}{2}} \quad (\text{Nie et al., p. 225})$$

yielded a contingency coefficient of .47388, indicating a slightly lower predictive strength of association between auditory learning disability and middle ear effusion than the actual strength of association computed with the phi statistic. A t-test was done to determine the level of significance of the contingency coefficient. The contingency coefficient was found to be significant at the .002 level

TABLE 6

Significance of the Strength of Relationship Between Middle Ear  
Effusion and Auditory-Learning Disability

Strength of Relationship		Level of Significance	
Levels of significance of phi	Value needed to reject $H_0$ at specified level	Phi obtained	Reject at .05
.05	.25	.53814	Yes
.01	.33	.53814	Yes
.001*	.41	.53814	Yes

\*Phi statistic significant at the .001 level.

when the two-tailed t-test was used (see Table 7).

An asymmetric uncertainty coefficient was also computed for the data. The formula used for this computation was:

$$\text{Uncertainty coefficient} = \frac{U(Y) - U(Y/X)}{U(Y)},$$

where

X = dependent variable  
Y = independent variable

(Nie et al., p. 226).

The asymmetric uncertainty coefficient determined the proportion by which uncertainty in the dependent variable was reduced by knowledge of the independent variable (Nie et al., p. 226). An uncertainty coefficient (asymmetric) of .22148 was computed with auditory learning disability as the dependent variable. With middle ear effusion as the dependent variable, an uncertainty coefficient of .22437 was computed. This coefficient did not greatly reduce the uncertainty in the dependent variable by knowledge of the independent variable. Tests were carried out to determine the level of significance of the asymmetric uncertainty coefficient. Rejection at the .05 level of significance was not obtained (see Table 7).

In summary, hypothesis I was rejected, as was the subhypothesis, at the .05 level with all statistical measures used for analysis of the data except for the asymmetric uncertainty coefficient. The null hypothesis assumed that auditory learning disability and the prevalence of middle ear effusion were identically distributed; this

TABLE 7

t-tests for Significance of Association Between Auditory Learning Disability and Middle Ear Effusion

	Coefficient obtained	Value needed to reject H at specified level	t-test computed statistic	Specified level of significance	Reject at .05
Contingency coefficient (predictive association)	.47388	3.23	< 4.10	.002	Yes
Asymmetric uncertainty coefficient	.22437 <sup>a</sup>	2.00	> 1.76	.05	No
Asymmetric uncertainty coefficient	.22148 <sup>b</sup>	2.00	> 1.76	.05	No

a. Middle ear effusion dependent variable

b. Auditory learning disability dependent variable

hypothesis was rejected at the .0001 level of significance. It can be concluded that there is a significant difference between the auditory-learning-disabled group and the comparison group with regard to the suggested presence or absence of middle ear effusion. The sub-hypothesis that there is no association between auditory learning disability and middle ear effusion, was also rejected. Two measures of association, phi and contingency coefficients, were rejected at the .001 level. The asymmetric uncertainty coefficient could not be rejected at the specified .05 level. The first two coefficients demonstrated moderate association. The strength of the relationship between auditory learning disability and middle ear effusion is moderate; predictive association is slightly lower than determined association. Little uncertainty in the dependent variable (either middle ear effusion or auditory learning disability), can be reduced by knowledge of the independent variable. Seventy percent of the auditory-learning-disabled school-age children evaluated in this study had middle ear effusion, whereas only 17 percent of the comparison group of school-age children had suggested middle ear effusion (see Table 8).

#### Group II Hypotheses

The second group hypotheses concern the correlation between middle ear effusion and three measures of auditory learning: auditory reception, auditory-vocal association, and auditory-sequential memory.

Group Hypotheses II 2A. There is no correlation between middle ear effusion and auditory reception.

TABLE 8

Percent of Middle Ear Effusion in Auditory-Learning-Disabled Group and a Comparison Group of School-Age Children

Middle Ear Effusion	Auditory-Learning-Disabled Group		Comparison Group	
	Number	Percent	Number	Percent
Yes	21	70%	5	17%
No	9	30%	25	83%
Column Total	30		30	

- 2B. There is no correlation between middle ear effusion and auditory-vocal association.
- 2C. There is no correlation between middle ear effusion and auditory-sequential memory.

For Group II hypotheses, this researcher used the biserial correlation coefficient. The formula used for computation of the biserial statistic is

$$r_{bis} = \frac{(xp-xq)}{st} \cdot \frac{pq}{h}$$

where N = Total number of cases

and p = % of cases in 0 category (middle ear effusion)  
 q = % of cases in 1 category (measures of auditory learning)  
 h = height of the normal curve computed from normal tables  
 st = standard deviation

(see SOUPAC - Biserial Correlation).

The biserial correlation coefficient is an estimate of the product-moment correlation when one variable is dichotomous (middle ear effusion) and the other is continuous (measures of auditory learning). The values calculated were -.50590, -.50143, and -.32230 (see Table 9 for the complete results from SOUPAC).

Variables Associated with Middle Ear Effusion	Value of $r_{bis}$
Auditory Reception	-.50590
Auditory-Vocal Association	-.50143
Auditory-Sequential Memory	-.32230

The biserial correlation coefficient indicated a negative correlation between middle ear effusion and all three measures of auditory learning. The assumption from these results is that the higher the

TABLE 9

Biserial Correlation Between Middle Ear Effusion and Three  
Measures of Auditory Learning

Continuous Variables	Dichotomous Variable 1			Middle Ear Effusion		
	Dichotomous Value 0			Dichotomous Value 1		
	Percent	Mean	STD Deviation	Percent	Mean	STD Deviation
1 = Auditory Reception	.56667	36.206	4.5360	.43333	31.5380	6.1032
2 = Auditory-Vocal Association	.56667	37.882	6.3420	.43333	32.3850	6.1898
3 = Auditory-Sequential Memory	.56667	34.382	6.1454	.43333	31.3460	5.0149
	Total Subjects	Mean	STD Deviation	$(r_{bis})$ Biserial Correlation*		
	60	34.183	5.7576	<u>-.50590</u> Auditory Reception and Middle Ear Effusion		
	60	35.500	6.8423	<u>-.50143</u> Auditory-Vocal Association and Middle Ear Effusion		
	60	33.067	5.8790	<u>-.32230</u> Auditory-Sequential Memory and Middle Ear Effusion		

\*  $r_{bis}$  = Negative correlations were computed between middle ear effusion and the three measures of auditory learning.



scores on measures of auditory learning, the lower the prevalence of middle ear effusion, and vice versa: the higher the prevalence of middle ear effusion, the lower the scores on measures of auditory learning. This was particularly true for the correlation between auditory reception and middle ear effusion. It was also true for the correlation between auditory-vocal association and middle ear effusion. It was true to a lesser degree for auditory-sequential memory and middle ear effusion.

