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Hourly Fluctuation of Middle Ear Pressure as a Function of Age in School-Age Children

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AN ABSTRACT OF THE THESIS OF Susan Hogue Henry for the Master of Science in Speech Communication: Speech and Hearing Science presented October 23, 1989.

Title: Hourly Fluctuation of Middle Ear Pressure as a Function of Age in School-age Children.

APPROVED BY MEMBERS OF THE THESIS COMMITTEE:

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Tympanometry is a useful means of evaluating the status of the middle ear. For the pediatric population, tympanometry is particularly valuable for determining the presence of middle ear effusion. The test has been incorporated in many school hearing conservation programs because of its ease of administration, objectivity, and diagnostic value.

In a study by deJonge and Cummings (1985), the hourly fluctuation of middle ear pressure was reported in a group of kindergarten-age children. The variability of middle ear pressure for that group of children averaged 150 daPa. In the present study, a maturational effect of this hourly fluctuation was observed between a group of first-grade age students and sixth-grade age students. Results indicated the younger group averaged a range of 145 daPa, correlating well with the deJonge and Cummings study, while the older group averaged a range of 92 daPa. Thus, as a child matures, the hourly fluctuation of middle ear pressure decreases significantly.

**HOURLY FLUCTUATION OF MIDDLE EAR PRESSURE AS A
FUNCTION OF AGE IN SCHOOL-AGE CHILDREN**

**by
SUSAN HOGUE HENRY**

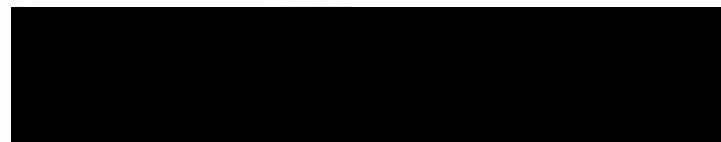
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**MASTER OF SCIENCE
in
SPEECH COMMUNICATION:
SPEECH AND HEARING SCIENCE**

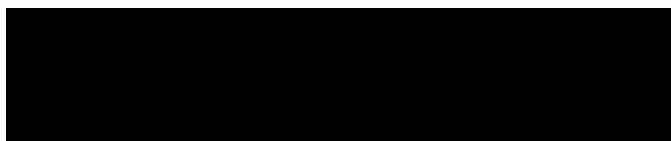
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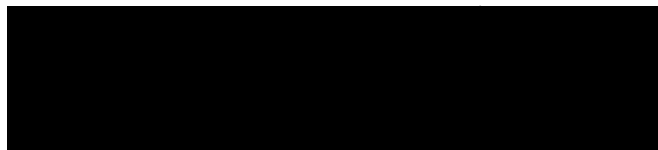
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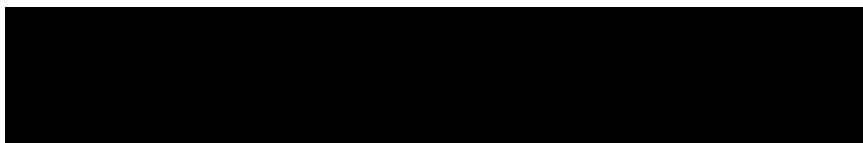


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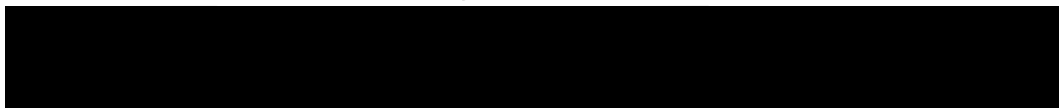


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The completion of a thesis brings forth a huge sigh of relief. Memories (some of them fond, some of them only slightly bearable) can be reflected upon and the people involved in those memories are seen with better insight. I will recall each of the people involved in this thesis as having a unique quality and always with a sense of appreciation.

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An immense amount of gratitude should be expressed to my parents. From early on, Mom and Dad have taught their children to better themselves and the world in which we live. They have also taught me how to endure difficult situations and times. This is a lesson usually learned with a great deal of heartache. I truly appreciate the love and dedication they have shown to me.

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CHAPTER I

INTRODUCTION

Pure tone audiometry and tympanometry have been considered useful tools for screening children's hearing in the school setting. Ben-David et al. (1981) suggested that the use of tympanometry in combination with audiometry appears to represent the best method available for detecting middle ear effusion and hearing deficits among children (for operational definitions of terms, see Appendix A). Likewise, Brooks (1980) indicated that impedance testing (tympanometry) appears to be highly suitable for identifying otitis media with effusion in a pediatric population. It is an accurate but not over-sensitive screening tool, while at the same time being simple, acceptable, and harmless.

