PREVALENCE OF OTITIS MEDIA AND HEARING LOSS AND EFFECTS OF SOUND-FIELD FM AMPLIFICATION AMONG FIRST NATIONS ELEMENTARY SCHOOL CHILDREN

by

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Submitted in partial fulfillment of the requirements
for the degree of Master of Science

at

Dalhousie University
Halifax, Nova Scotia
June 2006

Your file Votre référence
ISBN: 978-0-494-19490-4
Our file Notre référence
ISBN: 978-0-494-19490-4

DALHOUSIE UNIVERSITY

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Abstract

The present studies investigated the prevalence of otitis media and hearing loss among First Nations elementary school children. As well, the adequacy of the acoustic conditions in the Pictou Landing First Nations elementary school classrooms were examined. Finally, the effects of sound-field FM amplification on student classroom performance were determined using the SIFTER. Results revealed, consistent with previous research, that the First Nations children suffer from higher prevalence rates of otitis media and hearing loss than non-Native children. The classrooms of the First Nations elementary school were found to have an acceptable reverberation time, but unacceptable ambient noise levels. In general, students including those with and without hearing loss demonstrated an improvement in classroom performance during use of the sound-field FM amplification system. Clinical implications of hearing screenings in First Nations schools are discussed, as are the benefits of sound-field FM amplification and the need for its advocacy among clinicians.

Acknowledgements

I would like to express my deepest appreciation to Dr. Ravi Sockalingam who not only served as my research supervisor providing valuable resources, insight and guidance, but also constantly gave me support, encouragement and reassurance. I would also like to thank my committee member, Dr. Walter Green, for taking the time to work with me during this endeavour. Special thanks to my committee member, Dr. Rachel Caissie, who kindly agreed to take on a larger role during the later stages of this project. Thank you to Dr. Fred Wien for serving as my external reviewer. I would also like to thank my dear friends and family for their unconditional support and love. Finally, to my soon-to-be husband, Dean, thank you for not only providing your statistical expertise, but also for being so patient and understanding.

Chapter 1 General Introduction

It has been recognized for many years that among Canadian Aboriginal children the occurrence of otitis media (ear infection) and its associated hearing loss are significantly more common than among the general Canadian population (Julien, Baxter, Crago, Ilecki, & Therien, 1987). This hearing loss often fluctuates and may go unrecognized by parents due to the often asymptomatic nature of otitis media (Rosenfeld & Bluestone, 2003). Therefore, in the classroom, on any given day, children may unknowingly suffer from hearing loss which adversely affects their ability to hear and attend to the teacher (Berg, 1987).

Equally important as considering the hearing status of children within the classroom learning environment is the consideration of the acoustic environment offered by the classroom setting. It is assumed that students can hear clearly as well as attend to the spoken instruction provided by teachers, but in schools children are often placed in degraded listening situations (Flexer, 2005). Research has repeatedly shown that the background noise levels and amount of reverberation (echo) that exist in classrooms interferes with children's ability to hear the teacher (e.g., Finitzo-Hieber & Tillman, 1978).

All children, including those with hearing loss and those with normal hearing sensitivity, are affected by these poor acoustic conditions. Research indicates, however, that this challenging listening environment more adversely affects children with hearing loss because it further compounds the hearing difficulties they already face (Crandell, Smaldino, & Flexer, 2005). Considering the high prevalence of hearing loss among

Aboriginal children, it is reasonable to assume that the typical classroom setting offers an acoustically unacceptable learning environment for these students.

Sound-field FM amplification systems have been proposed as a remediation tool to improve the listening conditions of classrooms. This technology allows control of the acoustic environment of the classroom by amplifying the teachers voice and ensuring it reaches all children in all locations of the classroom (Flexer, 2005). The use of sound-field amplification systems have been shown to improve the classroom listening and academic behaviours in children (e.g., Allen & Patton, 1990). The majority of this research has focused on children with normal hearing sensitivity or on those with permanent hearing loss; the effects of amplification use on children with fluctuating hearing loss secondary to diagnosed otitis media, however, have not been thoroughly investigated.

The present study consists of two separate experiments designed to address the two major factors affecting the auditory learning environment: the hearing status of the students and the classroom listening conditions. The first experiment was completed to determine the prevalence of otitis media and its associated hearing loss among First Nations elementary school students. The purpose of the second experiment was twofold. First, the noise levels and amount of reverberation were evaluated in classrooms to determine the listening conditions of the school. Second, the effects of sound-field amplification use on the classroom performance of students with and without a hearing loss were investigated.

Chapter 2 Experiment One Introduction

Hearing loss has been reported to be highly prevalent among Canadian Aboriginal children compared to other groups of people, with prevalence rates among the school-age population ranging between 4-30% (e.g., Ayukawa, Bruneau, Proulx, Macarthur, & Baxter, 1997; Ayukawa, Lejeune, & Proulx, 2000; Eriks-Brophy & Ayukawa, 2000; Julien et al., 1987; Ling, McCoy, & Levinson, 1969; Schilling, Buelow, & Duval, 2002; Woods, Moffatt, Young, O'Neil, Tate & Gillespie, 1994). These studies were conducted in various regions across northern Canada and demonstrate that hearing impairment in school-aged Inuit children has been highly prevalent for over 3 decades. More specifically, in 1987 Julien and colleagues reported loss of hearing in Inuit children to be 23%, and more recently, in 2002, 30% of Inuit children were identified with hearing loss (Schilling et al., 2002). Comparatively, prevalence rates among the general population (non specific races) including 38000 school-aged children found only 2.63% to have a hearing impairment (Lundeen, 1991). Evidently, Aboriginal children, in particular Inuit children, suffer from exceedingly high rates of hearing loss.

Few studies exist regarding hearing loss among Aboriginal children living in the southern regions of Canada, namely First Nations children. One study completed on an entire reservation in British Columbia reported abnormal hearing among 31.3% of the community (Cambon, Galbraith, & Kong, 1965). Another study in British Columbia investigated the prevalence of hearing loss in First Nations children and found 19.2% of children to have a hearing impairment (Doyle & Morwood, 1976). More recently, a prevalence study completed on the eastern coast of Canada revealed hearing loss in 17.4% of First Nations elementary school children compared to 3.7% of non-Aboriginal age-matched children from a nearby community (Van Ek & Sockalingam, 2004). Although limited in number, these studies suggest that high rates of hearing impairment also exist among Aboriginal children beyond the arctic region.

The present study seeks to further the research by Van Ek and Sockalingam (2004) by following up in the 2004-2005 school year to determine the prevalence rates of hearing loss among the children who attend the First Nations elementary school in Pictou Landing, Nova Scotia.

Otitis Media

The most frequent cause of hearing loss in children is otitis media. Narrowly defined, otitis media is the presence of inflammation in the middle ear cavity. The terminology, definitions and classification of middle ear disease has evolved over the past few decades. During this time a multitude of terms have been used to describe the inflammatory condition of the middle ear often resulting in confusion and misunderstanding among clinicians and researchers (Bluestone & Klein, 1995). To avoid ambiguity, the terms and classification used in this study are defined below.

Acute otitis media (AOM) is the presence of middle ear effusion with the rapid and short onset of signs and symptoms of inflammation of the middle ear cavity. One or more symptoms include acute onset of otalgia, otorrhea, fever, malaise, irritability, anorexia, vomiting or diarrhea. Local findings present with a full or bulging tympanic membrane with limited or absent movement to pneumatic otoscopy. Erythema may be present (Bluestone & Klein, 1995). After resolution of AOM symptoms persistent middle ear effusion may persist for weeks to months following AOM, although this condition is indistinguishable from otitis media with effusion (Rosenfeld & Bluestone, 2003).

Otitis media with effusion (OME) is the presence of inflammation of the middle ear cavity with relatively asymptomatic middle ear effusion. OME is distinct from AOM because it lacks the signs and symptoms of an acute ear infection (e.g., fever) (Bluestone, 1998). OME may occur spontaneously because of poor Eustachian tube function or as an inflammatory response following AOM. The middle ear effusion may be serous, mucoid or purulent. The most frequent otoscopic finding is opacification of the tympanic membrane, which makes assessment of the type of effusion not possible. Thus, the diagnosis of OME is limited to the observation that fluid of a non-specific nature is present in the middle ear space. Local findings reveal a convex or retracted tympanic membrane with impaired mobility on the pneumatic otoscopy. However, bulging or fullness of the tympanic membrane may be visualized. In addition, an air-fluid level or air bubbles may be observed. The duration of the presence of the middle ear effusion can be acute (less than 3 weeks), subacute (3 weeks to 3 months) or chronic (more than 3 months) (Bluestone, 1998; Bluestone & Klein, 1995).

Atelectasis of the tympanic membrane, which may or may not be associated with otitis media, is either collapse or retraction of the tympanic membrane. Collapse involves passivity, whereas retraction implies active pulling inward of the tympanic membrane, usually due to negative middle ear pressure. Atelectasis of the tympanic membrane is not considered a type of otitis media, but rather a related condition which may be present prior to, concurrent or after an episode of OME (Bluestone & Klein, 1995).

Hearing loss secondary to otitis media can be affected not only by reduced air pressure in the middle ear space, but also by fluid retained in the middle ear cavity. The effusion compromises the traditional sound pathway of the middle ear by decreasing the mobility of the tympanic membrane and/or increasing the tension and stiffness of the middle ear mechanism which results in loss of hearing sensitivity (Bluestone & Klein, 1995; Rosenfeld et al., 2004).

Fluctuating conductive hearing loss is present in most children who have middle ear effusion as a result of OME or AOM. Due to their lack of symptoms, OME and persistent middle ear effusion following AOM and their concomitant hearing loss often go unrecognized by parents. The loss of hearing ranges from mild to moderate (15 to 40 dB), with an average hearing threshold of 27 dB HL (Rosenfeld & Bluestone, 2003). This variation in hearing loss is not influenced by the quality or viscosity of the fluid in the middle ear cavity (i.e., ears with serous fluid are not less impaired than those with more viscous fluid). Instead the volume of the effusion has been found to have an impact on hearing threshold. Ears that are only partially filled with fluid (as evident by the presence of an air-fluid level or bubbles on the pneumatic otoscopy) have less of a hearing impairment than those ears completely filled with fluid (Fria, Cantekin, & Eichler, 1985; Wiederhold, Zajtchuk, Vap, & Paggi, 1980).

Otitis Media Prevalence

Otitis media has been reported to be highly prevalent among Canadian Aboriginal children compared to other groups of people. More specifically, since the 1960s researchers have been finding overwhelming rates of chronic otitis media (COM) among this population (e.g., Baxter, 1999; Julien et al., 1987; Ling et al., 1969; Tremblay, 1990). COM is typically defined in these studies as a chronic infection of the middle ear cleft including perforation of the tympanic membrane, with and without otorrhea. This type of otitis media is uncommon in non-native children (Baxter, 1999) and is often a result of AOM, but may also occur when chronic or persistent OME is present (Bluestone, 1998).

Longitudinal data collected from the Eastern Canadian Arctic (Baffin Zone) has shown an evolving pattern of middle ear disease between 1968 – 1998. In particular, in the late 1960s and 1970s COM was the most common type of ear disease and AOM and OME were seldom seen. However, starting in the1980s this pattern of ear disease began to change and AOM and OME were more frequently being diagnosed and no longer were discharging ears prevalent (Baxter, 1999; Baxter, Stubbing, Goodbody, & Terraza, 1992). On the contrary, a study (Ayukawa et al., 1997) in Nunavik, Quebec compared prevalence rates of otitis media between 1987 and 1997 and discovered that rates of OME decreased from 3.1% to 0%, whereas the prevalence of COM increased from 9.4% to 16.9%. These findings suggest that although a decreasing trend is occurring in some areas, the problem of otitis media continues to persist (Ayukawa et al., 1997; Baxter, 1999).

There is limited data that exists on types of otitis media present in First Nations children outside of the arctic circle. A review of those studies which do report otitis media in First Nations children in the southern regions of Canada suggests that OME is the most common condition followed by some cases of perforated tympanic membranes, drainage of ears, and cholesteatoma (Cambon et al., 1965; Doyle & Morwood, 1976; Scaldwell & Frame, 1985). These studies were completed in western Canada and Ontario and there is currently no published data on the types of otitis media present in First Nations children in eastern Canada. The present study will determine the types of middle ear pathology present in First Nations elementary school children in Nova Scotia.

The majority of Canadian prevalence studies on otitis media have been conducted on Inuit children in the arctic regions. Prevalence rates of COM among the school-age population have been found to range between 3.1-50% (e.g., Ayukawa et al., 1997; Baxter, 1999; Baxter & Ling, 1974; Julien et al., 1987; Ling et al., 1969; Woods et al., 1994). These prevalence rates are exceptionally high especially considering that they represent Aboriginal children who are of school age. In the general population, typical prevalence patterns show episodes of otitis media to decline significantly after the 1st year of life becoming relatively uncommon in children 7 years and older (Bluestone & Klein, 1995).

In a First Nations elementary school population in Nova Scotia, Van Ek and Sockalingam (2004) categorized Type B tympanograms (suggestive of effusion in the middle ear) into three age groupings. They reported no Type B tympanograms in the 4-6 year olds, while 16.7% and 10% were found for the 7-9 and 10-12 year old groups, respectively. Furthermore, hearing loss for 4-6 year olds and 7-9 year olds was found to be equally high at 16.7%, whereas hearing loss in the older age group (10-12 year olds) was found to increase to 20%. These elevated rates in the older age categories are contradictory to the typical prevalence patterns found in the general population. They are, however, consistent with the high rates of otitis media and hearing loss reported in the school age Inuit children.

In the general population, by the age of 3 years, children can be categorized into one of three groups: otitis media free, occasional otitis media or otitis prone (Bluestone & Klein, 1995).

Clearly, Aboriginal children are often considered to be part of the later grouping. In fact, being of Aboriginal descent has been identified as a risk factor for developing recurrent otitis media (Bluestone & Klein, 1995). It has also been suggested that in Aboriginal children otitis media has the potential to establish itself and become chronic beyond the age of 3 (Ayukawa et al., 1997). On the contrary, a study completed in the general population found that persistent middle ear effusion is more common in children 2 years of age or younger (Pelton, Shurin, Donner, & Klein, 1977). In the general population middle ear disease is considered a disease of infancy and early childhood and its occurrence early in life is attributed to factors such as maturing anatomical, physiological, and immunology (Bluestone & Klein, 1995). It is not clear why the Aboriginal population seems to remain at risk for developing otitis media beyond early childhood (Baxter, 1999).

There is limited data on the prevalence of otitis media in First Nations children living in the more southern regions of Canada. The *First Nations Regional Longitudinal Health Survey* (2005) conducted a nation-wide survey on 270 First Nations communities across Canada (excluding Nunavut). The sample included 9483 children (0-11 years) and 8276 youth (12-17 years). According to parental report, chronic ear infections are among the top three most common health conditions experienced by the First Nations children and youth. In particular, 9.2% of children and 5% of youth were reported to suffer from chronic ear infections or ear problems (likely otitis media).

The Health of the Nova Scotia Mi'kmaq Population (1999) is a provincial research report which was established to contribute data in 1997 to the *First Nations Regional Longitudinal Health Survey* (2004). *The Health of the Nova Scotia Mi'kmaq*

Population (1999) includes 230 children (0-11 years) and 100 youth (12-17 years) all of Mi'kmaq heritage representing 13 Mi'kmaq communities around Nova Scotia. In this survey parents reported that ear problems were the most common (18%) chronic health condition that their children experienced. Similarly, the youth population self-reported that ear problems ranked in the top two or three most common health problems, with 22% of females affected, and 24% of males experiencing ear problems. These results support the findings which demonstrate that among Aboriginal children, otitis media is common beyond the age of 2 years (Bluestone & Klein, 1995).

Evers and Rand (1982) compared the number of physician visits between native children and non-native children in southern Ontario. They found that First Nations children had 3 times as many doctor visits for otitis media than non-native children. Interestingly, the *First Nations Regional Longitudinal Health Survey* (2005) also reported that only 1 in 4 (25%) of those children who suffer from ear infections were receiving treatment for them.