This investigator computed t-tests on the three biserial correlations to determine whether the coefficients were significantly different from zero. All Group II hypotheses were rejected at the .01 level of significance. Hypotheses 2A and 2B could also be rejected at the .001 level of significance (see Table 10).

In summary, Group II hypotheses were rejected as follows: 2A and 2B at the .001 level of significance, and 2C at the .01 level of significance. The biserial correlations computed between the three measures of auditory learning and middle ear effusion were negative.

The general conclusion reached on the basis of these negative biserial correlations was as follows:

Subjects with high scores on the three measures of auditory learning had a low prevalence of middle ear effusion, and vice versa: subjects with a high prevalence of middle ear effusion had low scores on the three measures of auditory learning.

### Hypothesis III

The third statistical hypothesis concerns the variation in the

TABLE 10

Significant Biserial Correlations Between Middle Ear  
Effusion and Three Measures of Auditory Learning

Measures of Auditory Learning and Middle Ear Effusion	Coefficient obtained	Computation t-test statistic	Specified level of significance	Reject at .05
1. Auditory Reception and Middle Ear Effusion	-.50590	5.20*	.001	Yes
2. Auditory-Vocal Association and Middle Ear Effusion	-.50143	5.09*	.001	Yes
3. Auditory-Sequential Memory and Middle Ear Effusion	-.32230	2.73*	.01	Yes

\* Negative correlations indicate a reverse relationship between middle ear effusion and the measures of auditory learning.

\* bis value for required level of significance.

.05: 1.96  
.01: 2.58  
.001: 3.20

dependent variable (auditory-sequential memory) due to variation in the independent variables of middle ear effusion, auditory reception, auditory-vocal association, the Peabody Picture Vocabulary Test Intelligence quotient, Wechsler verbal scale score, and Wechsler performance scale score. Auditory-sequential memory was chosen as the dependent variable over the two other measures of auditory learning (auditory reception and auditory-vocal association) in this multiple regression for three reasons:

1. It was apparent from the data collected on both the experimental and comparison groups that the auditory-sequential memory score was more variable than the other scores, for reception and association.
2. Auditory-sequential memory appears as an independent factor in learning. It also appears as an independent factor from other auditory skills (Kirk, 1968). Auditory-sequential memory did not correlate highly with auditory reception and/or auditory-vocal association. An intercorrelation of .27 was found with auditory reception, and an intercorrelation of .22 was computed with auditory-vocal association. An intercorrelation of .48 was, however, computed between auditory reception and auditory-vocal association. According to Paraskevopoulos et al.(1969), "Auditory memory emerges as an independent factor in the ITPA test battery" (p. 45). Lerner (1976) also reported auditory-sequential memory to be separable in concept from other facets of intellect and learning (p. 185).
3. Auditory-sequential memory is considered a key factor in mastery of reading and learning abilities. Lerner(1976) points out that children with learning disabilities often have difficulty with auditory memory (p. 185). She further states that poor readers and learners perform poorly on the auditory and visual short-term memory tests of the ITPA (p. 186). Johnson and Myklebust (1967) support her statements regarding the importance of auditory memory noting that an impairment in a child's ability to retain information heard (auditory memory) can result in reading and learning difficulties, primarily in remembering the sequence of sounds in words (p. 150).

Hypothesis III There is no linear relationship between auditory-sequential memory and the independent variables of middle ear effusion, auditory reception, auditory-vocal association, Peabody Picture Vocabulary Test Intelligence quotient, Wechsler verbal scale score, and Wechsler performance scale score.

To assess the relationship stated in Hypothesis III, this researcher used a multiple regression technique. The SPSS multiple regression program was run with middle ear effusion as a dummy variable, since the data were nominal level and did not meet the criteria for a multiple regression analysis (interval level data).

A hierarchial regression was chosen. The procedure involved adjustments for only those variables that precede a given variable in the hierarchial order and therefore reflect the "total influence" of each variable (Nie et al., 1970, p. 338). In the hierarchial procedure, the programmer selects the order in which the variables are to be entered into the equation. These particular independent variables were chosen because each contributed to the prediction about the dependent variable.

The multiple regression program outputs several items of interest:

B, Beta weights, R,  $R^2$ ,  $R^2$  change, and a table of intercorrelations (see Table 11 for definitions of these statistical terms).

The multiple regression program determines the best solutions with which to achieve the predicted score, Y. The following is the general form of the predicted equation:

$$Y = a + B_1 x_1 + B_2 x_2 + B_3 x_3 + B_4 x_4 + B_5 x_5 + B_6 x_6,$$

where B = nonstandardized form of the statistic

Y = dependent variable  
 x = independent variable  
 x<sub>1</sub> middle ear effusion  
 x<sub>2</sub> auditory reception  
 x<sub>3</sub> auditory-vocal association  
 x<sub>4</sub> Peabody I.Q. score  
 x<sub>5</sub> Wechsler verbal scale score  
 x<sub>6</sub> Wechsler performance scale score

The Beta weights were used to put the predictive equation into standardized form. The resulting equation was:

$$\bar{z}_y = .06162Zx_1 + .14088Zx_2 + .62820Zx_3 + \\ -.05413Zx_4 + .02907Zx_5 + .21030Zx_6$$

$\bar{z}_y$  = dependent variable - auditory-sequential memory

Auditory-vocal association has the heaviest Beta weight, adding the most predictability to the equation. The Peabody Intelligence quotient contributed least to the predictability by having a negative Beta weight. The Wechsler verbal scale score also offers little to the prediction equation.

R is the multiple correlation coefficient, that is, the correlation of predicted and obtained scores for variable x<sub>1</sub>.

R<sup>2</sup>, is the coefficient of multiple determination. It indicates the proportion of variance in x<sub>1</sub> accounted for by the set of 6-1 remaining variables. The total R<sup>2</sup> of the six independent variables was found to be .53978. Thus, the six independent variables accounted for 54 percent of the variation in auditory-sequential memory. This multiple regression left 46 percent of the variation in the dependent variable unaccounted for.