The measurement of middle ear pressure by means of tympanometry is becoming a primary method of assessing middle ear function in school screening programs. The American Speech-Language and Hearing Association (ASHA) outlined criteria for determining the necessity of further audiologic examinations and medical referrals based on the pure tone testing and tympanometric results obtained in a screening program (ASHA, 1979). According to the 1979 ASHA screening guidelines, when middle ear pressure becomes more negative than -200 dekapascals (daPa) the ear is considered to be in need of appropriate audiological or medical follow-up. Negative values of middle ear pressure may be indicative of poor Eustachian tube function, a common precursor to otitis media. Concern arises, however, over the prospect

of an over-referral rate based on a negative middle ear pressure in excess of the ASHA guideline. As deJonge and Cummings (1985) revealed in a study of daily fluctuations in middle ear pressure, it is reasonable to expect fairly large variations in middle ear pressure in kindergarten-age children within a typical day. Specifically, these researchers found a daily variation of 150 daPa throughout the study, representing a 95% range.

The study of deJonge and Cummings (1985) did not address the possibility of a maturational or age-related effect on the daily range of middle ear pressures. A number of studies have shown that the occurrence of otitis media decreases as a child develops and matures (Coffey, 1956; Lowe, Bamforth & Prach, 1963; Neil et al., 1966; Howie, 1977). This is believed to be largely due to the development of the cranio-facial structures and the change in slope of the Eustachian tubes. Specifically, during childhood the tubal opening is set low in relation to the nasal passages and therefore there is greater risk of ear infection through the tubes. Normal functioning of the tube is also impaired by the presence of a larger amount of glandular tissue at the opening in children than in adults (Mawson, 1977). Given the reduced occurrence of otitis media with age, the question arises as to whether the normal, daily variation in middle ear pressure is also reduced with maturation and development.

The purpose of this study was to determine if daily fluctuations in middle ear pressure in children include a maturational effect. This was investigated by comparing the daily middle ear pressure fluctuations of first-grade age children to the daily middle ear pressure fluctuations of sixth-grade age children. Hourly middle ear pressures were recorded over three consecutive days for two age groups of children.

CHAPTER II

REVIEW OF THE LITERATURE

DEFINITION OF HEARING LOSS

One of the primary goals of identification audiometry for the school-age child is to identify children at risk for inadequate functioning in the classroom due to hearing loss (Northern and Downs, 1984). The degree of hearing loss necessary to cause a child's classroom functioning to become inadequate has been a subject of debate in the past. The American Speech-Language and Hearing Association (ASHA, 1981) reported "hearing impairment is defined as a deviation or change for the worse in either auditory structure or auditory function, usually outside the range of normal." The question of what constitutes auditory function "outside the range of normal" has never been adequately resolved. According to Northern and Downs (1984) "the problem is that no one has adequately defined the parameters of a hearing handicap nor described the best method for securing the necessary data for such definition."

In a hearing survey conducted by the Department of Health, Education, and Welfare, the prevalence of hearing loss in the 6-11 year old age group [according to the criterion of 26 dB hearing level (HL; ANSI, 1969) average loss at 500-2,000 Hz] was less than one percent (Leske, 1981). This disagreed with a parental questionnaire from the same survey which indicated that four percent of the population had a "hearing handicap." Additionally, while parents reported a prevalence of hearing loss among children with abnormalities of the

tympanic membrane, audiometric test results did not indicate significant hearing loss in those children. This study made it clear that audiometric screening according to the 26 dB HL criterion was failing to identify children with abnormalities not reflected by loss of pure tone sensitivity. For example, in a survey by Jordan and Eagles (1961), it was found among children with otitis media, fully fifty percent had hearing levels lower (better) than 15 dB HL. This suggests that even a strict criterion of 15 dB HL screening (or testing) level would miss half of the children with middle ear pathology. According to Northern and Downs (1984), these findings do not imply a lack of relationship between middle ear disease and hearing loss, but rather an incorrect definition for one or the other. They point out that while middle ear disease is an observable fact, hearing loss is a concept that must be defined.

Kessner et al. (1974) conducted a survey of children, 4-11 year olds, using the more stringent screening level of 15 dB HL at 500-2,000 Hz. Among the 1,639 children screened, 2.2 percent failed for both ears and 4.5 percent failed for one ear. When data from the 4-5 year old age group was isolated, 4.1 percent of the children showed a bilateral hearing loss, a statistic that correlates well with data obtained from the department of Health, Education, and Welfare Survey (Leske, 1981). Additionally, the mean hearing threshold of children with normal ears was 7.8 dB, while those with confirmed middle ear infection averaged 15.2 dB. With a mean threshold difference between the normal and affected ears of only 7.4 dB, it is clear that middle ear disease cannot be reliably detected by pure tone screening only.

