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Job Burnout in Educational Audiologists: The Value of Work Experience

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Job burnout levels of educational audiologists were determined using a standardized inventory. Eighty-one percent of the 361 participants rated their overall job burnout in the "average or low" range. Participants' scores were in the low burnout range for both the Depersonalization and Personal Accomplishment subscales. A significantly greater number of participants with less than 10 years of experience had scores in the high burnout range for the Emotional Exhaustion subscale when compared with participants with more work experience. The importance of sharing these results with training programs and administrators is discussed in terms of recruitment and retention.

Introduction

According to Maslach (2003) "Job burnout is a psychological syndrome that involves a prolonged response to stressors in the workplace. Specifically, it involves the chronic strain that results from an incongruence, or misfit, between the worker and the job" (p. 189). The current research in the area of job burnout is replete with studies examining this phenomenon which is divided into three components based on Maslach's work (Maslach, 1982; 1998; 2003; Maslach, Jackson, & Leiter, 1996). The first component is emotional exhaustion, defined as feeling drained, tired and fatigued with a resulting need to distance oneself emotionally and cognitively from work. The second component is depersonalization, defined as becoming indifferent, callous and developing cynical attitudes toward children/individuals workers are trying to serve. The third component is a loss of the sense of personal accomplishment, defined as no longer feeling work has any significant impact or makes a difference in the lives of the children/individuals workers are committed to serve.

Burnout is a dynamic process, caused by excessive work demands and results in avoidance, absenteeism, withdrawal, physical and psychological health symptoms, turnover, and poor job performance (Maslach, 1982; 2003; Schaufeli & Buunk, 2003). It is a multibillion dollar problem in the United States and around the world. Maslach (2003) has speculated that identification of job burnout is the beginning of the treatment or management processes. She also suggests that job burnout is related to both individual characteristics and organization climate and environment.

Job Burnout in School Personnel

As early as 1991, Farber reported that between 5% and 20% of all teachers in the United States were burned out at any given time. According to the most recent report from the National Center for Education Statistics and the Teacher Follow-up Survey, 35.7% left the teaching profession in the last year (Marvel, Lyter, Peltola, Strizek & Morton, 2006). The shocking reality is that at least 50% of the educators leaving had less than nine years experience working in the schools (Marvel et al, 2006). Ingersoll (2003) reported that nearly 50% of all teachers who enter the field leave within the first five years due to dissatisfaction, inadequate working conditions, lack of planning time, and no influence over school policies.

Research suggests that professionals in educational settings are more susceptible to job burnout because of the intensity and frequency of one-to-one personal contacts, work overloads, lack of autonomy in the work setting, ambiguity about professional roles, and lack of recognition (Bakker & Schaufeli, 2000; Blood, Ridenour, Thomas, Qualls & Hammer, 2002; Boudreau & Nakashima, 2002; Burke & Greenglass, 1995; Kulik, 2006; Leiter & Maslach, 2000; Maslach, 2003; Maslach & Leiter, 1999; Maslach, Schaufeli, & Leiter, 2001; Wisniewski & Gargiulo, 1997). Job stress and resulting occupational burnout has been reported in general education teachers, special education teachers, school counselors, teachers of the deaf, school speech language pathologists, and administrators (Beer & Beer, 1992; Blood et al, 2002; Borg & Riding, 1993; Darcy, Kusznikow & Lester, 1995; Fimian, Lieberman, & Fastenau, 1991; Male & May, 1997; Moracco, Butcke, & McEwen, 1984; Schaufeli & Enzmann, 1998; Wisniewski & Gargiulo, 1997).

In discussing the individual characteristics which predict job burnout, Maslach et al. (2001) state "Of all demographic variables that have been studied, age is the one that has been most consistently related to burnout. Among younger employees the level of burnout is reported to be higher than it is among those over 30 and 40 years old. …so burnout appears to be more of a risk earlier in one's career" (p. 409). In the continuing search for predictors of job burnout in educators, Brewer and Shapard (2004) conducted a meta-analysis of 34 studies examining the relationship between years of experience on the job and burnout. The authors examined the most widely used measure of occupational burnout in the research literature – the Maslach Burnout Inventory (MBI) (Maslach, Jackson & Leiter, 1996). They reported a negative correlation between years of experience in a field and the MBI suggesting younger educators show more signs of burnout than their older counterparts.

The MBI provides a reliable and valid measure of job burnout for high stress jobs and provides normative data based on more than 11,000 individuals including law enforcement officers, general physicians, surgeons, dentists, nurses, social workers, air traffic controllers, teachers from kindergarten through university professors, taxicab drivers, lawyers, secretarial staff, business executives, administrators, etc. In addition, thousands of research studies have been reported in the literature using the MBI which has been translated into numerous languages (e.g. Spanish, Dutch, German, Chinese, Finnish, Norwegian, etc). It is currently the most widely used measure for job burnout in the world (Barling, 2005; Buchwald, 2007; Colbert, 2006; Greenberg, 2008; Quick, 2003).

Potential for Job Burnout in Educational Audiologists

During the past two decades, a technology and knowledge explosion in audiology has resulted in major changes to the discipline and expansion in the scope of practice. Children with hearing disabilities are requiring and receiving services at earlier ages. To guarantee the continuation of high quality services, educational audiologists must continually update their knowledge and skills sets in newborn hearing identification and intervention programs, miniaturization and digitalization of assistive devices, counseling in behavior and genetics, and other areas. However, these changes may also bring increased ambiguity in the roles of educational audiologists, oversized caseloads, and new uncertainties about team roles and responsibilities. Educational audiologists are expected to actively participate as consultants/counselors with parents, caregivers, educational personnel, administrators and child disability advocates while addressing increased accountability issues by school, state, and federal agencies. A possible result of trying to meet new job demands, oftentimes with limited support, training, and/or resources, is that educational audiologists may be placed at high risk for job burnout and job dissatisfaction.

The potential negative effects of job burnout in educational audiologists have received little systematic attention in the literature. The aim of the present study was to expand on previous research using a standardized scale of job burnout with individuals providing services to children in schools with speech, language and hearing disabilities. The primary purpose of this study was: a) to determine the performance of educational audiologists on the MBI (Maslach, Jackson, & Leiter, 1996) total score and subscales of Emotional Exhaustion, Depersonalization, and Personal Accomplishment, and b) to determine significant differences among burnout scores among four groups of educational audiologists based on the number of years of experience working in the field.

Method

Participants

The participants in this study were members of the Educational Audiology Association (EAA). The list of members was obtained via the EAA 2005 membership list. Eleven hundred and ninety one members were mailed a cover letter, a two-section survey, a commercially available, standardized job burnout questionnaire, and a return postage-paid envelope. After 4 weeks, another follow-up survey was sent to potential respondents requesting completion of the survey and/or thanking participants for their cooperation. The data were collected according to the procedures submitted to and approved by the Institutional Review Board, The Pennsylvania State University.

The mailing and follow-up resulted in responses from 481 participants for a 40.4% response rate. Of the returned survey, 120 were deemed unusable due to incomplete demographic information, returned unopened envelopes, incorrect addresses, incomplete surveys, incorrect response options on the surveys or partial completion of the MBI. Therefore, 361 surveys (30.3%) were deemed usable and included in the analyses.

Of the 361 surveys analyzed, 93% of the participants were female. Participants were white, non-Hispanic (91.1%), African American (4.2%), Hispanic American (2.8%), and Asian American (1.9%) with a mean age of 43.5 years. Caseloads ranged from 25 to 88, with 51% of the participants reporting caseloads with more than 56 children in a month. Participants were grouped into 4 categories based on the number of years of experience as educational audiologists. Sixty-eight (18.8%) participants had been working as educational audiologists for 1 -10 years (New Professionals), 111 (30.7%) for 11- 20 years (Young Professionals), 136 (37.8%) for 21- 30 years (Experienced Professionals), and 46 (12.7%) for 31-41 years (Long-Time Professionals).

Survey

The survey designed for this study consisted of two sections including: a) demographic and practice-related questions, and b) the commercially available Maslach Burnout Inventory (MBI; Maslach, Jackson & Leiter, 1996). For this study, we are reporting on the results of the MBI and the years of experience variable. Participants are asked to rate 22 items on a 7-point scale, in which 0 indicates never and 6 indicates everyday. The MBI consists of three subscales that measure Emotional Exhaustion (9 items), Depersonalization (5 items), and Personal Accomplishment (8 items). Examples of items from the Emotional Exhaustion subscale include, "I feel emotionally drained from my job," and "I feel like I'm at the end of my rope." Some items from the Depersonalization subscale include, "I feel I treat some students as if they were impersonal objects," and, "I've become more callous towards students since I've took this job." Examples of items from the Personal Accomplishment subscale include, "I feel I'm positively influencing students' lives through my job," and "I have accomplished many worthwhile things on this job." Schaufeli and Van Dierendonck (1993) found that the MBI was a reliable and valid indicator of burnout, and Cronbach's coefficient alphas of 0.90, 0.79, and 0.71 have been reported for the Emotional Exhaustion, Depersonalization, and Personal Accomplishment subscales, respectively (Maslach, Leiter, & Jackson, 1996). Higher scores on both the Emotional Exhaustion and Depersonalization subscales suggest the presence of burnout or the susceptibility to burnout. Lower scores on the Personal Accomplishment subscales suggest the presence of burnout or the susceptibility to burnout.

The manual provides normative data based on 11,067 participants from multiple occupations. It also provides cut-off scores for low susceptibility, average susceptibility and high susceptibility for job burnout. For the Emotional Exhaustion subscale, low susceptibility to burnout scores fall below 16, average susceptibility to burnout scores range from 17 to 26, and high susceptibility to burnout scores are above 27. For the Depersonalization subscale, low susceptibility to burnout scores fall below 6, average/moderate susceptibility to burnout scores range from 7 to 12, and high susceptibility to burnout scores are above 13. It should be noted that higher scores on both of these subscales suggest greater risk for burnout. For the Personal Accomplishment subscale, low susceptibility to burnout scores fall above 39, average/moderate susceptibility to burnout scores range from 32 to 38, and high susceptibility to burnout scores are below 31. In contrast to the other two subscales, lower scores on this subscale indicate greater risk for job burnout.

Results

Of the 361 participants, 152 (42%) had total MBI scores in the low susceptibility range, 141 (39%) in the average range and only 68 (19%) in the high susceptibility range. The mean score for the total MBI normative sample of 11,067 respondents is 64.2. The mean score and standard deviation for the total MBI for the educational audiologists were 60.1 and 12.2, respectively, with a range from 33 to 104 suggesting the majority of educational audiologists scored lower than other workers in terms of susceptibility for job burnout.

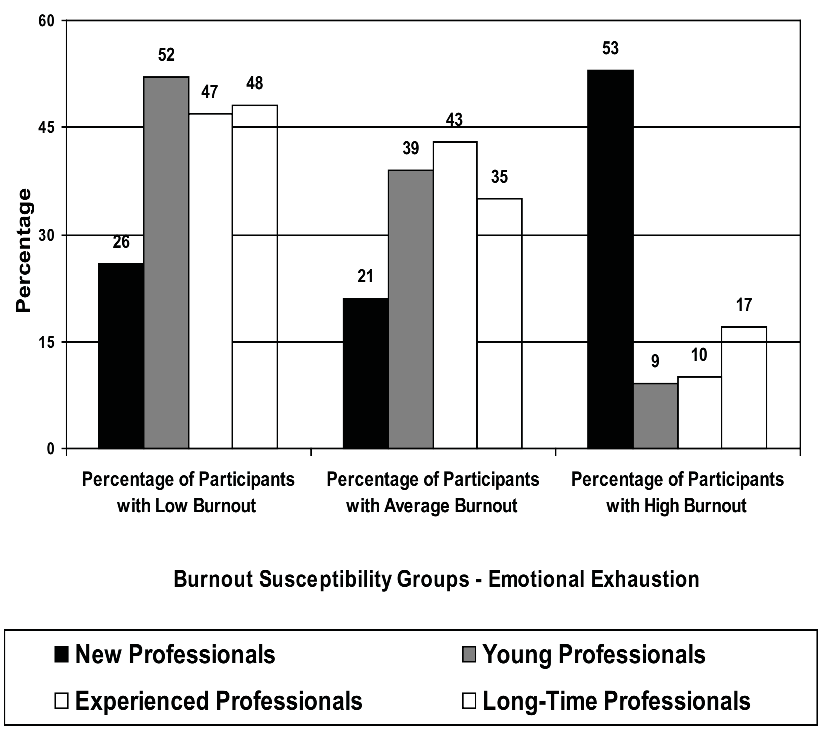
Analysis of the mean score on the Emotional Exhaustion subscale was 18.9 (S.D. = 9.2) indicating educational audiologists are in the average burnout category (scores between 17 - 26). The mean score on the Depersonalization subscale was 2.8 (S.D. = 2.9) indicating that participants were in the low burnout category (scores < 6). Based on the normative data, educational audiologists' mean score on the Personal Accomplishment subscale was 39.9 (S.D. = 6.1) suggesting participants were in the low burnout range (scores > 39). It is important to remember that lower scores on the Emotional Exhaustion and Depersonalization are good indicators and signal low burnout, while high scores on Personal Accomplishment are good indicators and signal low burnout.

Four, separate one-way analyses of variance (ANOVA) were computed to determine significant differences between the means for the four work experience groups (New Professionals, Young Professionals, Experienced Professionals and Long-Time Professionals). The four dependent variables were the scores from the total MBI, Emotional Exhaustion subscale, Depersonalization subscale, and Personal Accomplishment subscale. Results revealed a significant difference among the four means (25.3, 18.1, 17.7 and 15.5) for the Emotional Exhaustion subscale ($F(3, 357) = 14.1$, $p < 0.001$, eta-squared = 0.12, small effect size). Tukey post hoc analyses showed that New Professionals group had significantly higher mean scores than the other three work experience groups. The number and percentage of participants in the low burnout group, average burnout group and high burnout group were also computed. Inspection of Figure 1 shows that 53% of the New Professionals showed signs of high burnout in comparison to 9%, 10% and 17% of the Young Professionals, Experienced Professionals, and Long-Time Professionals, respectively. In order to determine the significance of the relationship between job burnout from the Emotional Exhaustion scale and the four work experience groups, a chi-square test was computed (Chi-square = 66.1, df = 6; $p < 0.0001$). This analysis suggests a significant relationship between these two variables that appears to be due to the high burnout observed in the New Professionals relative to the other three groups. Further analyses showed no significant differences among the means for the four work experience groups for the total MBI score ($F(3, 357) = 1.96$, $p = 0.12$), the Depersonalization subscale ($F(3, 357) = 2.07$, $p = 0.10$) and the Personal Accomplishment subscale ($F(3, 357) = 1.64$, $p = 0.18$).

Discussion

The finding that educational audiologists in this study show low susceptibility for burnout is very good news. Qualitative data from the comments section confirmed these quantitative results. Comments including: "I love my job"; "25 years and still going strong"; "I have good days and bad days, but I would recommend that anyone who wants to really help kids and see changes becomes an audiologist"; "It's an awesome job to watch a child hear sound for the first time"; "It's still my labor of love." As Maslach (2003) clarified in her research, there are a number of individual characteristics that influence job burnout. Researchers have studied martial status, gender, levels of resilience, self-esteem and internal locus of control and its relationship to job burnout. It is possible that audiology as a discipline tends to attract individuals who have a sense of control over their environments, openness to change, readiness to bounce back from small defeats and an internal locus of control. When choosing careers, individuals who select educational audiology may be those who use more active coping styles, easily engage in jobs, enjoy routines, share the values of helping others, possess a strong need to control their environment and have a better sense of their own personal and job autonomy than other workers. These factors would lead to job engagement and satisfaction with their jobs or chosen careers rather than job burnout and dissatisfaction.

Figure 1. Percentage of participants with low, average and high burnout on the Emotional Exhaustion subscale of the Maslach Burnout Inventory categorized by work experience as an educational audiologist.



The Depersonalization subscale scores for this study were below the mean of the normative data group. The depersonalization subscores were extremely low suggesting that even when educational audiologists report burnout, they are very unlikely to become cynical and start treating students/clients like impersonal objects. The Personal Accomplishment score for this study was above the mean of the normative data. This means that educational audiologists' scores above the mean for Personal Accomplishment represent higher levels of personal accomplishment. It appears that educational audiologists really do get a sense of making a difference in their daily work and report feeling good about the changes they effect in the lives of children, youth and families.

Of concern and interest is the finding that New Professionals (working less than ten years as an educational audiologist) reported the highest levels of Emotional Exhaustion among all the participants. In part this may be the result of high expectations, multiskilling needed to work in the schools, or even the scope of the job. Those who have been working in the schools for more than ten years may realize the need for multiple roles and continuing education, and develop systems for dealing with the inevitable work-family conflicts. Earlier studies (Mowday, Porter & Stone, 1978) showed that employees considered organizational loyalty a strong predictor of job satisfaction. Experienced employees accepted school policies, worked overtime and showed a strong desire to stay within the school district or organization they joined.

Current research shows that although the "baby boomers" will retire at much later dates, the Generation X-ers and the Millennials are going to demand higher pay and different opportunities for promotion and change than their older counterparts (Gandossy, 2006; Voydanoff, 2007). If the best and brightest are leaving the schools at alarming rates, and newly hired educational audiologists are feeling the most exhausted, something needs to be done. Maslach and Leiter (1999) proposed a model of teacher burnout which emphasizes the school setting (teacher autonomy, teacher influence), social support (both actual and perceived from colleagues and supervisors), and task qualities (workload, role ambiguity) to combat the problem. They suggest that mentoring programs can prove extremely effective in assisting younger employees to work through some of these inevitable issues. Job engagement for all workers is not an individual effort, but an organizational commitment to change for all employees to feel a sense of fulfillment and satisfaction in their work.

One other possible explanation for these findings is that as Young Professionals begin to show signs of high burnout, they leave the profession. This could explain the lower rates in the other age categories. In other words, the educational audiologists who stay in the field and continue to work in the schools are less likely to show signs of job dissatisfaction or the need to seek other types of employment.