The R<sup>2</sup> change gives the amount of additional variance added by each variable. In the hierarchial decomposition, the "independent" contribution of each variable adds up to the total variation explained in the six variables:

$$R^2 = \text{variation due to } x_1 + \text{variation due to } x_2 + \text{variation due to } x_3 + \text{variation due to } x_4 + \text{variation due to } x_5 + \text{variation due to } x_6$$

$x_5$  + variation due to  $x_6$

$R^2$  total reflects the percent of total variation in the dependent variable accounted for by variation in the independent variables. The variance contributed by each of the variables is reflected in the  $R^2$  change column (see Table 11). The independent variables are as follows in the order of significance:

.39864	auditory-vocal association
.06550	middle ear effusion
.03840	auditory reception
.03482	Wechsler performance scale score
.00219	Wechsler verbal scale score
.00023	Peabody I.Q. score

Auditory-vocal association thus accounts for 40 percent of the variance in the dependent variable, auditory-sequential memory. Middle ear effusion accounts for 7 percent, auditory reception 4 percent, and the Wechsler performance scale score 3 percent of the variance in the dependent variable. The contributions of the other two independent variables, Wechsler verbal scale score, and Peabody I.Q. score, was negligible.

The Peabody I.Q. score did not contribute to the prediction because it had a negative Beta weight. The Wechsler verbal scale score contributes very little beyond what has already been contributed by the other variables.

Looking at the table of intercorrelation (Table 12), we see a .45976 correlation between the Peabody Intelligence quotient score and the Wechsler verbal scale score. This higher intercorrelation suggests these two tests may predict similar data. It may therefore be unnecessary in the future to collect information from both tests. Correlation coefficients among all 7 variables were computed

TABLE 11

## Multiple Regression Statistical Summary Table

Dependent Variable		Auditory-Sequential Memory			
Independent Variables	Multiple R	R Square	RSQ Change	B	Beta
MEE (Middle Ear Effusion)	.25592	.06550	.06550	.7310261	.06162
AR (Auditory Reception)	.32234	.10390	.03840	.1438517	.14088
AA (Auditory-Vocal Association)	.70890	.50254	.39864	.5397600	.62820
PIQ (Peabody I.Q.)	.70906	.50277	.00023	-.03167874	-.05413
WISCV (Wechsler verbal scale scores)	.71061	.50496	.00219	.02007571	.02907
WISCP (Wechsler performance scale scores)	.73469	.53978	.03482	.1524352	.21030
Total	.73469	.53978			

Multiple R - the multiple correlation coefficient of predicted and obtained scores for variable  $x_1$ .

R Square - percent of variation in the dependent variable accounted for by variation in the independent variable.

R Square Total - percent of the total variation in the dependent variable accounted for by variation in all independent variables.

R Square Change - the amount of additional variation added by each variable.

B - weight of variables before standardization.

Beta Weights - standardized weights of all variables.

TABLE 12

## Table of Intercorrelation Among Variables

## Multiple Regression

	AM	MEE	AR	AA	PIQ	WISCV	WISCP
Auditory-sequential memory							
Middle ear effusion	-.25592						
Auditory reception	.28227	-.40171					
Auditory-vocal association	.70146	-.39816	.28578				
Peabody Picture Vocabulary Test Intelligence score	.21920	-.18325	.09272	.29680			
Wechsler verbal scale score	.25657	-.17741	.34953	.26569	.45976		
Wechsler performance scale score	.37815	-.07409	-.08811	.31324	.34118	.22431	

Number of cases = 60

Lower triangle = correlation coefficients.



(see Table 12). Tests that gave a higher correlation with Y (auditory-sequential memory) should receive more weight; tests that correlate highly with each other (e.g., Peabody I.Q. score and Wechsler verbal scale score) indicate duplication of information since they cover the same aspects of Y. Thus, collection of duplicate information can be eliminated in future research.

In further examination of Table 12, it is of interest that negative correlation coefficients were found between middle ear effusion and all other variables used in this multiple regression. The highest negative correlation  $-.40171$ , was found between middle ear effusion and auditory reception. An equally high negative correlation,  $-.39816$ , was noted between auditory-vocal association and middle ear effusion.

There was also a moderate inverse correlation,  $-.25592$ , between middle ear effusion and auditory-sequential memory.

A t-test was applied to the Multiple R total,  $.73469$ . R was found to be significant at the  $.002$  level (see Table 13).

In summary, a multiple regression technique with a dummy variable was used in Hypothesis III for analysis of the data. The six independent variables, middle ear effusion, auditory reception, auditory-vocal association, Peabody Picture Vocabulary Test Intelligence quotient, Wechsler performance scale score, and Wechsler verbal scale score, accounted for 54 percent of the variation found in the dependent variable, auditory-sequential memory. The Multiple R total

TABLE 13

t-test to Determine Level of Significance  
of Multiple R

t-test on Multiple R	Significance Level	Rejection Value	Computed Multi- ple R t-test Statistic	Reject at .05
$t = \frac{.73469 \text{ N-2}}{1(.73469)}$	.05	2.00	< 12.17	Yes
$= \frac{.73469 \cdot 7.62}{(-.54)}$	.01	2.66	< 12.17	Yes
$= \frac{5.60}{.46}$	.001	3.23	< 12.17	Yes
$= \underline{12.17}$				

Multiple R = .73469 is significant at the .002 level when a two-tail t-test with N-1 degrees of freedom is used.

.73469 was found, by t-test, to be significant at the .002 level (see Table 13).

#### Hypothesis IV

The last statistical hypothesis focused on the relationship between a history of middle ear effusion and auditory learning disability.

Hypothesis IV History of middle ear effusion and auditory learning disability are statistically independent.

Subhypothesis There is no association between a history of middle ear effusion and auditory learning disability.

A chi-square statistic was used for testing of the above hypothesis. Table 14 illustrates the data to which the chi-square statistic was applied. A chi-square value of 7.70218 with one degree of freedom was calculated and was found to be statistically significant at the .01 level. It was thus determined that a history of middle ear effusion and auditory learning disability are systematically related. The strength of the systematic relationship between the two variables was calculated by means of a phi statistic (Nie et al., p. 224). Phi indicated a moderately low strength of association, .39412, between a history of middle ear effusion and auditory learning disability. The level of significance of the phi coefficient was computed for levels of significance of .05, .01, and .001 (see Table 15). Phi was found to be significant at the .01 level.

The contingency coefficient, a measure of predictive association, was also computed for these data. The contingency coefficient

TABLE 14  
Contingency Table  
Relationship Between History of Middle Ear Effusion and  
Auditory Learning Disability

History of Middle Ear Effusion	Auditory-Learning- Disabled Group	Comparison Group
Yes	26	15
No	4	15
Column Total	30	30

$\chi^2 = 7.70218$ ; significant at the .01 level.