According to Northern and Downs (1984), "the occurrence of both ear pathology and hearing loss is age-related in all studies of prevalence." Kessner's (1974) data suggested that both the incidence of ear pathology and

hearing loss peak at about age 2, and decline steadily to age 11, after which time the incidence is the same as in the adult population. The maximum prevalence of ear pathology was 30 percent at age 2, declining to 15 percent at age 11. Prevalence of bilateral hearing loss was determined to be about 5 percent at age 2, and 1.9 percent at age 11. Hearing loss increased to 15 percent at age 2 when the criteria was a 15 dB HL loss in at least one ear (Kessner, 1974). While unilateral hearing loss may appear to be unrelated to academic achievement, such a loss may have a greater effect than can be objectively measured (Northern and Downs, 1984). Boyd (1974) found that 30 percent of children with unilateral hearing loss had a mean academic achievement lag of 1.12 years. These findings were confirmed by Bess (1982).

For many years the 25 db HL average of pure tone thresholds at 500, 1,000, 2,000, and 3,000 Hz has been accepted as the cut-off of normalcy and impairment for adults, above which hearing loss is thought to become impairing (Northern and Downs, 1984). This criterion may be appropriate in assessing the effect of hearing loss on adults, but is not realistic when applied to the communication needs of school-age children. The essential reason for this is that adults have acquired the ability to "fill in missing sounds, a contextual strategy that is learned through years of speech and language experience." This is a strategy generally unavailable to young children who need to hear all speech sounds clearly in order to conceptualize the entire speech message. This essential difference between children and adults has been elaborated by Skinner (1978) to include differences in: 1) speech sound categorization as a result of fluctuating hearing loss; 2) perception of acoustic parameters (duration, intensity and pitch) in rapid speech; 3) perception of plurality, verb tense, intonation, and stress patterns; 4) ability to perceive speech in a typical

classroom signal-to-noise ratio of +12 dB; 5) ability to discriminate and learn speech sounds as an infant; 6) ability to identify early words due to inability to hear the low-energy sounds; and 7) difficulty hearing stress patterns in the low-frequency range, necessary to perceive the emotional content of speech.

Dobie and Berlin (1979) studied the effects of a 20 dB HL hearing loss with the following findings: 1) morphological markers may be unclear; 2) short words in connected speech are often "lost"; and 3) intonation perception becomes distorted.

Using the previous information, Northern and Downs (1984; p. 10) propose the following definition for hearing loss: "A handicapping hearing loss in a child is any degree of hearing that reduces the intelligibility of a speech message to a degree inadequate for accurate interpretation of learning." Since many variables affect a child's ability to learn, it is difficult to isolate hearing loss alone as the singular cause. Thus, hearing loss is one of many parameters involved in the child's learning process. To further complicate the matter, what constitutes a hearing loss to one child may not affect another, i.e., the exact degree of a handicapping hearing loss is specific to any individual, child or adult.

MIDDLE EAR EFFUSION

Middle ear effusion is prevalent in the United States and other countries that primarily treat middle ear infections with antibiotics, whereas middle ear effusion is less prevalent in countries that principally utilize other methods of treatment (Northern and Downs, 1984). This is thought to be due to the fact that, while antibiotics clear the middle ear of the bacterial infection, fluid sometimes

remains in the middle ear space that can result in a chronic secretion or effusion.

Since middle ear effusion is thought to be related to decreased language and academic learning, early identification must be regarded as critical. The handicapping effects of hearing loss associated with middle ear effusion have been well-documented (Holm and Kunze, 1969; Needleman, 1977; Northern, 1984).

In a carefully controlled study, Holm and Kunze (1969) compared two groups of 5-9 year old children. One group had a history of middle ear disease prior to age 2, while the control group had no history of any medical problems. Upon examination through a battery of tests requiring the processing of auditory stimuli, the otitis group scored significantly lower, while there was no difference in test scores from a battery of tests requiring the processing of visual stimuli only.

Beal (1972) studied a large group of Eskimo children, known for their high prevalence of middle ear disease. When comparing an otitis group to a control group, the otitis group scored significantly lower in overall abilities related to auditory perception, agreeing with the Holm and Kunze (1969) study.

Thus, the lack of agreement on the criteria for hearing loss has made it impossible to determine the prevalence of children with a handicapping hearing loss (Northern and Downs, 1984). Beyond this, the identification of such children is either a task not attempted due to lack of standards, or it represents a subjective effort dependent upon an examiner's individual criteria. Perhaps most important is the fact that traditional pure tone techniques for screening hearing fail to identify numerous individuals who have a slight hearing loss.

The necessity for a more inclusive screening program arises from these concerns.

USE OF IMPEDANCE IN SCHOOL SCREENING PROGRAMS

The current state of affairs in school screening programs is to include impedance testing in the protocol. The impedance technique is well-suited for use with children since it requires little cooperation, provides objective results, and is easily administered (Northern and Downs, 1984).