Middle ear disease has been reported to be highly prevalent among the First Nations population in British Columbia. In 1965, Cambon and colleagues reported the prevalence rate of middle ear disease to be 13.7% (results were not given separately for children). Another study of western Canada found prevalence of middle ear disease in First Nations children (1-11 years of age) to be 12.7% (Doyle & Morwood, 1976).

The prevalence rates of otitis media were investigated among 739 Cree and Ojibway school-aged children in six communities in Ontario. It was found that OME was present in 23% of the total sample with communities ranging from 8.3-35.7% (Scaldwell & Frame, 1985). No published research currently exists on the prevalence of diagnosed otitis media in the First Nations population on the eastern coast of Canada. The present study was intended to determine the prevalence of otitis media among First Nations elementary school children in Nova Scotia.

Etiology

There is a lack of research regarding the etiology of the high prevalence rates of middle ear pathology in the aboriginal population. The majority of research suggests that these high rates are a result of the dramatic lifestyle change imposed upon the aboriginal people. In particular, with the development of northern Canada and the building of the Distant Early Warning Radar Line across the north in the early 1950s all but a few individuals abandoned their traditional nomadic ways of life and settled into communities (Baxter, 1990). This theory is supported by one of the earliest studies conducted on the middle ear status of an Inuit community. Baxter (1974) found little evidence of past or present ear disease in the adult population born prior to 1950 and concluded that these high rates of middle ear pathology are a relatively recent phenomenon. Furthermore, it has been reported that the rates of healed or persistent otitis media are five times higher among Inuit living in larger settlements compared to those living more traditional ways (Baxter, 1990).

It is hypothesized that the initiation of contact with the outside world brought pathogens for which the Inuit had little or no immunity to. In addition, it is suggested that this change to modern living introduced a host of environmental risk factors which contribute to increase the susceptibility to develop middle ear pathology (Baxter, 1990). A few of these variables are discussed below.

To begin, nutrition and breastfeeding have been identified as potential risk factors. Bowd (2005) stated that prevalence rates of otitis media were lower when traditional hunting was maintained and breastfeeding widely practiced. In particular, the change from the traditional high protein, high fat diet to a high carbohydrate diet may have altered their immune resistance and increased the risk of developing otitis media (Baxter, 1990). Studies have shown that the risk of otitis media is significantly reduced by breastfeeding due to its properties which help protect against otitis media and respiratory infection during, as well as after breastfeeding is discontinued (Bowd, 2005). *The Health of the Nova Scotia Mi'kmaq Population* (1999) reported that only 28% of Nova Scotia Mi'kmaq mothers breast fed their child which is in sharp contrast to the 72% of mothers who breastfeed in the general population across Canada.

Exposure to tobacco smoke is another variable which has been recognized as a risk factor for otitis media. In particular, the inhalation of smoke may result in inflammation of the mucous membranes of the nasopharynx, middle ear and Eustachian tube (Bowd, 2005). According to *The Health of the Nova Scotia Mi'kmaq Population* (1999) 73% of youth live in a household with someone smokes and two thirds of these households have more than one person smoking. Furthermore, 43% of youths reported to smoke themselves.

Seasonal variation

Research strongly suggests that otitis media is a frequent complication of upper respiratory infections (Henderson et al., 1982). The seasonal incidence of middle ear infections parallels the seasonal variations of upper respiratory tract infections; a moderate positive correlation of $r = 0.48$ has been found between the two outbreaks

(Henderson et al., 1982). In addition, medical reports show that respiratory illnesses are identified as a concomitant diagnoses with otitis media in 59.2% of cases (Schappert, 1992).

The seasonal incidence of upper respiratory tract infections and otitis media have been reported to peak during the winter month, but episodes are also frequent in the spring and fall months. They are least frequent in the summer months (Henderson et al., 1982; Williamson, Dunleavey, Bain, & Robinson, 1994). For example, one study observed the seasonal patterns of otitis media and found 27% of children to have episodes in the summer, compared with 48% in the spring and fall, and 51% in winter season (Teele, Klein, & Rosner, 1989). The current study will investigate the prevalence rates of otitis media across seasons by identifying the number of episodes that present in the fall and spring months.

Summary

Although there are several studies demonstrating the high prevalence rates of otitis media and hearing loss in Canadian Inuit children, there are a limited number of studies on First Nations children in the southern regions of Canada. In fact, there is no published data on the prevalence of otitis media and hearing loss among the Mi'kmaq children of Nova Scotia. However, *The Health of the Nova Scotia Mi'kmaq Population* (1999) reported high percentages of ear problems among children and youth, and high rates of hearing loss in a Mi'kmaq elementary school were reported in an unpublished study (Van Ek & Sockalingam, 2004). These findings suggest that ear problems and hearing loss are common among Mi'kmaq children of Nova Scotia. However, the prevalence of middle ear disease among Mi'kmaq children is unknown. As well, the prevalence of hearing loss of Mi'kmaq elementary school children at during different seasons of the school year have not been documented.

The objectives of the present study are as follows.

1. Determine the prevalence and type of middle ear pathology in Mi'kmaq elementary school children on two separate evaluations throughout the school year.

2. Determine the prevalence of hearing loss among Mi'kmaq elementary students on two different occasions throughout the school year.

3. Determine the distribution of hearing loss and middle ear pathology across student ages.

4. Determine if there are seasonal effects of the prevalence of otitis media.

Chapter 3 Experiment One Method

Pictou Landing

The Pictou Landing First Nations community was established in 1865 and currently has a total population of 563 people of Mi'kmaq heritage (Department of Indian Affairs and Northern Development, 2006; Pictou Landing First Nation, n.d.) The reserve is approximately 465 hectares and is located in the northern regions of Nova Scotia, approximately 20 kilometers north of the city of New Glasgow, on the shores of the Northumberland Strait. The majority of the children on the reserve attend the Pictou Landing First Nations Elementary School, while some children attend other schools outside of the reserve (Van Ek & Sockalingam, 2004).

According to *The Health of the Nova Scotia Mi'kmaq Population* (1999) report less than one third of Mi'kmaq children in Nova Scotia speak the Mi'kmaq language well and less than one third are able to understand the language. As well, only about a quarter of youth reported that they can speak the language well, however more than a quarter of the youth are able to understand the language. In the Pictou Landing First Nations Elementary School all but one student was reported to use English as their first language and the Mi'kmaq language is taught as a second language class.

Ethics

Ethical approval to conduct this study was obtained by the First Nations Mi'kmaq band council, the Pictou Landing First Nations Elementary school officials, as well as by the Dalhousie Univeristy Research Ethics Board. In particular, the proposed research was presented to the Band Chief of the Pictou Landing Mi'kmaq Nation and approval was granted on the condition that the Dalhousie Research Ethics Board provided approval of the research. In addition, support for the proposed research was obtained from the educational director, as well as from the principal of the Pictou Landing First Nations Elementary school.

Participants

The participants were 48 children (29 boys and 19 girls) of Mi'kmaq heritage from the Pictou Landing First Nations Elementary School in Pictou Landing, Nova Scotia. These included 48/60 (80%) of all students from the Pictou Landing First Nations Elementary School. The first screening consisted of 47 children and 41 children took part in the second screening. Participation in each screening was based on those students in school attendance on each particular screening day. The participants included children enrolled in the school's headstart program, grade primary level, as well as all subsequent grades represented at the school (i.e., grades 1 to 6). The mean age of all the participants at the time of the initial assessment was 6.73 years (SD = 2.32 years), with a range of 3 to 11 years old. Parental consent was obtained from all students involved prior to the commencement of the study.

Procedure

Two separate otolaryngological and audiological evaluations were conducted during the school year (October and April). On both screening dates pnuematic otoscopy was performed by the same otolaryngologist and the audiological evaluations were completed by the same audiologist with the assistance of graduate students. All evaluations were performed in one of three consultation rooms located in the medical center in Pictou Landing, Nova Scotia.

Otolaryngological examination. The otolaryngological examination included a pneumatic otoscopy evaluation. The U.S. Department of Health and Human Services strongly recommends the use of pneumatic otoscopy in clinical practice as the primary diagnostic method for diagnosing otitis media (Rosenfeld et al., 2004). The pneumatic otoscopy allows visual inspection of the ear canal and tympanic membrane, using a light source and magnifying lens. As well, the pneumatic otoscopy is used to create a seal in the ear canal and then slight positive and negative pressure is applied in order to observe the tympanic membrane and evaluate its mobility (Bluestone & Klein, 1995).

An otolaryngologist assessed each child's ears with the pneumatic otoscopy. Diagnoses were classified according to the following criteria.

1. Normal tympanic membrane
2. Retracted tympanic membrane/negative pressure
3. Otitis media with effusion
4. Acute otitis media
5. Tympanostomy tube (normal)
6. Tympanostomy tube (with otorrhea)
7. Dry tympanic membrane perforation
8. Tympanic membrane perforation with otorrhea
9. Granulation or cholesteatoma

Tympanometry Examination. Tympanometry was performed with a Microtymp 2 Middle Ear Analyzer (Welch Allyn, New York) to evaluate immittance characteristics of the middle ear system. The U.S. Department of Health and Human Services suggests the use of tympanometry as an optional diagnostic tool to confirm the diagnosis of middle ear effusion (Rosenfeld, 2004). Tympanometry is performed by sealing a small probe with three small holes into the ear canal. One hole emits a 220 Hz tone, a second hole is for an air pressure system which creates positive, negative or atmospheric pressure in the ear canal between the probe tip and tympanic membrane and the third hole leads to a microphone that records the amount of sound energy reflected from the tympanic membrane as a function of ear canal air pressure. The sound energy is determined by the compliance of the tympanic membrane and integrity of the middle ear system. For example, a high amount of reflected energy is measured when middle ear system is stiff due to otitis media (Northern & Downs, 1991).

Tympanometry results were classified according to the method described by Jerger (1970) into three categories: type A (single peak at ambient air pressure), type C (single peak at a negative pressure point) and type B (no pressure peak). Only type B tympanogram was considered to be abnormal and indicative of OME (Babonis, Weir, & Kelly, 1991; Dempster & Mackenzie, 1991). Type B tympanogram has been found to have a positive predictive value (83.6%) for middle ear effusion (Babonis et al., 1991).

Although both pneumatic otoscopy and tympanometry essentially measure the same thing, that is, tympanic membrane mobility, they have been recognized to compliment each other because the strengths of one measure can offset the weaknesses of the other test. Tympanometry provides a quantitative measure of the tympanic membrane activity, whereas pneumatic otoscopy gives a qualitative diagnosis (Stool et al., 1994). A diagnosis of middle ear pathology was determined based on clinical findings with the pneumatic otoscopy. Middle ear dysfunction revealed through tympanometry were used to supplement the pneumatic otoscopy findings.

Hearing Examination. Hearing screenings were conducted on all participants with pure tone air-conduction threshold audiometry - AD226 Diagnostic Audiometer (Interacoustics, Denmark). The ambient noise in the testing rooms were measured with a sound level meter revealing an average ambient noise level that did not exceed 35 dBA, with a range of 30 to 40 dBA. Hearing sensitivity was classified as normal if an average threshold of 25 dB HL or better was obtained over all 4 frequencies at 500, 1000, 2000, and 4000 Hz. If hearing thresholds at any frequencies exceeded 25 dB HL then the loss was classified as mild (26-30 dB HL), moderate (31-50 dB HL), moderately severe (51-70 dB HL), and severe (71-90 dB HL). The parents/guardians of those students diagnosed with otitis media and/or a hearing loss were contacted by telephone and referred for further medical follow-up and/or audiological testing.

Chapter 4 Experiment One Results

Pneumatic otoscopy was performed on 47 students (1 student absent) in the first screening and 41 students (4 students absent, 2 students no longer attended that school) in the second screening. In total 48 students were tested because the absent student in the first screening was tested in screening two. The percentage of children diagnosed with middle ear pathology in at least one ear was 25.5% (N=12) in the first screen (fall season) and 24.4% (N=10) in the second screen (spring season).

As seen in Figures 1 and 2, the most common types of middle ear pathology present in each ear on both screening dates was OME. There were no cases of AOM, tympanic membrane perforations, granulation or cholesteatoma diagnosed in either screening. Half (50%) of those students found to have a middle ear pathology in the first screening presented with the same pathology (i.e., OME, retracted tympanic membrane and tube with otorrhea) in the second screening.

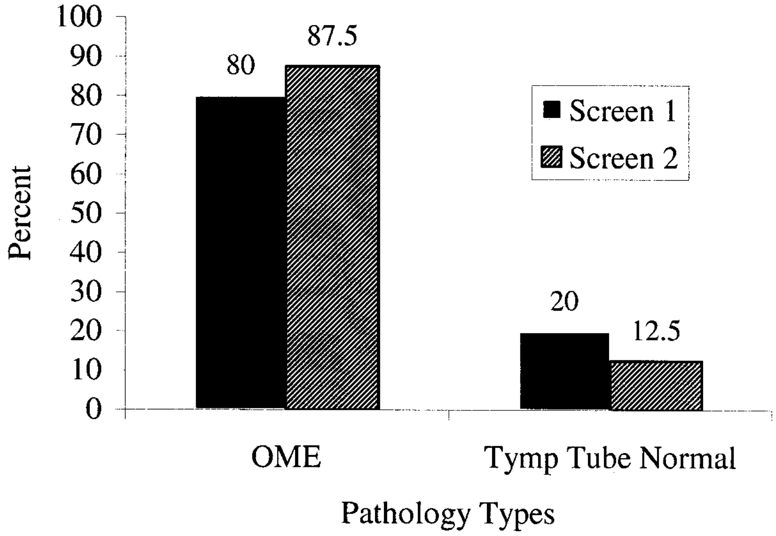

Figure 1. Percentage of middle ear pathology types diagnosed in the right ear in screen 1 and 2. OME means otitis media with effusion; and Tymp Tube Normal means tympanostomy tube in normal condition.

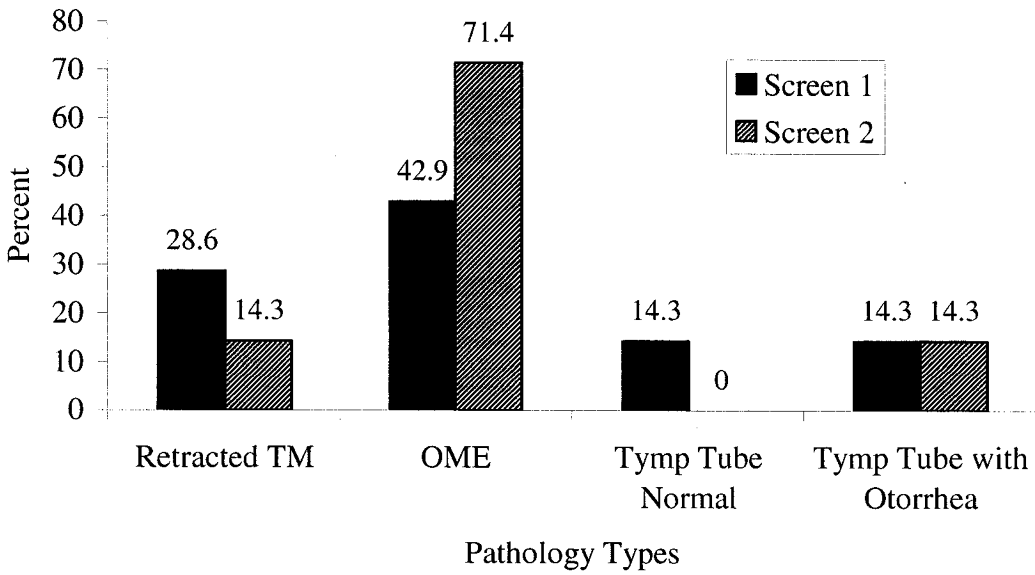

Figure 2. Percentage of middle ear pathology types diagnosed in the left ear in screen 1 and 2. Retracted TM means a retracted tympanic membrane; OME means otitis media with effusion; Tymp Tube Normal means tympanostomy tube in normal condition; and Tymp Tube with Otorrhea means tympanostomy tube in place with discharge.

Figure 3 shows the percentage of children with middle ear pathology across three age ranges, 3 to 5 years, 6 to 8 years and 9 to 11 years of age in both screenings. Children between 6 to 8 years of age were found to have the highest percentage of middle ear disease in at least one ear at 10.7% and 12.2% in screen one and screen two, respectively.