TABLE 15

Significance of the Strength of Relationship Between a History  
of Middle Ear Effusion and Auditory Learning Disability

Strength of Relationship		Level of Significance	
Phi formula:	Value of $\phi$ needed to reject $H_0$ at speci- fied level	Phi obtained	Reject at .05
.05: $1.96 \div \sqrt{60}$	.25	.39412	Yes
.01: $2.58 \div \sqrt{60}$	.33	.39412	Yes
.001: $3.20 \div \sqrt{60}$	.41	.39412	No

Statistic demonstrated a strength of association between a history of middle ear effusion and auditory learning disability of .39412, significant at the .01 level.

was .36667, indicating a slightly lower predictive strength of association between a history of middle ear effusion and auditory learning disability than was determined by the phi statistic (see Table 16).

A t-test was used to determine the level of significance of the contingency coefficient (see Table 16). The contingency coefficient was found to be significant at the .01 level.

Asymmetric uncertainty coefficients were computed with auditory learning disability as the dependent variable and also with a history of middle ear effusion as the dependent variable. An asymmetric uncertainty coefficient of .11747 was obtained with auditory learning disability as the dependent variable, and a coefficient of .13041 with a history of middle ear effusion as the dependent variable. The asymmetric uncertainty coefficients were weak; thus, uncertainty in the dependent variable is not reduced by knowledge of the independent variable. t-Tests were applied to determine the level of significance of the asymmetric uncertainty coefficients (see Table 16). The uncertainty coefficient could not be rejected at the .05 level.

In summary, hypothesis IV was rejected at the .01 level of significance on the basis of all statistics applied to the data, except for the asymmetric uncertainty coefficient. The null hypothesis assumed that auditory learning disability and a history of middle ear effusion were identically distributed; this was rejected at the .01 level of significance. This indicates a systematic relationship between a history of middle ear effusion and auditory learning disability.

TABLE 16

Significance of Association Between a History of Middle Ear Effusion  
and Auditory Learning Disability

	Coefficient obtained	Rejection value	Computed t-test statistic	Specified level of sig- nificance	Reject at .05
Contingency coefficient (predictive association)	3.6667	2.68	3.00	.01	Yes
Asymmetric uncertainty coefficient	.11747 <sup>a</sup>	2.00	.91	.05	No
Asymmetric uncertainty coefficient	.13041 <sup>b</sup>	2.00	1.00	.05	No

a - dependent variable: auditory learning disability

b - dependent variable: history of middle ear effusion

The determined strength of association indicated by the phi statistic, was moderately low, although the .01 level of significance was obtained with a phi value of .39412. The contingency coefficient of predictive association was slightly lower than phi, .36667, also indicating moderately low predictability. This statistic of association was also significant at the .01 level. Regardless whether the dependent variable was auditory learning disability or history of middle ear effusion, uncertainty in the dependent variable was not reduced by knowledge of the independent variable. A level of significance of .05 could not be obtained with this statistic. Thus, 86 percent of school-age children in the experimental group diagnosed as auditory-learning-disabled, were found to have a history of middle ear effusion, whereas 50 percent of the children in the comparison group had histories of middle ear effusion (see Table 17).

#### Summary

Chapter IV focused on analysis of the data and results. Four statistical hypotheses were tested and rejected at the .05 level of significance. In most cases, a .01 level of significance was obtained. A systematic relationship between a history of middle ear effusion and auditory learning disabilities has been shown in this study. Further, the higher the prevalence of middle ear effusion, the lower the scores on three measures of auditory learning, the Wechsler verbal and performance scale scores and the Peabody Picture Vocabulary Test Intelligence quotient score. The reverse was also substantiated: the lower the prevalence of middle ear effusion, the higher the scores on



TABLE 17

Percent of Auditory-Learning-Disabled Group and a Comparison Group  
of School-Age Children with a History of Middle Ear Effusion

History of Middle Ear Effusion	Auditory-Learning-Disabled Group	Comparison Group
Yes	26 (86%)	15 (50%)
No	4 (14%)	15 (50%)
Column Total	30	30

these three measures of auditory learning, the Wechsler verbal and performance scale scores and the Peabody Picture Vocabulary Test Intelligence quotient score. Thus, all four of the null hypotheses were rejected.

## CHAPTER V

### SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

It has been hypothesized that reduced auditory acuity, especially during the first few years of life, affects the acquisition of language, learning, and cognition in children. A hearing loss of as little as 15 dB is sufficient to result in reduced levels of language, learning, and cognitive development. The effect of reduced sound conduction resulting from middle ear effusion during the critical learning years may not be apparent until a child reaches school age. At this time, the child begins to experience difficulty in one or more academic areas related to auditory learning such as mathematics, reading, spelling, and/or language skills. If a relationship between the suggestion of middle ear effusion and auditory learning disability can be established, early identification and treatment of middle ear effusion is essential.

#### Purpose

This study was designed to investigate the relationship between the suggestion of middle ear effusion and several measures of auditory learning in school-age children with average or above-average intelligence.

#### Methods and Procedure

Sixty children between the ages of seven years and ten years 3 months with average or above-average intelligence were evaluated for

learning disability at Holy Cross Hospital between January 1, 1979, and December 31, 1979.

The experimental group consisted of 30 randomly selected school-age children evaluated and diagnosed as auditory-learning-disabled. The comparison group also consisted of 30 randomly selected school-age children evaluated and found not to be auditory-learning-disabled.

The two groups were matched for social class level by means of the Hollingshead Two-Factor Index of Social Class (see Appendix B). The average and median social class was found to be IV (lower middle) in both the experimental and comparison groups. Testing was administered to both groups by the same trained, experienced specialists in learning disabilities, psychology, and audiology. The experimental group had a sex ratio of seven boys to one girl. The sex ratio in the comparison group was comparable.

### Research Design and Statistical Hypotheses

This study consisted of a statistical analysis of variables related to suggested middle ear effusion and auditory learning disability. The relationship between the variables was assessed by means of chi-square, biserial correlation, and multiple regression techniques. SPSS and SOUPAC computer programs were used for the statistical analysis.

#### Hypotheses

Four major hypotheses were formulated and tested in this research:

1. Auditory learning disability and the prevalence of middle ear effusion are statistically independent.

There is no association between auditory learning disability and middle ear effusion.

2. There is no correlation between middle ear effusion and auditory reception.

There is no correlation between middle ear effusion and auditory-vocal association.

There is no correlation between middle ear effusion and auditory-sequential memory.

3. There is no linear relationship between auditory-sequential memory and the independent variables: Middle ear effusion, auditory reception, auditory-vocal association, Peabody Picture Vocabulary Test Intelligence quotients, Wechsler verbal scale scores, and Wechsler performance scale scores.

4. History of middle ear effusion and auditory learning disability are statistically independent.

There is no association between a history of middle ear effusion and auditory learning disability.