Training programs should be made aware of these results. Changes in the current model of "on the job" training about the vast amounts of paperwork, administrative activities, counseling issues, and time necessary to provide high quality services to students and their families in the schools need to be implemented. Programs may want to introduce specific courses or modules for graduate students on how to deal with work stress and job pressures, how to build effective transdisciplinary teams, successful strategies for staying current with new technologies and changing legislation, how to develop mentoring relationships, and the influence of work on personal and/or family dynamics. Again, the data suggest that the "best teachers" are those active educational audiologists who are currently enjoying their chosen professions and making significant contributions.

School districts may be able to provide workshops and educational opportunities on time management, coping with overloads, delegation and relaxation. While these are good places to begin, educational activities are only as good as their implementation and generalization. Without providing the resources or time to build these components into the current organizational structure and job descriptions, a cycle of job-person mismatch leading to burnout will continue. Both organizational and individual interventions need to be developed and implemented to assure that children with hearing disabilities continue to receive the best services in the optimal environments. Further research should examine the efficacy of studies examining the mentor-protégé, novice- expert, rookie-professional partnerships and the moderating effect on job burnout.

Educational audiologists really are engaged in their work and jobs. They report a low susceptibility for job burnout. It is possible that many of the participants in this study already informally participate in engagement activities like mentoring, workshops, and student training. However, with 53% of New Professionals reporting emotional exhaustion, it may be time to formalize some of these activities and develop "best practices" for the next generation of highly skilled and competent educational audiologists.

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Background Noise Levels and Reverberation Times in Old and New Elementary School Classrooms

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The adequacy of the acoustic environment of classrooms is an important factor in a child's ability to listen and learn. Undesirable noise and reverberation can affect the achievement and educational performance of children, both those with normal and impaired hearing. The purpose of this study was to evaluate the acoustical conditions of old and new elementary school classrooms. Results were compared to the American National Standards Institute standard for acoustical characteristics of classrooms (ANSI S12.60-2002). Results indicated that neither new nor old classrooms for children with normal hearing were in compliance with the ANSI classroom background noise standard but all classrooms met the minimum reverberation criteria.

Introduction

The two principle factors that degrade the acoustic quality of learning environments are background noise and reverberation. Background noise commonly refers to any undesired sound that impedes what a child needs or wants to hear (Boothroyd, 2005). Examples of background noise in learning environments include external noise such as outdoor traffic noise, noise from halls and other adjacent rooms, heating, ventilating and air-conditioning (HVAC) systems, as well as noise generated by the students themselves. Reverberation refers to the persistence or prolongation of sound within a space (Knecht, Nelson, Whitelaw & Feth, 2002). In rooms with excessive reverberation, speech signals are delayed and can overlap the direct sound – sound coming from the speaker – which often masks the message of the speaker. Research has shown that the reverberation and background noise levels of classrooms are frequently too high for optimum speech recognition by children to occur (Crandell, Smaldino & Flexer, 2005; Yacullo & Hawkins, 1987; Gelfand & Silman, 1979; Nabelek & Pickett, 1974) and therefore can interfere with the child's ability to learn. Poor acoustics can be detrimental to all children. This includes those with normal hearing, mild hearing losses, children with hearing aids or assistive devices, children with learning disabilities, children for whom English is a second language, as well as those with temporary hearing loss due to ear infections (Crandell et al., 2005).

In 1995, the American Speech Language Hearing Association (ASHA) established guidelines for acceptable background noise and reverberation within classrooms; however no empirical evidence exists indicating that these guidelines were ever implemented in school settings. In 2002, the American National Standards Institute (ANSI) established a voluntary standard for acceptable acoustic conditions within classrooms. This standard was created so that schools would consider building acoustics and the generated criteria for acceptable acoustical measures during construction and remodeling of schools. Currently, standards for classroom acoustics have not yet been mandated by law, which has made compliance infrequent and inconsistent. As new schools are designed and older schools remodeled, school districts are not legally required to abide by the ANSI standard or ASHA acoustical guidelines (ASHA, 2005).

Due to lack of compliance with the ANSI standard or the ASHA guidelines for desirable classroom acoustics, acoustical conditions in U.S. classrooms are highly variable. Studies have documented that reverberation times can vary from 0.3 seconds to greater than 1.5 seconds (Crandell & Bess, 1986; Finitzo-Hieber & Tillman, 1978; Pekkarinen & Viljanen, 1991), and background noise levels vary from 34-70 dBA for "typical" unoccupied classrooms in the United States (Knecht et al., 2002). Knecht et al. (2002) measured reverberation times and background noise levels in 32 unoccupied elementary school classrooms and compared the results to the ANSI S12.60-2002 standard. Results from their study indicated that most of the classrooms studied were not in compliance with the ANSI noise and reverberation standard. However, the study did not directly compare the results between older and newer classrooms to determine if there was a correlation between the age of the building, the acoustical environment and implementation of the ANSI standard.

The effects of poor acoustics in the classroom setting have been well documented in the literature. Yacullo and Hawkins (1987) found that children with normal hearing demonstrated reduced speech recognition with increased background noise and reverberation times. According to the ANSI standard, the recommended reverberation time that maximizes speech intelligibility is between 0.6-0.7 seconds and recommended background noise levels in occupied classrooms are below 35 dBA(ANSI, 2002). Nabelek and Pickett (1974) studied the influence of noise and reverberation on monaural and binaural reception of consonants. Results from their study demonstrate that children with hearing aids experience significantly greater difficulty recognizing speech in the presence of reverberation and background noise. Although all testing was completed in simulated environments where reverberation and background noise were alterable, the implications for the classroom environment are significant, especially for deaf and hard of hearing (DHH) children. As indicated by Jerger, Martin, Pearson, & Dinh (1995) degraded or impoverished stimuli may often be more difficult to remember, require more time and effort to process and may directly affect a child's ability to sustain voluntary attention. Jamieson, Kranjc, Yu & Hodgetts (2004) examined the ability of young children aged five to eight to understand speech (i.e., monosyllables, spondees, trochees, and trisyllables) when listening in a background of real-life classroom noise. Results showed that children in kindergarten and grade 1 had much more difficulty than older children, although all children had some difficulty understanding speech when the noise was at levels found in most classrooms (i.e., 65 dBA). The results from the Jamieson et al. study suggest that the youngest children in the school system, whose classrooms often tend to be the noisiest, are the most susceptible to the effects of excessive background noise.

Although the literature reports evidence of the detrimental impact poor classroom acoustics have on children, there is still no mandate that classrooms abide by nationally recognized standards. The ANSI standard is "strictly voluntary" (ANSI, S12.60-2002) and, consequently, often ignored. Bistafa and Bradley (2000) utilized analytical formulas for various speech intelligibility metrics (i.e., Speech Transmission Index, Articulation Index) to determine what conditions of noise and reverberation provide the greatest degree of speech understanding in classrooms. Results from their study suggested that in order to achieve 100% speech intelligibility in quiet classrooms, the reverberation time should actually be between 0.4 and 0.5 seconds. In addition, the same authors recommended that the ideal maximum background noise level for classrooms is 25 dB less than the voice level at 1 meter in front of the talker. This criterion is even more stringent than that suggested by the ANSI S12.60-2002 standard. However, Bistafa and Bradley suggested that these "ideal" conditions for reverberation and background noise levels would result in a classroom signal-to-noise ratio of more than +15 dB.

As older schools are renovated and new schools are being built, it is critical that the acoustical design of the classroom be considered in order to optimize the learning environment for children. Unfortunately, schools built after the development of the ASHA and ANSI acoustical documents still fail to follow acoustic guidelines in the classrooms (Knecht et al, 2002). For both the parents and professionals who advocate in favor of a law that would govern the acoustical conditions in the classrooms (www.parentsvoice.org), it is important to know if schools follow the voluntary measures established by ANSI and ASHA. The purpose of this study was to determine whether or not classroom acoustics are better in newly constructed and/or renovated elementary school classrooms compared to older classrooms based upon the ANSI S12.60-2002 standard established for schools.

Methods

Acoustic measurements were taken in thirty-six unoccupied elementary school classrooms located in nine school buildings in Chicago, and public schools in Wilmette, Frmont, Woodland, Wood Dale, and Kaneland, Illinois. Both urban and suburban schools were included and the sample is believed to be representative of the schools in and around a large metropolitan area. Sixteen of the thirty-six classrooms were considered to be "new" because they were built after 2002. Twenty of the thirty-six were considered to be "old" because they were in schools built prior to 1960. Table 1 shows the year each school was built. The dimensions of the unoccupied classrooms were measured and volumes calculated. These volumes are shown in Table 1.

All of the "new" classrooms and nearly all of the "old" classrooms were carpeted, had acoustic ceiling tiles and had some sort of absorptive materials covering much of the walls. The performance levels of these materials were unknown. The "old" classrooms all had window air conditioners or wall units for heating, ventilation and air conditioning (HVAC). The "new" classrooms typically had ducted central air conditioning units and many had ceiling fans. Of the thirty-six classrooms, four "old" and four "new" were used specifically as classrooms for DHH children. Each of the 8 rooms was carpeted, and had acoustic ceiling tiles and cork or some other absorptive materials in place. In addition, special noise reduction provisions were made in these DHH classrooms ranging from ducted HVAC systems to the use of ceiling fans for air circulation. For all rooms, the HVAC system, fans and lighting operated at their typical settings and equipment, such as computers, was turned off. The location of windows and doors were noted, as was the apparent composition of ceiling and wall materials. The rooms were believed to be representative of typical classrooms in the schools evaluated.

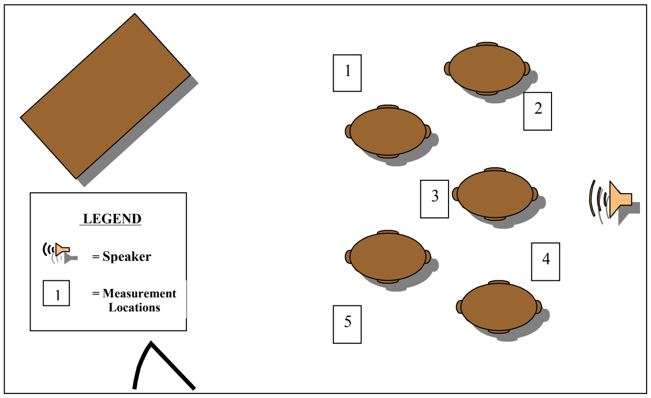
Background noise and reverberation acoustic measurements were conducted according to the ANSI S12.60-2002 procedures with some modifications. A Quest Technologies 2900 Integrating sound level meter (SLM) set at the A-weighting and fast response was used to measure the background noise at five different locations in the classroom in and around the students' desks. The SLM was positioned at 4 feet above the floor at each measurement location to simulate the position of a student's head when seated at a desk. The results of the five measurements were averaged and resulted in a single number representing the background noise level. A Quest Technologies OB-100 octave band filter was used in conjunction with the SLM to obtain the octave band measurements (63-8000 Hz) of the noise at each of the five measurement locations. These were averaged and used to determine the single noise criteria (NC) of each classroom. Reverberation time (RT60) was measured at each of the five measurement locations using a Gold Line 60 Reverberation Time Meter. Measurements at each

Old Classrooms	Year Built	Room Volume (ft^3)
1a	1949	8540
1b	1949	8540
1c	1949	8135
1d	1949	8284
2a	1958	8581
2b	1958	8390
2c	1958	8576
2d	1958	8691
3a	1942	8374
3b	1942	9494
3c	1942	7884
3d	1942	8196
4a	1952	7735
4b	1952	7850
4c	1952	7575
4d	1952	7630
5a	1917	5146
5b	1917	6153
5c	1917	6792
5d	1917	6792

New Classrooms	Year Built	Room Volume (ft^3)
6a	2003	3635
6b	2003	2720
6c	2003	1756
6d	2003	2447
7a	2005	7648
7b	2005	7469
7c	2005	7445
7d	2005	7648
8a	2005	7696
8b	2005	7696
8c	2005	7696
8d	2005	7696
9a	2004	7696
9b	2004	7696
9c	2004	7696
9d	2004	7696

Table 1. Description of classrooms, including room volume and year built.

Figure 1. Diagram of data collection set-up.



location were taken at .5, 1 and 2 KHz and averaged together. The five location measurements were then averaged to give a single RT60 measurement for each room. A noise burst generated by a Gold Line PN3 Pink Noise generator connected to an amplified speaker system served as the RT60 measurement stimulus. The speaker system was positioned in the front of the room at a height of about 5.5 feet approximating the height of a teacher standing in front of the classroom. See Figure 1 for the measurement arrangement.

Results

The background noise levels (dBA) in the thirty-six schools are shown in Figure 2. The average noise levels in the "old" schools ranged from 32.6 to 54.4 dBA. Only the four classrooms used for DHH children met the ANSI performance criterion of 35 dBA. The average noise levels in the "new" classrooms ranged from 31.0 to 52.9 dBA. Again, only classrooms used for DHH children met the

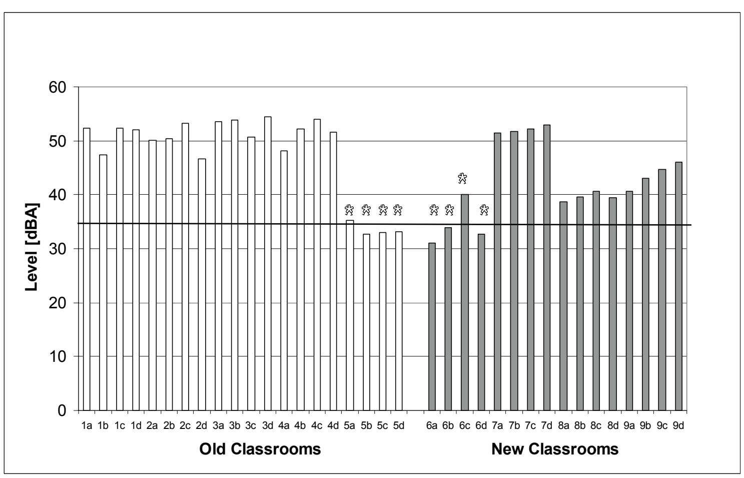


Figure 2: Average background noise levels in old and new schools. Numbers (1-9) represent the schools and letters (a-d) represent the classrooms. ✩ = classrooms for DHH children

ANSI criterion; one of the four classrooms did not meet the criterion. If measurements from classrooms for DHH children are removed from the averages, the background noise level for the "old" classrooms averaged 51.2 dBA and the levels for the "new" schools averaged 44.7 dBA. A two-tailed non-parametric Mann-Whitney test revealed a significant difference ($p < .002$) between the noise levels in the "old" and "new" classrooms. Although the "new" classrooms had a lower noise level, neither "old" nor "new classrooms met the ANSI noise criterion.

While not an ANSI-2002 criterion, noise criteria curve measurements showed results similar to the single number noise measurements and are shown in Figure 3. Of the thirty-six classrooms, only two classrooms (both used for DHH children) met an

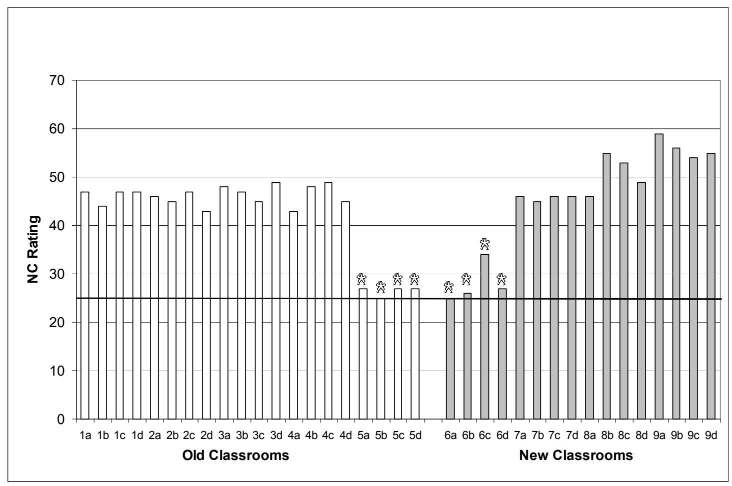


Figure 3: NC curve values for old and new schools. Numbers (1-9) represent the schools and letters (a-d) represent the classrooms. ✩ = classrooms for DHH children

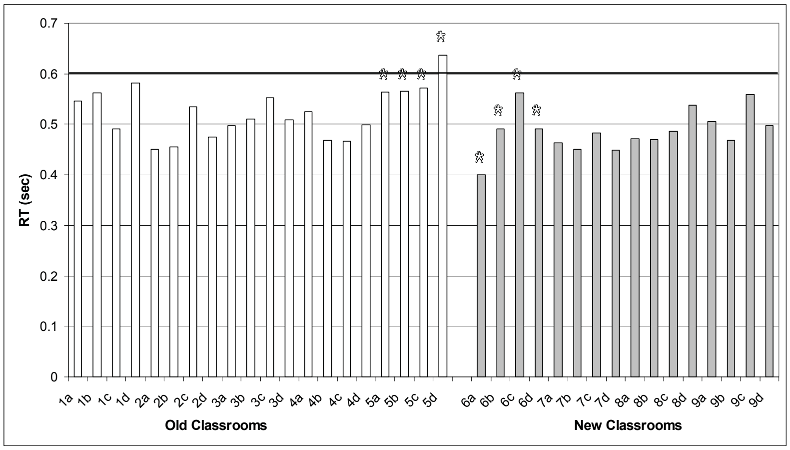
acceptable classroom criterion of NC 25.

Reverberation time measurements (averages of RT60 at .5, 1 and 2 KHz at 5 locations) in the thirty-six classrooms were 0.45-0.64 seconds in the "old" schools and 0.40-0.56 seconds in the "new "schools. The reverberation times are shown in Figure 4 (see page 20)

It should be noted that classrooms in school #5 had twelve foot ceilings, the highest of all classrooms measured. The average RT60 of these classrooms was the highest (0.58 seconds) when compared to the other classrooms with lower ceilings. Because all of the classrooms except for one with an RT60 of 0.64 seconds (#5d) complied with the ANSI criterion of 0.6 seconds and because the measurement ranges were similar in the "old" and "new" classrooms, no further analyses were made of these data.