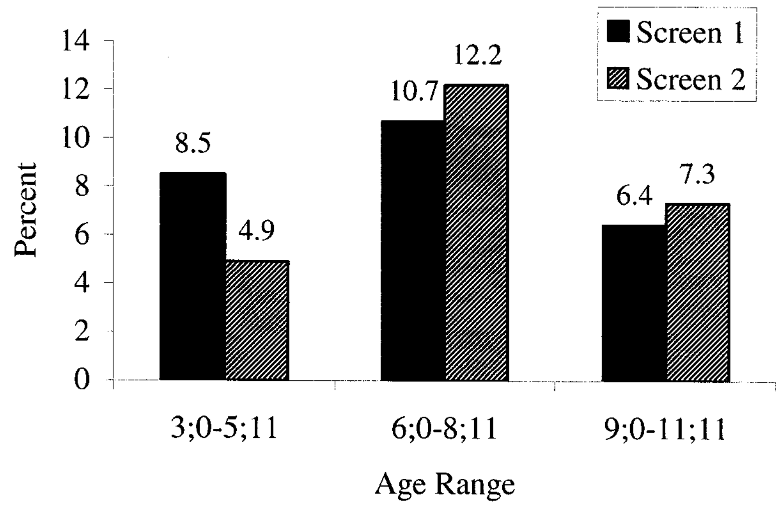

Figure 3. Percentage of middle ear pathology in screen 1 and 2 across age groups.

Hearing screenings were performed on 45 students who participated in the initial assessment (2 students could not be tested due to noncompliance). Of those students tested, 20% (N=9) were found to have a hearing loss in at least one ear in the first screening. A unilateral hearing loss was identified in 11.1% of the students and a bilateral hearing loss was found in 8.9% of the students tested.

In the second screening, hearing tests were completed on 40 students (4 students were absent, 1 student was noncompliant and 2 students no longer attended that school). This screening revealed that 25% (N=10) of students had a hearing loss. Of these students tested in the second screening, 12.5% were found to have a unilateral hearing loss and 12.5% had a bilateral hearing loss.

Figure 4 shows the percentage of hearing loss in both screens across age groups, 3 to 5 years, 6 to 8 years and 9 to 11 years of age. Children between 4 to 6 years of age had the highest percentage of hearing loss (11.1%) in the first screening. In the second screening, students in the 6 to11 years old category had the highest percentage of hearing loss (12.5%).

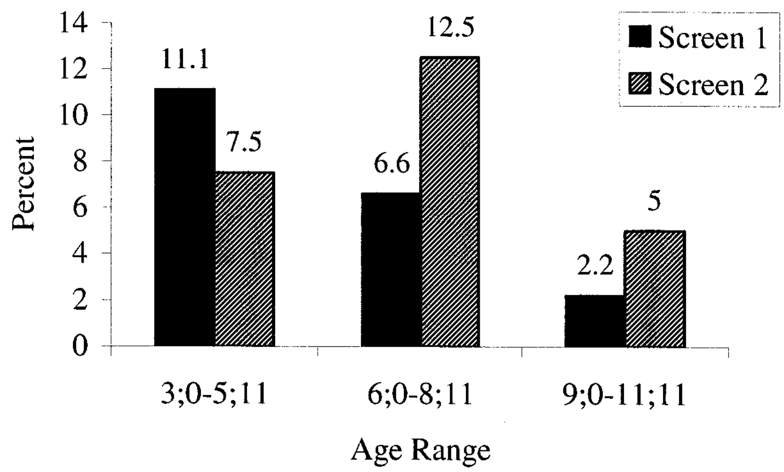

Figure 4. Percentage of hearing loss in screen 1 and 2 across age groups.

The degree of hearing loss was determined by averaging the thresholds across all frequencies (500, 1000, 2000, 4000). As seen in Table 1, the degree of hearing loss identified in both screenings ranged from mild (26-30 dB HL) to severe (71-90 dB HL). In the both screenings, the majority of children (77% and 70%, respectively) were found to have a mild hearing impairment.

Table 1

Degree of Hearing Loss in Screen 1 and 2

Degree of hearing loss	Screen	
	1	2
Mild	7 (77%)	7 (70%)
Moderate	2 (22%)	2 (20%)
Moderately severe	-	1 (10%)
Severe	-	-

Note. Brackets indicate percentage of those with hearing loss in each screen.

Chapter 5 Experiment One Discussion

The purpose of the present study was to determine the prevalence and type of middle ear pathology in First Nations students attending an elementary school in Pictou Landing, Nova Scotia. Furthermore, the prevalence of hearing loss among this population was determined. Two screening evaluations were performed throughout the school year (in October and April), each including pneumatic otoscopy performed by an otolaryngologist, as well as tymanometry and audiometry conducted by an audiologist and graduate students. Results were compared to the data obtained with the same population in 2004 (Van Ek & Sockalingam, 2004) to track changes in the hearing and middle ear status of this cohort, as well as to investigate the impact of seasonal variations on middle ear disease.

The percentage of children found to have a middle ear pathology in at least one ear was equally high in both screening one and two at 25.5% and 24.4%, respectively. These results are consistent with prevalence rates of middle ear disease in Aboriginal school-aged children reported in the Arctic, as well as in First Nations communities of Canada. For example, on First Nations reservations throughout Ontario, Scaldwell and Frame (1985) found 23% of all children sampled to have a middle ear pathology.

The prevalence of otitis media has been shown to coincide with the seasonal variations of upper respiratory infections, with rates peaking in the winter season, but also frequent in the fall and spring seasons (Henderson et al., 1982). The present study found prevalence rates of ear pathology to be greater than 20% during both the fall and spring seasons. In comparison, Van Ek and Sockalingam (2004) investigated the prevalence of middle ear dysfunction on the same elementary school population used in the current study during the winter season and found Type B tympanograms to be greater than 15% across age groups. This would suggest that middle ear disease among the Mi'kmaq elementary school children remains relatively high throughout the fall, winter and spring seasons. It should be noted that the Van Ek and Sockalingam (2004) study did not include a pneumatic otoscopy evaluation, although a Type B tympanogram has a high positive predictive value of middle ear effusion (Babonis et al., 1991).

The most common type of middle ear pathology in both screenings was OME, which has also been found to be the most frequent ear pathology in First Nations children living in British Columbia and Ontario (e.g., Doyle & Morwood, 1976). This finding is not surprising considering that OME is easily overlooked in an asymptomatic child (Rosenfeld & Bluestone, 2003).

A meta-analysis conducted on spontaneous resolution rates of OME reported average rates to be 56% after 3 months, 72% by 6 months, and 81% after 9 months (Rosenfeld & Bluestone, 2003). The time interval between screening dates in the current study was 5 months; during that time, assuming no children in this category received medical attention, 42.9% of children diagnosed with OME in the first screening showed spontaneous resolution by the second screening, whereas, 57.1% of those students who presented with OME in the initial and subsequent screening likely represent cases of chronic OME (i.e., middle ear effusion lasting longer than 3 months).

In both screenings, middle ear pathology was found to be highest in the 6 to 8 year old group compared to the 3 to 5 year old and 9 to 11 year old groups. In the second screening, the prevalence in the 3 to 5 and 6 to 8 year old group increased from 4.9% to 12.2%, while that of the 9 to 11 age category decreased only slightly, to 7.3%. These findings are similar to those found by Van Ek and Sockalingam (2004) where the 7-9 year old age range had the highest percentage of abnormal tympanograms. This pattern of ear pathology across age groups contradicts that found in the general population, where rates of otitis media typically decline with age after the first year of life. It does, however, lend support the contention that Aboriginal children are more prone to persistent or recurrent middle ear effusion (Bluestone & Klein, 1995).

The prevalence of hearing loss found was 20% of students in the first screening and 25% of students in the second screening. A study (Van Ek & Sockalingam) completed on the same First Nations school-age population in 2004 found 17.4% of the students to have a hearing loss, a rate consistent with those found in Aboriginal children across northern and southern regions of Canada (e.g., Ayukawa et al., 1997; Doyle & Morwood, 1976).

The results of Van Ek and Sockalingam's study indicate that the Mi'kmaq elementary students in Pictou Landing suffer from high rates of hearing loss across school years. These findings are exceptionally high in comparison to the prevalence of hearing loss in non-Aboriginal students near Pictou Landing (3.7%) (Van Ek & Sockalingam, 2004), and in school-age children in the general population (2.63%) (Lundeen, 1991).

It is important to note that the hearing screenings conducted in the present study were based on a 25 dB threshold cut-off and would consequently have missed those children with depressed hearing sensitivity (less than 25 dB). This criterion is 10 dB higher than that known to pose educational and learning problems because even a 15 dB hearing impairment poses problems for children learning language and acquiring knowledge (Dobie & Berlin, 1979; Northern & Downs, 1991). This is especially noteworthy considering hearing loss associated with otitis media is typically found to be relatively mild with an average 27 dB loss and range of 15 to 40 dB (Bluestone & Klein, 1995).

Overall, the present study demonstrates that Mi'kmaq elementary school children of Nova Scotia suffer from considerably higher rates of otitis media and hearing loss than non-native elementary school children. Past research has recognized this pattern since the 1960s and the present findings suggest that middle ear pathology and hearing loss continue to be an ongoing problem for Aboriginal children. OME, the most common middle ear pathology found in the Mi'kmaq population, is often asymptomatic and therefore these children may experience a loss of hearing that goes unnoticed.

The effects of unrecognized hearing loss within the classroom are often associated with problems or causes other than hearing impairment. For example, when a child is off-task or struggles to keep up with the rapid pace of class discussion, the cause of that child's behaviour may be attributed to noncompliance, attention problems or learning difficulties rather than hearing problems (Crandell, Smaldino, & Flexer, 1995). Considering the high rates of fluctuating hearing loss in the Aboriginal elementary school population, it is essential to implement modifications to the classroom environment in order to accommodate their incomplete and inconsistent hearing.

Chapter 6 Experiment Two Introduction

Classrooms are auditory/verbal environments where listening is the primary mode for learning, and thus a critical skill for success for any child (Berg, 1987). Elliott, Hammer, and Scholl (1989) evaluated elementary school children who had normal hearing sensitivity and found that the ability to perform fine-grained auditory discrimination tasks (e.g., discriminate "pa" and "ba" as different syllables) correctly classified 80% of the primary-level students according to their school placements (i.e., as progressing normally or as having language and learning difficulties). The authors concluded that auditory discrimination has primary importance for developing basic competencies that are essential for school success.

The direct relationship between listening and learning demands that children have access to clear and consistent oral instructions (Berg, 1987). There is an underlying assumption that students can hear and attend to the teacher's oral instructions, however, in schools, children are often placed in demanding, degraded, and constantly changing classroom listening situations. There are many acoustical variables within the classroom that contribute to decrease the intelligibility of a teacher's voice including the level of the teacher's voice, the distance between the student and teacher, the reverberation that exists due to solid classroom surfaces and the ambient noise present in the classroom (Crandell et al., 1995).

Student-Teacher Distance

The speaking level of a teacher's voice varies depending upon a number of factors such as the amount of breath available, the ability to project the speech signal and the fatigue level of the teacher. In addition, the teacher is often moving around the classroom at varying distances from the students (Crandell et al., 1995). Leavitt and Flexer (1991) utilized the Rapid Speech Transmission Index (RASTI) to measure the effect of teacher distance on the integrity of a speech-like signal. In particular, a measure of speech transmission fidelity is obtained empirically based on the perception of sound quality and speech intelligibility for normal hearing participants listening to various speech stimuli. They investigated how much of a teacher's speech signal is diminished as the sound propagates from his/her mouth to the students sitting in 17 different seating locations around an occupied, quiet classroom. The value of the RASTI can be within 0 and 1, with higher scores mean greater speech intelligibility (Leavitt & Flexer, 1991).

Results indicated a significant sound degradation as the RASTI receiver was moved away from the RASTI transmitter. Even the front row center seat (2.65 meters away), which is considered preferential seating, had a RASTI score in which intelligibility dropped to 0.83. The back row seating revealed a RASTI score of 0.55 reflecting a loss of 45% of equivalent speech intelligibility. It is important to note that a perfect RASTI score of 1.0 (i.e., an exact reproduction of the RASTI signal) was only attained at 6 inches from the transmitter. Evidently, there is a loss of critical speech information when a student moves 6 inches away from the teacher's mouth resulting in a less than complete speech signal for the students in all locations of the classroom. Furthermore, it is important to consider that this loss in speech transmission would be even more problematic for children with hearing loss (Leavitt & Flexer, 1991).

Reverberation

Reverberation is another important factor that influences the quality of classroom acoustics. Reverberation is the persistence of sound in a room due to multiple reflections from its surroundings, in particular, sound is reflected off of smooth surfaces such as walls and ceilings (Boothroyd, 2005). Classrooms tend to be highly reverberant environments due to their large size, high ceilings, bare walls, bare linoleum floors, chalkboards and numerous desktops (Flexer, 1997).

Reverberation of sound persists in the environment and is problematic for two reasons. First, the reflected sound may reach the child's ear too late to be utilized successfully for perception of speech sounds, thus providing a degraded speech signal. Second, reverberation may compromise speech perception through masking or smearing of the direct sound energy by the reflected energy. That is, the reflected speech signal reaches the child's ear temporarily delayed and it overlaps with the direct subsequent speech signal, resulting in a distortion of the speech signal (Boothroyd, 2005; Crandell & Smaldino, 1995).

Reverberation time is defined as the amount of time it takes for the sound level to decrease by 60 dB following termination of the sound source. The longer the reverberation time, the more difficult it is for children to hear the speech signal clearly (Flexer, 1997). In general, speech recognition scores decline with increasing reverberation time, especially for children with hearing impairment. For example, a study investigated speech recognition scores across various reverberation times for children with normal hearing sensitivity and with hearing loss. Both groups of children were found to have average speech recognition scores which declined as the reverberation time increased. The hearing loss group obtained poorer recognition scores at each listening condition. More specifically, at a reverberation time of 0.4 seconds the normal hearing group children obtained mean word recognition scores of 82.8 and the hearing loss group had a score of 69. At 1.2 seconds of reverberation time recognition abilities decreased in the normal hearing and hearing loss group to 76.5 and 61.8, respectively (Finitzo-Hieber & Tillman, 1978).

The American Speech-Language-Hearing Association (ASHA, 1995) recommends that reverberation time in the classroom should not exceed 0.4 seconds for optimum speech recognition to occur for children. However, research has suggested that classroom environments are exceeding this acoustic standard with reverberation levels typically reported to be from 0.35 to 1.2 seconds (Blair, 1977; Crandell & Smaldino, 1994). For example, in 32 classrooms, Crandell and Smaldino (1994) found that mean reverberation times were 0.52, with only 28% of the classrooms exhibiting less than 0.4 seconds. Overall, classroom reverberation times seldom meet the recommended criteria and are approximately 0.1 to 0.8 seconds longer than recommended (Crandell et al., 1995). The present study will determine the reverberation time of a typical classroom in the Pictou Landing First Nations Elementary School in Nova Scotia.

Background Noise

Typically, classrooms exhibit excess levels of background or ambient noise, which can degrade the perception of speech by distorting or masking the speech signal. In particular, noise in the classroom predominately reduces the recognition of consonant phonemes, which significantly influences speech recognition because consonant spectral energy provides the majority of the auditory cues necessary to understand speech (Crandell et al., 1995). Obviously, the greater the ambient noise level, the more difficult it is for children to hear the speech signal clearly (Flexer, 1997).

Ambient noise in the classroom can originate from a myriad of potential noise sources including noise outside of the school building (e.g., traffic, playground), noise inside the school, but not in the actual classroom (e.g., busy hallways, cafeteria), as well as from noise generated inside the classroom (e.g., children laughing, talking, sliding of chairs, computers or heating/cooling systems) (Crandell et al., 1995).