### Results and Conclusions

1. The chi-square statistical analysis of hypothesis I showed that a systematic relationship exists between auditory learning disability and middle ear effusion, significant at the .001 level. A moderate strength of association was found between middle ear effusion and auditory learning disability, significant at the .01 level.
2. Biserial correlation statistical analysis of Group II hypotheses showed a negative correlation between middle ear effusion and three measures of auditory learning (auditory reception, auditory-vocal association; and auditory-sequential memory), significant at the .01 level. The general conclusion drawn from the negative correlation of the dichotomous variable of middle ear effusion and the continuous variables of auditory reception, auditory-vocal association, and auditory-sequential memory was: School-age children with a higher suggested prevalence of middle ear effusion scored lower on measures of auditory learning, and children with higher scores on measures of auditory learning have a lower suggested prevalence of middle ear effusion.

3. A multiple regression technique was employed for assessment of the linear relationships between the dependent variable auditory-sequential memory and the independent variables middle ear effusion, auditory reception, auditory-vocal association, Peabody Picture Vocabulary Test Intelligence quotient score, Wechsler verbal scale score, and Wechsler performance scale score. Fifty-four percent of the variation in the dependent variable was predicted by the six independent variables. Auditory-vocal association, .62830 added the most predictability to the equation. The multiple R correlation coefficient total was .73469. This variation was found to be significantly different from zero. A .002 level of significance was determined by t-Test.
4. A chi-square statistic was used to determine the relationship between a history of middle ear effusion and auditory learning disability. A systematic relationship between a history of middle ear effusion and auditory learning disability was found which was significant at the .01 level. Phi and uncertainty coefficients were calculated to determine the strength of association. The determined and predictive strength of association between a history of middle ear effusion and auditory learning disability were found to be significant at the .01 level. Eighty-six percent of school-age children in the auditory-learning-disabled group had histories of middle ear effusion. Fifty-percent of children in the comparison group had histories of middle ear effusion.

All four hypotheses formulated in this research were thus rejected at the previously set .05 level of significance.

The percentage of school-age children in the comparison group who had a history of middle ear effusion and/or the presence of middle ear effusion at the time of evaluation paralleled the percentages reflected in previously reported studies on normal children. Fifty percent of the children in the comparison group had a history of middle ear effusion. The prevalence of middle ear effusion in the comparison group was 17 percent. Recent studies have demonstrated a higher prevalence of histories of

middle ear effusion in learning-disabled school-age children than in normal school-age children. No study to date, however, has isolated auditory-learning-disabled school-age children from learning-disabled school-age children in general. In this study, auditory-learning-disabled school-age children were isolated from the general category of learning-disabled children. The hypothesis of this researcher was that middle ear effusion, which dampens and/or reduces auditory acuity, should have its greatest effect on the auditory areas of learning. This study confirmed this researcher's hypothesis. Eighty-six percent of the experimental group (auditory-learning-disabled school-age children) were found to have histories of middle ear effusion, whereas 70 percent had suggestion of middle ear effusion at the time they were evaluated.

### Main Conclusions

On the basis of the specific data analyzed and the statistical hypotheses that were rejected, three main conclusions were drawn:

1. A systematic relationship exists between the prevalence of suggested middle ear effusion and auditory learning disability in school-age children.
2. There is a negative association between middle ear effusion and measures of auditory learning.

The higher the prevalence of middle ear effusion, the lower the scores on measures of auditory learning, and the lower the prevalence of middle ear effusion, the higher the scores on measures of auditory learning.

3. Auditory-learning-disabled school-age children have a significantly higher history of middle ear effusion than do other school-age children.

## Recommendations

Three recommendations can be made on the basis of the present research: recommendations for clinical practice, for improvement and continuation of this research, and for future research.

Recommendations for Clinical Practice. Five recommendations are made for improvement of the present methods of clinical detection, treatment, and follow-up of suggested middle ear effusion. These recommendations, based on the knowledge and test results gained from this study, are intended to prevent acquisition and/or decrease present auditory learning disabilities in children:

1. Infants and preschool children should be screened for middle ear effusion.
2. All school-age children should be tested for middle ear effusion, with special concern for those children in whom learning disability is suspected.
3. Frequent audiologic evaluations, medical consultation, and education of parents and children are advised when middle ear effusion is present.
4. Medical follow-up and monitoring of frequency and duration of suggested middle ear effusion is crucial in reducing language, learning, and cognitive delays in developing children.
5. Early and aggressive medical intervention and treatment for middle ear effusion should be employed to prevent and/or reduce any future lag in language, learning, and intellectual development.

## Recommendations for Improvement and Continuation of Present Research.

Several recommendations are made which will improve the design and methodology of the present research on the basis of the experience gained in this initial study:

1. A larger sample of auditory learning-disabled and normal school-age children is needed for effective determination of the relationship and association of middle ear effusion with auditory learning disability. The data obtained will



- be more representative and detect more differences in a general population.
2. A revised method of data collection on middle ear effusion is needed to allow the data to be used at a higher statistical level. Instead of recording middle ear effusion as present or absent, the investigator should note the exact number score where the tympanogram peak occurs. This method insures objectivity and avoids the risk of canceling out an effect which may occur when the usual method of data classification is employed (present or absent).
  3. The incidence of middle ear effusion in the normal and auditory-learning-disabled school-age populations should be determined. It appears to this researcher that knowledge of the incidence of middle ear effusion is more predictive of future auditory learning disability than is knowledge of the prevalence of middle ear effusion gathered in this study. Testing for middle ear effusion at three-month intervals (incidence testing) would provide more sensitive data for predicting reduced auditory learning, focusing on the duration and frequency of middle ear effusion.
  4. A revised method for determining whether a child has a history of middle ear effusion should be considered. Having the parents respond yes or no on a case history form does not appear to give totally accurate information. Interviews with parents and gathering of medical substantiation of middle ear effusion should be considered in an attempt to accurately determine frequency and duration of middle ear effusions.

#### Recommendations for Future Research.

1. The results of this study indicate the need for research on the efficacy of controlled impedance screening for large numbers of preschool and school-age children. (Specific guidelines and testing procedures should be employed universally to insure accurate determination of the prevalence and incidence of middle ear effusion in the general population.)
2. The review of the literature for this study demonstrated the need to develop consistent standards for the use of impedance audiometry.
3. The need for longitudinal studies on incidence of middle ear effusion in children was also suggested by the literature reviewed in this research.
4. This study also pointed to the need for research on the frequency and duration of middle ear effusion necessary to reduce language, learning, and cognitive development in children.