Brooks (1968, 1969, 1973, 1975, 1980) repeatedly provided evidence and rationale for the use of acoustic impedance measurement in conjunction with the standard pure tone screening for the school-age population. ASHA currently provides guidelines which outline referral criteria based on results of pure tone air conduction and impedance testing.

Opponents to the use of impedance testing in school screening programs base their concerns on the validity of impedance testing, or the false identification of individuals who do not have middle ear disease (Northern and Downs, 1984). Data describing daily fluctuations in middle ear pressure of school-age children were outlined by deJonge and Cummings (1985). In this study, the results demonstrated a large variability in middle ear pressure. A range of + or - 95% representing approximately 150 daPa was noted in kindergarten students when tested over a consecutive three and one-half day period. These results suggest that caution should be exercised in interpreting negative middle ear pressure since this degree of daily fluctuation can cause an ear to be passed or failed on a screening program criterion.

As described previously, the maximum incidence of ear pathology declines by 15% as a child matures from age 2 to age 11 (Kessner, 1974). The

study by deJonge and Cummings (1985) failed to indicate if a maturational effect exists in the daily fluctuations in middle ear pressure. Furthermore, research has not been published which directs itself to this issue.

CHAPTER III

METHOD

SUBJECTS

Two groups of elementary school students, consisting of 23 and 22 members in each group respectively, were chosen to participate in this study. Group I included 11 females and 12 males, while group II included 11 females and 11 males, therefore the groups were balanced for gender. The subjects were selected from the Montessori Earth School on the basis of age level, otoscopic results, and normal air conduction hearing thresholds [0-15 dB HL (ANSI, 1969) at 500-4,000 Hz]. A human subjects clearance and an informed consent form was obtained for each of the subjects under investigation (see Appendices B, C, and D).

Group I contained 23 children between the ages of 6 years, 6 months and 7 years, 6 months, while group II contained 22 children between the ages of 10 years, 3 months and 11 years, 3 months. Subject number 19 of group I had a pressure equalization tube in place in the left ear, therefore the left ear of subject 19 was eliminated from the study. The right ear was evaluated to be within the acceptable limits of hearing for the study, and foreign matter was not observable by otoscopy. A total of 45 ears were tested for group I and 44 ears were tested for group II.

INSTRUMENTATION

To determine eligibility for participation in the study, each child was examined otoscopically with a Welch-Allyn otoscope to rule out the presence of occluding cerumen. Pure tone air conduction threshold testing was performed with a Maico Model MA-41 audiometer. Immittance screening was performed with a Maico 610 portable immittance meter which had the capability to test -350 to +200 daPa. The audiometer and immittance meters were calibrated within one week prior to the onset of the testing. The immittance meters were re-calibrated before each day of testing.

PROCEDURE

Four days of actual testing were required to gather data from the participants. These days were consecutive school days, beginning on a Monday and concluding on a Thursday. During the first day, each child was examined otoscopically, and pure tone threshold testing was conducted for air conduction at the frequencies of 500, 1,000, 2,000, 3,000, and 4,000 Hz for both ears. This evaluation was performed in a sound-treated booth in a mobile testing van. Those children who had thresholds in the range of 0-15 dB HL bilaterally were therefore considered appropriate candidates for the remainder of the study.

During the second day the actual data gathering process began. Each of the 45 children received immittance testing on each qualifying ear hourly at seven times during the day, beginning at 8:30 a.m. The procedures for the third day were identical to the second day, i.e., immittance measures were taken

hourly at seven points throughout the school day for each child. The fourth day consisted of hourly immittance measurements from 8:30 a.m. to 12:30 p.m. Each child was then re-evaluated by pure tone air conduction testing in a manner similar to that on day one.

When immittance data collection was completed, each child's data were analyzed for mean pressure levels and standard deviations from the mean, in a manner similar to deJonge and Cummings (1985). More specifically, ranges of middle ear pressure data were compared between the two age groups and these ranges were analyzed by the Mann-Whitney U test to determine if a statistically significant difference existed between age groups, and if the difference exceeded the normal variations observed during successive measures within groups.

CHAPTER IV

RESULTS

Middle ear pressure means, standard deviations, and ranges for each individual child tested are presented in figures 1, 2, and Appendix E. The mean middle ear pressure for all individuals of group I was -67 daPa, significantly less ($p < 0.0001$) than the mean of -14 daPa for group II (see Appendix F). Mean absolute magnitude of the ranges for group I averaged a range of 145 daPa, significantly greater ($p < 0.001$) than the range of 92 daPa for group II (see Appendix G).

The pre- and post-test hearing threshold measurements were consistent by ± 5 dB for each individual ear evaluated at each test frequency. Thus, in no ear was there a greater variation of 5 dB between test days. This was also evaluated to be a constant and each subject served as their own control. Table I displays mean thresholds for each group, broken down to pre- and post-study (first and last day), and right and left ears.