Discussion

Figure 4: Average reverberation times (RT) at 0.5, 1 and 2 kHz in old and new schools. Numbers (1-9) represent the schools and letters (a-d) represent the classrooms.
✩ = classrooms for DHH children



This study was conducted to determine if old and new schools meet the ANSI standard for background noise level and reverberation time. Measurements were collected in thirty-six unoccupied classrooms. Results showed that all classrooms met the recommended reverberation times, however, most of the classrooms did not meet the recommended background noise levels. All 7 classrooms that met the acceptable noise criterion as specified in the ANSI standard were classrooms for DHH students. Four classrooms within a new school specifically designated for DHH children were included in the study as well as four classrooms from an old school with classrooms for DHH children. All four classrooms from the old school (built in 1916) met the ANSI standard for background noise levels of 35 dBA or less while three of the four classrooms from the new school (built in 2003) met the ANSI standard. The reason why one classroom did not meet the ANSI standard in the new school was perhaps due to airplane noise during the time of data collection. The school is located near a busy international airport and while obtaining measurements in that particular classroom, several large planes passed over the building. The children who are most challenged by adverse listening environments are those with hearing impairments, and it is comforting to find that these classrooms met acoustical standards for both reverberation and background noise levels. It should be noted, however, that DHH children and children with special needs in general are often mainstreamed in a school building and may have classes in rooms not specifically designated for them.

The difference between noise levels in the old and new classrooms is significant. Results from this study indicated that the background noise levels in the newer classrooms were slightly lower than the older classrooms. This statistically significant difference may be attributed to the variation in cooling systems between the two groups of classrooms. The old classrooms all had window or wall unit HVAC systems, whereas the new schools contained central cooling systems and/or ceiling fans. The centrally ducted HVAC systems were more common in the newly constructed schools, which may be indicative of a trend toward quieter classrooms. Despite the statistically significant difference between the old and new classrooms for children with normal hearing, new classrooms still did not meet the recommended ANSI standard for classroom noise levels. This suggests that even centrally ducted HVAC systems may not provide a complete solution to the noise problem. Central systems produce noise levels less than window and wall units, but still exceed the recommended 35 dBA level.

The most significant source of classroom noise is in the lower frequencies, which is commonly attributed to HVAC systems. The NC curve data confirm that the major source of noise generated in the classrooms is from the HVAC systems. If the HVAC systems had been turned off while measurements were collected, it is likely that the background noise levels would have been notably reduced. However, the measurements that are most representative of everyday classroom noise levels are with the HVAC systems turned on, as these systems run nearly continuously when schools are in session. There was some variation among the types of HVAC systems used in the old and new schools. All of the classrooms in the old schools, except the four classrooms for DHH children, had window units. Eight classrooms in the new schools had centrally-ducted HVAC systems and for these rooms background noise levels were still greater than the ANSI standards, but by a lesser degree (approximately 5-10 dB louder than the standard). Classroom #7b in a new school that emphasizes energy conservation had multiple ceiling fans in place of a HVAC system, yet background noise levels were still louder than the ANSI standard of 35 dBA with the fans turned to their lowest setting. These findings suggest that achieving quiet HVAC systems will be the largest challenge facing schools.

Reverberation times in all 36 classrooms met the ANSI recommendations of 0.6 seconds. This may be partly due to the fact that room modifications (i.e., carpeting, acoustic tiling, and corkboard) are more cost-effective and easier to achieve, as opposed to renovating a school's HVAC systems. All of the new schools and nearly all the old schools were carpeted and had acoustic ceiling tiles. In addition, cork-board and other absorptive materials were covering almost all wall space. This may account for the consistency among reverberation measurements across the 36 classrooms. It was not clear whether these room modifications were done specifically to improve the room acoustics, although they had that result.

Future considerations for studies in classroom acoustics may look to evaluate whether or not school administrations take into account the acoustical environment during the design and construction of new schools and what measures are performed in order to ensure acceptable acoustics. A cost-benefit analysis of acoustic modifications, including carpeting and centrally ducted HVAC, would be beneficial for old schools as well as for new schools that are being designed and constructed.

The results of this study suggest that undesirable background noise levels are a major problem in schools. The quality of the learning environment affects student achievement and one way this can be improved is by reducing background noise levels to acceptable limits. Despite the development of the ANSI S12.60-2002 standard, new schools appear to continue being built with classrooms that have background noise levels 10-15 dBA louder than recommended. It is obvious that in order to improve the listening, learning and teaching environment in the classroom setting, a consensus regarding and enforcement of specifications for classroom acoustics are needed. It is critical that parents, teachers and professionals advocate for quieter classrooms and, ideally, the implementation of a law requiring schools to consider background noise levels.

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Click ABR Characteristics in Children with Temporal Processing Deficits

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Temporal processing deficits are one characteristic of a (central) auditory processing disorder [(C)APD]. Combining behavioral and electrophysiologic methods in the (C)APD battery is valuable. This investigation focuses on auditory brainstem response (ABR) measures in a group of children with specific temporal processing deficits and an age-matched control group. No significant differences in ABR waveform latency were found, but there were significant amplitude differences between control and experimental groups. The ABR in an interaural time delay (ITD) paradigm did not demonstrate differences between groups. While group differences in this study were limited, they nonetheless support the value of electrophysiological measures in (C)APD assessment.

Abbreviations: ABR = auditory brainstem response, (C)APD = central auditory processing disorder, ITD= interaural time delay MLD= masking level difference, PPST=Pitch Pattern Sequence Test

Introduction

(Central) auditory processing disorders [(C)APDs] have received considerable attention over the past few decades. (C)APD is not a new entity in audiology. For many years, professionals have been aware that some individuals with normal results on tests of peripheral function report difficulty understanding speech. Recent attention has focused on controversies surrounding the operational definition of (C)APD, the heterogeneous nature of (C)APD, and an appropriate test battery for (C)APD assessment. This renewed interest in (C)APD has generated a clinical demand for improved diagnostic methods.

Temporal processing refers to the time aspects of an auditory or acoustic signal. Phillips (1995) defines temporal processing in several ways including determination of a sound source or “spatial percept,” determination of the pitch of a sound, and the perceptual segregation of two successive acoustic events. Temporal processing is important in the discrimination of duration and variations in pitch, which are critical to following the prosody of speech and music perception (Phillips, 1995).

Poor temporal processing is one of the characteristics of (C)APD. Efficient temporal processing is a key component of auditory function (Chermak and Musiek, 1997). Temporal processes are critical in a number of auditory functions “including auditory discrimination, binaural interaction, pattern recognition, localization/lateralization, monaural low-redundancy speech recognition, and binaural integration” (Show et al., 2000, p. 67).

Tests of Temporal Processing

The underlying physiological neural mechanisms for temporal processing may be assessed by behavioral and electrophysiological means. Several behavioral tests “stress” the auditory system by degrading the acoustic environment or signal by introducing background or speech noise or by filtering the signal. Behavioral tests may require multiple auditory processes such as attention, memory, and perception (Jirsa and Clonz, 1990). Further, behavioral tests may be confounded by learning, attention, fatigue, hearing sensitivity, intelligence, developmental age, motivation, motor skills, language experience, and language impairments (Jerger and Musiek, 2000).

Although temporal processes are critical in a number of auditory behaviors, there are limited clinical tests used to assess temporal processing abilities. These tests are based on the assumption that important acoustic signals, such as speech vary over time. If a person is to extract meaning from these acoustic signals, the listener must be able to detect very small and rapid time variations. Temporal processing deficits may be evident on tests of temporal resolution, such as gap detection tests, or on temporal patterning tests. Temporal processing deficits may also result in poor performance on monaural low-redundancy speech tests, especially time compressed speech tests.

Gap Detection

Gap detection reflects the ability of the auditory system to detect a brief silent interval in noise. This test requires temporal fusion of the auditory system. Investigators have found larger auditory fusion thresholds in children with language, learning, and reading disorders (McCroskey & Kidder, 1980; Isaacs, Horn, Keith, & McGrath, 1982). Gap detection thresholds systematically decrease with increasing age from three to nine years (McCroskey & Keith, 1996). Gap detection thresholds remain stable throughout adulthood until the fifth decade of life, and then increase with age (McCroskey & Keith, 1996).

Time Compressed Speech

Compressed speech alters the temporal and frequency characteristics of the signal. Historically, the first compressed speech tests were accomplished by having the speaker read the passage faster or by increasing the playback speed of the tape recorder. Soon after, electromechanical alterations and later digital computer editing of natural speech were used to distort the temporal and frequency components of speech. This test of reduced temporal redundancy is sensitive to dysfunction at all levels of the central auditory pathway (Pinheiro & Musiek, 1985; Thompson & Abel, 1992a, 1992b).

Discrimination scores of time-compressed speech in school-aged children also improve with age (Beasley & Maki, 1976). Allen (1997) reports that temporal auditory discrimination and detection is often more variable in school-age children than adults. Certainly, it is evident that there are improvements in temporal related auditory tasks with age.

Masking Level Difference

The Masking Level Difference (MLD) is a widely used test of temporal processing and binaural interaction. The MLD compares the threshold of two binaural signals: either a low-frequency tone (500 Hz) or speech embedded in noise. The thresholds for the signals are measured in noise while the noise is in-phase (homophasic- No) and out-of- phase (antiphasic- Nπ) with the signal, or while the signal is in phase (homophasic- So) and out-of-phase (antiphasic Sπ) with the noise (Hirsh, 1948; Olsen, Noffsinger, & Carhart, 1976; Olsen, Noffsinger, & Kurdziel, 1975). In most cases, there is a release of masking, or improvement in threshold, either when the noise or signal is out-of-phase between the two ears. This release of masking occurs because the listener perceptually can separate the signal from the competing noise. The stimulus appears to originate from a different source while out-of-phase. The MLD is mediated by the lower brainstem. The MLD has been shown to be abnormal in patients with brainstem lesions (Olsen et al, 1976; Lynn, Gilroy, 1977); whereas, cortical lesions have shown no effect on the MLD (Cullen & Thompson, 1974).

There are limited data reporting MLDs in children. Sweetow & Redell (1978) found a reduced MLD in children with auditory perceptual difficulties. However, Wayras & Battin (1985) did not report a reduced MLD in learning disabled children but attributed this finding to the wide heterogeneity of learning disabled children. Roush & Tait (1984) also found normal MLDs in children with APD.

Temporal Pattern Tests

Pinheiro (1977) first reported the use of the Pitch Pattern Sequence Test (PPST) to assess pattern perception and temporal sequencing skills. The stimuli consist of a low frequency tone and a high frequency tone. This test is “not designed to assess fine temporal acuity per se but rather to assess the listener’s ability to perceive a pattern of auditory events occurring over time” (Bellis & Ferre, 1999, p. 321). Pinheiro (1977) found a significant deficit in the ability of dyslexic children and a control group of normal children. The PPST is sensitive to cortical lesions. Information on laterality, as well as inter-hemispheric transfer via the corpsus callosum, can also be obtained.

The Duration Pattern Test (Pinheiro & Musiek, 1985) is similar to the Pitch Pattern Test. The frequency of the stimulus tones are the same, however, the duration of one of the tones is different from the other two. The listener must respond to the correct sequence of “long” (500 msec) and “short” (250 msec) tones. This test is also sensitive to cortical lesions. Information about laterality and inter-hemispheric transfer can also be obtained.

Electrophysiologic Recordings

In electrophysiologic recordings of the central and peripheral neural auditory pathway, the early latency Auditory Brainstem Response (ABR) may objectively assess neural functions that are believed to be involved in early neural coding for temporal processes. The ABR reflects synchronous firing of neurons of cranial nerve VIII and brainstem structures. This electrophysiologic recording provides information about the integrity of the peripheral and brainstem auditory pathways that are involved in auditory processing and the requisite capabilities of the auditory system to encode information.

The inclusion of electrophysiological measures is recommended by the Working Group on Auditory Processing Disorders (2005) when there is a questionable neurologic disorder, to assess auditory neuropathy or auditory dys-synchrony (AN/AD), or in difficult to test children. Electrophysiological tests in the (C)APD evaluation may aid in the diagnosis or in the validation of the results of the behavioral test battery (Bellis, 2003; Chermak and Musiek, 1997). Electrophysiological recordings were also recommended by the Bruton Conference on auditory processing disorders (Jerger and Musiek, 2000).

Previous research investigations reporting electrophysiologic recordings and (C)APD have been conflicting. Sohmer and Student (1978) reported abnormal ABR latency results in 16 subjects with minimal brain dysfunction. Subjects placed in this category had traits of hyperactivity, learning difficulty and coordination defects. Additionally, the Sohmer & Student investigation reported ABR latency abnormalities in other broad-spectrum disorders such as autism and mental retardation.

Worthington (1981) reported no differences in the ABR latencies between controls and children with (C)APD. This lack of difference is in contrast to the investigation by Worthington et al. (1981), which reported abnormal ABR latencies in 8 out of 18 subjects with severe developmental and or/ language delays. Conductive hearing loss accounted for an additional five abnormalities. The other three abnormalities related to interaural asymmetries which were greater than .3 msec. Subject selection criteria for these studies were not reported.

Protti (1983) reported increased ABR latencies in 2 of 13 subjects with (C)APD. Again, the type of (C)APD, or how the diagnosis of (C)APD was made, was not specified in this paper. However, Protti's work supports inclusion of electrophysiological measurements in the assessment of (C)APD.

Hall & Mueller (1997) reviewed ABR recordings for 102 pediatric patients with (C)APD and found abnormal findings in approximately 10% of these subjects. They reported a greater percentage of abnormalities for the left auditory pathway, than for the right auditory pathway. They did not comment on this finding. Information about the subject's age or specific type of (C)APD also was not reported.

Mason & Mellor (1984) reported latency and amplitude measurements in eight children diagnosed with a language disorder and six children with motor speech disorders. No significant group differences in latency were reported. The amplitudes of the ABR were smaller in the language delay and motor speech group than the normal group. It is important to remember that the ABR is recorded from surface electrodes, making it a "far-field" recording. The amplitudes of the ABR recording will depend upon the conductivity of the tissue and the distance of the electrode from the generator site. It is worth noting that each group's mean amplitude measures were within normal limits. It is also important to note that ABR amplitude is more variable than peak latency (Lauter et al., 1993). Inherent noise conditions may affect the amplitude of the ABR. In addition, other factors such as head size, the thickness of the skull, and electrode placement will affect the amplitude of the ABR.

Test stimuli typically used to elicit the ABR, which consist of clicks, filtered clicks, tone pips, and tone bursts, rather than speech-like stimuli, may be a contributing factor in distinguishing children with (C)APD. Early latency ABR responses merely reflect the auditory mechanism's ability to recognize a signal, not the processing functions reflected by the late potentials (Brugge, 1975).

Binaural ABRs

Binaural stimulation in ABR recordings was initially used to enhance wave peaks. However, other investigators believed that diagnostic information, such as the localization of possible brainstem disorders, could be obtained from the binaural recording (Levine, 1981). Binaural stimulation causes changes in ABR recordings such as 1) an increase in the amplitude of the waveforms, 2) a decrease in the latency of the ABR wave peaks, and 3) morphological changes in the wave form peaks occurring approximately 4 msec post-stimulation (Blegvad, 1975; Davis, 1976). The binaural ABR is not a summation of the monaural recordings, but reflects central neural interaction in the superior olivary complex and in the inferior colliculus (Arslan et al, 1981). From animal recordings, these nuclei are responsible for time-encoding processes (Erulkar, 1976; Sample & Aikin, 1979).

Introduction of an ITD binaural click has previously been employed to investigate lateralization. The introduction of an ITD click will change the perception of the fused binaural click. Arslan et al. (1981) investigated the binaural auditory brainstem response with interaural time delays of the binaural stimulus. These investigators reported morphological changes in the latency range of 3.5 to 6.5 msec when the ITD was greater than 2 msec.

Study Rationale

While previous investigations have shown that the ABR is not sensitive to (C)APD, some studies have shown that some subjects with (C)APD do have abnormal ABRs (Sohmer & Student, 1978; Worthington et al, 1981; Protti, 1983; Mason & Mellor 1984; Hall and Mueller, 1997). The purpose of this study was to investigate ABR characteristics in a group of (C)APD children with specific temporal processing deficits. Specific temporal deficits were identified by behavioral assessment. Although most behavioral temporal processing tests are more sensitive to central lesions, temporal encoding occurs initially in the peripheral auditory system and is represented throughout the central auditory nervous system. This investigation is based upon the premise that specific temporal processing deficits may arise from a disruption in the early firing patterns of the VIII nerve and auditory brainstem nuclei, and thus, individuals with temporal processing disorders may show differences in auditory brainstem response recordings. We recorded ABRs using standard and temporally altered click stimuli in a group of children with behaviorally identified problems of auditory temporal processing and compared these results to a matched group of children with no auditory processing disorders.

Methods

Subjects

The majority of investigations of (C)APD have not described the specific auditory deficits or characteristics of their subjects. This may have led to some of the conflicting results in both behavioral and electrophysiological measures in children with (C)APD. This study will report findings in a sub-group of children with (C)APD for whom we tried to carefully define specific temporal processing deficits.

The subjects for this research were 24 experimental and 24 control male subjects between the ages of 7 and 12 years of age. Only male subjects were included because of the gender effect on wave latency in the electrophysiologic recordings (Cox et al., 1981). All subjects gave informed assent and had parental or legal guardian consent, as approved by the Louisiana State University Health Sciences Center Institutional Review Board. All subjects had normal peripheral hearing as assessed by normal pure-tone audiometric thresholds from 500 to 4000 Hz < 15 dB HL (re: ANSI, 1989) and normal middle-ear pressure and static admittance as evidenced by normal (type A) tympanograms. All subjects were native English speakers. All subjects were paid a small stipend for participation in this study. All behavioral and electrophysiological measures were collected by one of the authors (AH). Data collection was completed in one or two sessions. At least two breaks were given during the behavioral assessment and another before beginning the electrophysiological assessment.