5. This research raised the question of what degree of hearing loss, over what period of time, results in reduced auditory learning. Future studies should be developed which can answer this question.
6. This research indicated the need to examine physiologic changes, produced by middle ear effusion, which may occur within the central auditory nervous system of the developing child and, as a result of auditory sensory deprivation during critical language-learning years, cause future language and learning lags. More histologic studies in animals are needed to determine whether fluctuating and transitory hearing loss, the result of middle ear effusion, can result in anatomic and behavioral changes.
7. This study demonstrated the need for research on the prevention of middle ear effusion. Research is urgently needed on the development of a suitable vaccine against the common types of bacteria causing middle ear effusion (*diplococcus*, *Hemophilus influenzae*).
8. Studies on the epidemiology, pathogenesis, natural history, and long-term implications of middle ear effusion appear necessary on the basis of this study.
9. Finally, this research reported a lack of consensus about appropriate treatment for middle ear effusion. Further research is required to determine the most effective methods of treatment and prevention of middle ear effusion.

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APPENDIX A

Difference in Sound Pressure Level Between the Standards  
of Hearing Sensitivity

Frequency Hz	1951 ASA*	1964 ISO*	1969 ANSI*	0dB Hz
125	54.5 dB	45.5	45	0Hz
250	39.5 dB	24.5	25.5	0Hz
500	25 dB	11.0	11.5	0Hz
1000	16.5 dB	6.5	7.0	0Hz
1500	16.5 dB	6.5	6.5	0Hz
2000	17.0 dB	8.5	9.0	0Hz
3000	16.0 dB	7.5	10.0	0Hz
4000	15.0 dB	9.0	9.5	0Hz
6000	17.5 dB	8.0	15.5	0Hz
8000	21.0 dB	9.5	13.0	0Hz

\*ASA (American Standard Association) 1951 - From public health survey 1935-6

\*ISO (International Standard Organization) 1964 - Based on later European and American studies

\*ANSI (American National Standard Institute) 1969 - Current levels used today

APPENDIX A

A Comparison of Diagnoses of Middle Ear Effusion By Two Certified Audiologists

Possible Combinations of Test Results	Type of Test				Suggests Middle Ear Effusion	
	Air Conduction	Bone Conduction	Impedance Audiometry	Acoustic Reflexes	Audiologist I*	Audiologist II*
1	-	-	-	-	no	no
2	-	-	-	+	no	no
3	-	-	+	-	yes	yes
4	-	-	+	+	yes	yes
5	-	+	-	-	yes	yes
6	-	+	-	+	yes	yes
7	-	+	+	-	yes	yes
8	-	+	+	+	yes	yes
9	+	-	-	-	no	no
10	+	-	-	+	no	no
11	+	-	+	-	yes	yes
12	+	-	+	+	yes	yes
13	+	+	-	-	yes	yes
14	+	+	-	+	yes	yes
15	+	+	+	-	yes	yes
16	+	+	+	+	yes	yes

- Normal (negative) test results  
 + Abnormal (positive) test results

\*100% agreement on the suggestion of middle ear effusion based on the sixteen combinations that can occur from administration of four audiometric tests.

APPENDIX B

## THE HOLLINGSHEAD TWO FACTOR INDEX OF SOCIAL POSITION

### I. Introduction.

The Two Factor Index of Social Position was developed to meet the need for an objective, easily applicable procedure to estimate the positions individuals occupy in the status structure of our society. Its development was dependent both upon detailed knowledge of the social structure, and procedures social scientists have used to delineate class position. It is premised upon three assumptions: (1) the existence of a status structure in the society; (2) positions in this structure are determined mainly by a few commonly accepted symbolic characteristics; and (3) the characteristics symbolic of status may be scaled and combined by the use of statistical procedures so that a researcher can quickly, reliably, and meaningfully stratify the population under study.

Occupation and education are the two factors utilized to determine social position. Occupation is presumed to reflect the skill and power individuals possess as they perform the many maintenance functions in the society. Education is believed to reflect not only knowledge, but also cultural tastes. The proper combination of these factors by the use of statistical techniques enable a researcher to determine within approximate limits the social position an individual occupies in the status structure of our society.

### II. The Scale Scores.

To determine the social position of an individual or of a household two items are essential: (1) the precise occupational role the head of the household performs in the economy; and (2) the amount of formal schooling he has received. Each of these factors are then scaled according to the following system of scores.

#### A. The Occupational Scale.

##### 1. Higher Executives, Proprietors of Large Concerns, and Major Professionals.

###### a. Higher Executives

Bank Presidents; Vice-Presidents  
Judges (Superior Courts)  
Large Business, e.g., Directors,  
Presidents, Vice-Presidents,  
Assistant Vice-Presidents,

Military, Commissioned  
Officers, Major and above,  
Officials of the Executive  
Branch of Government,  
Federal, State, Local,

a. Higher Executives (Continued)Executive Secretary,  
Treasurer.e.g., Mayor, City Manager,  
City Plan Director, In-  
ternal Revenue Directors.  
Research Directors, Large Firmsb. Large Proprietors (Value over \$100,000<sup>1</sup>).Brokers  
ContractorsDairy Owners  
Lumber Dealersc. Major ProfessionalsAccountants (C.P.A.)  
Actuaries  
Agronomists  
Architects  
Artists, Portrait  
Astronomers  
Auditors  
Bacteriologists  
Chemical Engineers  
Chemists  
Clergyman (Professionally  
Trained)  
DentistsEconomists  
Engineers (College Graduates)  
Foresters  
Geologists  
Lawyers  
Metallurgists  
Physicians  
Physicists, Research  
Psychologists, Practicing  
Symphony Conductor  
Teachers, University, College  
Veterinarians (Veterinary  
Surgeons)2. Business Managers, Proprietors of Medium Sized Businesses,  
and Lesser Professionals.a. Business Managers in Large Concerns.Advertising Directors  
Branch Managers  
Brokerage Salesmen  
District Managers  
Executive Assistants  
Executive Managers, Govt.  
Officials, minor, e.g.,  
Internal Revenue Agents  
Farm ManagersOffice Managers  
Personnel Managers  
Police Chief; Sheriff  
Postmaster  
Production Managers  
Sales Engineers  
Sales Managers, National  
Concerns  
Sales Managers (Over \$100,000)

<sup>1</sup> The value of businesses is based upon the rating of financial strength in Dun and Bradstreet's Manual.

b. Proprietors of Medium Businesses (Value \$35,000 - \$100,000)