ASHA (1995) recommends that ambient noise levels in unoccupied classrooms should not exceed 30 dBA. However, several studies have shown that this acoustic criteria is infrequently achieved with average unoccupied classroom noise levels found to range between 41 dBA to 60 dBA (Arnold & Canning, 1999; Sanders, 1965; Bess, Sinclair, & Riggs, 1984; Crandell & Smaldino, 1994; Rosenberg et al., 1999). In fact, Crandell and Smaldino (1994) found mean unoccupied noise levels to be 50.2 dBA, and reported that none of the 32 classrooms investigated met the recommended criterion. The current study will measure the unoccupied noise levels of all classrooms in the Pictou Landing First Nations Elementary School.

Signal-to-Noise Ratio

In the classroom learning environment the fundamental consideration for the effects of ambient noise on speech recognition is the relationship between the intensity of the primary signal (i.e., teacher's speech) and the intensity of the background noise, known as the signal-to-noise (S/N) ratio. Speech recognition ability is greatest at favourable S/N ratio and decreases as a function of reduction in S/N ratio (Crandell et al., 1995).

Finitzo-Hieber and Tillman (1978) investigated word recognition scores for children with normal hearing and children with mild to moderate SNHL at various S/N ratios (+12 dB, +6 dB, and 0 dB). Reverberation time was also controlled for in order to determine the main effect of S/N ratios on speech perception abilities. For both groups of children the results showed significantly better recognition scores at high S/N ratios than at low S/N ratios. In particular, in the absence of reverberation, the children with normal hearing obtained a mean recognition score of 89.2% at S/N ratio of +12, this score dropped to 79.7% and 60.2% at S/N ratios of +6 dB and 0 dB, respectively. The children with a hearing loss obtained an average recognition score of 77.8% at +12 dB which decreased to 65.7% and 42.2% at S/N ratios of +6 dB and 0 dB, respectively (Finitzo-Hieber & Tillman, 1978).

These results demonstrated that children with a hearing loss perform significantly worse than those children with normal hearing sensitivity across each S/N ratio listening condition. As well, the performance decrement between the two groups increased as the S/N ratio became less favourable. That is, the hearing impaired group had recognition scores which decreased to a greater extent with each reduction in S/N ratio. It is important to note that in these listening conditions the reverberation time was 0.0 seconds and that word recognition scores have been shown to be even poorer at each S/N ratio when reverberation time is increased (Finitzo-Hieber & Tillman, 1978).

ASHA (1995) recommends that the acoustic standards for S/N ratios for children in learning environments should exceed +15 dB. Due to the excessive noise levels found in many classrooms, unfavourable S/N ratios have been reported to range between +5 dB to -7 dB (Sanders, 1965; Blair, 1977). For example, Sanders (1965) reported classroom S/N ratios to range from +1 dB in kindergarten classrooms to +5 dB in elementary classrooms. Although S/N ratios are somewhat dynamic due to the varying levels of ambient noise, the teacher's voice and distance between the teacher and students, it is evident that many classrooms are not achieving the recommended S/N ratio criteria and at times, the teacher's speech drops below the ambient level providing an adverse classroom listening situation.

The Classroom Environment

Thus far, the effects of classroom ambient noise and reverberation on speech recognition have been considered individually. However, in a typical classroom these acoustic events do not occur in isolation. Rather the interaction of noise and reverberation in the classroom create a synergistic effect, in that, together they have a greater adverse effect on speech recognition than the sum of each individual effect (Finitzo-Hieber & Tillman, 1978). It is assumed that this synergistic outcome occurs because when noise and reverberation are combined, the reflections act to fill in the noise gaps which make it more steady and constant in nature (Crandell et al., 1995).

When the distance variable between the teacher and student is considered in combination with noise and reverberation the consequence is an inappropriate degraded listening environment for all types of students in the classroom (Crandell et al., 1995). For example, research has shown that children with a conductive hearing loss, as well as those with normal hearing sensitivity experience greater speech perception difficulties in degraded listening environments (e.g., Dobie & Berlin, 1979; Finitzo-Hieber & Tillman, 1978).

Normal Hearing Sensitivity. Research suggests that children do not listen in the same way as adults and as a result require a more accurate auditory signal (Boothroyd, 1997). It has been proposed that the auditory neurological network in children, in particular the myelination process and electrophysiological responses to sound, is not fully developed until approximately 15 years of age. Therefore, in listening situations they are at a disadvantage compared to adults because their auditory perception abilities are immature (Boothroyd, 1997).

Furthermore, children do not bring the years of language and life experience that adults bring to a listening situation. These experiences enable adults to fill in the gaps or perform auditory-cognitive closure of missed information, whereas children may not even realize that they have misheard a message because of their limited experience of language and the curriculum topic under discussion. As a result, children require more complete, detailed auditory information than adults (Crandell et al., 1995).

When a classroom is noisy and/or reverberant children with normal hearing sensitivity have difficulty listening effectively. Finitzo-Hieber and Tillman (1978) examined the synergistic effects in several conditions of noise and reverberation in children with normal hearing sensitivity. They found a decreasing trend in speech recognition scores as the reverberation time increased and the S/N ratio became less favourable. For example, in a listening environment with S/N ratio of +6 dB and reverberation time of 0.4 seconds children with normal hearing only recognized 71.3% of words. In a poorer, but likely more typical classroom listening condition (S/N ratio = 0 dB; RT = 1.2 seconds) the normally hearing children had a score of only 29.7%.

Crandell and Bess (1986) (as cited in Crandell & Smaldino, 1995) also examined the effects of a typical classroom environment (S/N ratio = +6 dB; RT = 0.45 seconds) on speech recognition abilities in children with normal hearing sensitivity. To further simulate the typical classroom learning environment they varied the distances (6, 12, 24 feet) between the speaker and listener. Results indicated a decrease in speech recognition scores as the speaker and listener increased with mean scores of 89%, 55%, and 36% at 6, 12, and 24 feet, respectively. These results suggest that normal hearing children have greater difficulty understanding speech in a typical classroom setting as the distance is increased between the teacher and student.

Conductive Hearing Loss. As previously discussed (in experiment one), conductive hearing loss associated with otitis media has an average hearing threshold of 27 dB HL ranging from mild to moderate (15 to 40 dB HL) (Rosenfeld & Bluestone, 2003). Research has shown that even mild hearing loss can drastically influence the transmission of acoustical information. For example, Dobie and Berlin (1979) investigated the potential loss of acoustic information in listeners with a simulated hearing loss of 20 dB. The results showed that children with mild degrees of conductive hearing loss would experience significant difficulty hearing very brief utterances, unstressed words and lose a majority of morphological markers such as plural endings. The student may hear the teacher's voice and intonation patterns, but may not be able to hear individual speech sounds clearly enough to differentiate one word from another. Northern and Downs (1991) also explained that a mild hearing loss only enables the child to hear the louder, voiced speech sounds and the shorter unstressed words and less intense speech sounds are inaudible.

Children with hearing loss secondary to otitis media are already disadvantaged in their ability to hear the teacher and unfortunately, the classroom itself compounds their hearing deficit (Crandell et al., 1995). Crandell and Flannagan (1999) examined the effects of conductive hearing loss caused by OME on speech perception abilities in quiet and at a S/N ratio of 0 dB. The speech stimuli was presented to normal hearing adults at conversation level and was filtered to simulate an average conductive hearing loss associated with OME. Unfiltered stimuli was also presented. Findings revealed significantly worse speech perception scores in the filtered (i.e., conductive hearing loss) versus unfiltered (i.e., normal hearing) listening condition in both quiet and noise. In fact, in noise, the hearing loss group only obtained speech perception scores of 54%.

Sound-Field Amplification Systems

Acoustical modifications (e.g., ceiling tiles, soft wall coverings) to the classroom are often recommended to reduce the noise problem in the classroom, however, these modifications cannot overcome the degradation of sound transmission created by distance from the teacher. Therefore, as a result of the poor S/N ratio typically reported in classrooms and the degraded speech signal offered even in preferential seating in the classroom, a favourable S/N ratio is not possible without special technological assistance. Sound-field frequency-modulated (FM) amplification has been proposed as a solution to the problem of background noise and student-teacher distances in classrooms (Crandell et al., 1995).

Sound-field FM amplification systems can counteract weak teacher voice levels and background noise by increasing the overall speech (signal) level, thereby substantially improving the S/N ratio, and producing a nearly uniform speech level throughout the classroom. It creates an environment where each student is at a favourable distance from the teacher by routing the teacher's voice to loudspeakers around the classroom. In particular, the teacher wears a small wireless microphone 3-6 inches from his/her mouth. The teacher's speech is sent to an amplifier that drives the loudspeakers positioned around the classroom (Crandell et al., 1995).

The purpose is to amplify the teacher's voice by approximately 10 dB to improve the S/N ratio by about 10-20 dB in all listening areas of the classroom unrelated to the position of the teacher or student. Not only is the amplified speech signal louder, but also each child is closer to the signal (loudspeaker), thereby reducing the magnitude of the degradation of the speech signal as the signal travels across the classroom environment (Flexer, 1997).

Effects of Sound-Field Amplification. Research has shown positive effects of sound-field FM amplification use on academic behaviour, attending behaviour, and on overall classroom performance for students with and without hearing loss (Allen & Patton, 1990; Eriks-Brophy & Ayukawa, 2000; Palmer, 1998; Rosenberg et al., 1999; Sarff, Ray, & Bagwell, 1981). Following is a review of studies which examined the effects of sound-field amplification on the academics, attending, listening and learning behaviours in children with normal hearing sensitivity and children with conductive hearing loss.

Project MARRS (Mainstream Amplification Resource Room Study) (Sarff et al., 1981) compared the effects of two instructional techniques, sound-field amplification and resource room instruction, as well as a control group with no amplification on the academic performance of students in grades 4 to 6. At the onset of this 3-year study the children were identified with minimal hearing loss (10-40 dB) and below average academic achievement. Results indicated that the students receiving sound-field amplification increased academic standardized achievement test scores significantly, and this change was equal to or greater than the increase obtained in the resource room, however both groups gained more than students in the control group. It was concluded that the sound-field system is more cost effective than utilization of the resource room.

Allen and Patton (1990) investigated the on-task behaviour exhibited in students with normal hearing sensitivity in grades one and two. The researchers conducted online observations of students before, during and after amplification use, as well as a control group of students not exposed to the sound-field system. They found that under the amplified condition the students were more attentive and less distractible and required fewer repetitions from the teacher. Student overall on-task behaviour increased significantly (17%) with the amplification system. This study demonstrates the positive effects that sound-field amplification has on the attending behaviours of children in primary grades with normal hearing sensitivity.

Palmer (1998) evaluated the impact of sound-field amplification through online data collection with a software observational package. Observations were conducted before, during and after amplification use on 8 children from kindergarten to grade two over a 2-year time period. The children were chosen based on having attention difficulties as reported by their teachers. None of the children were known to have hearing or learning difficulties. The results showed an immediate reduction in inappropriate behaviour and an immediate increase in the occurrence of task management (e.g., attending to task) for all 8 children with the introduction of sound-field amplification. During the post-treatment period the students showed an immediate increase in inappropriate behaviours back to baseline for all but 1 child. The increase in the occurrence of task management found during the use of the sound-field system was maintained during the post-treatment period. These post-treatment findings suggest that following amplification use some improved behaviours are maintained.

Another study (Eriks-Brophy & Ayukawa, 2000) which also used online observational methods examined the attending behaviour before and during amplification use in 7 Inuit students from kindergarten to grade three. The students included 3 with a hearing loss (1 fluctuating) and 4 students with normal hearing. Total student scores on four categories of attending behaviours showed a significant increase from the unamplified to the amplified conditions. Individual student scores showed an improvement for 6 of the 7 students during FM amplification use. The student with the fluctuating hearing loss did not improve in total on-task behaviours, however, it is important to note that this student was also diagnosed with an attention problem. All students showed increased improvement in at least one of the attention categories. This study shows an online observable improvement in the attending behaviours of Inuit students with and without hearing loss with the use of sound-field amplification.

Allcock (1999) observed the attending behaviours of students in junior elementary classrooms with normal hearing and those with a hearing loss (unknown type). Observations were conducted over an 8-week time period and results revealed a significant increase in on-task behaviour when the amplification system was in use. This significant improvement in attending behaviour was found for both children with normal hearing sensitivity and those with a hearing loss. A comparison of attending behaviours between the groups of children was not performed. Through online observations, Allcock (1999) demonstrated that children with normal hearing and those with a hearing loss have increased on-task behaviour when classroom amplification is used.

Rosenberg et al. (1999) conducted a 3-year study to examine how sound-field amplification affects the listening and learning behaviours of students in 64 amplified compared to 30 unamplified classrooms from kindergarten to grade two. Hearing screenings were performed on approximately half of the students in this large study and they found that approximately 25% of students had a hearing loss greater than 15 dB. The type of hearing loss was not reported. Teachers completed observational surveys before, during and after sound-field amplification use. Results revealed a significant improvement in the listening and learning behaviours of students in the amplified classrooms. For example, students in the amplified classrooms showed greater change in behaviours such as paying attention, following directions and appropriately participating in class discussion. In all amplified classrooms, the greatest gains were found in the kindergarten students. This large study used teacher appraisal and found improved listening and learning behaviour with the use of sound-field amplification systems for all students in primary classrooms. Results were not analyzed separately for students with and without a hearing loss.

Flexer, Richards and Buie (as sited in Crandell et al., 1995) investigated teacher-rated performance of students in grade one under amplified and unamplified listening conditions. The teachers identified those children "at-risk" with histories of hearing problems from a "no-risk" group of students (no history of hearing problems). The Screening Instrument for Targeting Educational Risk (SIFTER) (Anderson, 1989) was completed four times throughout the school year to evaluate student behaviour in the areas of academics, attention, communication, class participation, and school behaviour. Results showed better overall ratings for both the at-risk and no-risk group of children in the amplified classroom. The at-risk group of students in the unamplified classroom received the lowest teacher ratings. This study suggests that students with a history of hearing problems will show improvements in classroom performance with the use of sound-field amplification.

Teacher Satisfaction. Teachers have provided positive feedback and preference for the use of sound-field amplification in their classrooms. In particular, teacher surveys have shown that teachers are highly satisfied with using the sound-field system. They have reported that their students benefited from the amplification, were more attentive, and better able to follow and understand directions. As well, teachers described that the sound-field system was easy to use and reduced vocal strain and fatigue at the end of the school day (Eriks-Brophy & Ayukawa, 2000; Mendel, Roberts, & Walton, 2003; Nelson & Nelson, 1999; Palmer, 1998; Rosenberg et al., 1999). The present study will conduct a survey to determine teacher impressions regarding use of the sound-field amplification system.

Summary

The perceptual deficits experienced by children with normal hearing sensitivity and those with hearing loss in a degraded listening environment, emphasize the importance of providing appropriate acoustic conditions in the classroom. In 1995, ASHA recommended standards to be implemented in the classroom setting in order to ensure an adequate acoustical environment for listening and learning. These acoustic guidelines include ambient noise levels in unoccupied classrooms to be no greater than 30 dBA, reverberation time not to exceed 0.4 seconds, and an overall teacher S/N ratio of at least +15 dB. Unfortunately, despite information about the necessity of having a favourable classroom listening environment, most classrooms continue to remain "acoustically hostile" (Flexer, 1997). The present study will determine the listening conditions which exist in the classrooms of the Pictou Landing First Nations Elementary School in Nova Scotia.

Research has shown improved academic and classroom performance with the use of sound-field amplification on children with and without a hearing loss (e.g., Allcock, 1999; Allen & Patton,1990; Sarff et al., 1981). However, none of the studies included children with diagnosed otitis media and its associated hearing loss. One study (Eriks-Brophy & Ayukawa, 2000) identified the type of hearing loss present in the children and this only included one student with fluctuating hearing loss. Another study (Sarff et al., 1981) which tracked the changes in student academic performance over 3 years only identified hearing loss at the onset of the study and failed to report the type of hearing loss. If some or most of the cases represented hearing loss due to otitis media it is unclear how persistent or recurring the hearing losses were throughout the duration of the study. Flexer et al. (1993) did identify those children with histories of hearing problems (likely due to middle ear pathology), but did not determine their hearing status at the time of the study.

Therefore, there is minimal evidence indicating how children suffering from fluctuating hearing loss perform in the classroom under sound-field amplification. Flexer and colleagues (1995) noted that although there is ample evidence of the perceptual difficulties that children with hearing loss due to otitis media experience, there is a lack of information on the effects of sound-field amplification on this population. The present study will investigate the effects of sound-field amplification on the classroom performance of students with a hearing loss secondary to otitis media, as well as on those students with normal hearing sensitivity.