Behavioral and electrophysiological data were collected on 24 males who had been diagnosed with (C)APD. These subjects were self-referred to the Louisiana State University Health Sciences Center Speech and Hearing Clinic for a (C)APD assesment. The experimental subjects had abnormal temporal processing skills as assessed by behavioral tests in the (C)APD behavioral test battery. Criterion for abnormal performance on the behavioral tests was defined as a score at least 2 standard deviations below normative data on four of five selected tests of behavioral tests of temporal processing. Parents and/or guardians of potential subjects were informed about this prospective investigation and consented to additional testing as described in the later section. Subjects with the possibility of attention deficit hyperactivity disorder, as reported by a medical diagnosis, or parent's report, were excluded from this investigation. Academic difficulties experienced by these subjects included reading and language-based learning disability.

Additional inclusion criteria for this study included normal language scores on the Peabody Picture Vocabulary Test III (Third Edition) (PPVT-III) and two subtests of the OWLS. The PPVT-III is designed as a measure of an individual's receptive vocabulary. In addition, it is an achievement test of the level of a person's vocabulary acquisition. The Listening Comprehension subtest of the OWLS is designed to measure the understanding of spoken language. The Oral Expression Scale is designed to measure the understanding and use of spoken language.

Twenty-four age-matched males comprised the control group, recruited from families and friends of the LSU Health Sciences Center Department of Communication Disorders faculty and staff. Members of the control group had normal temporal processing, as indicated by normal performance on behavioral tests of temporal processing. They also had normal scores on the PPVT-III and the two subtests of the

Oral and Written Language Scales (OWLS). In addition, the parent or legal guardian of the control subjects reported that there were no academic, language, learning, reading, attention, or hearing concerns.

Additional demographic information from both groups was obtained. The educational level of the mother and father was obtained and grouped into five categories: 1) did not finish high school, 2) finished high school, 3) some college, 4) college graduate, and 5) post-graduate degree. Information about the type of school each subject attended was also obtained. The type of the school each subject attends was obtained and grouped into four categories: 1) public school, 2) private school, 3) parochial school, and 4) home-schooled. This demographic data ensured that groups were similar in socio-economic status.

Behavorial Tests

Behavioral tests of auditory processing were completed in order to appropriately include or exclude subjects from the experimental and control groups. Thus the behavioral measures are considered baseline and grouping measures, while the electrophysiologic measures (described below) are the experimental measures in this study. Behavioral tests were administered in a sound treated room. With the exception of the masking level difference (MLD), all behavioral tests were recorded on compact disks available from Auditec of St. Louis. The clinical audiometer, Interacoustics 40, was calibrated to the 1000 Hz calibration tone on each individual CD before administering the behavioral tests. The recorded stimuli were presented at 55 dB HL and delivered through EAR 3A insert earphones. The presentation order for the behavioral tests was counterbalanced to eliminate order effects.

Masking Level Difference

The Masking Level Difference (MLD) was derived by measuring the masked threshold for a 500 Hz tone. Thresholds were obtained for SoNo (homophasic) and SπNo (antiphasic) conditions. The 500 Hz pure tone signal was generated using the Interacoustics 40 audiometer. The narrow band noise, also generated by the Interacoustics 40 audiometer, had a 146 Hz band of noise centered at 500 Hz with a 12 dB per octave roll-off. The 500 Hz signal was set to 70 dB HL. Signal attenuation of the narrowband noise was in 1 dB steps. Thresholds were obtained by averaging the level of the noise that masked the 70 dB, 500 Hz signal in four ascending and four descending trials for a total of eight trials in SoNo and SπNo conditions. The MLD was defined as the difference in threshold between homophasic and antiphasic stimuli. The MLD was considered abnormal if it was less than 10 dB (Sweetow and Reddell, 1978; Roush and Tait, 1984).

Frequency Pattern Test

The Pitch Pattern Test, or Frequency Pattern Test, which requires auditory discrimination, temporal ordering and pattern recognition, was administered. This test consists of 120 pattern sequences made up of three tone bursts, two are the same frequency and one is different. The pure tones were 1122 and 880 Hz. The subject repeated the pattern by verbalizing the pattern of the tones. Thirty monaural trials were presented at 55 dB HL. This test was scored based on the percentage correct.

Duration Pattern Test

The Duration Pattern test is very similar to the Pitch Pattern Test. This test also requires temporal ordering and pattern recognition. The tones do not vary in frequency, but vary in duration as being either long (500) ms or short (200) ms. Thirty monaural trials were presented at 55 dBHL. The subject repeated the pattern by verbalizing "long or short". The test was scored based on the percent correct.

Discrimination of Time Compressed Speech

Time compression alters the temporal characteristics of speech by reducing the duration of the signal without affecting the frequency characteristics (Fairbanks, Everitt, & Jaeger, 1954). Time compressed (45%) NU-6 word lists were presented monaurally at 55 dB HL. Test scores were reported as percent correct.

Gap Detection

Gap detection thresholds were obtained using the Random Gap Detection Test. This test requires temporal resolution of the auditory system. The Random Gap Detection Test is a revision of the Auditory Fusion Test-Revised. This test consists of a calibration tone, a practice subtest and four subtests at 500, 1000, 2000, and 4000 Hz. Each pure tone is seventeen msec in duration. Stimuli with inter-stimulus intervals (gaps) of 0, 2, 5, 10, 20, 25, 30, and 40 milliseconds were randomly presented. Stimuli were presented binaurally at 55 dBHL. The gap detection threshold was the lowest interval where the subject consistently identified two tones, rather than one tone. A composite gap detection threshold was obtained by averaging the gap detection thresholds at 500, 1000, 2000, and 4000 Hz. Composite thresholds greater than 20 msec indicate temporal processing deficits that could interfere with speech perception and phoneme recognition (McCroskey and Keith, 1996).

Electrophysiologic Recordings

Electrophysiologic recordings were obtained while the subject rested comfortably in a chair and watched silent videos (animated videos with captioning) or played a hand-held video game with no audible sound.

Stimulus

Test stimuli were generated using the Tucker Davis Workstation System III. Test stimuli consisted of 100 µsec condensation clicks with a rate of 11.1 /sec, presented at 70 dB nHL via insert ER3A earphones. Two stimulation sequences consisting of 2000 click presentations were recorded for each test condition for a total of 4000 presentations. The protocol consisted of two recordings each of right, left and binaural (diotic) stimulations of 2000 clicks per run.

In order to further assess temporal effects in the ABR, responses were obtained to dichotic stimuli in which the right stimulus was delayed relative to the left stimulus by an interaural time delay (ITD) interval of 0.1, 0.4, 0.9, and 1.9 ms. Conditions were counterbalanced across subjects to reduce order effects.

Recordings

Recordings were made with five surface electrodes attached to the skin at the vertex (positive), each ipsilateral mastoid (negative), nape of the neck, and ground placed at the forehead. Electrode impedance was below 5 kΩ. Three channel recordings were obtained: 1) vertex to ipsilateral earlobe, 2) vertex to contralateral ear, and 3) vertex to nape of neck (Cz-Oz). The response was averaged over a 12 msec window. The response was amplified and filtered (bandpass 10-3000 Hz). A 10 Hz low-frequency filter was chosen to enhance wave V amplitude. Artifact rejection was employed. Peak-to-following trough amplitude and latency of Waves I, III, and V were measured for each subject in the ipsilateral and mid-line channels.

Results

An important consideration before beginning this investigation was to recruit children for the control and experimental groups that were similar in age and socioeconomic level. The control group had a mean age of 8 years and 6 months. The experimental group has a mean age of 8 years and 8 months. An analysis of variance indicated no significant differences in age between the two groups [F(1, 46)=.143, p=.707]. A Chi Square analysis indicated no significant differences between the education level of the mother *[x^2 = 1.66, 3, p=.645]*, educational level of the father, *[x^2 = 2.462, 4, p=.651]*, or the type of school the subject attends *[x^2 =1.667, 3, p=.644]*. Therefore, there were no statistical differences between the two groups in demographic composition.

Another important consideration for this study was to recruit and test similar experimental and control subjects who had normal receptive vocabulary as evidence by their standard scores on the PPVT-III. Both groups had clinically "normal" scores; the experimental group had a mean score of 102.33 and the control group had a mean score of 115.29. There was a significant difference between the groups, even though each individual subject was "clinically normal [F(1,46) =15.396, p=.001].

Behavioral Tests of Temporal Processing

A nonparametric statistic (Chi Square) was used to examine group differences because the homogeneity of variance assumption was not met. For statistical comparisons, the behavioral tests for temporal processing are interpreted as either normal or abnormal. (Again, for the behavioral test to be considered 'abnormal', the score must be at least two standard deviations below published norms.) A Chi Square analysis, shown in Table 1, indicates significant differences between the control and experimental groups for each of the behavioral tests. This finding suggests that the two groups differ in their temporal processing. An analysis of variance

Table 1. Chi Square analysis, mean scores, standard deviations, for the control and experimental groups for the behavioral tests of temporal processing.

			EXPERIMENTAL		Number of Experimental	CONTROL	
TEST	χ2	*p*	Group Mean	St. Dev	Abnormalities	Group Mean	St. Dev
Time Compressed Speech Right	9.36	0.002	62%	20.43	21	91%	5.74
Time Compressed Speech Left	19.05	0.001	63%	20.59	21	93%	5.62
Pitch Pattern Right	40.33	0.001	20%	19.49	23	73%	27.94
Pitch Pattern Left	27	0.001	26%	25.5	22	71%	28.56
Duration Pattern Right	27.19	0.001	14%	19.63	23	71%	27.42
Duration Pattern Left	16.45	0.001	21%	25.7	20	68%	26.56
Masking Level Difference	12.63	0.001	8 dB	2.76	19	11 dB	1.3
Random Gap Detection	31.45	0.001	16 msec	14.39	9	8 msec	3.2

Table 2. Latency measures for Waves I, IIII, and V for right, left, and binaural modes of stimulation.

	Left			**Right**			**Binaural**		
	I	**III**	**V**	**I**	**III**	**V**	**I**	**III**	**V**
Experimental	1.69	3.82	5.86	1.67	3.84	5.84	1.68	3.81	5.84
St. Dev	0.08	0.17	0.18	0.12	0.16	0.23	0.09	0.14	0.19
Control	1.69	3.85	5.85	1.70	3.87	5.85	1.69	3.90	5.82
St. Dev	0.10	0.17	0.25	0.11	0.12	0.16	0.09	0.26	0.15

indicated a statistical difference between the groups in the behavioral tests of temporal processing. Listed in Table 1 are the mean, standard deviation, and p value for each behavioral test, as well as the number of abnormal test results for the experimental group.

Electrophysiologic Measures

Latency. No significant differences in ABR peak latency for Waves I, III, or V were found between the control and experimental groups [F (2, 27) =1.25, p=.303]. In addition, no significant latency differences for Waves I, III, and V were found between the right, left, or binaural modes of stimulation [F (2, 2), = 1.639, p=.208]. Group means and standard deviations for latency measures of Waves I, III, and V for right, left, and binaural stimulation are shown in Table 2.

Amplitude. The control group had higher peak-to-peak amplitude measurements for ABR waves I, III, and V than the experimental group, and differences were significant for Waves I and III. These significant differences occurred for all stimulation modes: right, left, and binaural (see Table 3). Significantly greater amplitudes were obtained for binaural than monaural stimulation for both groups [F (2, 27 = 8.105, p=.001]. Peak-to-peak amplitude measures for Waves I, III, and V are displayed in Table 3.

Group-mean amplitude measures for the Cz-ipsilateral ear lobe trace for the right, left, and binaural stimulation modes for Waves I and III are displayed in Figures 1 and 2, respectively. As noted above, amplitude is greater for binaural stimulation for both groups for Waves I, III, and V, and amplitudes are greater in the control than experimental group.

Binaural ITD. Latency and amplitude measurements for binaural wave V with an ITD of 0, 0.1, 0.4, 0.9, and 1.9 msec for the midline electrode montage recordings are displayed in Figures 3 and 4, respectively. In addition, an example of a midline recording for each binaural ITD for one control subject is shown in Figure 5.

Wave V latency increased and amplitude decreased with an increase in the ITD for both groups. A repeated measures analysis of variance indicated no significant differences in latency between the control and experimental groups [F (4,42) = .814, p=.523], although the experimental group has slightly longer wave V latencies.

A significant difference was observed for the 0.9 msec ITD amplitude measure between the experimental and control groups [F (4, 42) = 2.209, p= .001].

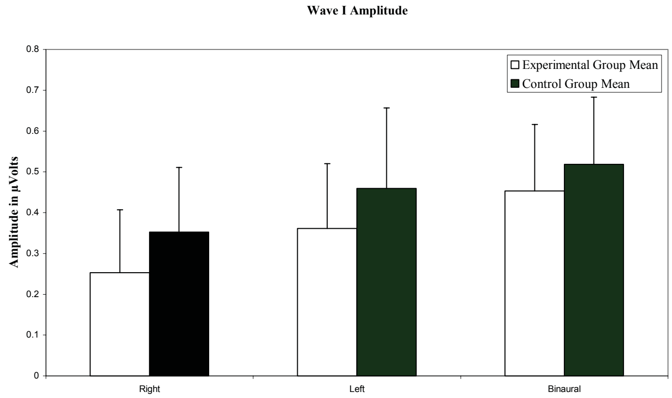
Discussion

The objective of the present study was to evaluate ABR measures in a group of children with a specific temporal processing disorder. Because the brainstem

Table 3. Amplitude measures and statistical differences for Waves I, III, and V for right, left, and binaural modes of stimulation.

	Left			**Right**			**Binaural**		
	I'	**III'**	**V'**	**I'**	**III'**	**V'**	**I'**	**III'**	**V'**
Experimental	0.36	0.22	0.47	0.25	0.21	0.53	0.45	0.31	0.74
St. Dev.	0.16	0.1	0.21	0.15	0.11	0.22	0.21	0.16	0.22
Control	0.46	0.38	0.55	0.35	0.33	0.58	0.52	0.44	0.8
St. Dev.	0.2	0.2	0.17	0.18	0.18	0.17	0.16	0.22	0.23
p	0.005	0.004	0.056	0.02	0.006	0.115	0.039	0.003	0.173

Figure 1. Group means and standard deviations for Wave I amplitude for right, left and binaural stimulation.



auditory centers are involved in early encoding of timing parameters, and these centers are involved in generation of the ABR, we reasoned that early electrophysiologic recordings in children with temporal processing deficits may differ from normal children.

One of the difficulties in reviewing published investigations of (C)APD is the frequent, inadequate definition of the study participants. The temporal processing deficits of the subjects in this investigation are clearly defined by the differences in the specific behavioral measurements of temporal processing.

Electrophysiological Measures

Measures of ABR latency showed no significant differences in the latency of ABR waves I, III, and V between the experimental and control groups. There were also no significant differences in the wave V latency between the midline and Cz-ipsilateral recording sites. This is consistent with previous investigations which report no latency differences in the ABR recording from various recording sites (Hall, 1992; Hashimoto et al, 1981). In addition, there were no significant differences in latency in the mode of stimulation, right, left or binaural. This is consistent with previous investigations of monaural versus binaural stimulation (Dobie & Norton, 1980; Hosford-Dunn, Mendelson & Salamy, 1981).

Wave I and III latencies and Waves I, III, and V amplitudes were within normal clinical limits for all control and experimental subjects (Musiek, Josey, & Glassock, 1986). Wave V latencies were within normal limits (Musiek et al., 1986) for all but two experimental subjects. Careful inspection of individual ABR waveform latency data indicates that two experimental subjects had Wave V latencies that were two standard deviations greater than the experimental group mean latency value. Here, the electrophysiological data adds objective evidence to support the diagnosis of a central auditory processing disorder with a possible neurophysiological etiology in each of these two cases. It is also noted that both of these experimental subjects had a positive history of middle ear infections, as evidenced by having had pressure equalization tubes. In addition, both reported infant jaundice. Additional information of other abnormal or neurological findings was not mentioned in the case history. Other experimental subjects who had both infant jaundice and a history of middle ear infections had ABR recordings that were within normal limits.

The control group had greater amplitudes for all waves, but significantly greater for waves I and III in all modes of stimulation (right, left, and binaural). These results are similar to Mason & Mellor (1984) who found smaller ABR amplitudes in the language delay and motor speech group. This amplitude difference may be attributed to better neural synchrony in the control group subjects.

A significant difference between groups in wave V amplitude for the 0.9 ITD condition was shown. A gradual decrease of .27 µV in amplitude was observed as the ITD increased from 0-.4 msec in the control group. This is similar to .17 µV decrease in amplitude as the ITD increased from .1 to .4 msec in the experimental group. An abrupt decrease in amplitude was observed as the ITD increased from 0.4 to 0.9 msec. Around 1 msec, the image is no longer fused; therefore, the amplitude reduction at 0.9 msec ITD is exhibited. The control group had a decrease of .23 µV in wave V amplitude, while the experimental group had a decrease of .44 µV in wave V amplitude.