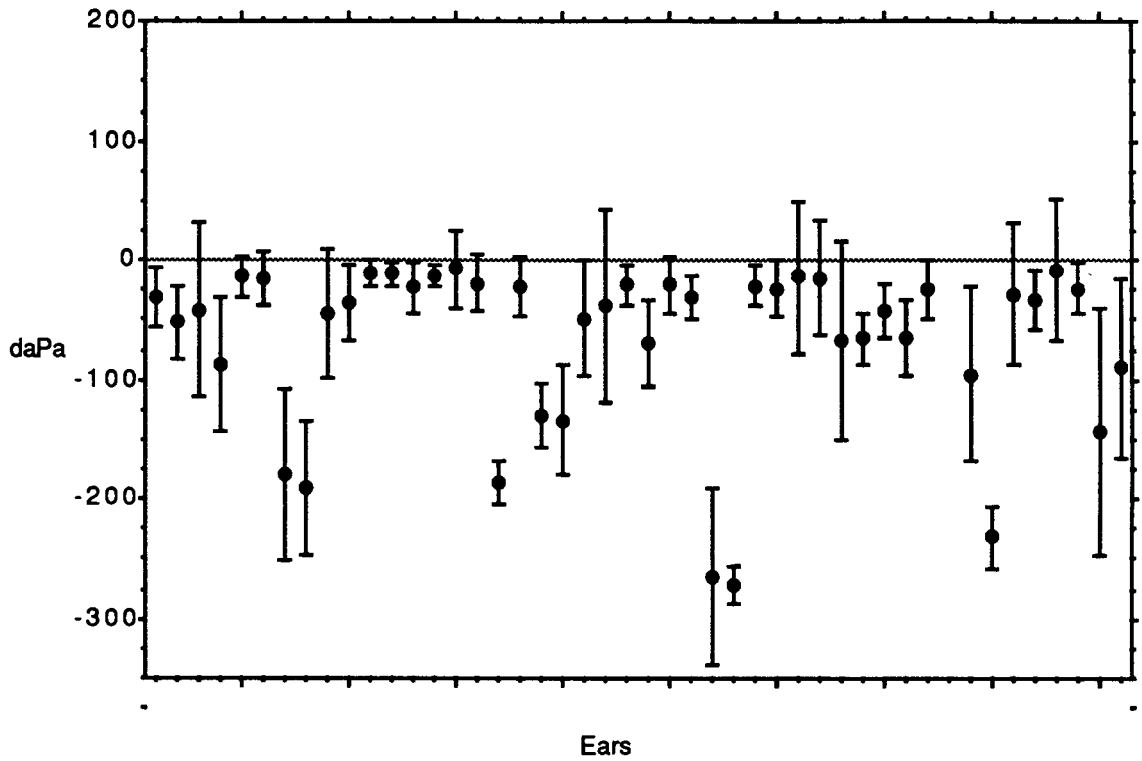


Figure 1. Means of middle ear pressures for group I. Bars indicate ± 1 standard deviation.