In addition, the majority of the previously described studies only included children from kindergarten to grade two. These younger classrooms are full of excited, energetic, and noisy students which typically increases background noise and provides a poor acoustic environment for learning. As well, these children are just beginning to develop the attending and listening skills necessary for academic success which contributes to the need for an improved S/N ratio in these classrooms (Flexer, 1992). However, children in upper elementary school years are also placed in degraded learning environments and are required to attend to the teacher for longer periods of time. Considering that children's auditory brain structures are not fully matured until about 15 years of age (Boothroyd, 1997), it is reasonable to assume that children beyond the second grade also require a positive S/N ratio. The present study will determine the changes in classroom performance from amplification use in First Nations elementary school children from kindergarten to grade six.

Objectives

Research has shown that typical classrooms are often too noisy and reverberant to provide an adequate learning environment for students (Crandell & Smaldino, 1994; Sanders, 1965). In fact, they offer a less than optimal learning environment for students with normal hearing sensitivity and an unacceptable learning environment for students suffering from a hearing loss (Crandell et al., 1995). The present study will determine the adequacy of the noise levels and reverberation time in the classrooms of the Pictou Landing First Nations Elementary School.

Collectively, results of sound-field amplification research suggest significant benefits in academics, attending and learning behaviours for children with normal hearing sensitivity in elementary school. There is a lack of evidence illustrating the effects of amplification use on children with hearing loss secondary to otitis media. The current study will expand this body of research by demonstrating the effects of sound-field amplification use on the classroom performance of First Nations elementary school children with and without hearing loss. A variety of student classroom behaviours (e.g., academics, attention) will be evaluated by teachers. The high prevalence of otitis media and hearing loss among this population has inspired this research. Lastly, the present study will determine teacher impressions of sound-field amplification use.

Following are the objectives.

1. Determine the noise levels and reverberation time of unoccupied classrooms.
2. Demonstrate whether there is a change in the classroom performance of students during and after sound-field amplification use.
3. Determine whether change in classroom performance during and after sound-field amplification use differs by classroom (grade).
4. Demonstrate if the treatment conditions scores differ for students with normal hearing sensitivity compared to students with hearing loss.
5. Determine teacher impressions of sound-field amplification use.

Chapter 7 Experiment Two Method

Participants

A total of 40 Mi'kmaq students (23 boys and 17 girls) from the Pictou Landing First Nations Elementary School in Pictou Landing, Nova Scotia were involved in this second experiment. These participants represented 40/60 (67%) of all students at the Pictou Landing First Nations Elementary School and included students from grade primary level to grade 6. The mean age of all the students was 7.75 years (SD = 1.86 years), with a range of 5 to 11 years old.

The school consists of 6 teachers which instruct a headstart program and grades primary level to 6. Two of the teachers conduct split grade classrooms (grades 3 /4 and 5/6). Five of the six teachers (grades primary to 6) participated in the evaluation of their students. The headstart classroom was not included because the teacher left the school during this study and multiple substitute teachers were used as replacements for the majority of the school year.

Acoustic Measurements

The Pictou Landing First Nations Elementary School consists of 6 classrooms, 2 of which share one room with a partial divider between the two classes. See Appendix A for a visual layout of the school. The size of each classroom was determined and the general construction (e.g., number of windows present) of each classroom was noted. Acoustic measurements were recorded in all classrooms to provide baseline information regarding the acoustics in the classrooms prior to installation of the sound-field systems. An Extech 407762 sound level meter was used to measure the background noise levels in each of the classrooms when unoccupied. The measures were conducted in the center of each classroom with the florescent lighting on and the doors and windows closed. The levels recorded were averages (dBA) taken over several minutes. Calibration of the sound level meter was performed and found to meet or exceed ANSI standards (ANSI S1.40, 1984) class 2.

Reverberation measurements were obtained with a Jex model 202 starter pistol, which fires two gunpowder caps simultaneously. The pistol was situated about one foot away from the center of the side wall of classroom C, and then fired. The process was recorded digitally with an Audio Technica model ATM10a omnidirectional professional microphone, which feeds into a laptop computer's Sound Forge's version 5.0 spectrum analyzer software.

Sound-Field FM Amplification

The EMP 2015 sound-field amplification FM systems provided by Sennheiser Electronic Corporation were installed into all 6 classrooms. Four speakers were mounted on the walls or ceilings of each classroom. Upon installation, the FM system amplifier was adjusted to a comfortable level for each classroom. This was determined by the investigators in consultation with individual teachers. The teachers were asked to use the sound-field amplification systems whenever instructing their classes. They were suggested to turn off the system when providing one-on-one assistance to individual students. All of the teachers were provided with in-service training regarding the basic use of the amplification system, as well as basic troubleshooting strategies. Regular contact was maintained with the researcher by telephone and email throughout the study.

Student Evaluations

Teachers of students in grades 1 to 6 completed the SIFTER (Anderson, 1989) and the primary grade teacher completed the Preschool SIFTER (Anderson & Matkin, 1996) to evaluate their students' level of performance in the classroom. Both questionnaires rely on the teacher's observations of the student's classroom performance related to listening skills (Flexer, 1997). They consist of a brief checklist regarding five different content areas including academics, attention, communication, class participation, and school behaviour. These questionnaires were chosen for the present study because the different content areas target a variety of classroom performance behaviours.

There are three questions in each area for a total of 15 questions. A 5-point scale is used to rate each question, 1 = below average and 5 = above average. The three questions in each area are added together and a maximum of 15 points may be achieved in each area. As well, all five areas are summed for a total SIFTER score (maximum 75 points). The Preschool SIFTER has been created for children 3 years of age to kindergarten and contains questions which are relevant for classroom performance of this young age group. These instruments are located in Appendix B and C.

The SIFTER is designed to identify educational difficulties due to hearing problems and is a valuable tool for teachers to evaluate the efficacy of using sound-field amplification system (Flexer, 1997). For the purpose of this study the term SIFTER will be used to denote both the Preschool SIFTER and SIFTER questionnaires.

Procedure

An A (pre-treatment) B (sound-field treatment) A (post-treatment) experimental design was used in this experiment over a 7-month time period. Teachers completed

SIFTERs to document students' performances in the classroom for each of the 7 months, including 2 months before the FM system was turned on, 3 months with the amplification system in use, and 2 months with the system turned off. These data represents student listening behaviour at baseline, during sound-field treatment, and following amplification.

Teachers completed the SIFTERs at the end of each month and were asked to base their evaluations on each student's classroom performance during that month only. Thus, each monthly SIFTER was supposed to represent observations of each student's classroom behaviour pertaining only to the month under evaluation.

As well, the SIFTER questionnaire is designed to have teachers rate the student under evaluation compared to his/her classmates. The first SIFTER was completed this way, but for each subsequent SIFTER the teachers were asked to base their ratings by comparing the student under evaluation to his/her performance in the previous month. Therefore students were not compared to their classmates and each subsequent SIFTER was to document the change in a student's performance compared only to how he/she performed the prior month. This allows for a valid measure of change in performance.

Completion of the SIFTERs began 1 month (December) prior to the installation of the sound-field amplification systems. The following month (January), the sound-field systems were installed into all classrooms but not turned on and the teachers filled out the SIFTERs again. This was done to rule out the possibility that the mere presence of the sound-field system in the classrooms would have an effect on student behaviour. This information provided 2 months of baseline data on the students' listening behaviour before the sound-field systems were turned on. Next, all of the classrooms' sound-field systems were turned on and used for the following 3 months (February, March and April). The teachers completed the SIFTERs for each month the sound-field systems were in use which made up the sound-field treatment observation data. Finally, the sound-field systems were turned off for the last 2 months (May and June) of the school year and the teachers filled out the SIFTERs which provided the post-treatment data.

The results of the hearing screenings performed in the first experiment were incorporated into the present study to predict which students experienced hearing loss during the sound-field observation period. The first hearing screening was conducted in October, two months prior to the start of the SIFTER questionnaires, and the second screening was completed in April which was during the sound-field amplification use. The teachers were not informed about the results of the hearing screenings and therefore were not aware of which students in their classroom had hearing loss or normal hearing sensitivity.

Teacher Questionnaire

Following completion of the study, teachers were asked to fill out a survey which was adapted from Mendel et al. (2003). See Appendix D for a copy of the survey. The questionnaire includes 10 questions regarding the teachers' subjective impressions of the use of sound-field amplification in their classrooms. The teachers were also asked to estimate the average number of hours they used the sound-field system on a daily basis.

Chapter 8 Experiment Two Results

Classroom Acoustic Measures

Refer to Appendix A for a nonscale map of the classrooms. The average size of classrooms A through D is approximately 580 square feet, with a total volume of approximately 5220 cubic feet. The classroom ceilings are suspended with quasi-sound absorbent panels. The walls of the classrooms are plasterboard with wall-mounted chalkboards, bulletin boards, etc. Each classroom has 2 standard windows on the exterior walls. The floors of the classrooms are tile on concrete surface.

Most of the ambient noise in unoccupied classrooms was noted to be from forced-air heating ducts, plumbing, fluorescent lighting, computers, and noise generated exterior to the room (e.g., hallways, playground). Classroom B has a cable internet system located at the back of the room which also is a major source of background noise.

Results of the sound-field level measurements taken in each of the classrooms are presented in Table 1. The unoccupied noise levels of all classrooms had a mean of 41.4 dBA and a range from 38.6 dBA to 45.3 dBA.

Table 1

Average Unoccupied Noise Levels for all Classrooms

Classroom	Grade	Noise Level
A	3/4	38.6 dBA
B	5/6	44.6 dBA
C	2	45.3 dBA
D	1	39.4 dBA
E1	headstart	40.9 dBA
E2	primary	39.7 dBA

Reverberation time was tested in classroom C, and findings were generalized to the other classrooms because of their similar set-up and amount of reflective surfaces. The amount of reverberation time in classroom C was found to be 0.306 seconds.

Classroom Performance

The average pre-treatment, treatment and post-treatment SIFTER scores were calculated for all students. The pre-treatment mean score consists of the average SIFTER content area scores of the 2 months of baseline data, the treatment mean score represents the mean SIFTER content area scores for the 3 months of sound-field treatment data, and the post-treatment mean score consists of the average SIFTER content area scores of the 2 months of post-treatment data. Findings revealed a pre-treatment mean SIFTER score of 51.43, a treatment score of 54.28 and a post-treatment average score of 49.34. This shows a 2.85 mean increase of SIFTER scores from the pre-treatment to treatment condition and a mean decrease of 4.95 from the treatment to post-treatment condition.

A repeated measures analysis of variance (ANOVA) was performed to determine if there were significant within subject differences between the three treatment conditions and SIFTER content areas. The factors included treatment (fixed effect), SIFTER content areas (fixed effect) and classroom (random effect). The variable 'classroom' was included as a between subjects variable to examine difference between the classrooms in the three treatment conditions. The ANOVA yielded a significant pre-during-post treatment main effect, $F(1.64, 57.47) = 13.93$, $p < .001$ (note that the Greenhouse-Geisser correction was applied because the sphericity assumption was not met).

Post hoc analyses on the main treatment effect were performed using the Sheffé method, and based on alpha .05. Significance differences were found between the pre-treatment and treatment conditions as well as between the treatment and post-treatment conditions.

The ANOVA revealed a significant SIFTER main effect, $F(2.12, 74.27) = 11.07$, $p < .001$ (note that the Greenhouse-Geisser correction was applied because the sphericity assumption was not met). There was also a significant two-way interaction found between treatment conditions and SIFTER content area scores, $F(3.01, 105.37) = 3.53$, $p = .017$. The plot of the interaction shown in Figure 1 illustrates the pattern of changes which occurred for each SIFTER area across the treatment conditions. Visual inspection of Figure 1 shows that each SIFTER area increased in the treatment condition and decreased in the post-treatment condition. These changes across treatment conditions are varied and demonstrate that some SIFTER content areas were more affected by the treatment than others.

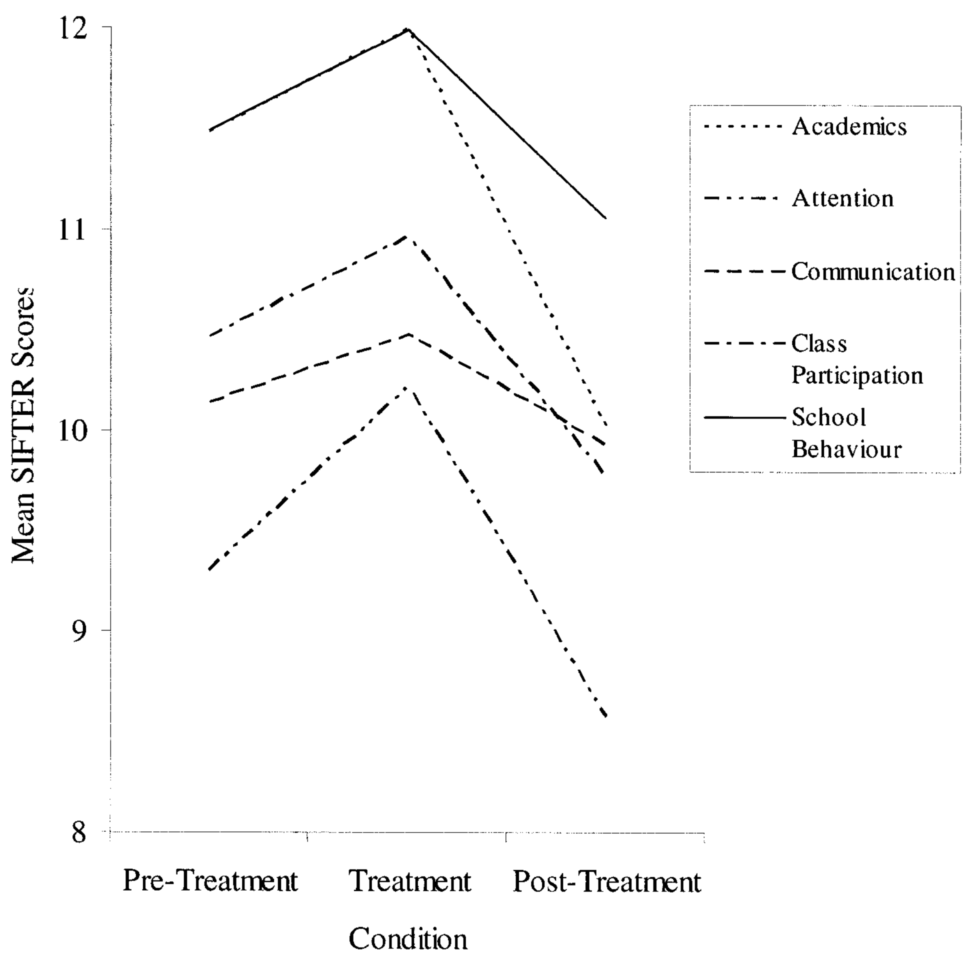

Figure 1. Interaction between treatment conditions and SIFTER content areas.

As shown in Table 2, the mean differences for each SIFTER area across each treatment conditions were relatively small. The SIFTER area of attention had the largest increase from the pre-treatment to treatment condition, although all SIFTER areas had a mean increase of less than 1. Attention and academic SIFTER areas were found to have the largest decrease in mean scores from the treatment to post-treatment condition, but again all areas showed a minimal mean difference of less than 2.

Table 2

Differences in treatment conditions by SIFTER content areas for all students.

SIFTER Area	Pre-Treatment mean score	Treatment mean score	Post-Treatment mean score	Pre-Treatment to Treatment (Mean Diff)	Treatment to Post-Treatment (Mean Diff)
Academics	11.48	11.99	10.01	0.51	1.98
Attention	9.3	10.21	8.58	0.91	1.63
Communication	10.13	10.47	9.93	0.34	.54
Class Participation	10.46	10.96	9.77	0.5	1.19
School Behaviour	11.49	11.99	11.06	0.5	.93

Note. Mean Diff means mean difference.