The finding of limited differences between groups on the ABR may be related to the specific stimuli and paradigms used or to the possibility that the temporal processing deficits in these subjects arise at more

Figure 2. Group means and standard deviations for Wave III amplitude for right, left and binaural stimulation

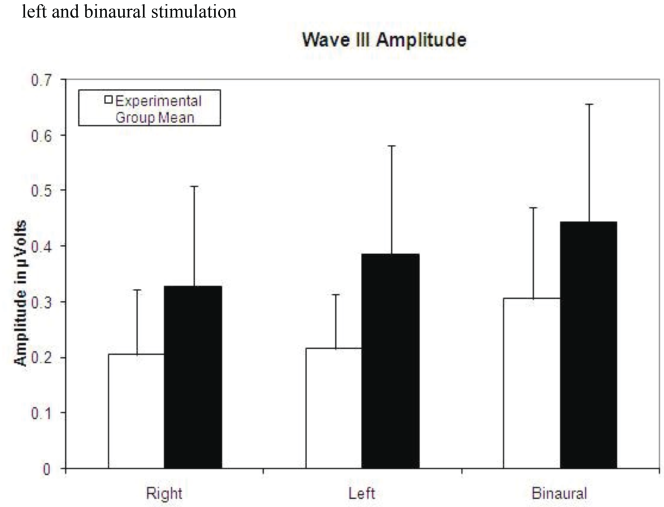
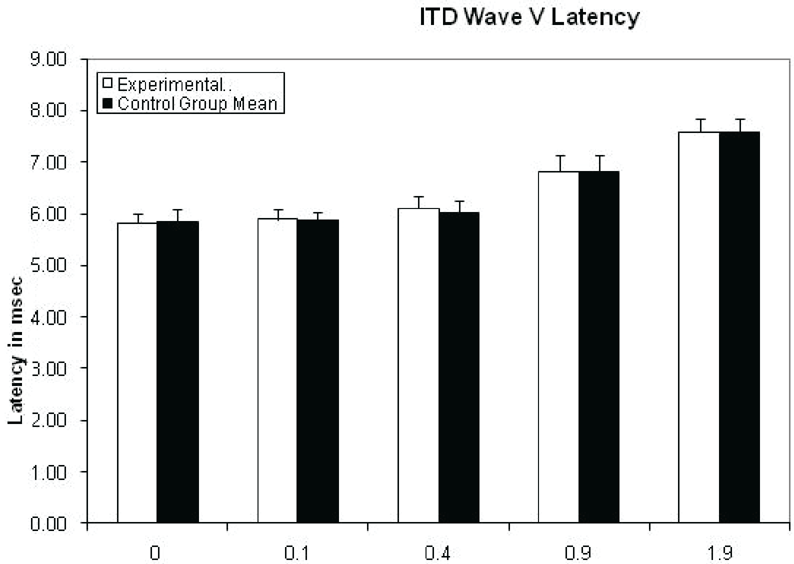


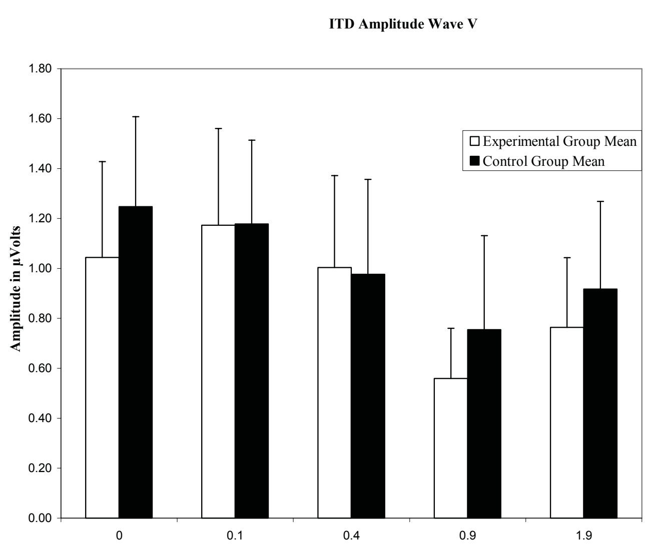
Figure 3. Group means and standard deviations for Wave V latency mid-line recording at each ITD condition.



central levels. Recent work by Kraus and colleagues has reported that about one third of individuals with language-based learning problems have reduced temporal synchrony at the upper brainstem level (Banai, Nicol, Zecker & Kraus, 2005; Cunningham, Nicol, Zecker, Bradlow, & Kraus, 2001; King, Warrier, Hayer, & Kraus, 2002; Wible, Nicol, & Kraus, 2004). Electrophysiologic recordings to a speech ABR may be more useful in distinguishing temporal processing deficits at the level of the brainstem.

The results of this investigation are similar to the findings of Arslan et al. (1981) who reported morphological changes in the ABR recording when the ITD was greater than 2 msec.

Figure 4. Group means and standard deviations for Wave V amplitude at each ITD condition.



As the ITD increased, the Wave V latency increased and the amplitude decreased for both groups. There were no significant differences between the control and experimental groups in wave V latency as a function of ITD.

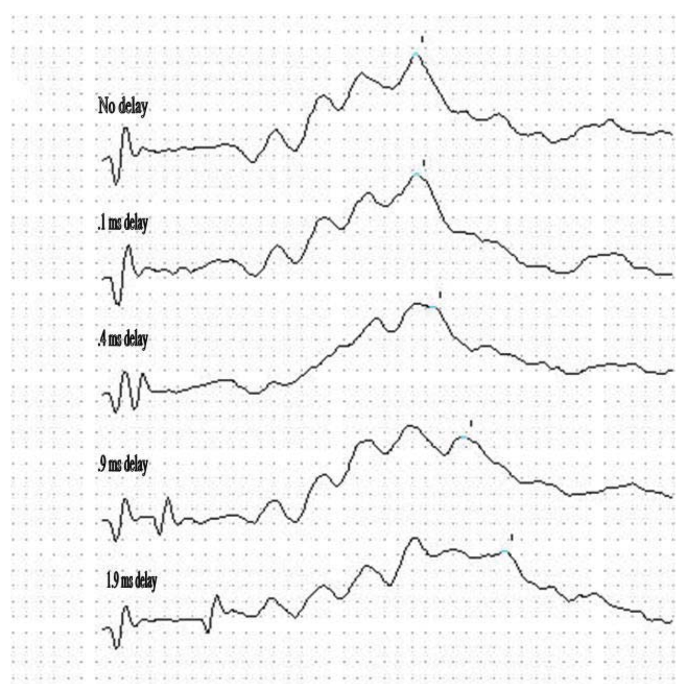
Summary

This investigation reported electrophysiological data on a group of children with temporal processing deficits and an age-matched control group. Although there were no group differences in ABR latency, significant group amplitude differences were observed. These amplitude differences may be attributed to better neural synchrony for the control group. While amplitude measures for the experimental group were not abnormal based upon current clinical norms; nonetheless, there were statistical differences between the two groups.

This investigation does not negate the importance of including electrophysiological recordings as part of the (C)APD battery. In fact, two experimental subjects had abnormal ABR wave V latencies (Hood and Berlin, 1986). These two subjects did have a positive history of otitis media; however, they did not perform poorer than other experimental subjects on the behavioral measures.

The ABR provides powerful information about the neurophysiological integrity of the peripheral

Figure 5. An example of one subject's midline binaural ITD recording. A cursor is placed on wave V.



and brainstem auditory nervous system and is useful in differentiating central auditory disorders (C)APD from auditory dys-snchrony/auditory neuropathy. Future investigations of temporal processing deficits using electrophysiological measures that include speech and other complex stimuli in ABR and other cortical potential paradigms may help clarify these relationships. Although this investigation did not show statistical differences in the ABR latency, there were significant amplitude differences for waves I and III. A normal ABR may be used implicate that temporal processing deficits in this individual result from asynchronies beyond the brainstem. An abnormal ABR may suggest the possibility of dys-synchrony at the level of the brainstem.

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Survey of Hearing Screeners: Training and Protocols Used in Two Distinct School Systems

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This study compared the training and protocols used by two groups of elementary school hearing screeners: one group of school nurses and one group of contractually hired personnel. The participants were asked to complete a survey concerning their training, screening protocols, and opinions on minimal hearing loss (MHL). Results revealed that the school nurses listed more sources of training and reported a greater variation in hearing screening protocols, while the contractual screeners listed fewer training sources and used more uniform screening protocol. Possible reasons for these differences are given, and comparisons on other survey items, including opinions on MHL, are discussed.

Introduction

It has long been determined that children identified with hearing loss through screening procedures receive earlier, more appropriate interventions that help them achieve more age-appropriate speech/language, academic, and social levels, while children who are not identified through screenings continue to fall behind their peers in these areas (West & Harris, 1983; Tharpe & Bess, 1991, 1999). Yet, even with hearing loss lending itself so readily to hearing screening programs, there are no national or, in some cases, state regulations for mass school-based hearing screening programs (Johnson, Benson, & Seaton, 1997a). Several entities have proposed general guidelines and procedures (Roush, Bess, Flexer, Gravel, Margolis, Northern, et al., 1997; ASHA, 1997; Missouri Department of Health and Senior Services, 2004); however, guidelines are only recommendations and include no specific rules that have to be followed.

ASHA's Guidelines for Audiologic Screening (1997) contain a section specific to the screening of hearing in school-aged children. The document outlines protocol for testing pure-tones at three frequencies: 1000, 2000, and 4000 Hz. The recommended criterion intensity level is 20 dB HL, and children need to respond reliably to each tone at this intensity in both ears in order to pass the screening. If a child does not respond to any of the test frequencies in either ear at the ASHA recommended criterion level, it is appropriate to reinstruct the child, reposition the earphones, and conduct an immediate re-screening.

There are several procedures that are not recommended by ASHA. For instance, it is never appropriate to adjust the pass/fail criteria to compensate for a poor testing environment. It has been found that "many [screening programs] appear to screen at higher levels, presumably to compensate for excessive ambient noise levels" (Roush, 1992, p. 306). Screeners, however, should avoid changing the criterion intensity level if the screening room has high intensity background noise levels. Changing the criterion might seem to correct for a noisy environment, but children who have borderline or minimal hearing loss (MHL) might not be identified due to this seemingly small procedural change (Kaderavek & Pakulski, 2002). A student with MHL (hearing in the 16-25 dB HL range) might legitimately fail at 20 dB HL and just as legitimately pass at 25 dB HL. Therefore, screenings should be relocated to a quieter room or completed on a different day. ASHA's list of inappropriate procedures also includes: using speech stimuli, nonconventional instrumentation (hand-held audiometers), uncalibrated signals, group screenings, and otoacoustic emission (OAE) testing.

In addition to providing guidelines for screening protocols, ASHA (1997) indicates that screeners should either be appropriately credentialed audiologists and speech-language pathologists or personnel supervised by a certified audiologist.

In general, it is not cost effective for audiologists to actually administer the screening tests, not to mention the fact that there is a shortage of educational audiologists in school systems throughout the United States (Johnson et al., 1997a). Technicians and volunteers are considerably less expensive and more easily accessible. Therefore, state guidelines for hearing screenings often indicate that school-based screening programs are conducted by a variety of personnel, including "school nurses and medical technicians" (Pennsylvania Department of Health, 2001), "speech-language professionals" (Missouri DHSS, 2004), and "trained volunteers" (Colorado Department of Education, 2001; Missouri DHSS, 2004). Volunteers should be allowed to conduct the initial pure-tone procedure only after receiving "appropriate training and instruction" on the screening forms, procedures, and equipment (ASHA, 1997; Missouri DHSS, 2004). What constitutes appropriate training and instruction is not specified, however, several state guidelines (Louisiana Department of Education, 2007; Missouri DHSS, 2004; Pennsylvania Department of Health, 2001) indicate that the school nurse is often the primary professional involved in screenings. Likewise, Johnson et al. (1997a) recognize nurses as effective professionals for conducting hearing screenings because school nurses are likely to carry out and manage the screening program for several years. They also have a significant amount of medical knowledge, particularly concerning the students in their schools. Unlike volunteers, the nurse is present on designated screening days and on regular school days, when re-screenings are administered.

School-based hearing screenings began on the local level as early as the 1930s in some school systems (Indiana Speech-Language-Hearing Association, n.d.), but were not discussed nationally until the 1960s at the National Conference on Identification Audiometry (Darley, 1961; Flanary, Flanary, Colombo, & Kloss, 1999). The conference, which took place in 1961, marked the beginning of mass school-based hearing screenings. During this conference, several goals for the screening programs were established: "(1) identification of even minimal hearing loss, (2) identification of active ear disease, (3) referral of abnormal exams to physicians, and (4) referral for hearing rehabilitation" (Flanary, et al., 1999, p. 96).

By the end of the 1960s, all states had implemented some form of hearing screening in their schools; however, almost 50 years later, many states still do not have mandated screening protocols for schools (Mannina, 1997; Roush, 1992). Roush stated that while "one would expect to find consistent and well-standardized procedures… nationwide surveys have repeatedly shown substantial disagreement on the philosophical as well as procedural aspects of school screening" (p. 306). Several studies demonstrate the inconsistency of screening programs in achieving these goals (Kemper, Fant, Bruckman, & Clark, 2004; McDermott & VanTassell, 1981; Sophocles & Muzzarelli, 1970). These studies found that screening protocols varied widely within the same state, county, and even school district.

Sophocles and Muzzarelli (1970) conducted a survey within the public school districts of Mercer County, New Jersey. They found that there was no uniformity in the grades screened, frequencies tested, presentation intensity level, or referral method. Two of the school districts did not have a screening program and none of the schools had calibrated audiometers.

McDermott and VanTassell (1981) assessed the need for statewide screening standards in Minnesota by conducting a survey of 195 of the state's school districts. The study was conducted under the assumption that schools throughout the state used uniform screening procedures. The investigators found, however, that this was not the case. One hundred twenty-four school districts used a single combination of levels and frequencies (although the same combination was not used in each school), 15 used two or more combinations of levels and frequencies, 54 districts provided incomplete information, six used a Verbal Auditory Screening for Children instead of a pure tone screening, and one district did not conduct screenings.

In a more recent study, Kemper et al. (2004) showed that lack of consistency in school-based hearing screenings remains a problem in Michigan. The investigators found that there was significant variability in the administration of the screening programs, including the grades screened, services offered to the children who did not pass, and the way in which parents were informed about the screenings.

Screenings of the school-aged population attempt to identify children with educationally significant hearing problems. Yet, it has been reported in numerous studies (e.g., Johnson, Stein, Broadway, & Markwalter, 1997b; Bess, Dodd-Murphy, & Parker, 1998; Tharpe & Bess, 1999; Kaderavek & Pakulski, 2002;) that even a mild hearing loss can have a significant impact on a student's educational achievement. Because of this fact, and because one of the initial goals of the 1961 National Conference on Identification Audiometry was the identification of "even minimal hearing loss," the identification of MHL during hearing screenings needs to be addressed.

Elementary school hearing screeners are in the unique position to identify students with undiagnosed hearing loss. However, training, supervision, experience, and personal beliefs of these hearing screeners might affect the identification and referral rates of students with hearing loss, including MHL. The purpose of the present study was to compare the training and protocols used by two groups of elementary school hearing screeners. The first group consisted of elementary school nurses, while the second group consisted of contractually hired screeners. The participants were asked to complete a survey concerning their training, the screening protocols they used, and their opinions on MHL. There were three research questions addressed in this study: (1) Are there differences in training between these two groups of screeners?, (2) Are there differences in the screening protocols used by the two groups of screeners?, and (3) Are there differences in the personal opinions of the two groups of screeners regarding students with minimal hearing loss?

Method

Participants

Participants in this study were hearing screeners who conduct hearing screenings in two school systems within the state of Missouri. The first group of hearing screeners consisted of elementary school nurses working in a mid-size metropolitan area (population 151,800), with a single school district containing 38 elementary schools. All of the school nurses were registered nurses (RN). Of the 38 elementary school nurses employed by this school system, 17 nurses completed this survey. This represents 44.7% of the total population of this school system's nurses. This group did not have direct contact with an educational audiologist.

The second group of hearing screeners consisted of contractually hired hearing screeners working in a large metropolitan area (population 1,013,123) containing 28 school districts. Each district has several (e.g., 2-21) elementary schools. All of the contractual screeners were required to hold the minimum of a high school degree. The majority of these screeners, however, were retired teachers with a college degree. Of the 29 contractual screeners employed by this school system, 18 completed the survey (13 hearing screeners, three team leaders, and one coordinator, all of whom conducted hearing screenings). This represents 62.1% of the total population of this school system's contractual screeners. An educational audiologist trained and supervised the contractual screeners.

Each survey respondent was the primary professional responsible for screening the hearing of elementary school students in grades kindergarten through fifth. The school nurses conducted the hearing screenings for only the elementary school in which they worked. The contractual screeners conducted screenings in a larger number of schools, ranging from two to 80 elementary schools (M = 50; sd = 22.0).

Participants' experience in their current positions ranged from less than one year to 25 years. In general, the school nurses had fewer years of experience (9 months – 19 years: M = 5.6 years, median = 4 years) than the contractual screeners (2 – 25 years: M = 11.2 years, median = 9 years).

The job responsibilities of the school nurses were varied, with hearing screening being only part of their role as the primary healthcare professional at the elementary schools. The job responsibilities of the contractual screeners consisted almost exclusively of screening the hearing of students. The contractual screeners reported to team leaders, who then reported to a coordinator (an educational audiologist).

Survey Instrument

A 21-item survey was administered to the participants of this study (see Appendix A). This survey was subdivided into three sections: (a) demographic information, (b) hearing screening procedures used by the respondent, and (c) opinions on MHL. Survey items were designed using a mixed format. The four items covering demographic information were open-ended, asking the respondents to describe their position and length of time in that position. The 13 items in the screening procedures section were either open-ended or closed-ended with an open-ended alternative. The third section of the survey presented four statements on a 5-point Likert scale (1 = strongly agree, 2 = agree, 3 = no opinion, 4 = disagree, 5 = strongly disagree) to identify the participants' level of agreement or disagreement with concepts related to MHL. Space was provided at the end of the survey for the respondents to write comments.

Procedures

Following IRB approval at the sponsoring university, the investigators contacted three individuals to obtain permission to conduct the study: the Director of Research and Assessment and the Director of Student Health Services in the school system where nurses performed the hearing screenings and the Director of Related Services in the school system that hired contractual hearing screeners.

The surveys were distributed to the school nurses (left at the front office or handed directly to the nurse) and collected by the investigators. Due to distance constraints, the investigators mailed the surveys to the Director of Related Services for distribution to the contractual hearing screeners. Most of the surveys were collected by the Director and mailed back to the investigators, although some of the respondents opted to mail the survey directly.

Each participant was provided with a cover letter describing the study and asked to respond to the four-page survey. Participants' completion of the survey represented their informed consent to participate in the study. The survey took approximately 15 minutes to complete.

Data Analysis

As each survey was returned, data were entered into an SPSS program for analysis (Norusis, 1990). Descriptive data, including median, mean, and range of responses, were documented for each group of screeners for each survey item. Chi-square and Cramer's V (tests of goodness of fit) were calculated between the two groups of screeners and their responses to the items concerning screening protocol (Morgan, Leech, Gloeckner, & Barrett, 2004).

There is debate as to whether data obtained through a Likert-type scale should be considered ordinal or interval (Jaccard & Wan, 1996; Morgan et al., 2004; Salkind, 2004). For the purposes of this study, the Likert data were considered to be ordinal, and a Mann-Whitney U test was used for calculations (Morgan et al., 2004).