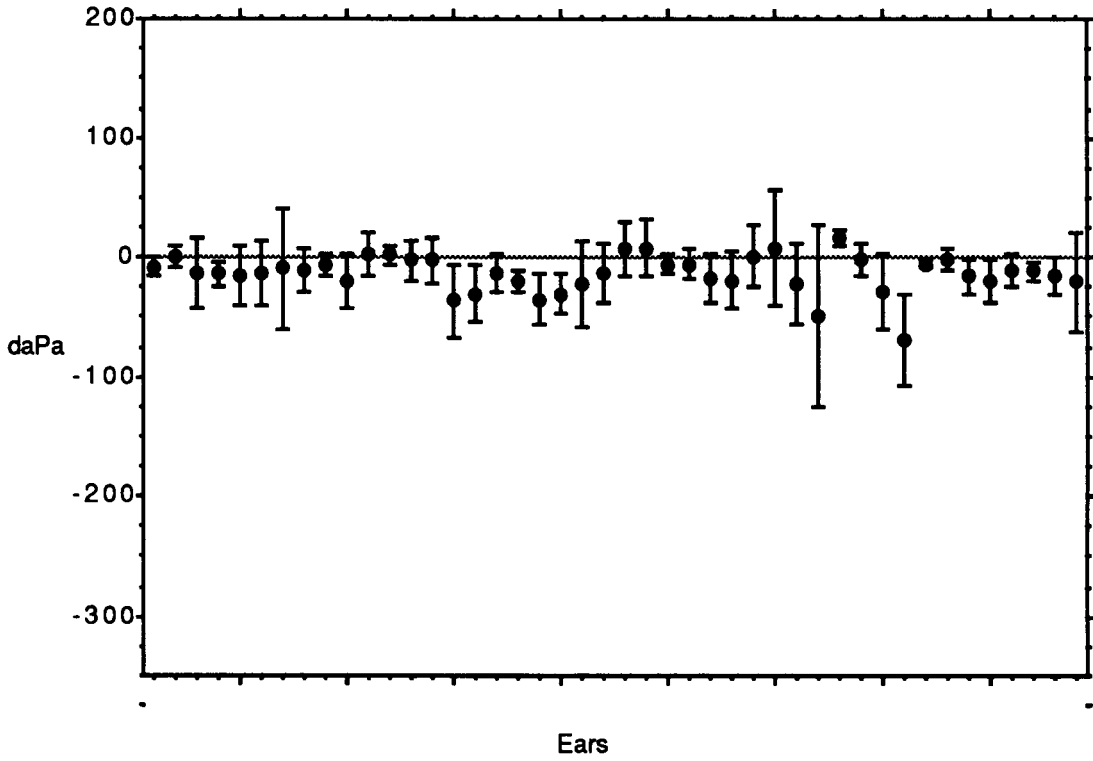


Figure 2. Means of middle ear pressures for group II. Bars indicate ± 1 standard deviation.

TABLE I
 MEAN PURE TONE AIR CONDUCTION THRESHOLDS

freq (Hz)	group I		group II		pre-		post-	
	right	left	right	left	right	left	right	left
500	13	13	13	12	14	14	13	13
1,000	8	8	9	9	8	7	8	7
2,000	5	7	7	7	7	7	7	8
3,000	5	5	8	7	7	6	6	7
4,000	6	8	7	6	7	8	5	5

CHAPTER V

DISCUSSION

The purpose of this study was to investigate the hypothesis that the hourly range in middle ear pressure decreases with age in the primary school age population. The results indicate a greater range in middle ear pressures for the first-grade group when compared to the sixth-grade group. These statistics appear to support the hypothesis that the hourly range in middle ear pressure decreases with age. Also of interest was the difference between the means of middle ear pressures between the two groups, with the younger group reflecting a significantly more negative value of middle ear pressures.

Middle ear pressure is measured in relation to whatever the atmospheric pressure is at the time of testing. A measurement of "0 daPa" indicates the pressure in the middle ear tympanum is the same as the air pressure outside of the tympanic membrane. If the middle ear pressure is negative, pressure within the tympanum is less than the ambient pressure. If the pressure is positive, it is greater than atmospheric pressure.

Middle ear pressure is typically negative in children due to the anatomical and physiological differences between children and adults. When the Eustachian tube does not open for an extended period of time, the air in the tympanum becomes absorbed into the middle ear mucosal lining to the point of reducing the middle ear pressure to less than atmospheric, resulting in "negative middle ear pressure." It is believed that children eventually outgrow

this phenomenon due to the maturity of their middle ear systems and the physiological growth, allowing the Eustachian tubes to open at appropriate intervals of time to provide sufficient balance in air pressure between the tympanum and the atmosphere.

The Eustachian tube and its function matures from birth through adulthood in more ways than just the development of cranio-facial structures and the slope orientation. Some of the less well-known changes include differences in cartilage and muscle as they relate to the ostium of the Eustachian tube. Research repeatedly has indicated that the ostium of the Eustachian tube lies lower in the nasopharyngeal vault in children than it does in adults. According to Holborow (1970), the tubal cartilage lies more in the plane of the base of the skull, unlike the adult tubal cartilage which lies at right angles to this plane. The medial laminae of the cartilage is relatively shorter and the levator palati muscle is separated by a considerable distance from the cartilage. There are also considerable changes in the amount of glandular tissue around the tube which decreases with age. Holborow continues to say that these changes occur from birth to age 7 years, during which time the tensor palati muscle is the only active muscle concerning Eustachian tube function.

Results of the present study are consistent with the physiological changes reported by Holborow (1970). It has been shown that there is a significant difference in the variability in middle ear pressure between the first- and sixth-grade groups, roughly corresponding to the 6- and 11-year old age groups respectively. It is possible that these differences between the two age groups studied may be attributed to the anatomical and physiological changes described by Holborow and other researchers.

A hearing conservation program in the schools should not be solely dependent upon pure tone air conduction threshold measurements as a basis for referring other tests. The status of the middle ear space, particularly in the younger child, may be less than optimal even though the hearing test results are normal. Feldman (1977) agreed with many other researchers in saying that children will typically have more problems with otitis media and periodic Eustachian tube blockage and subsequent tympanic membrane retraction than adults. These conditions will modify the middle ear pressure, but not necessarily impair the hearing of the child. This has been found true in this study, where all the children maintained normal hearing of 0-15 dB HL thresholds, yet the variability and absolute values of middle pressure were found to decrease as the child matures. Therefore, a hearing test alone will not indicate the physiological status of the child, particularly a young child who has had bouts of recurrent otitis media. Subsequently, appropriate medical referrals may be overlooked.