The classrooms were labelled as 1 = primary level grade; 2 = grade 1; 3 = grade 2; 4 = split grades 3/4; and 5 = grades 5/6. A significant two-way interaction was also found between treatment conditions and classrooms, $F(6.57) = 2.88$, $p = 0.01$. This interaction is displayed in Figure 2, which illustrates that the classrooms responded differently across the treatment conditions.

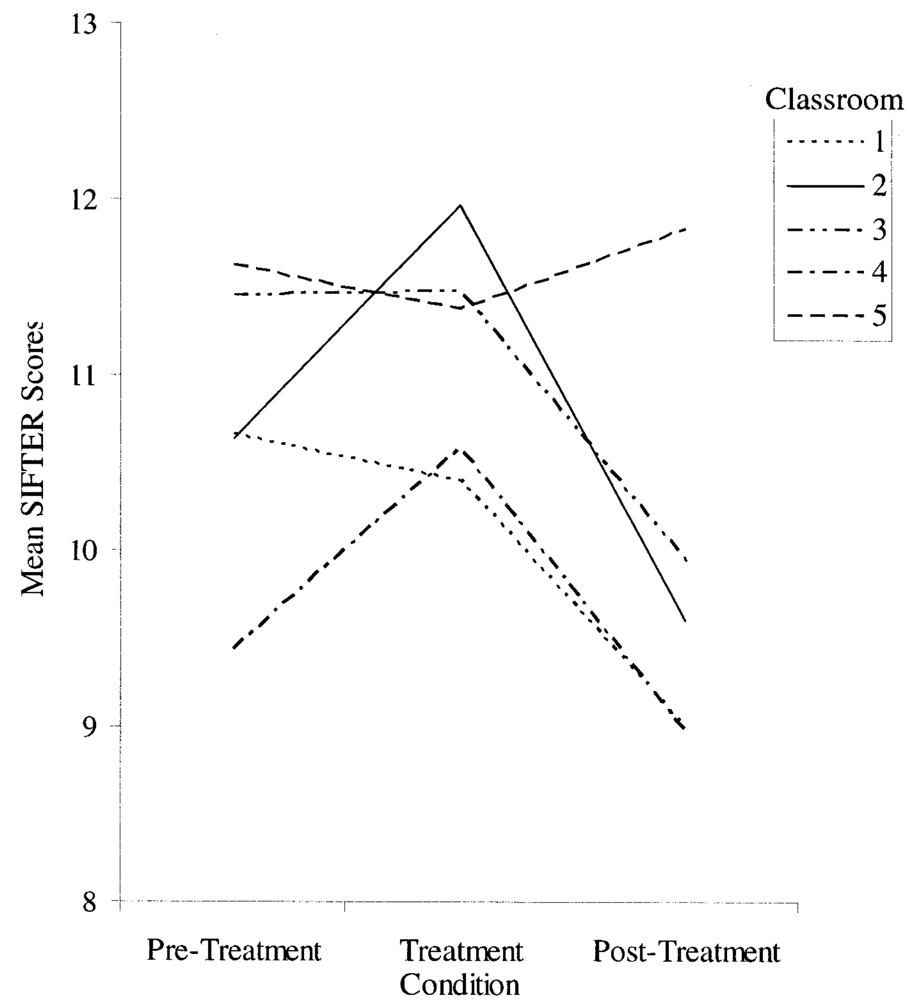

Figure 2. Interaction between treatment conditions and classrooms. Classroom1 means primary grade (N=5); classroom 2 means grade 1 (N=8); classroom 3 means grade 2 (N=5); classroom 4 means grades 3/4 (N=13); and classroom 5 means grades 5/6 (N=9).

Figure 3 represents the mean differences between pre-treatment and treatment conditions, as well as between treatment and post-treatment conditions for each classroom. Visual examination of Figure 3 illustrates how the treatment effects varied by classroom. Only classrooms 2 and 4 had an increase in total SIFTER mean scores from the pre-treatment to the treatment condition. All classrooms expect classroom 5 demonstrated a decrease in total SIFTER mean scores from the treatment to the post-treatment conditions. Classroom 2 showed the greatest increase in scores (7.4) from the pre-treatment to treatment conditions as well as the greatest decrease in scores (-10.95) from the treatment to post-treatment conditions.

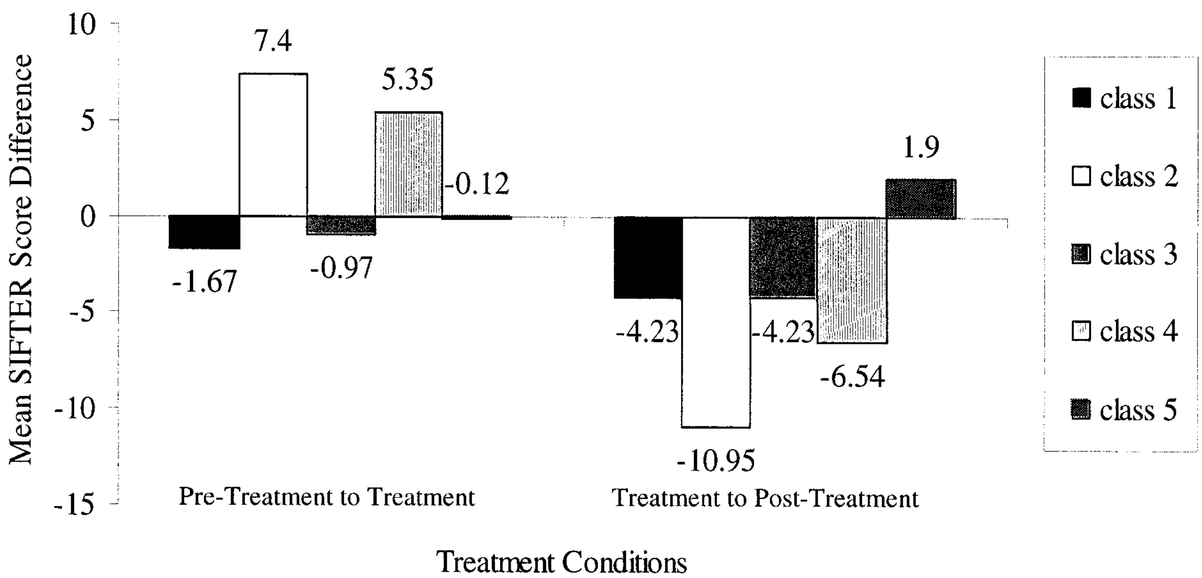

Figure 3. Changes in mean SIFTER scores between treatment conditions by classrooms. Class 1 means primary grade (N=5); class 2 means grade 1 (N=8); class 3 means grade 2 (N=5); class 4 means grades 3/4 (N=13); and class 5 means grades 5/6 (N=9).-

Hearing Loss vs. Normal Hearing

Total average SIFTER scores were computed for those students found to have normal hearing sensitivity in both screenings (N=26), those with a hearing loss in both the first and second hearing screening (N=4), and those students found to have a hearing loss in only one of two hearing screenings (N=10). These groups were formed based on the assumption that students with normal hearing sensitivity at both screenings would have normal hearing sensitivity throughout the sound-field observation. Likewise, those students who had a hearing loss in the first and second screenings likely suffered from a loss of hearing for the duration of the sound-field observation. The group found to have a hearing loss in one of the two hearing screenings represent those students who may potentially have suffered from a fluctuating loss of hearing at some point during the sound-field observation.

The percentage of children whose mean SIFTER scores increased from the pre-treatment to treatment condition and decreased from the treatment to post-treatment condition were calculated for the normal hearing, hearing loss in both screenings, and hearing loss in one screening group. As shown in Figure 4, a high percentage of children increased from the pre-treatment to treatment condition. Similarly, a high percentage of children decreased from the treatment to post-treatment condition. The hearing loss in both screenings group had the greatest percentage (75%) of students which increased in mean SIFTER scores from the pre-treatment to treatment condition and decreased from the treatment to post-treatment condition.

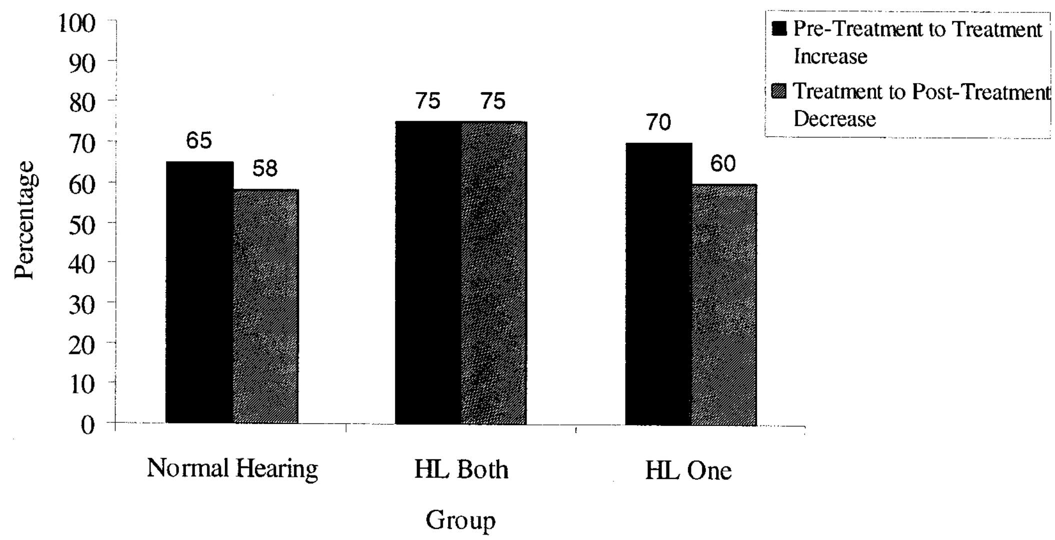

Figure 4. Percentage of children whose mean SIFTER scores increased from the pre-treatment to treatment condition and decreased from the treatment to post-treatment condition. Normal Hearing means those children found to have normal hearing sensitivity in both hearing screenings (N=26); HL Both means hearing loss in both screenings group (N=4); and HL One means hearing loss in one screening group (N=10).

Figures 5, 6, and 7 show the mean SIFTER scores for each of the three groups during the pre-treatment, treatment, and post-treatment conditions, respectively. A visual comparison of Figures 5, 6, and 7 reveals that all groups demonstrated greater mean scores during the treatment condition compared to the pre-treatment and post-treatment conditions. In particular, from the pre-treatment to treatment condition the normal hearing group, the hearing loss in both screenings group and the hearing loss in one screening group had mean SIFTER scores which increased 2.31, 2.5, and 4.45 respectively. From the treatment to post-treatment condition the groups showed decreases in scores of 4.88, 7.37 and 4.15, respectively. This demonstrates that the group of children found to have a hearing loss in one screening had the greatest increase in mean

SIFTER scores, whereas the normal hearing and hearing loss in both screenings groups had relatively similar mean increases from pre-treatment to treatment condition. However, from treatment to post-treatment conditions the group of students found to have a hearing loss in both screenings showed the greatest decrease in scores, while the other groups had similar but less substantial decreases.

As shown in Figures 5, 6, and 7, across each of the treatment conditions the normal hearing sensitivity group had the highest mean SIFTER scores, followed by the those children with a hearing loss in one screening. Finally, the group with a hearing loss in both screenings obtained the lowest scores in each treatment condition. The Kruskal-Wallis procedure was performed to determine if any of the groups of children significantly differed in their mean SIFTER scores in each of the pre-treatment, treatment, and post-treatment conditions. The non-parametric Kruskal-Walls test was used as an alternative to the one-way independent-samples ANOVA because the groups of children with hearing loss were not normally distributed. Findings revealed that although all differences between the groups in all treatment conditions were close to being significant, only the treatment condition was significant ($p = .044$). An examination of the error bars in Figure 6 suggests meaningful differences between normal hearing group and hearing loss group in both screens, as well as between the hearing loss in both screens group and hearing loss in one screen group.

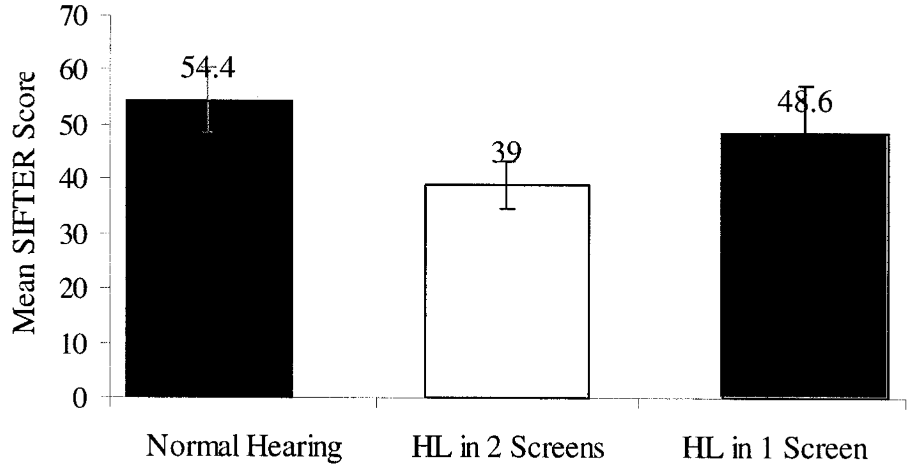

Figure 5. Mean SIFTER scores in the pre-treatment condition for normal hearing (N=26), hearing loss in both screenings (N=4), and hearing loss in one screening (N=10). Normal hearing represents those students with normal hearing sensitivity in both hearing screenings; HL in 2 screens means those students with a hearing loss in both screenings; and HL in 1 screen means those students with a hearing loss in only one of two hearing screenings. Error bars denote standard deviations.

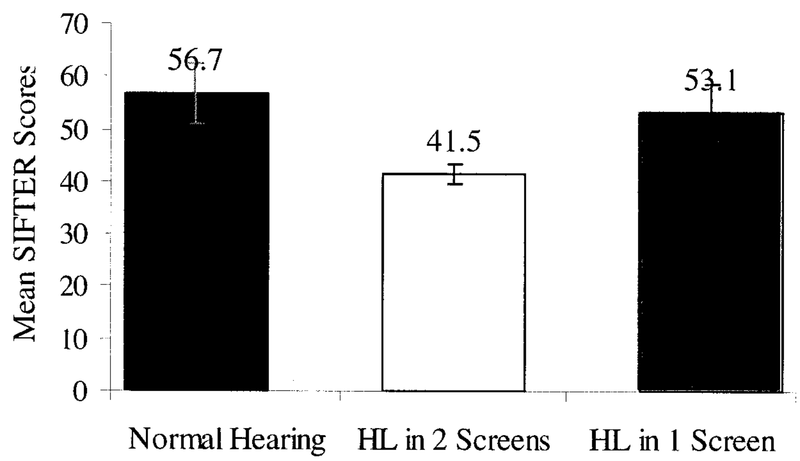

Figure 6. Mean SIFTER scores in the treatment condition for normal hearing (N=26), hearing loss in both screenings (N=4), and hearing loss in one screening (N=10) across treatment conditions. Normal hearing means those students with normal hearing sensitivity in both hearing screenings; HL in both screens means those students with a hearing loss in both screenings; and HL in one screen means those students with a hearing loss in only one of two hearing screenings. Error bars denote standard deviations.

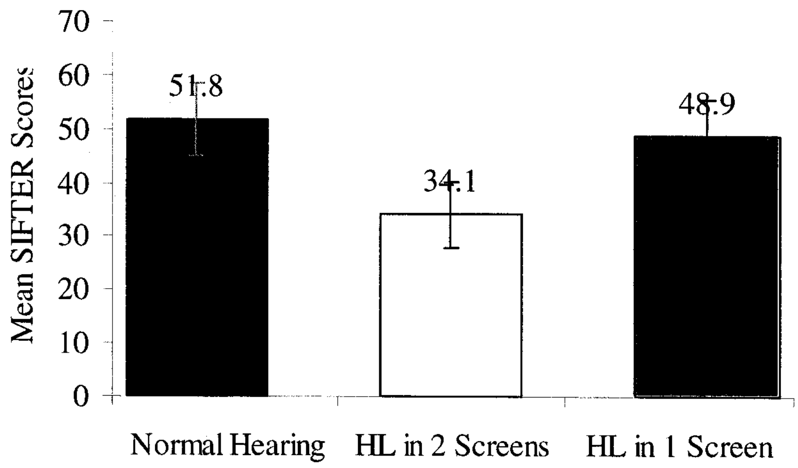

Figure 7. Mean SIFTER scores in the post-treatment condition for normal hearing (N=26), hearing loss in both screenings (N=4), and hearing loss in one screening (N=10) across treatment conditions. Normal hearing means those students with normal hearing sensitivity in both hearing screenings; HL in both screens means those students with a hearing loss in both screenings; and HL in one screen means those students with a hearing loss in only one of two hearing screenings. Error bars denote standard deviations.