Results

Survey Questions Regarding Hearing Screening Procedures

The first research question in this study asked, "Are there differences in training between these two groups of screeners?" Item #8 on the survey addressed this research question. Thirteen of the school nurses (72.2%) reported multiple sources (2 to 3) for their training. All seventeen of the contractual screeners (100%) reported that they received their training on hearing screening protocols from an in-service session provided by an educational audiologist. Five contractual screeners (29.4%) listed additional sources of training. The reported sources of training and the percentage of responses are detailed in Table 1.

Table 1

Reported Sources of Hearing Screeners' Training

Source	School Nurses (%)	Contractual Screeners (%)
School Policy	83.3%	-
State Guidelines	44.4%	-
In-Service	33.3%	100%
Shown Procedure	22.2%	11.8%
ASHA Guidelines	5.6%	-
Other	5.6%	17.6%

Note. Multiple responses were allowed.

The second research question in this study asked, "Are there significant differences in the screening protocols used by the two groups of screeners?" Items #7a-f, #11, #12, and #13 on the survey addressed this research question. These items included questions concerning frequencies, intensities, pass/fail criteria, number of children tested at one time, middle ear screening, use of otoscopy, and re-screening and referral procedures. The responses to these individual items are presented below.

Frequencies used. The hearing screeners were asked what frequencies were used during screenings (#7a). Seventeen of the 18 school nurses (94.4%) screened students' hearing using 500, 1000, 2000, and 4000 Hz as test frequencies. One school nurse (5.6%) responded, "200, 400, 800, and 1000."

Fifteen of the contractual screeners (88.2%) used 500, 1000, 2000, 4000 and 6000 Hz as test frequencies. One contractual hearing screener (5.9%) reported using 500, 1000, 2000 and 4000 Hz. One contractual screener (5.9%) reported that she tested 1000, 3000, 5000, and 6000 Hz, but if a student failed two frequencies during the initial screening, she also tested 500 Hz.

A Cramer's V was calculated to determine if the school nurses and contractual screeners differed on which frequencies they tested. This test is more appropriate than a chi-square in the analysis of this data because there is a larger cross tabulation (2x3, not 2x2). The Cramer's V indicated that school nurses and contractual screeners were significantly different in the frequencies that they screened ($V = 0.914$, $p < 0.001$).

Intensity levels used. The hearing screeners were asked what intensity levels they used during hearing screenings (#7b). Five school nurses (27.8%) used 25 dB as the standard intensity level tested, four (22.2%) used 20 dB, and four (22.2%) used "20-25 dB." Three school nurses (16.7%) reported using "20 and up" and one nurse (5.6%) used 20-30 dB. One elementary school nurse (5.6%) reported using "whatever is needed."

Fourteen of the contractual screeners (82.4%) used 25 dB as the standard intensity for screenings. The remaining three (17.6%) did not respond to the survey item.

A Cramer's V again was calculated to determine if the school nurses and contractual screeners differed on which intensities they tested. The Cramer's V indicated that school nurses and contractual screeners were not significantly different in the intensities that they screened ($V = 0.712$, $p = 0.001$).

Pass/fail criteria used. The hearing screeners were asked what criteria they used for failing a student (#7c). The elementary school nurses gave twelve different responses to this survey item. The most common responses for failure criteria were: "missing two frequencies greater than 30 dB" (16.7%), "after 25 dB" (16.7%), and "no response above 20 dB in either ear at 1000, 2000, or 4000 Hz or above 30 dB at 500 Hz in either ear" (11.1%). The nine other responses for failure criteria can be seen in Table 2.

Fourteen of the contractual screeners (82.4%) reported that missing any two frequencies (at 25 dB HL) was designated a failure. The remaining three contractual screeners (17.6%) did not respond to the question (Table 2).

It was evident without the use of statistics that the twelve responses on pass/fail criteria from the nurses were different in number and in content from the one response given by the contractual screeners. Therefore, no statistical analysis was performed for this survey item.

Table 2

Reported Pass/Fail Criteria for Hearing Screenings

Criteria	School Nurses	Contractual Screeners
"Missing two frequencies greater than 30 dB"	N=3	-
"After 25 dB"	N=3	-
No response above 20 dB in either ear at 1000, 2000, or 4000 Hz or above 30 dB at 500 Hz	N=2	-
Missing two frequencies in one ear or one in each ear at 30 dB	N=1	-
Any frequency not detected between 25 and 40 dB	N=1	-
Missing two frequencies greater than 25 dB	N=1	-
Missing two frequencies at 25 dB	-	N=14
Referral after 20 dB	N=1	-
Missing two frequencies or missing one frequency at 40 dB or greater	N=1	-
Missing more than one frequency per ear	N=1	-
">20; >30"	N=1	-
"Two failed tones above 500 Hz at 30 dB"	N=1	-
Not hearing a tone at 30 dB	N=1	-
No Response	-	N=3

Use of otoscopy and tympanometry. Respondents were asked if they used otoscopy or tympanometry at any point during the hearing screening process (#7e-f). Eleven (61.1%) of the school nurses used otoscopy as part of their re-screening protocol, performing it only on students who failed the initial screening. Five (27.8%) nurses used otoscopy as part of their standard screening protocol. One school nurse (5.6%) never used otoscopy, and one (5.6%) reported that she "sometimes" used otoscopy. None of the contractual screeners reported performing otoscopy during the hearing screening process. Neither the school nurses nor the contractual screeners reported using tympanometry.

Procedures used following screening failure. Three survey items required the screeners to describe the procedures they used for re-screenings and referrals (#11-13). The first item asked the professionals to describe the procedure they followed when a child failed a hearing screening. The second item asked to whom the child was referred, and the third item asked about the actions taken when a child was absent on the screening day.

The school nurses gave 17 responses for the procedures they used following a failed screening (#11). The majority of nurses used similar procedures, but several included additional, less common procedures. Sixteen school nurses (88.9%) reported that they personally conducted a re-screening of students who failed the initial screening; 15 of these nurses reported that the re-screenings occurred one to two weeks later, and one nurse reported that the re-screenings occurred two to three weeks later. Four (22.2%) school nurses reported that they conducted otoscopy and a case history during the re-screening. Additional procedures reported by the school nurses following the screening are included in Table 3.

The contractual screeners provided eight different responses, each with multiple steps. Fourteen (77.8%) reported that the names of students who failed the screening were given to the school nurse, and she re-screened them at a later date. Ten (58.8%) contractual screeners reported that parents were mailed a letter explaining the need for a complete audiologic evaluation. Six (35.3%) reported that any student who failed the screening was immediately rescreened by another contractual hearing screener. One contractual hearing screener (5.9%) reported that the team leader conducted the immediate re-screening. Five (29.4%) responded that the names of students who failed the screening were put on a list that was given to the school system's educational audiology office. Three (17.6%) reported that they referred the student directly to the educational audiology office, and one (5.9%)

Table 3

Additional Procedures Reported by the Nurses Following a Screening Failure

Procedure	School Nurses
Parent Letter	50%
Referral to Primary Care Physician (PCP)	50%
Referral to "Hearing Specialist"	22.2%
Threshold Search	11.1%
Parent Phone Call	5.6%
Parent Conference	5.6%
Referral to PCP after 3 failures	5.6%
Immediate Referral to PCP if visible fluid	5.6%
Referral to Bureau of Special Health Care Needs or University Audiology Clinic	5.6%
Inform Teacher	5.6%

Note. Multiple responses were allowed.

Table 4

Reported Referral Sources for Hearing Screening Failures

Referral	School Nurses (%)	Contractual Screeners (%)
PCP	72.2%	23.5%
Local University Clinic	27.8%	-
School Audiology Office	-	58.8%
ENT	11.1%	-
Parent's Choice	5.6%	-
Bureau of Special Health Care Needs	5.6%	-
Specialist	5.6%	-
Audiologist	5.6%	-
School Nurse	-	52.9%
Don't Know	5.6%	-
No Response	5.6%	5.9%

Note. Multiple responses were allowed.

reported that she referred the child to his or her physician.

Referral procedures used. The hearing screeners were asked to whom they referred students who failed the hearing screening (#12). Most of the hearing screeners gave multiple responses. The list of referral sources and the percentage of responses can be seen in Table 4.

Procedures used for hearing screening absences. The respondents were asked to describe the procedures they used when a student was absent on the scheduled screening day (#13). Ten of the school nurses (55.6%) responded that they scheduled days for "make-up screenings." Six (33.3%) nurses reported that they individually screened students who were absent in their offices. One school nurse (5.6%), who had less than one year of experience in her current position, reported that she had "not run into this yet." One school nurse (5.6%) did not respond to the survey item.

All (100%) of the contractual screeners responded with the same answer. They stated that the school nurse performed the hearing screening at a later date if a student was absent on the scheduled screening day.

Survey Questions Regarding Opinions on Minimal Hearing Loss

The third research question in this study asked, "Are there differences in the personal opinions of the two groups of screeners regarding students with minimal hearing loss?" Items #14 through #17 addressed this research question. The hearing screeners were asked to rate their level of agreement with several statements concerning MHL using a five-point Likert scale. The statements are four of the "myths" from a previous study by McCormick Richburg and Goldberg (2005). A brief definition of MHL was provided to the respondents (see Appendix A).

Five of the 18 elementary school nurses (27.8%) did not respond to the four questions regarding MHL. Likewise, ten of the 17 contractual screeners (58.8%) did not answer any of the items on MHL. Seven of these ten (70.0%) contractual screeners wrote that they were "not qualified" as their reason for not responding to this set of survey items. Two of the contractual screeners in this group of seven added that they were not qualified because they were "not an audiologist," and one screener added that (s)he was not qualified because (s)he had "no expertise." Three of these ten respondents did not provide a reason for not answering the final four survey items. Of the seven contractual screeners who did provide a response, one (14.3%) answered "no opinion" for each of the four items. The remaining six (6/17: 35.3%) contractual screeners provided responses for these last four survey items. Therefore, all results (percentages) discussed below will be based on only the 13 school nurses and the seven contractual screeners who responded to the four items in this section.

For the statement, *"There is no such entity as minimal hearing loss. In essence, these students have hearing within normal limits,"* eight school nurses (8/13: 61.5%) indicated that they agreed. One school nurse (1/13: 7.7%) had no opinion and, four school nurses (4/13: 30.8%) disagreed with this statement. None of the school nurses strongly agreed or strongly disagreed with the statement.

None of the contractual screeners strongly agreed with the statement and one contractual hearing screener (1/7: 14.3%) agreed with this statement. Three (3/7: 42.9%) had no opinion and two (2/7: 28.6%) disagreed. One contractual hearing screener (1/7: 14.3%) strongly disagreed with the statement (see Figure 1).

A Mann-Whitney U test was used to compare the mean rank responses of the school nurses (9.04) to the contractual screeners (13.21). The analysis did not reveal a significant difference between the two groups (U = 26.50, $p = 0.11$).

For the statement, *"Students with minimal hearing loss will be identified through school hearing screenings,"* one school nurse (1/13: 7.7%) strongly agreed with this statement. Six of the school nurses (6/13: 46.1%) agreed with the statement. One nurse (1/13: 7.7%) had no opinion, and five nurses (5/13: 38.5%) disagreed. None of the school nurses strongly disagreed with the statement.

One contractual hearing screener (1/7: 14.3%) strongly agreed with this statement, and the majority of the contractual screeners (3/7: 42.9%) who responded to this item agreed with the statement. Two (2/7: 28.6%) contractual screeners had no opinion and one (1/7: 14.3%) disagreed. None of the contractual screeners strongly disagreed with the statement (see Figure 2).

A Mann-Whitney U test was used to compare the mean rank responses of the school nurses (11.08) to the contractual screeners (9.43). The analysis did not reveal a significant difference between the two groups (U =38.00, $p = 0.53$).

For the statement, *"If students with minimal hearing loss pass the hearing screening, they will have no difficulties learning in the classroom,"* three school nurses (3/13: 23.1%) agreed. One school nurse (1/13: 7.7%) had no opinion, while the majority of school nurses (9/13: 69.2%) disagreed. None of the school nurses strongly agreed or strongly disagreed with the statement.

Two contractual screeners (2/7: 28.6%) agreed with this statement, and one contractual screener (1/7: 14.3%) had no opinion. The majority of contractual screeners (4/7: 57.1%) disagreed with this statement, while none of the contractual screeners strongly agreed or strongly disagreed with this statement (see Figure 3).

Again, a Mann-Whitney U test was used to compare the mean rank responses of the school nurses (10.88) to the contractual screeners (9.79). Results revealed no significant difference between the two groups (U = 40.50, $p = 0.64$).

For the fourth and final statement, *"Students are not exposed to noises loud enough to create minimal hearing loss,"* none of the school nurses strongly agreed. One school nurse (1/13: 7.7%) agreed with the statement. Nine school nurses (9/13: 69.2%) disagreed, and three (3/13: 23.1%) strongly disagreed with the statement.

One contractual hearing screener (1/7: 14.3%) agreed with the statement. Three contractual screeners (3/7: 42.9%) had no opinion and three (3/7: 42.9%) disagreed with the statement. None of the contractual screeners strongly agreed or disagreed with the statement (see Figure 4).

A Mann-Whitney U test was used to compare the mean rank responses of the school nurses (12.46) to the contractual screeners (6.86). This analysis revealed a significant difference between the two groups (U = 20.00, $p < 0.05$).

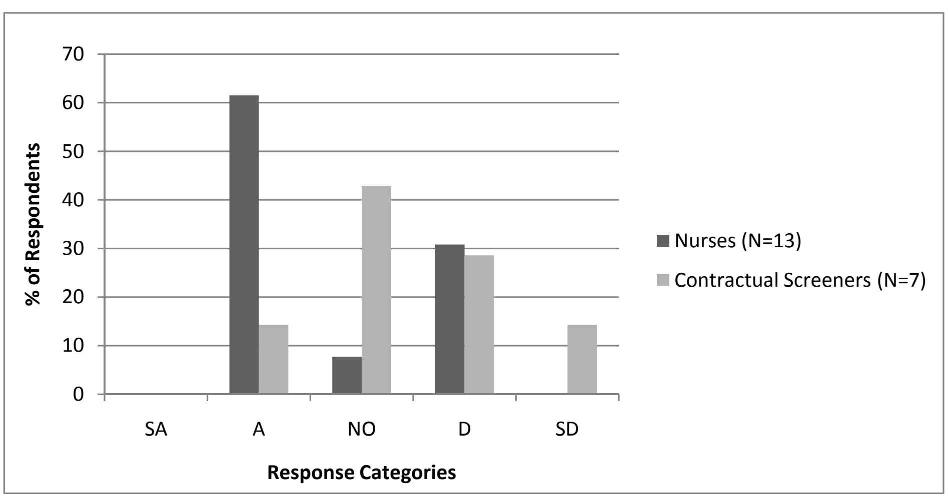
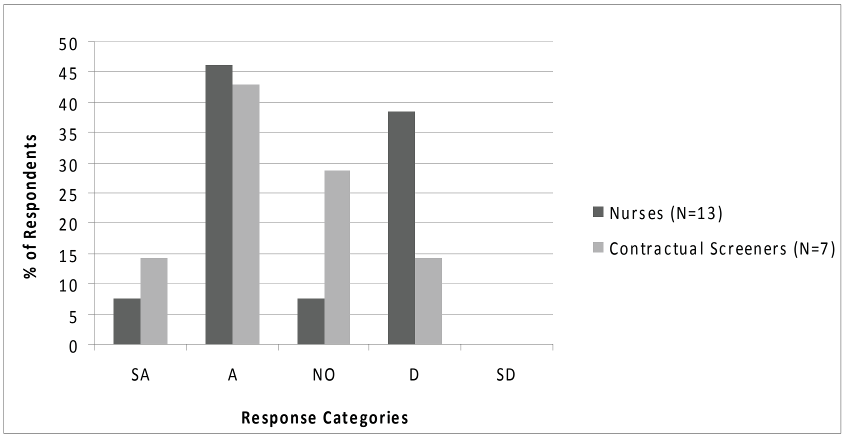


Figure 1. Responses to MHL Statement One: "There is no such entity as minimal hearing loss. In essence, these students have hearing within normal limits." SA = strongly agree, A = agree, NO = no opinion, D = disagree, and SD = strongly disagree.

Figure 2. Responses for MHL Statement Two: “Students with minimal hearing loss will be identified through school hearing screenings.” SA = strongly agree, A = agree, NO = no opinion, D = disagree, and SD = strongly disagree.



Discussion

The present study is based on the responses of 35 participants, 18 school nurses and 17 contractual screeners. There were several interesting findings associated with the responses from the hearing screeners, and the following discussion helps to emphasize the importance of training and establishing protocols with the assistance of a primary source, preferably an educational audiologist. The intent of this discussion is not to determine why the two groups provided different responses or whether or not these different responses were appropriate for each group. Each group had separate school administrations that chose to interpret and implement hearing screenings in two distinct manners: one school system used the already available nursing staff and one system hired temporary contractual staff. It is understood that funding issues and staff availability played a role in the decision processes for establishing these two hearing screening programs. However, reasons for the differences were described when a plausible explanation could be used to support the differences.

When addressing the first research question, “Are there significant differences between the hearing screening training of elementary school nurses and the contractual screeners?,” the responses from school nurses showed less uniformity in training sources than the contractual screeners in this study. The majority of school nurses reported having multiple training sources. Although this majority stated that they followed “school policy,” five other sources were identified. It should be noted that school policy itself varies from school to school; therefore, school nurses reporting “school policy” might actually have been trained differently. All of the contractual screeners reported that they received their training during an in-service provided by an educational audiologist. In all likelihood, the uniform training of this group (by one supervising educational audiologist) contributed to the uniformity in the screening protocols they followed.

It was interesting to discover that only one of the 35 respondents (an elementary school nurse) indicated that she followed ASHA guidelines for hearing screenings. It could be assumed that the educational audiologist who trained the contractual screeners used ASHA guidelines. However, none of the respondents indicated this on the survey, and some of the procedures used by the contractual screeners did not adhere to the guidelines put forth by ASHA (1997).

When addressing the second research question, “Are there significant differences in the screening protocols used by the two groups of screeners?,” responses from survey items concerning frequencies, intensities, pass/fail criteria, use of otoscopy and

Figure 3. Responses for MHL Statement Three: “If students with minimal hearing loss pass the hearing screening, they will have no difficulties learning in the classroom.” SA = strongly agree, A = agree, NO = no opinion, D = disagree, and SD = strongly disagree.