Advertising Owners (-\$100,000)	Manufacturer's Representatives
Clothing Store Owners (-\$100,000)	Poultry Business (-\$100,000)
Contractors (-\$100,000)	Purchasing Managers
Express Company Owners (-\$100,000)	Real Estate Brokers (-\$100,000)
Fruits, Wholesale (-\$100,000)	Rug Business (-\$100,000)
Furniture Business (-\$100,000)	Store Owners (-\$100,000)
Jewelers (-\$100,000)	Theater Owners (-\$100,000)
Labor Relations Consultants	

c. Lesser Professionals

Accountants (Not C.P.A.)	Military, Commissioned Officers, Lts., Captains
Chiropodists	Musicians (Symphony Orchestra)
Chiropractors	Nurses
Correction Officers	Opticians
Director of Community House	Pharmacists
Engineers (Not College Grad.)	Public Health Officers (M.P.H.)
Finance Writers	Research Assistants, University (Full-time)
Health Educators	Social Workers
Librarians	Teachers (Elementary and High)

3. Administrative Personnel, Small Independent Businesses, and Minor Professionals.

a. Administrative Personnel

Adjusters, Insurance	Section Heads, Federal, State, and Local Government Offices
Advertising Agents	Section Heads, Large Businesses and Industries
Chief Clerks	Service Managers
Credit Managers	Shop Managers
Insurance Agents	Store Managers (Chain)
Managers, Department Stores	Traffic Managers
Passenger Agents -- R.R.	
Private Secretaries	
Purchasing Agents	
Sales Representatives	

b. Small Business Owners (\$6,000 - \$35,000)

Art Gallery	Cigarette Machines
Auto Accessories	Cleaning Shops
Awnings	Clothing
Bakery	Coal Businesses
Beauty Shop	Convalescent Homes
Boatyard	Decorating

b. Small Business Owners (\$6,000 - \$35,000)

Brokerage, Insurance	Jewelry
Car Dealers	Machinery Brokers
Cattle Dealers	Manufacturing
Dog Supplies	Monuments
Dry Goods	Package Store (Liquor)
Electrical Contractors	Painting Contracting
Engraving Business	Plumbing
Feed	Poultry Producers
Finance Co., Local	Publicity & Public Relations
Fire Extinguishers	Real Estate
5 & 10	Records and Radios
Florist	Restaurant
Food Equipment	Roofing Contractor
Food Products	Shoe
Foundry	Shoe Repairs
Funeral Directors	Signs
Furniture	Tavern
Garage	Taxi Company
Gas Station	Tire Shop
Glassware	Trucking
Grocery - General	Trucks and Tractors
Hotel Proprietors	Upholstery
Inst. of Music	Wholesale Outlets
	Window Shades

c. Semi-Professionals

Actors and Showmen	Morticians
Army M/Sgt; Navy C.P.O.	Oral Hygienists
Artists, Commercial	Photographers
Appraisers (Estimators)	Physio-therapists
Clergymen (Not professionally trained)	Piano Teachers
Concern Managers	Radio, T.V. Announcers
Deputy Sheriffs	Reporters, Court
Dispatchers, R.R. Train	Reporters, Newspaper
I.B.M. Programmers	Surveyors
Interior Decorators	Title Searchers
Interpreters, Court	Tool Designers
Laboratory Assistants	Travel Agents
Landscape Planners	Yard Masters, R.R.

d. Farmers

Farm Owners (\$25,000 - \$35,000)

4. Clerical and Sales Workers, Technicians, and Owners of Little Businesses. (Value under \$6,000)



a. Clerical and Sales Workers

Bank Clerks and Tellers	Factory Storekeepers
Bill Collectors	Factory Supervisors
Bookkeepers	Post Office Clerks
Business Machine Operators, Offices	Route Managers (Salesmen)
Claims Examiners	Sales Clerks
Clerical or Stenographic	Shipping Clerks
Conductors, R.R.	Supervisors, Utilities, Factories
Employment Interviewers	Toll Station Supervisors
	Warehouse Clerks

b. Technicians

Camp Counselors	Operators, P.B.X.
Dental Technicians	Proofreaders
Draftsmen	Safety Supervisors
Driving Teachers	Supervisors of Maintenance
Expeditor, Factory	Technical Assistants
Experimental Tester	Telephone Co. Supervisors
Instructors, Telephone Co., Factory	Timekeepers
Inspectors, Weights, Sanitary	Tower Operators, R.R.
Inspectors, R.R., Factory	Truck Dispatchers
Investigators	Window Trimmers (Store)
Laboratory Technicians	
Locomotive Engineers	

c. Owners of Little Businesses

Flower Shop (\$3,000 - \$6,000)  
 Newsstand (\$3,000 - \$6,000)  
 Tailor Shop (\$3,000 - \$6,000)

d. Farmers

Owners (\$10,000 - \$20,000)

5. Skilled Manual Employees.

Adjusters, Typewriter	Casters (Founders)
Auto Body Repairers	Cement Finishers
Bakers	Cheese Makers
Barbers	Chefs
Blacksmiths	Compositors
Bookbinders	Diemakers
Boilermakers	Diesel Engine Repair & Main- tenance (Trained)
Brakemen, R.R.	Diesel Shovel Operators
Brewers	Electricians
Bulldozer Operators	Electrotypists
Butchers	Engravers
Cabinet Makers	Exterminators
Carpenters	

### 5. Skilled Manual Employees (Continued)

Fitters, Gas, Steam	Patrolmen, R.R.
Firemen, City	Pattern and Model Makers
Firemen, R.R.	Piano Builders
Foremen, Construction, Dairy	Piano Tuners
Gardeners, Landscape (Trained)	Plumbers
Glassblowers	Policemen, City
Glaziers	Postmen
Gunsmiths	Printers
Gauge Makers	Radio, T.V., Maintenance
Hair Stylists	Repairmen, Home Appliances
Heat Treaters	Riggers
Horticulturists	Rope Splicers
Lineman, Utility	Sheetmetal Workers (Trained)
Linoleum Layers (Trained)	Shipsmiths
Linotype Operators	Shoe Repairmen (Trained)
Lithographers	Stationary Engineers (Licensed)
Locksmiths	Stewards, Club
Loom Fixers	Switchmen, R.R.
Lumberjacks	Tailors (Trained)
Machinists (Trained)	Teletype Operators
Maintenance Foremen	Toolmakers
Installers, Electrical Appliances	Track Supervisors, R.R.
Masons	Tractor-Trailer Trans.
Masseurs	Typographers
Mechanics (Trained)	Upholsterers (Trained)
Millwrights	Watchmakers
Moulders (Trained)	Weavers
Painters	Welders
Paperhangers	Yard Supervisors, R.R.