Teacher Questionnaire

Four of the five teachers who took part in the study completed the questionnaire regarding their impressions of the sound-field amplification system in their classrooms. A survey was not done for classroom 4. Table 3 provides a summary of the teachers' responses. The majority of the responses (87.5%) were positive impressions (strongly agree or somewhat agree) and no responses were found to be negative (somewhat disagree or strongly disagree). Figure 8 illustrates how many hours per day the teachers reported that they used the sound-field amplification systems. Two of the four teachers reported that they used the sound-field system 4-6 hours per day.

Table 3

Summary of Teacher Responses to the Sound-Field Questionnaire (N=4).

Question	Strongly agree	Somewhat agree	Neutral	Somewhat disagree	Strongly disagree
1. My students were able to hear and understand me better when using the sound field system.	4	0	0	0	0
2. I feel that more seating options were available to all of my students with the use of the sound field system; especially those students with hearing loss, attentional deficits, behavioural problems, learning problems, and those students who often fatigued during the day.	2	2	0	0	0
3. I feel that all of my students benefited from the use of the sound field system.	3	1	0	0	0
5. I felt comfortable using the sound field system.	4	0	0	0	0
6. I did not have to speak as loudly and/or strain my voice when I used the sound field system.	4	0	0	0	0
7. I felt more relaxed and less tired at the end of the teaching day when I used the sound field system.	0	1	3	0	0
8. I feel that I benefited from the use of the sound field system.	2	2	0	0	0
9. My students and I enjoyed using the sound field system in our classroom.	1	2	1	0	0
10. The sound field system was easy to use.	4	0	0	0	0

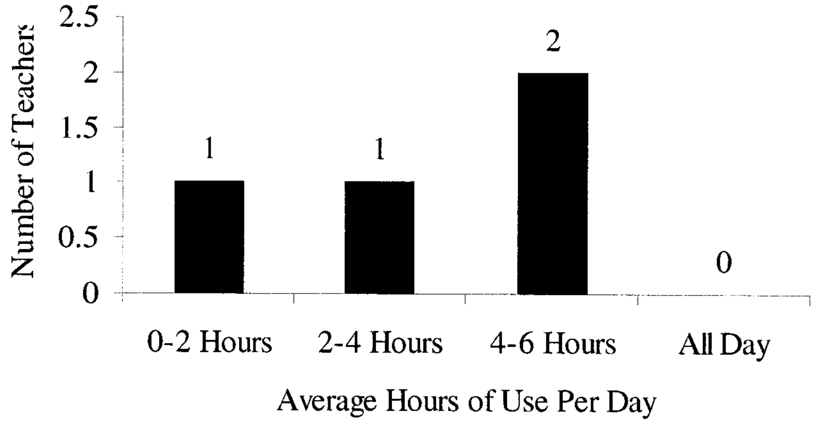

Figure 8. Teacher reported hours of amplification use per day.

Chapter 9 Experiment Two Discussion

The purpose of the present study was twofold. To begin, the adequacy of the classroom acoustics of the Pictou Landing First Nations Elementary School was determined to evaluate whether the unoccupied noise levels and reverberation time of the classrooms met the acoustic standards set by ASHA (1995). Next, sound-field amplification systems were installed in all classrooms and student performance in the classroom was recorded. Teachers completed SIFTER questionnaires to track the student classroom performance over a 7-month time period including before, during, and after sound-field amplification use.

Classroom Acoustic Measures

The unoccupied noise levels reported for each classroom had an average intensity of 41.4 dBA with a range from 38.6 dBA to 45.3 dBA. These findings are above the recommended unoccupied classroom noise levels of 30 dBA (ASHA, 1995). None of the 6 classrooms in the Pictou Landing First Nations Elementary School were found to have unoccupied classroom noise levels which met the recommended standard. These high noise levels are not surprising considering that research has repeatedly reported unoccupied average classroom noise levels to range between 41 dBA to 60 dBA (Arnold & Canning, 1999; Sanders, 1965; Bess et al., 1984; Crandell & Smaldino, 1994; Rosenberg et al., 1999).

As previously discussed, there are a variety of sources (heating ducts, playground, etc.) which can influence unoccupied classroom noise levels, and the noise levels of the classrooms in the Pictou Landing First Nations school are impacted by these typical noise sources. Other noise sources were also discovered. For instance, classroom B, the second noisiest room, was found to have a cable internet system located at the back of the room which contributed to its ambient noise levels.

ASHA's (1995) recommended criterion for unoccupied background noise levels to not exceed 30 dBA is based on the assumption that appropriate S/N ratios are difficult to achieve if the ambient noise levels exceed these levels (Crandell & Smaldino, 1995). Finitzo-Hieber and Tillman (1978) reported a decreasing trend in speech recognition scores as the S/N ratio becomes less favourable. It is also important to consider that when classrooms are occupied the background noise levels increase further which creates even more adverse S/N ratios. It is reasonable to assume, therefore, that the classroom noise levels in the Pictou Landing First Nations Elementary School create a less than ideal S/N ratio which influences speech recognition abilities and student performance in the classroom.

Reverberation time was found to be 0.306 seconds which is under the recommended time of 0.4 seconds (ASHA, 1995). This is an encouraging result since studies typically report reverberation levels ranging from 0.35 to 1.2 seconds (Crandell & Smaldino, 1994). A reverberation time of ≤ 0.4 seconds is critical for optimal word recognition scores in children with normal hearing sensitivity and those with hearing loss (Finitzo-Hieber & Tillman, 1978). It is important to note that testing was completed in only one classroom and although the generalization of findings to all other classrooms based on similar construction seems appropriate, there exists the possibility that not all classrooms have the same reverberation time.

Classroom Performance

The main effect for treatment was found to be significant and post hoc analyses revealed significant differences between mean SIFTER scores from the pre-treatment to the treatment condition, as well as from the treatment to post-treatment conditions. The significant increase from the pre-treatment to treatment condition suggests that, in general, student performance in the classroom improved when the sound-field system was used. These results are consistent with other studies (Flexer et al., 1993; Rosenberg et al., 1999) which showed, based on teacher observations, an improvement in classroom behaviours with the introduction of sound-field amplification.

The significant decrease from the treatment condition to the post-treatment condition shows that there was no maintenance of improved classroom performance when the amplification was ceased. This is in partial agreement with Palmer (1998) who reported that following amplification use there was a return of inappropriate behaviours, but the task management behaviours which improved during amplification use were shown to maintain after use of the sound-field system. In the present study, the overall increase in classroom performance with the use of the amplification system and the decrease in performance upon the withdrawal of the sound-field system indicates that the improvements were only available during the actual use of the sound-field system.

It is interesting to note that the overall reduction (4.95) in total mean SIFTER scores in classroom performance from the treatment to post-treatment condition in classroom performance was greater than the overall improvement (2.85) of scores found from the pre-treatment to treatment condition. A possible explanation for this decrease in performance beyond baseline is that the post-treatment condition scores were influenced by the fact that they were obtained during the last 2 months of the school year, a time typically exciting and distracting for students.

The significant interaction found between SIFTER content areas and treatment conditions indicates that some SIFTER content areas were more affected by the treatment than others. An examination of the SIFTER content area score mean differences across treatment conditions reveals that all areas increased from the pre-treatment to treatment condition as well as decreased from the treatment to post-treatment conditions. This finding indicates that the classroom performance of students improved across a variety of behaviours with the use of sound-field amplification.

Of particular note, the attention category was found to have the greatest increase from the pre-treatment to treatment condition, as well as a large decrease from the treatment to post-treatment condition compared to the other areas. This finding shows that, as a group, student attending behaviours increased as a result of the sound-field system. This is comparable to other research (e.g., Allen & Patton, 1990; Eriks-Brophy & Ayukawa, 2000) which found a significant increase in on-task behaviour with amplification use.

It may be suggested that, in the present study, the attention category was most affected by the amplification system because attention may be the most readily influenced behaviour. That is, it is possible that sound-field amplification has a more immediate impact on attending behaviours, whereas the other SIFTER content areas (e.g., academics) require more time to reveal the influence that amplification has on them. This is supported by the fact that Palmer (1998) found change in attending behaviours as early as one week following the introduction of amplification.

The SIFTER content area of communication was found to have the smallest increase in mean scores with amplification use, as well as the smallest decrease in scores from the treatment to post-treatment condition. Although this is somewhat surprising considering past research has shown an improvement in spoken comprehension test scores (Arnold & Canning, 1999) and verbalization usage (Benafield, 1990), it is probable that these types of changes are not readily observed unless they are directly tested or intentionally monitored. For example, student comprehension may not have been easily recognized because it manifests in many different student behaviours. For instance, if students improved in their ability to complete assigned seat work in class because they had a better understanding of the material, teachers may have only recognized this as in increase in attention span and not attributed this to a concomitant improvement in comprehension.

The SIFTER areas of class participation and school behaviour were also found to have relatively small increases from the pre-treatment to treatment condition. These results, however, may be due to the nature of the questions asked. For example, a class participation question is "With what frequency does the student complete his class assignments within the time allocated?" and a school behaviour question asks "How would your rank the student's relationship with peers?" The questions likely do not constitute a measure of student performance related to sound-field amplification use. Although it is suggested that the SIFTER is a fast and easy method for teachers to evaluate the efficacy of using sound-field amplification (Flexer, 1997), it was originally designed as a screening tool for identifying students at educational risk and, therefore, may not be an ideal instrument for tracking observable changes with sound-field amplification.

A significant two-way interaction was noted between treatment conditions and classrooms which suggests that the classrooms reacted differently to the treatment conditions. A visual inspection of this graphical representation confirms that the different classroom responses to treatment were varied.

Classrooms 2 (grade 1) and 4 (split grades 3/4) were shown to increase in classroom performance from the pre-treatment to treatment condition. This is consistent with past research which reports improvements in attending, listening and learning behaviours of students in kindergarten to grade 2 (Allcock, 1999; Palmer, 1998; Rosenberg et al., 1999), and also demonstrates the potential for increased classroom performance with older children in later grades. Surprisingly, all other classrooms demonstrated a slight decrease in the student performance in the classroom from the pre-treatment to treatment condition.

There are at least two possible explanations for the lack of increase in student performance from the pre-treatment to treatment condition in classrooms 1, 3, and 5. First, with teacher evaluations there is an implicit assumption that each evaluator will be equally observant and diligent. These variables cannot be controlled for and surely have an impact, for better or worse, in terms of the measured efficacy of the system. Second, teachers may be too closely involved with students to be adequately objective in their evaluations. Palmer (1998, p. 821) notes, "although the SIFTER deals with a variety of essential classroom behaviours and abilities that one might expect sound-field amplification to affect, it is difficult to quantify the direct impact of sound-field amplification on the basis of teacher observations when the teachers are so intimately involved in the classroom environment."

The number of hours teachers report having used the sound-field system per day must also be taken into consideration as a factor influencing classroom performance from the pre-treatment to treatment condition. For example, classroom 2 was noted to have the greatest mean increase in SIFTER scores and this teacher reported to have used the sound-field system 4-6 hours per day. Conversely, classroom 3 demonstrated no increase in student performance and the teacher reported to have used the sound-field system only 0-2 hours per day. Classroom 1 also failed to show an increase in student performance, where the teacher reported using the system 2-4 hours per day. This teacher commented on her use of the system, saying, "I only like using it when I am starting a new concept". The results, however, suggest that such selective use of the sound-field system reduces its efficacy.

All classrooms, except classroom 5, showed a decrease in student performance from the treatment to post-treatment condition. Those classrooms (2 and 4) which had an increase in performance from the pre-treatment to treatment condition were shown to have the greatest decrease from treatment to post-treatment. These findings support the conclusion that the sound-field system was a causal factor in the observed change in behaviour in classrooms 2 and 4.

Hearing Loss vs. Normal Hearing

A high percentage of both children with normal hearing and those with hearing loss showed increases in mean SIFTER scores from the pre-treatment to treatment condition. A high percentage of children in these groups also showed decreases in mean scores from the treatment to post-treatment condition. This indicates that the majority of children in each group showed improvement in classroom performance with amplification use. It should be noted that a slightly greater percentage of children improved in the hearing loss in both screenings group than in either of the other two groups.

Children with normal hearing sensitivity and those with hearing loss in one or both hearing screenings showed an increase in mean SIFTER scores from pre-treatment to treatment condition and a decrease in scores from treatment to post-treatment conditions. These findings suggest that sound-field amplification improves classroom performance in both normally hearing children and children with hearing loss. This is consistent with past research (Allen & Patton, 1990) which has shown that children with normal hearing sensitivity significantly improve in classroom performance with the introduction of sound-field amplification.

No other studies have investigated the effects of sound-field amplification on a group of students with diagnosed otitis media and fluctuating hearing loss. Eriks-Brophy and Ayukawa (2000) did, however, identify one student with fluctuating hearing loss and found that the student improved in one of four observed categories of attending behaviour. As well, although Flexer et al. (1993) did not obtain hearing thresholds, they did found significant improvements in SIFTER scores in the amplified condition of those students with a history of hearing problems. The present study contributes to the existing corpus of data by demonstrating that children with hearing loss secondary to diagnosed otitis media perform better in the classroom under amplification. In addition, it shows that students with fluctuating hearing loss at some point throughout the school year also improve in classroom performance with amplification.

The group of children who were found to have a hearing loss in one of the two hearing screenings demonstrated the greatest improvement in SIFTER mean scores from the pre-treatment to the treatment condition. Past research has not compared the classroom performance improvements of children with normal hearing sensitivity and those with hearing loss.

Without knowing the history of hearing problems and otitis media of the students it is difficult to hypothesize why the group with hearing loss in one screening demonstrated the greatest gains, but a number explanations are possible. First, if the diagnosis of hearing loss at only one screening implies that these students suffer from recurring fluctuating hearing loss at various times throughout the school years, then it is possible that they suffered from loss of hearing at various times throughout the study. In other words, with the variability of this hearing loss these children may have had a hearing loss inconsistently throughout the different treatment conditions. For example, these students may not have experienced a loss of hearing during the treatment condition and therefore their scores increased considerably because their hearing status had in fact improved as well. Second, the degrees of hearing loss experienced by both groups of children with hearing loss may have influenced how much their scores increased. For instance, those students with moderate losses may not have improved to the same degree as those with mild losses.

From the treatment to post-treatment condition, the group with hearing loss in both screenings demonstrated the greatest decrease in scores compared to the other groups. It has already been discussed that the end of school year excitement may have played a role in this decline in scores following the treatment condition, and perhaps those children with hearing loss are more affected during this distractible time.

It may also be suggested that this greater decline in scores from the treatment to post-treatment condition for the hearing loss in both screenings group is a result of having experienced the amplification system. Children with hearing loss, even minimal ones, typically expend a high level of effort as they attempt to learn from classroom instruction (Crandell et al., 2005). In the present study, if the use of the amplification system allowed those children with hearing loss to lessen their efforts to hear the teacher, then it may be that, following amplification use, these children did not exert as much effort trying to hear as they typically do. Thus, the withdrawal of the sound-field system may have had a greater impact on the hearing loss group because of the ease of listening the amplification provided.

It is worth noting, though, that the hearing loss in both screenings group remained lower than the normal hearing and hearing loss in one screening group in each treatment condition. This suggests that children with a hearing loss perform at a lower level than children with normal hearing sensitivity, even with sound-field amplification. In fact, an examination of the error bars during amplification use suggests that the hearing loss in two screenings group remained meaningfully lower than the normal hearing group and hearing loss in one screening group. This shows, consistent with previous research (Dancer, Burl, & Waters, 1995), that elementary school children with hearing loss receive lower SIFTER scores compared to their normally hearing peers, however, it appears as though those children with hearing loss continue to remain lower even during amplification use.