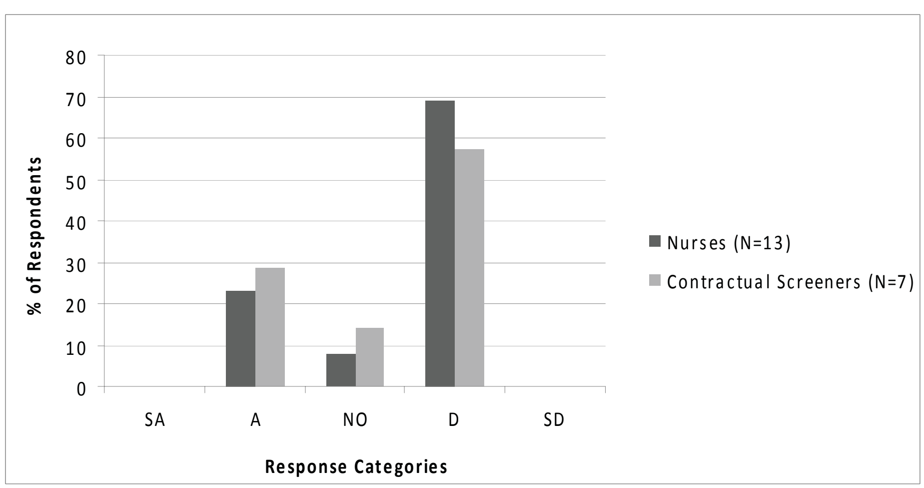
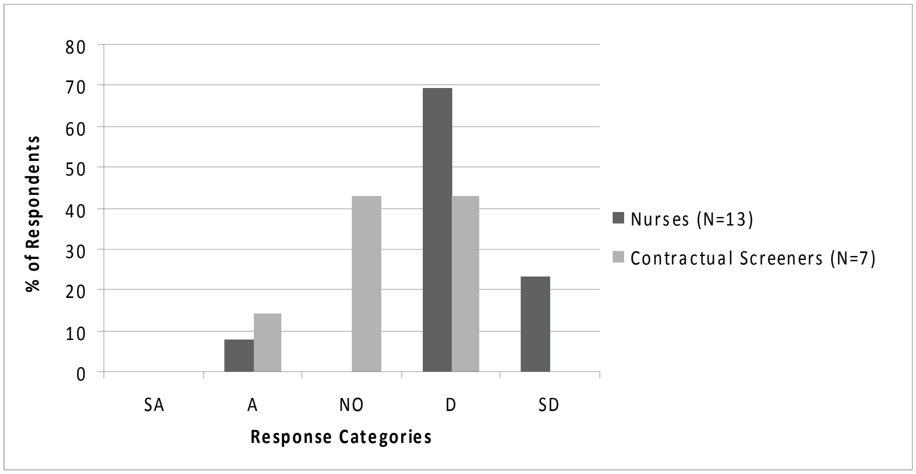


Figure 4. Responses for MHL Statement Four: "Students are not exposed to noises loud enough to create minimal hearing loss." SA = strongly agree, A = agree, NO = no opinion, D = disagree, and SD = strongly disagree.



tympanometry, and re-screening and referral procedures were examined. Analysis of the frequencies used for hearing screenings showed that the two groups of hearing screeners were statistically significantly different, due to the fact that the contractual screeners tested one additional frequency. That is, the elementary school nurses were uniform in their responses of the frequencies they tested, with all but one nurse screening 500, 1000, 2000, and 4000 Hz. The majority of contractual screeners also screened these frequencies, but they included 6000 Hz. Although the reason for including this frequency cannot be explicitly determined from the survey, this inclusion is consistent with the Missouri DHSS (2004) guidelines for older students. This frequency can also be used to identify students with the early signs of noise-induced hearing loss (Niskar, Kieszak, Holmes, Esteban, Rubin, & Brody, 2001).

Interestingly, none of the published guidelines for school-based hearing screenings indicate that 500 Hz should be screened, but almost all of the respondents from both school systems indicated that they screened this frequency. Due to the ambient environmental noise in a typical school screening location, this particular frequency is often masked, thereby falsely increasing the threshold level at which students respond (Missouri DHSS, 2004; ASHA, 1997). Screening in even a moderately noisy environment often causes the hearing screener to adjust the pass/fail criteria in an effort to make the screening "fair" for the student (Roush, 1992). The responses of many of the school nurses to the survey item concerning failure criteria seem to reflect this type of adjustment. For example, one elementary school nurse wrote that her criterion was 20 dB for 1000, 2000, and 4000 Hz, but "above 30 dB" for 500 Hz. Missouri DHSS (2004) guidelines state in explicit detail that "it is not appropriate to make adjustments for a noisy environment, i.e., increasing the level of decibels above 25" (p. 14). Any adjustments to the recommended screening protocol can lead to unintentionally passing students with MHL, either sensorineural or conductive in nature (Roush, 1992; Tharpe & Bess, 1999). Hence, the modification of individual hearing screening procedures contributes to the system-wide discrepancies in hearing screening protocols (Kemper et al., 2004; McDermott & VanTassell, 1981; Roush, 1992; Sophocles & Muzzarelli, 1970).

Another example of these discrepancies could be seen with the school nurses' varied responses to intensities and failure criteria used. And even though all of the contractual screeners used 25 dB HL as the standard screening intensity (thereby showing more consistency in screening procedures), they all indicated that missing any two frequencies at this intensity level constituted a failure. This is in spite of the fact that ASHA guidelines indicate missing a single frequency requires a referral.

According to Johnson and her colleagues (1997a), "the most critical part of any hearing screening program is the follow-up" (p. 43). ASHA (1997) recommends that re-screenings take place as soon as possible following an initial failure (possibly on the same day). Missouri DHSS (2004) guidelines also recommend performing an immediate re-screening. The Missouri guidelines, however, state that re-screening can "be done up to two weeks later if the student has cold and allergy symptoms" (p. 8). This allows time for any slight middle ear disturbance caused by an upper respiratory infection to clear.

While the majority of respondents in both groups of this study described re-screening and referral procedures that were similar or involved some of the same steps, very few respondents provided the same response. In fact, none of the elementary school nurses reported following the same protocol. The majority of school nurses reported that they referred students to their PCP. However, additional responses (e.g., "I don't know," "a specialist," and "parent's choice") seem to indicate that some school nurses do not have adequate training or knowledge regarding the appropriate follow-up procedures. In contrast, the contractual screeners gave only three different responses: the school nurse, the school system's audiology office, and the PCP. It is speculated that the single source of training for these contractual screeners allowed a more stream-lined response to the question.

Missouri DHSS (2004) guidelines state that if a student is referred for a comprehensive evaluation, his or her teacher should be notified by the hearing screening professional. The classroom teacher can monitor the student more closely than the hearing screening professional because the teacher is in closer contact with the student everyday. Interestingly, only one respondent to this survey indicated that (s)he notified a student's teacher regarding a failed screening.

When addressing the third research question concerning differences in the personal opinions of the two groups of screeners regarding students with minimal hearing loss, the last four survey items were analyzed and examined. For the statement, *"There is no such entity as minimal hearing loss. In essence, these students have hearing within normal limits,"* the majority of elementary school nurses agreed with this statement and the majority of contractual screeners had no opinion.

These responses possibly indicate that neither group of hearing screeners ever received accurate, or even any, information on MHL. It is particularly important for hearing screeners to be aware of the existence and characteristics of this type of hearing loss because they are in the unique position of evaluating the hearing of students with MHL on a regular basis (for several years during elementary school). If they are not aware of the characteristics of MHL, as many of the hearing screeners in the present study appear to be, they are less likely to identify this as a hearing loss during hearing screenings.

For the statement, *"Students with minimal hearing loss will be identified through school hearing screenings,"* almost an equal number of school nurses agreed as disagreed, while the majority of contractual screeners agreed. The majority of responses again indicate that there is a lack of information provided to both groups of hearing screeners on this form of hearing loss.

Many of the elementary school nurses surveyed in this study used pass/fail criteria that were much more lenient than those recommended by ASHA and Missouri DHSS guidelines. The contractual screeners also reported using 25 dB HL instead of the 20 dB HL recommended by those guidelines. Modifications to hearing screening protocols such as these might seem to make the test "more fair" to the students, but it is essentially allowing children with unidentified MHL to pass the hearing screening.

For the statement, *"If students with minimal hearing loss pass the hearing screening, they will have no difficulties learning in the classroom,"* the majority of school nurses and contractual screeners disagreed with this statement. This is interesting in light of the fact that the majority of the respondents felt that students with MHL would actually fail (be identified through) the hearing screening. Yet, these responses indicate that many of the hearing screeners are aware that simply passing the hearing screening does not preclude further learning and listening difficulties in the classroom.

For the final statement, *"Students are not exposed to noises loud enough to create minimal hearing loss,"* statistical analyses found the only significant difference for all four statements concerning MHL. The majority of school nurses disagreed or strongly disagreed with this statement, while most of the contractual screeners either had no opinion or disagreed. It is not surprising that the school nurses responded more accurately. The National Association of School Nurses (2003) published a position statement on the issue of noise-induced hearing loss, which states that, "addressing noise induced hearing loss should be an integral part of the school nurse's responsibility" (p. 2). Therefore, it is likely that the school nurses incorporate hearing conservation as part of their job in promoting the overall health of their students. It is possible that because the contractual screeners do not have the same major role in the general health of the students, they do not know as much about hearing conservation. This is a topic in need of further study.

School-age children with minimal hearing loss often passed their newborn hearing screenings (Yoshinaga-Itano, 2006). According to Yoshinaga-Itano, it is more efficient, in terms of cost and time (due to a possible increased false positive rate), for the newborn screening equipment to pass infants with hearing better than a mild to moderate hearing loss. For this reason, it is imperative that school-based hearing screenings identify students with MHL. Strict adherence to proposed guidelines, with minimal adjustments to the screening protocol, will help to ensure that students with MHL will be identified during the hearing screening. More importantly, however, the people who conduct school-based hearing screenings need to have an accurate understanding of MHL.

This relatively small sample size may have affected some of the results of the study and due to the small number of participants, the use of statistical analyses was limited. A larger sample size might have resulted in more statistically significant differences between the two groups. Therefore, the results of this study cannot be generalized to the school-based hearing screening protocols and hearing screeners in other school systems.

Conclusions

Guidelines have been developed by national and state agencies in order to encourage greater uniformity in screening protocols. However, based on the responses of the participants in this study, these guidelines are not being followed. Even the group directly supervised by an educational audiologist incorporated some procedures that are specifically discouraged in the state and national guidelines (e.g., including 500 Hz and using 25 dB, instead of 20 dB, as the failure criteria).

Despite the lack of overall uniformity in the hearing screening protocols of the elementary school nurses and despite the direct supervision of the contractual screeners by an educational audiologist, the two groups responded similarly on the majority of the MHL survey items. It is possible that the more accurate responses from the school nurses concerning noise-induced hearing loss were due to their role as the primary healthcare professional in each elementary school. It is also possible that because the contractual screeners are directly supervised by an educational audiologist, they defer many of their questions to the expertise of the supervising audiologist. Whatever the reason, it is evident that all of these hearing screeners could benefit from more information regarding MHL.

The findings in this study lend further support to previous research on the uniformity and effectiveness of school-based hearing screenings. Very little seems to have changed in 40 years. The work and efforts that the National Conference on Identification Audiometry and ASHA have put forth throughout the years are still not being uniformly embraced and used. Earlier studies found that different schools, even those within the same school system, followed different hearing screening protocols (Kemper et al., 2004; McDermott & Van Tassell, 1981; Roush, 1992; Sophocles & Muzzarelli, 1970). The present study supported these findings. This study also showed that in a school system with no common source of training or supervision, there was great variation in the protocols used by the individuals who conduct the hearing screenings. In a school system in which all of the hearing screeners had a single supervisor (an educational audiologist and the primary person in charge of training), the protocol was much more uniform.

It can be concluded that supervision by an educational audiologist can lead to more uniform screening protocols. A uniform screening protocol for an entire school system should result in more accurate screening results, a better system for referrals, and proper diagnoses. Therefore, the presence of educational audiologists in the school setting (especially during the screening process) would be beneficial for students with previously undiagnosed hearing loss, including MHL.

Future Studies

Several areas of further research were identified throughout the course of this study. A follow-up survey of the contractual hearing screeners who chose not to respond to questions on MHL may provide more insight into the reasons why these participants felt they were unqualified to offer their opinions on this topic. It would also be valuable to gather more information on the hearing screeners' understanding of and experience with students who have hearing loss, especially MHL. Additionally, further research should examine the opinions of clinical and educational audiologists on issues related to MHL.

This study revealed that some hearing screeners, even when supervised by an audiologist, do not adhere to published screening guidelines. Again, it would be advantageous to determine if audiologists themselves follow the protocols put forth by ASHA and other state organizations, or if they also make modifications based on the screening situation. Lastly, due to the lack of exposure of some elementary school nurses to audiologists, it might also be beneficial to survey audiologists on the interactions they have had with nurses who conduct school hearing screenings.

Acknowledgements

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Appendix A

Survey for Hearing Screeners

DEMOGRAPHIC INFORMATION:

Job Title____

Job responsibilities ____
____

At how many schools do you perform hearing screenings?___________

How long have you held this position?________________________

Please answer the following questions about hearing screenings. Feel free to make comments in the margins or at the end of the survey.

1. If applicable, who helps perform the hearing screenings for grades K through 3rd ? (Circle all that apply)

Nurses Parents/Volunteers
Teachers Teacher's aide
Speech-Language Pathologists Audiologists from surrounding areas
Special Education Teachers University Students
Other____

2. Where are the hearing screenings conducted? (Circle all that apply)

Library Classrooms Office Area
Hallways Closet Cafeteria
Auditorium/Gym Trailer brought in by contractor of services
Band Hall/Choir Room Other____________________________

3. How would you describe the noise levels where the hearing screenings are provided? (Circle one)

1 2 3 4 5 6 7 8 9 10
very soft average very loud

4. How often are the hearing screenings typically conducted? (Circle one)

Once during a school-year Twice during a school-year
Three times during a school-year Only when needed
Other_________________________

5. What students are screened? (Circle all that apply)
Kindergarten 1st grade 2nd grade
3rd grade 4th grade 5th grade
Special Education New Students
Other________________________

6. When are the hearing screenings conducted? (Circle one)

Fall Spring Other_________________

7. During the hearing screening procedure...

   a. what frequencies are tested?

   b. what intensity levels are tested?

   c. what criteria are used for failing?

   d. how many children are tested at one time (in the same room if there are multiple screeners)?

   e. is middle ear screening (tympanometry) used? YES NO

   f. is otoscopy (looking into the ear canal) used? YES NO

8. Where did you get the information regarding the procedure that you follow during a hearing screening? (Circle all that apply)

State Guidelines American Speech-Language-Hearing Association Guidelines
School Policy I was shown this procedure by the previous hearing screener
I don't know In-service training Other____

9. Approximately how many children are screened every year per elementary school? __________________

10. During the most recent hearing screening, how many children failed the screening?
(Fill in for all schools, if you screen at more than one.)
#______ at school 1 #______ at school 7
#______ at school 2 #______ at school 8
#______ at school 3 #______ at school 9
#______ at school 4 #______ at school 10
#______ at school 5
#______ at school 6

Add more if necessary ____

____

11. Please describe the procedure you follow when a child fails a hearing screening. Please include information about re-testing days, follow-up times, and referrals.

12. If a child is referred for failing a screening, to whom is that child referred?

13. When a child is absent on the screening day, what actions are taken, if any.

PLEASE READ THIS STATEMENT:
When children are tested for hearing impairment, they are presented with tones at soft levels (0 – 25 dB HL) across a range of pitches (low to high). Children who can hear at these levels are considered to have normal thresholds of hearing. However, some people believe that having hearing thresholds in the 16-25 dB HL range can affect children's speech development and learning capabilities. Therefore, this range has been named the range of "minimal hearing impairment."

WITH THIS INFORMATION, PLEASE USE THE FOLLOWING FIVE-POINT SCALE TO RESPOND TO THE STATEMENTS BELOW. CIRCLE YOUR ANSWER. ONE ANSWER ONLY, PLEASE.

(1) strongly agree (2) agree (3) neutral (4) disagree (5) strongly disagree

14. There is no such entity as minimal hearing impairment. In essence, these students have hearing within normal limits.

(1) strongly agree (2) agree (3) no opinion (4) disagree (5) strongly disagree

15. Students with minimal hearing impairment will be identified through school hearing screenings.

(1) strongly agree (2) agree (3) no opinion (4) disagree (5) strongly disagree

16. If students with minimal hearing impairment pass the hearing screening, they will have no difficulties learning in the classroom.

(1) strongly agree (2) agree (3) no opinion (4) disagree (5) strongly disagree

17. Students are not exposed to noises loud enough to create minimal hearing impairment.

(1) strongly agree (2) agree (3) no opinion (4) disagree (5) strongly disagree

Additional comments.____

____

____

Thank you for completing this survey.

Clinical Evluation of a Verification Strategy for Personal FM Systems and Nonlinear Hearing Aids

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The primary aim of this study was to characterize the problems that may arise when following the ASHA 2002 guideline for fitting of FM systems to conduct electroacoustic verification of the FM advantage provided by nonlinear hearing aids. Electroacoustic output of FM systems coupled to nonlinear digital hearing aids was determined using the ASHA recommended procedure. When the ASHA recommended +10 dB FM advantage was not obtained, gain of the FM receiver was adjusted and additional electroacoustic measurements were conducted to illustrate changes in output, distortion, and equivalent input noise that may occur when increases in FM receiver gain are provided.

Introduction

The use of a frequency-modulated (FM) system is an effective method to improve speech recognition in noise for children and adults using personal hearing aids (HAs) (Boothroyd & Iglehart, 1998; Hawkins, 1984; Lewis, Crandell, Valente, & Horn, 2004; Pittman, Lewis, Hoover, & Stelmachowicz, 1999). Additionally, personal FM systems can alleviate difficulties associated with communication in reverberant environments and in situations in which the signal of interest is located at a distance from the HA user (Nabelek & Mason, 1981). Children and adults alike can benefit from the use of a personal FM system, but the most widespread application of FM technology is for children in academic settings.