#### Small Farmers

Owners (under \$10,000)  
 Tenants who own farm equipment

### 6. Machine Operators and Semi-Skilled Employees

Aides, Hospital	Cooks, Short Order
Apprentices, Electricians,	Delivery Men
Printers, Steamfitters,	Dressmakers, Machine
Toolmakers	Drill Press Operators
Assembly Line Workers	Duplicator Machine Operators
Bartenders	Elevator Operators
Bingo Tenders	Enlisted Men, Military Services
Building Superintendent	Filers, Benders, Buffers
(Cust.)	Foundry Workers
Bus Drivers	Garage and Gas Station
Checkers	Assistants
Clay Cutters	Greenhouse Workers
Coin Machine Fillers	Guards, Doorkeepers, Watchmen

6. Machine Operators and Semi-Skilled Employees (Continued)

Hairdressers	Sprayers, Paint
Housekeepers	Steelworkers (Not Skilled)
Meat Cutters and Packers	Stranders, Wire Machines
Meter Readers	Strippers, Rubber Factory
Operators, Factory Machines	Taxi Drivers
Oiler, R.R.	Testers
Paper Rolling Machine Operators	Timers
Photostat Machine Operators	Tire Moulders
Practical Nurses	Trainmen, R.R.
Pressers, Clothing	Truck Drivers, General
Pump Operators	Waiters-Waitresses ("Better Places")
Receivers and Checkers	Weighers
Roofers	Welders, Spot
Set-up Men, Factories	Winders, Machine
Shapers	Wiredrawers, Machine
Signalmen, R.R.	Wine Bottlers
Solderers, Factory	Wood Workers, Machine
	Wrappers, Stores and Factories

Farmers

Smaller tenants who own little equipment.

7. Unskilled Employees.

Amusement Park Workers (Bowling Alleys, Pool Rooms)	Laborers, Unspecified
Ash Removers	Laundry Workers
Attendants, Parking Lots	Messengers
Cafeteria Workers	Platform Men, R.R.
Car Cleaners, R.R.	Peddlers
Car Helpers, R.R.	Porters
Carriers, Coal	Roofer's Helpers
Counter men	Shirt Folders
Dairy Workers	Shoe Shiners
Deck Hands	Sorters, Rag and Salvage
Domestics	Stagehands
Farm Helpers	Stevedores
Fishermen (Clam Diggers)	Stock Handlers
Freight Handlers	Street Cleaners
Garbage Collectors	Unskilled Factory Workers
Grave Diggers	Truckmen, R.R.
Hod Carriers	Waitresses -- "Hash Houses"
Hog Killers	Washers, Cars
Hospital Workers,	Window Cleaners
Unspecified	Woodchoppers
Hostlers, R.R.	Relief, Public, Private
Janitors, Sweepers	Unemployed (No Occupation)
Laborers, Construction	

## 7. Unskilled Employees (Continued)

### Farmers

#### Share Croppers

This scale is premised upon the assumption that occupations have different values attached to them by the members of our society. The hierarchy ranges from the low evaluation of unskilled physical labor toward the more prestigious use of skill, through the creative talents of ideas, and the manipulation of men. The ranking of occupational functions implies that some men exercise control over the occupational pursuits of other men. Normally, a person who possesses highly trained skills has control over several other people. This is exemplified in a highly developed form by an executive in a large business enterprise who may be responsible for decisions affecting thousands of employees.

### B. The Educational Scale.

The educational scale is premised upon the assumption that men and women who possess similar educations will tend to have similar tastes and similar attitudes, and they will also tend to exhibit similar behavior patterns. The educational scale is divided into seven positions: (1) Graduate Professional Training. (Persons who complete a recognized professional course leading to a graduate degree are given scores of 1). (2) Standard College or University Graduation. (All individuals who complete a four-year college or university course leading to a recognized college degree are assigned the same scores. No differentiation is made between state universities, or private colleges). (3) Partial College Training. (Individuals who complete at least one year but not a full college course are assigned this position. Most individuals in this category complete from one to three years of college.) (4) High School Graduates. (All secondary school graduates whether from a private preparatory school, a public high school, a trade school, or a parochial high school, are assigned the same scale value). (5) Partial High School. (Individuals who complete the tenth or the eleventh grades, but do not complete high school are given this score.) (6) Junior High School. (Individuals who complete the seventh grade through the ninth grade are given this position.) (7) Less Than Seven Years of School. (Individuals who do not complete the seventh grade are given the same scores irrespective of the amount of education they receive.)

### III. Integration of Two Factors.

The factors of Occupation and Education are combined by weighing the individual scores obtained from the scale positions. The weights for each factor were determined by multiple correl-

ation techniques. The weight for each factor is:

<u>Factor</u>	<u>Factor Weight</u>
Occupation	7
Education	4

To calculate the Index of Social Position score for an individual the scale value for Occupation is multiplied by the factor weight for Occupation, and the scale value for Education is multiplied by the factor weight for Education. For example, John Smith is the manager of a chain supermarket. He completed high school and one year of business college. His Index of Social Position score is computed as follows:

<u>Factor</u>	<u>Scale Score</u>	<u>Factor Weight</u>	<u>Score X Weight</u>
Occupation	3	7	21
Education	3	4	12
Index of Social Position Score			33

#### IV. Index of Social Position Scores.

The Two Factor Index of Social Position Scores may be arranged on a continuum, or divided into groups of scores. The range of scores on a continuum is from a low of 11 to a high of 77. For some purposes a researcher may desire to work with a continuum of scores. For other purposes he may desire to break the continuum into a hierarchy of score groups.

I have found the most meaningful breaks for the purpose of predicting the social class position of an individual or of a nuclear family is as follows:

<u>Social Class</u>	<u>Range of Computed Scores</u>
I	11-17
II	18-27
III	28-43
IV	44-60
V	61-77

When the Two Factor Index of Social Position is relied upon to determine class status, differences in individual scores within a specified range are ignored, and the scores within the range are treated as a unit. This procedure assumes there are meaningful differences between the score groups. Individuals and nuclear families with scores that fall into a given segment of the range of scores assigned to a particular class are presumed to belong to the class the Two Factor Index of Social Position score predicts for it.

The assumption of a meaningful correspondence between an estimated class position of individuals and their social behavior has been validated by the use of factor analysis.<sup>2</sup> The validation study demonstrated the existence of classes when mass communication data are used as criteria of social behavior.

<sup>2</sup> See August B. Hollingshead and Frederick C. Redlich, Social Class and Mental Illness, John Wiley and Sons, New York, 1958, pp. 398-407.

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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 Doctorate in Education.

4/29/80

Date

  
Director's Signature