This discrepancy in performance may exist for several reasons. First, although teachers were not informed of the hearing status of their students they were found to give lower SIFTER scores to those students with hearing loss. Therefore, it is possible that if the group of students with hearing loss were already recognized by their teachers as being low achievers compared to their normally hearing peers, the teachers may not have expected significant change in classroom performance from these students. They might, therefore, be unable to objectively observe changes that may have occurred. Second, presuming that those students with hearing loss had a history of hearing problems due to otitis media, it is likely that they have developed poor listening and attending skills. Feagans, Sanyal, Henderson, Collier, and Appelbaum (1987) hypothesized that the long-term effect of hearing loss may be that students learn to become inattentive to language. Three months of sound-field amplification use could not rectify these learned behaviours; it could not enable those with hearing loss to achieve the level of classroom performance of the normally hearing children. Attention deficits, which are beyond the poor acoustics of the classroom environment, should receive clinical intervention and this, in combination with sound-field amplification, provides a very good chance that classroom performance will be strengthened (Crandell et al., 1995).

Teacher Questionnaire

All of the teachers reported benefits from the use of the sound-field amplification. For example, all teachers felt that their students were better able to understand them and that the sound-field system prevented them from having to speak loudly or strain their voices. These findings are consistent with other research which reported teacher satisfaction with the use of sound-field amplification (Eriks-Brophy & Ayukawa, 2000; Mendel, Roberts, & Walton, 2003; Nelson & Nelson, 1999; Palmer, 1998; Rosenberg et al., 1999). Teachers reported to use the systems from 0-2 hours to 4-6 hours per day.

Summary

Overall, the present findings suggest that children with and without hearing loss will show improvements in classroom performance with sound-field amplification use. In this study, students with hearing loss (i.e., hearing loss in both screenings) were most likely to benefit from sound-field amplification, while children with fluctuating hearing loss (i.e., a loss of hearing in one screening) were more likely to show a greater improvement in classroom performance with amplification use.

However, a few limitations to this research must be discussed. To begin, the mean differences in SIFTER scores between treatment conditions were all noted to be quite small, and should therefore be interpreted with caution; it is important not to lose sight of clinical or practical significance. Clinical significance requires that the research findings make a real and important difference to the students under study. Thus, the small mean differences found between treatment conditions here may not transfer to experiential differences in the classrooms. However, the positive responses obtained by the teachers regarding their impressions of the use of the amplification system would suggest that improvements did in fact occur, and it may be, then, that the SIFTER questionnaires were not sensitive enough to demonstrate the benefits.

Another limitation of the present study was the small sample size, especially of the hearing loss in both screenings group (N=4). This limited sample hinders the ability to generalize the findings to other children. In addition, potential diagnoses (e.g., learning disabilities, attention deficit disorder) which may exist among the cohort and have influenced performance abilities in the classroom were not identified.

The present study lacked a control group of non-amplified classrooms which would have provided further support to the findings that the changes in classroom performance were in fact a result of the sound-field systems and not due to potential extraneous variables. For example, it is possible that the teachers showed an increase in the SIFTER scores because they expected that their students would have improved over the school year merely as a result of their teachings. That is, students are expected to improve throughout the school year and therefore teachers recorded an improvement in classroom performance regardless of the sound-field system. In an attempt to overcome this limitation, the present study implemented an ABA experimental design in order to strengthen the findings that improvements in the classroom were due to the amplification use.

However, there still exists the possibility that teachers responded to the SIFTER questionnaires with socially desirable answers which may have confounded the results. That is, the teachers knew when the amplification system was or was not used in the classrooms and therefore may have favourably recorded student classroom performance according to what they believed was expected with and without amplification use. A control group consisting of non-amplified classrooms with teachers also completing the SIFTER questionnaires would have been beneficial to overcome the potential social desirability bias. It would be ideal if this control group consisted of classrooms from the same school and unfortunately this was not feasible in the present study considering the limited number of classrooms in the school.

Nevertheless, the results of the present study contribute to research demonstrating that elementary school children with and without fluctuating hearing loss benefit from sound-field amplification use. These findings are important because First Nations children repeatedly show high prevalence rates of hearing loss secondary to otitis media, and, with its asymptomatic nature, may affect students on any given school day. The benefits of sound-field amplification use, therefore, should be seriously considered as a solution to improve the classroom learning environment for all children.

In the present study the hours of amplification use appeared to have an impact on the amount of improvement found in classroom performance. That is, the more the sound-field system was used per day by the teachers the greater the benefit found in student performance. Future research should investigate the relationship between the number of hours of amplification use and the degree of classroom benefit. The present findings suggest that students benefit more the longer amplification is in use, but future research might determine whether there is a limit to its efficacy. At this point, however, the merits of sound-field amplification seem clear, and clinicians might consider engendering greater awareness of it among teachers. To maximize benefits where systems have been or are to be implemented, clinicians should ensure that teachers are comfortable with the sound-field equipment, and make themselves available to provide support over the long-term.

Chapter 10 General Conclusion

The present study found, consistent with previous research, that First Nations elementary school children suffer from substantially higher rates of otitis media with effusion and hearing loss than elementary school children in the general population. The reasons for the inflated prevalence rates among the First Nations population are unknown, but future research should continue to diagnose otitis media, as well as conduct hearing screenings to develop longitudinal data on Aboriginal children. A more comprehensive body of research will contribute to understanding the etiology of these high rates in this particular population.

Clinicians should also be mindful of these high prevalence rates and, when possible, conduct regular hearing and tympanometry screenings on First Nations children. Considering that these children suffer from persisting and recurring otitis media, these screenings will enable clinicians to monitor the hearing and middle ear status, as well as provide the necessary referrals. The present study noted that those children with hearing loss received lower mean SIFTER scores than those children with normal hearing sensitivity. In situations where caseloads do not allow clinicians to perform regular school-wide screenings they should consider utilizing the SIFTER as a screening tool to identify those children who are at educational risk due to potential hearing problems. In addition, it is important for clinicians to provide education on the occurrence of otitis media and hearing loss to First Nations communities in order to raise awareness and implement remediation strategies.

The fluctuating hearing loss associated with otitis media suggests that on any given day in the classroom, First Nations children may not be receiving the necessary instruction provided by the teacher. To further compound this hearing deficit, the classrooms of the Pictou Landing First Nations Elementary School were found to exceed the recommended unoccupied noise levels. Implications of a degraded learning environment include a reduction in speech recognition abilities which suggests that the classrooms are not providing a favourable condition to facilitate learning.

The use of sound-field amplification resulted in significant increases in student performance in all classrooms. This suggests that children can improve in the areas of academics, attention, communication, class participation and school behaviour when amplification is utilized. The area of attention was shown to have the greatest increase, which suggests that it is the most readily influenced behaviour. Overall, both those children with normal hearing sensitivity and those with hearing loss were found to improve in classroom performance with amplification use.

Overall, the findings of the present research demonstrate that the prevalence rates of otitis media and hearing loss among First Nations children continue to remain an area of concern for this population. Furthermore, results of this research provide support for the efficacy of sound-field FM amplification to improve classroom performance of elementary school children. It is up to future research to add to the present findings to further validate the use of sound-field amplification on the First Nations children.

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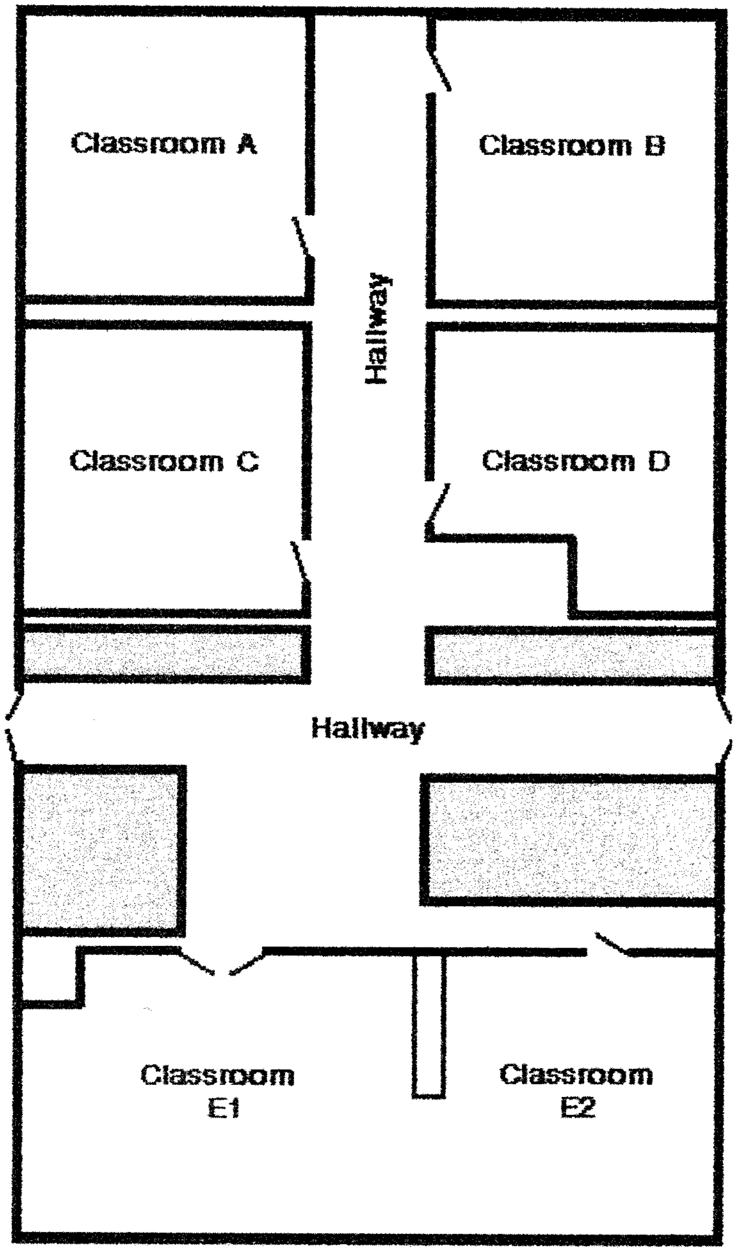
Appendix A

Non-Scale Map of the Pictou Landing First Nations Elementary School



Appendix B

S.I.F.T.E.R.
Screening Instrument For Targeting Educational Risk

by Karen L. Anderson, Ed.S., CCC-A

STUDENT ____________________________ TEACHER ___________________ GRADE ________

Academics

1. What is your estimate of the student's class standing in the last month?

UPPER — MIDDLE — LOWER
5 4 3 2 1

2. How did the student's achievement compare to your estimation of his/her potential in the last month?

EQUAL — LOWER — MUCH LOWER
5 4 3 2 1

3. What was the student's reading level, reading ability group or reading readiness group in the classroom (e.g., a student with average reading ability performs in the middle group) last month?

UPPER — MIDDLE — LOWER
5 4 3 2 1

Attention

4. How distractible was the student in the past month?

NOT VERY — AVERAGE — VERY
5 4 3 2 1

5. What was the student's attention span last month?

LONGER — AVERAGE — SHORTER
5 4 3 2 1

6. How often did the student hesitate or become confused when responding to oral directions (e.g., "Turn to page . . .") last month?

NEVER — OCCASIONALLY — FREQUENTLY
5 4 3 2 1

Communication

7. How was the student's comprehension abilities last month?

ABOVE — AVERAGE — BELOW
5 4 3 2 1

8. How was the student's vocabulary and word usage skills last month?

ABOVE — AVERAGE — BELOW
5 4 3 2 1

9. How proficient was the student at telling a story or relating happenings from home last month?

ABOVE — AVERAGE — BELOW
5 4 3 2 1

Class Participation

10. How often did the student volunteer information to class discussions or in answer to teacher questions in the last month?

FREQUENTLY — OCCASIONALLY — NEVER
5 4 3 2 1

11. With what frequency did the student complete his/her class and homework assignments within the time allocated last month?

ALWAYS — USUALLY — SELDOM
5 4 3 2 1

12. After instruction, did the student have difficulty starting to work (looks at other students working or asks for help) in the last month?

NEVER — OCCASIONALLY — FREQUENTLY
5 4 3 2 1

School Behaviour

13. Did the student demonstrate any behaviors that seemed unusual or inappropriate in the last month?

NEVER — OCCASIONALLY — FREQUENTLY
5 4 3 2 1

14. Did the student become frustrated easily, sometimes to the point of losing emotional control in the last month?

NEVER — OCCASIONALLY — FREQUENTLY
5 4 3 2 1

15. In general, how would you rank the student's relationship with peers (ability to get along with others) in the last month?	GOOD		AVERAGE		POOR
	5	4	3	2	1

Appendix C

PRESCHOOL S.I.F.T.E.R.
Screening Instrument for Targeting Educational Risk in Preschool Children (age 3-Kindergarten)

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STUDENT ______________________ TEACHER ________________ GRADE _______

Academics

Question					
1. How well did the child understand basic concepts in the last month (e.g., colors, shapes, etc.)?	ABOVE		AVERAGE		BELOW
	5	4	3	2	1
2. How often was the child able to follow two-part directions in the last month?	ALWAYS		FREQUENTLY		SELDOM
	5	4	3	2	1
3. How well did the child participate in group activities in the last month (e.g., calendar, sharing)?	ABOVE		AVERAGE		BELOW
	5	4	3	2	1

Attention

Question					
4. How distractible was the child during large group activities in the last month?	SELDOM		OCCASIONAL		FREQUENT
	5	4	3	2	1
5. What was the child's attention span in the last month?	LONGER		AVERAGE		SHORTER
	5	4	3	2	1
6. How well did the child pay attention during a small group activity or story time in the last month?	ABOVE		AVERAGE		BELOW
	5	4	3	2	1

Communication

Question					
7. How was the child's vocabulary and word usage skills last month?	ABOVE		AVERAGE		BELOW
	5	4	3	2	1
8. How proficient was the child at relating an event in the last month?	ABOVE		AVERAGE		BELOW
	5	4	3	2	1
9. How was the child's overall speech intelligibility (i.e., production of speech sounds) last month?	ABOVE		AVERAGE		BELOW
	5	4	3	2	1

Class Participation

Question					
10. How often did the child answer questions appropriately (verbal or signed) last month?	ALMOST ALWAYS		FREQUENTLY		SELDOM
	5	4	3	2	1
11. How often did the child share information during group discussions last month?	ALMOST ALWAYS		FREQUENTLY		SELDOM
	5	4	3	2	1
12. How often did the child participate with classmates in group activities of group play last month?	ALMOST ALWAYS		FREQUENTLY		SELDOM
	5	4	3	2	1

School Behaviour

Question					
13. Did the child play in socially acceptable ways (i.e., turn taking, sharing) last month?	ALMOST ALWAYS		FREQUENTLY		SELDOM
	5	4	3	2	1

14. How proficient was the child at using verbal language or sign language to communicate effectively with classmates (e.g., asking to play with another child's toy) in the last month?	ABOVE		AVERAGE		BELOW
	5	4	3	2	1
15. How often did the child become frustrated, sometimes to the point of losing emotional control in the last month?	NEVER	SELDOM		FREQUENTLY	
	5	4	3	2	1

Appendix D
Teacher Questionnaire

Question	Strongly agree	Somewhat agree	Neutral	Somewhat disagree	Strongly disagree
1. My students were able to hear and understand me better when using the sound field system.					
2. I feel that more seating options were available to all of my students with the use of the sound field system; especially those students with hearing loss, attentional deficits, behavioural problems, learning problems, and those students who often fatigued during the day.					
3. I feel that all of my students benefited from the use of the sound field system.					
4. I feel that class time was saved because instructions and information did not have to be repeated.					
5. I felt comfortable using the sound field system.					
6. I did not have to speak as loudly and/or strain my voice when I used the sound field system.					
7. I felt more relaxed and less tired at the end of the teaching day when I used the sound field system.					
8. I feel that I benefited from the use of the sound field system.					
9. My students and I enjoyed using the sound field system in our classroom.					
10. The sound field system was easy to use.					
11. Estimate the average number of hours per day you used the sound field system.	0-2 Hours	2-4 Hours	4-6 Hours	All Day	

Additional comments....