CONCLUSION

Because of the variability of middle ear pressure found in this study, a correlation is apparent with the findings of the Nashville Task Force of 1977, which was presented in an article by Bess (1980). The Task Force recognized the value of impedance as a diagnostic tool while cautioning greatly against mass screenings and the diagnosis of middle ear functioning based solely upon impedance results. Bess emphasized that mass screening using impedance measurements is premature, and felt that the ASHA guidelines proposed in 1979 may be a more appropriate alternative guideline. However, after reviewing the ASHA guidelines, and comparing them with the results of this

study, one has to question the reliability of tympanometry as a screening tool for school-age children. Because of the variability, it is proposed that criterion for passing or failing screening be reviewed and repeated measures of tympanometry be made mandatory.

In review of this discussion it is apparent that many areas have been addressed. These can be summarized as follows: 1) hearing test thresholds do not always reflect the middle ear status of children; 2) the anatomical and physiological changes with maturity and how these changes relate to middle ear pressure becomes obvious; 3) the variability of middle ear pressure in children lessens with maturity; 4) the guidelines currently proposed for screening school age children need to be reviewed and revised.

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APPENDIX A

OPERATIONAL DEFINITIONS OF TERMS

Source: Taber's Cyclopedic Medical Dictionary, 1985

Effusion: Escape of fluid into a cavity or tissue. (In this text effusion will indicate the escape of fluid into the middle ear cavity.)

Otitis media: Inflammation of the middle ear which may be marked by pain, fever, abnormalities of hearing, tinnitus, and vertigo.

Otitis media, adhesive: Otitis media resulting in the formation of adhesions between the tympanic membrane and the bony walls of the middle ear or the ossicles.

Otitis media, secretory: A painless accumulation of serous or mucoid fluid in the middle ear, resulting from obstruction of the eustachian tube and causing conductive hearing loss.

Otitis media, serous: Inflammation of the middle ear accompanied by fluid which resembles serum.

Otitis media, suppurative: Otitis media, serous: Inflammation of the middle ear accompanied by fluid which resembles pus.

APPENDIX B

HUMAN SUBJECTS CLEARANCE FORM

Portland State University

MEMORANDUM

HUMAN SUBJECTS RESEARCH REVIEW COMMITTEE
1987-88

DATE: 21 March 1988
TO: Susan Henry, SP
FROM: Robert C. Holloway, Chairperson
Human Subjects Research Review Committee (HSRRC)
RE: HSRRC Approval

In accordance with your request, the Human Subjects Research Review Committee has reviewed your proposal entitled Maturatioonal Effects on the Daily Fluctuations of Middle Ear Pressure in Children for compliance with DHHS policies and regulations on the protection of human subjects.

The committee is satisfied that your provisions for protecting the rights and welfare of all subjects participating in the research are adequate and therefore the project is approved. Any conditions relative to this approval are noted below:

Modification of Consent Letter Re: Parents Consent Letter needs to be written in simpler, much less technical language. Child's Consent Letter recommended not to use words "audiologist", "tympanogram", etc.

c: Office of Grants and Contracts

RCH:asm

APPENDIX C

INFORMED CONSENT LETTER: PARENTS

Dear Parents:

I am a graduate student in Audiology at Portland State University. I am conducting a study, under the supervision of Dr. James Maurer and Dr. Thomas Dolan, regarding the fluctuation in middle ear pressure (compliance) in a pediatric population when measured by tympanometry. I am attempting to determine the degree of fluctuation of the compliance values throughout the day and whether there is a maturational effect associated with the degree of fluctuation. The results of the study should give insight to the reliability of tympanometry measurements used in a school hearing screening program.

This study can be accomplished by the following: I will test your child's hearing by use of pure tone air conduction audiometry during school on the first day of the investigation. Should your child meet the criterion for "normal hearing," he/she may be considered a candidate for the remainder of the study. During the course of the next three days, your child will have a tympanogram performed for the right and left ears each hour for a consecutive seven hours throughout the school day. Neither the pure tone audiometry nor the tympanometry is physically harmful to your child.

The pure tone air conduction testing will take approximately 5 minutes. Each of the tympanometry testing will take approximately 20 seconds. In no way will your son/daughter's name be used in reporting the results of this study. You may withdraw from this study at any time.

If there are any questions or problems regarding any aspect of this study, I may be reached at the Oregon Health Sciences University at 279-8510. Additionally, Dr. James Maurer may be reached at Portland State University at 464-3533. If you should experience problems as a result of your child's participation in this study, please contact Victor Dahl, Office of Graduate Studies and Research, 105 Neuberger Hall, Portland State University, 464-3423.

Please sign below indicating your approval. If you are interested in the results please indicate below and I will send an abstract of the results of the study. This will require approximately 6 months from the time of the investigation.

Thank you for your help.

Susan Hogue Henry, CCC-A
Portland State University
Speech and Hearing Sciences

YOUR NAME: _____ DATE: _____

CHILD'S NAME: _____ BIRTH DATE: _____

ADDRESS: _____

APPENDIX D

INFORMED CONSENT LETTER: GROUP II CHILDREN (OLDER GROUP)

My name is _____. Susan Henry has asked me to help her finish a project at her school where she is studying to be an Audiologist. My part in the project is to have my hearing tested under headphones on one day, and have a tympanogram done each hour during school for the next three days. Susan Henry will walk me from my classroom on the first day to a very quiet room to test my hearing and then take me back to my class when I am finished. This will take about 5 minutes. During the next three days, Susan Henry will come to my classroom and ask me to come to a desk where she will have a tympanometer. This means she will put a small soft plug in my ears and it will feel like I am going up and down in an elevator. Susan Henry will do this each hour for seven hours throughout the day. Each time it will take about 20 seconds.

I know it may be frustrating to leave my activity for the 20 seconds each hour but I know it will not harm me physically in any way.

My part in the project may help the hearing screening programs in all schools.

If I decide not to be a part of this project, it will not change anything at school for me. If I don't want to do it no one will be mad at me and my grades will not be any different.

Susan Henry has told me she will help me if I don't understand or have any questions about her project. I know that if I change my mind and do not want to finish my part in the project I can stop at any time.

I am signing my name below to tell Susan Henry that I will help her finish her project, and that I understand everything that is said in this letter.

SIGNATURE: _____ DATE: _____

APPENDIX E

MEANS, STANDARD DEVIATIONS, AND RANGES OF MIDDLE EAR PRESSURES FOR EACH EAR EVALUATED IN GROUPS I AND II

ear	mean group I	mean group II	s.d. group I	s.d. group II	range group I	range group II
1R	-31	-8	25	8	84	31
1L	-52	0	30	9	119	41
2R	-41	-13	74	29	381	147
2L	-87	-14	56	10	178	44
3R	-14	-16	18	24	69	85
3L	-16	-14	23	27	104	107
4R	-180	-9	72	50	250	269
4L	-190	-12	56	18	275	60
5R	-44	-7	54	10	200	44
5L	-35	-20	31	22	103	75
6R	-11	3	12	18	51	82
6L	-11	1	10	8	31	32
7R	-23	-3	21	17	66	75
7L	-13	-3	10	19	28	72
8R	-7	-36	33	30	156	128
8L	-19	-31	24	24	84	97
9R	-186	-14	19	15	66	66
9L	-22	-19	24	9	100	41
10R	-130	-35	26	21	109	97
10L	-134	-30	46	17	144	66
11R	-49	-22	48	36	200	163
11L	-38	-13	80	24	163	100

12R	-20	7	17	23	78	85
12L	-70	8	36	24	128	100
13R	-21	-6	23	8	79	34
13L	-31	-5	18	13	63	60
14R	-264	-18	74	20	275	84
14L	-272	-19	16	24	50	97
15R	-21	1	18	26	56	116
15L	-24	7	23	48	98	210
16R	-14	-23	64	34	247	153
16L	-15	-50	48	76	197	331
17R	-67	16	83	6	362	19
17L	-66	-2	21	13	91	47
18R	-42	-29	23	31	81	109
18L	-65	-69	32	39	141	141
19R	-24	-5	24	4	85	22
19L	•	-2		8	•	38
20R	-96	-16	73	14	215	50
20L	-231	-20	26	19	122	78
21R	-28	-12	60	14	275	62
21L	-34	-12	25	8	107	25
22R	-8	-15	60	16	269	72
22L	-24	-21	22	42	94	193
23R	-144	•	103		253	•
23L	-90	•	75		219	•
average	-67	-14	24	14	145	92

APPENDIX F

**SUMMARY TABLE OF MANN-WHITNEY U CALCULATED TO COMPARE
MEANS OF MIDDLE EAR PRESSURES BETWEEN GROUPS I AND II**

Mann-Whitney U X₁ : group # Y₁ : means

	Number:	Σ Rank:	Mean Rank:
Group 1	45	1355	30.111
Group 2	44	2650	60.227

U	320	
U-prime	1660	
Z	-5.498	p = .0001
Z corrected for ties	-5.5	p = .0001
# tied groups	21	

APPENDIX G

**SUMMARY TABLE OF MANN-WHITNEY U CALCULATED TO COMPARE
RANGES OF MIDDLE EAR PRESSURES BETWEEN GROUPS I AND II**

Mann-Whitney U X₁ : group # Y₁ : mag of rmg

	Number:	Σ Rank:	Mean Rank:
Group 1	45	2426.5	53.922
Group 2	44	1578.5	35.875

U	588.5	
U-prime	1391.5	
Z	-3.295	p = .001
Z corrected for ties	-3.295	p = .001
# tied groups	21	