With most types of personal FM systems, an environmental microphone is active on the users' HAs or FM receiver to allow access to signals in the immediate environment, particularly for situations in which the microphone of the FM system is located at a relatively great distance from the user. The system can typically be configured to operate in one of three modes: (1) HA only: the output only includes signals delivered to the environmental microphone, (2) FM only: the output only includes signals delivered to the FM microphone, and (3) HA + FM: the output includes signals delivered to the environmental microphone and to the FM microphone.

Using a personal FM system in the "FM only" mode typically results in an improvement of 20 dB or greater in the signal-to-noise ratio relative to the HA alone (Dillon, 2001). However, the wearer has limited audibility for his/her own voice or to sounds originating from the immediate environment, especially if the FM microphone is located at a relatively great distance from the wearer. In a classroom setting, the "FM only" mode offers access to the teacher's voice (assuming the teacher is using the FM transmitter), but it may limit a child's access to the responses of other children in the class. As such, personal FM systems are frequently used in the "HA + FM" mode, allowing the user consistent audibility for all sounds in the environment. In the "HA + FM" mode, the signal-to-noise ratio decreases significantly from that obtained in the "FM only" mode. Hawkins (1984) showed that the typical improvement in the signal-to-noise ratio obtained when using an FM system in the "HA + FM" mode was 4 to 7 dB, a decrease of approximately 13 dB from that obtained in the "FM only" mode. Furthermore, Hawkins found no difference in speech-recognition-in-noise scores between the "HA only" mode and the "HA + FM" mode. The lack of difference between these two conditions may be due to the fact that the relationship of the FM signal to the HA signal was not optimized.

Audiologists are responsible for setting the electroacoustic parameters of personal FM systems so that the signal of interest becomes audible in the presence of noise and reverberation, as well as when the signal originates from a great distance. While the main focus is on the signal of interest, the system should also enable access to other important environmental sounds. The American Speech-Language Hearing Association (ASHA) Ad Hoc committee developed guidelines to assist audiologists in the electroacoustic evaluation and fitting of personal FM systems (ASHA, 2002). The ASHA Guidelines for Fitting and Monitoring FM Systems refers to the FM advantage as the difference in output of the HA for a typical input to the FM microphone (i.e., 80 dB to 85 dB SPL) compared to the output of the HA for a typical input to the HA microphone (65 dB SPL). The guideline recommends an FM advantage of 10 dB, so that the output of the HA for a typical input to the FM microphone is 10 dB greater than the output of the HA for a typical input to the HA microphone.

To evaluate the FM advantage, ASHA (2002) recommends that a series of electroacoustic measures be conducted. Calibrated real speech is the preferred choice of signal for the assessment of digital hearing aids. First, the output of the HA is measured for an input signal of 65 dB SPL presented to the HA microphone. This measure is made without the FM receiver coupled to the HA. Then, the FM receiver is coupled to the HA, and the output of the HA is measured for a 65 dB SPL signal delivered to the FM microphone only. ASHA recommends that the outputs of the HA be identical for these two measures. It may also be prudent to measure the output of the HA for a 65 dB SPL signal presented to the HA microphone while the FM receiver is coupled to the aid. Once again, the output should be identical to the first measurement. This measure is important, as the addition of the FM receiver to a HA may change the output characteristics of the HA if a significant impedance mismatch exists between the HA and FM receiver. Finally, an 80 dB SPL signal is presented to the FM microphone and the output of the HA measured (while the FM receiver is coupled to the aid). It should be noted that the intensity of the signal may vary depending upon the placement of the FM microphone, with a higher level typically chosen if a boom microphone placement is employed. Ideally, the output of this measure should be 10 dB greater than the previous measures. Contemporary personal FM systems are coupled directly to users' personal HAs by way of direct-auditory input (DAI). Some systems allow the audiologist to adjust the gain of the FM receiver to maximize the FM advantage, providing greater flexibility to optimize audibility.

Prior to the publication of the 2002 ASHA guidelines, most HAs provided linear amplification. Because the same amount of gain was applied to the input signal until the point of output limitation, measurements of output using sequential inputs (ASHA procedure) were appropriate for determining FM advantage. For example, for a HA that provides 30 dB of gain, a 65 dB SPL input to the HA alone should result in an output of 95 dB SPL. When the FM receiver is coupled to the same HA, and an 80 dB SPL is provided to the FM transmitter microphone, the HA output should be approximately 105 dB SPL . Subtracting the two outputs (105-95) results in an FM advantage of 10 dB.

Currently, most HAs possess nonlinear amplification so that the gain may vary across a wide range of input levels. Nonlinear amplification has a varied effect on signals delivered at different intensities in a sequential test format; therefore, the FM advantage may be compromised. A 65 dB SPL input to a HA that provides 30 dB of gain (2:1 compression ratio) will have an output of 95 dB SPL, while an 80 dB SPL input to the transmitter microphone will result in an output of 100 dB SPL. Effects of the nonlinear amplification allow for a 5 dB FM advantage as measured in a sequential test approach. However, in realistic use, the signal from the hearing aid microphone and the signal from the FM transmitter are processed at the same time, and each receives the same amount of compression (the amount of which is determined by the signal with the greatest intensity). As such, nonlinear amplification seems to decrease the FM advantage when evaluated with sequential measurements, but it does not affect the FM advantage of a personal FM system in realistic use. This is because input signals arriving at the FM microphone and HA microphone simultaneously receive the same amount of compression.

Several researchers have noted the limitations of using a sequential test protocol (i.e., the ASHA procedure) to assess the FM advantage provided by contemporary HAs (Hostler, 2004; Lewis & Eiten, 2004; Platz, 2004). In fact, Lewis and Eiten (2004) have noted that when using the sequential test approach with nonlinear HAs, the attainment of an FM advantage of at least 5 dB is appropriate and will correspond to a larger FM advantage when signals are delivered to the FM microphone and hearing aid microphone simultaneously (which occurs in realistic use). Platz (2006) and Lewis (2006) have demonstrated that nonlinear hearing aids that provide a 10 dB FM advantage in realistic situations (with simultaneous presentation of inputs to the HA microphone and FM microphone) may provide anywhere from a +3 to +10 dB FM advantage when measured with the sequential approach. Furthermore, Hostler (2004) has indicated that attempts to increase the gain of contemporary FM transmitters to provide a 10 dB FM advantage frequently results in substantial increases in distortion and equivalent input noise (EIN). This may be particularly concerning for users who have severe to profound hearing loss and a narrow dynamic range in which to present amplified speech. There are, however, no reports that quantify the effects of using the ASHA 2002 procedure for verification of personal FM systems with contemporary hearing aids.

Given the concerns of previous researchers regarding sequential electroacoustic procedures (Hostler, 2004; Lewis & Eiten, 2004; Platz, 2004), the primary aim of this study was to characterize the problems that may arise when following the ASHA 2002 guidelines for electroacoustic verification of the FM advantage provided by nonlinear HAs. Electroacoustic output of contemporary personal FM systems coupled to nonlinear HAs at default settings was determined using the ASHA recommended procedure (2002). When the ASHA recommended +10 dB FM advantage was not obtained for these systems, the gain of the FM receiver was adjusted (as suggested by the ASHA procedure), and additional electroacoustic measurements were conducted to illustrate changes in output, distortion, and EIN that may occur when increases in FM receiver gain recommended by the ASHA procedure are provided.

Method

Equipment

Electroacoustic measurements were performed for 12 digital HAs coupled to two FM systems. The HAs were from four manufacturers as shown in the Appendix (designated as Aid A, B, C, and D). Within each manufacturer, three types of digital HAs were selected: low-end, high-end, and power-digital model. For example, within the Manufacturer A group, there were three hearing aid types: “LowA,” “HighA,” and “PowerA.” Two personal FM systems (FMTx1 and FMTx2) were selected, and boots or DAI shoes were obtained so that every HA but one (the “HighB”) could be assessed with each FM system. The “HighB” HA could not be coupled to the FMTx1 system; therefore, no data were obtained for this configuration. The measures were made with each HA programmed for two degrees of hearing loss: a flat moderate sensorineural hearing loss (45 dB HL pure tone thresholds from 250 to 4000 Hz) and a flat severe sensorineural hearing loss (80 dB HL pure tone thresholds from 250 to 4000 Hz). Because one of the HAs used in this study could only be coupled to transmitter “FMTx1,” 46 series of measurements were conducted.

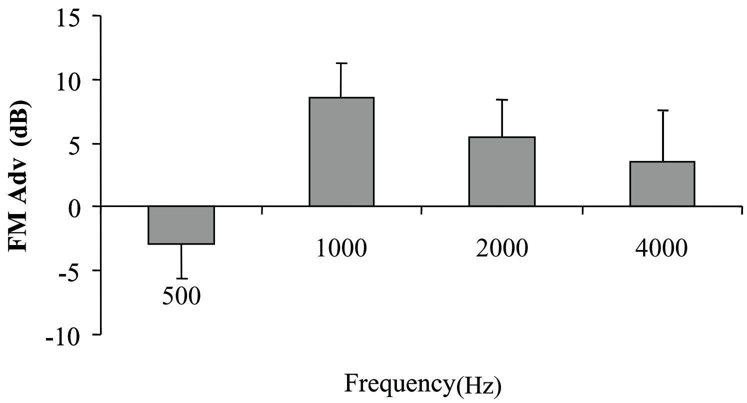
The electroacoustic assessment of the FM advantage was conducted with the Audioscan Verifit HA analyzer and a HA-2 coupler. Measures of EIN and total harmonic distortion (THD) were also conducted. The microphone of the HA and FM system were placed next to the reference microphone in accordance with the recommendations of the test box manufacturer.

Procedures

A modified version of the ASHA electroacoustic verification protocol was used to assess the FM advantage. First, the output of each HA was measured for a 65 dB SPL input signal presented to the HA microphone using the speech-shaped signal available within the Audioscan Verifit system. The output of each HA was adjusted to match the Desired Sensation Level (DSL) I/O 4.1 target (Cornelisse, Seewald, & Jamieson , 1995) for average conversational level speech, and the maximum output of each HA was set so as not to exceed the predicted uncomfortable loudness level as indicated by DSL I/O 4.1. The signal processing characteristics and compression parameters of each HA were set to manufacturer defaults for the hearing loss entered into the programming software. Secondly, an FM receiver set to the manufacturer default (+10 FM advantage) was coupled to the HA, and the output of the HA was measured for a 65 dB SPL speech-shaped signal presented to the HA microphone. This measure was conducted to ensure that the addition of the FM receiver did not change the output of the HA for inputs delivered to the HA microphone. Finally, an 85 dB SPL speech-shaped signal was presented to the FM microphone, and the output of the HA was measured. An 85 dB SPL was the default signal level for assessment of FM systems in the Audioscan Verifit system, and Dillon (2001) suggested that 85 dB SPL represents a typical input level to an FM microphone positioned 6 to 8 inches from the speaker’s mouth. All measures were made with the hearing aid in the FM +HA mode.

Measurements for each FM and HA combination were conducted at octave frequencies from 500 to 4000 Hz. The FM advantage was defined as the difference in output averaged at 1000 and 2000 Hz

Figure 1. Mean FM advantage (Adv) obtained across all hearing aid and FM transmitter combinations (forty-six conditions) with FM receivers set at default settings.



between each measurement (Formula: average output at 1000 and 2000 Hz for 85 dB SPL signal delivered to FM microphone – average output at 1000 and 2000 Hz for 65 dB SPL delivered to HA microphone while coupled to FM receiver = FM Advantage). The FM advantage recorded with the FM receiver set to default settings was noted as FM Advantage 1. The 1000 and 2000 Hz criteria were selected given their importance for speech intelligibility (French & Steinberg, 1947) and their test-retest reliability (Lewis, 2006). In addition, the EIN and THD were measured for each HA while the FM receiver was coupled to the aid.

If the measured FM advantage (average at 1000 and 2000 Hz) did not meet or exceed 9.5 dB, then the gain of the FM receiver was increased in an attempt to achieve the ASHA recommended +10 dB FM advantage. If the recommended +10 dB FM advantage was not be obtained, the maximum FM advantage for the HA was recorded. The FM advantage recorded after necessary adjustments were made was denoted as FM Advantage 2. Finally, EIN and THD measures were repeated with the FM receiver gain set at the revised setting.

Results

FM Advantage 1

The mean FM advantage for all octave frequencies from 500 to 4000 Hz of the 46 measurements is provided in Figure 1. The minimum FM advantage occurred at 500 Hz (-3 dB), while the maximum FM advantage occurred at 1000 Hz (8.6 dB). Analysis of variance (ANOVA) was conducted and showed a statistically significant difference in the FM advantages as a function of frequency ($p < .0001$). Post-hoc analysis (Tukey) indicated a significantly lower FM advantage at 500 Hz relative to all other frequencies, and a significantly higher FM advantage at 1000 Hz relative to other frequencies. No significant difference was detected between the FM advantages at 2000 and 4000 Hz.

FM Advantage 1: Comparisons across Aids, Manufacturers, and Severities of Hearing Loss

An analysis of variance (ANOVA) was used to examine four main effects: HA manufacturer (Aid A, B, C, and D), HA type (power, high-end DSP, and low-end DSP), hearing loss (45 or 80 dB HL), and FM system manufacturer (FM1 or FM2). The two dependent variables were FM Advantage 1 (mean FM advantage at 1000 and 2000 Hz with FM receiver at default settings) and FM Advantage 2 (mean FM advantage at 1000 and 2000 Hz obtained after necessary adjustment of FM receiver).

Overall, the mean FM Advantage 1 for conditions assessed was 6.98 dB ($SD = 1.96$), with a range of 2.5 to 10.5 dB. Of the 46 conditions evaluated, eight had an FM Advantage 1 of 9.5 dB or greater. The ASHA recommended +10 dB FM Advantage 1 was obtained for six HA and FM system combinations in the 45 dB HL hearing loss group and two HA/personal FM system combinations in the 80 dB HL group.

Mean FM Advantage 1 for each level of the four main effects is provided in Figures 2a-2d. Analysis of variance for FM Advantage 1 indicated that the only statistically significant main effect was HA manufacturer ($F = 31.88$, $p < .0001$). Additionally, a statistically significant interaction was found between HA manufacturer and HA type ($F = 9.65$, $p < .0001$).

The mean FM Advantage 1 for the different HA types across the four HA manufacturers is provided in Figure 3. Post-hoc tests (Tukey) were performed for HA manufacturers using reduced data sets where the HA type was held constant. The results of the post-hoc testing are provided in Figure 4 with non-significant differences between HA manufacturers denoted by connecting lines.

Although the primary dependent variable of interest was the average FM Advantage 1 obtained between 1000 and 2000 Hz, a statistically significant interaction occurred between personal FM system and frequency ($F = 16.6$, $p < .0001$). Mean FM Advantage 1 for each FM transmitter as a function of frequency are provided in Figure 5. Pair-wise comparisons indicated that the FM advantage 1 was higher for FMTx1 at 1000 Hz and below ($p < .0001$), while the FM advantage was higher for FMTx2 for frequencies higher than 1000 Hz ($p < .0001$).

Figure 2. Mean FM advantage (Adv) 1 for 1000 and 2000 Hz with FM receiver set at default settings for each (a) degree of hearing loss, (b) type of hearing instrument, (c) FM transmitter, and (d) hearing aid manufacturer.

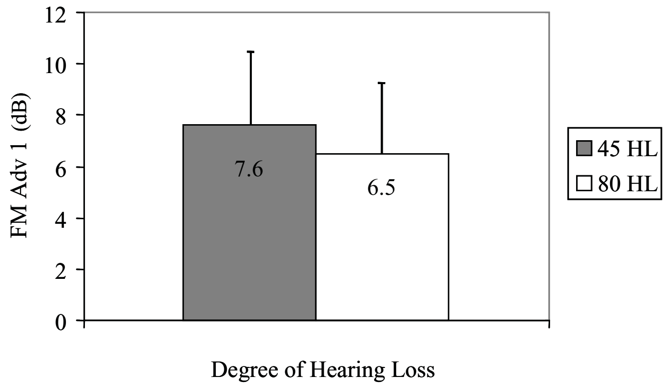


Figure 2 A.

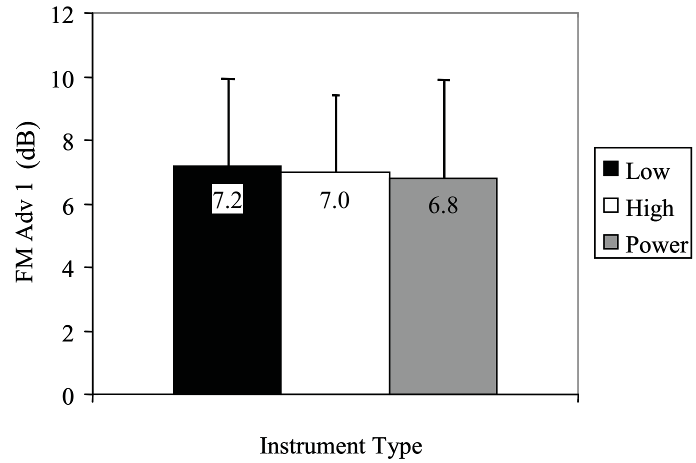


Figure 2 B.

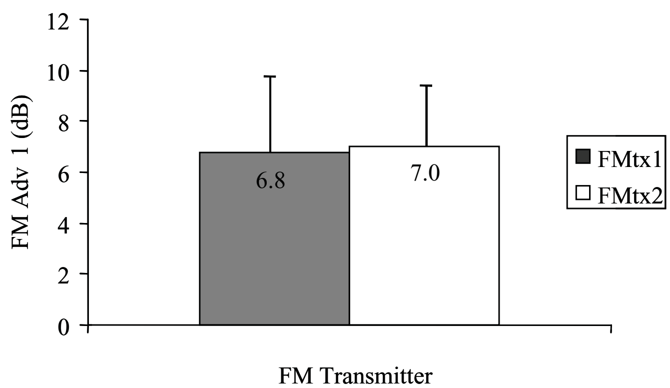


Figure 2 C.

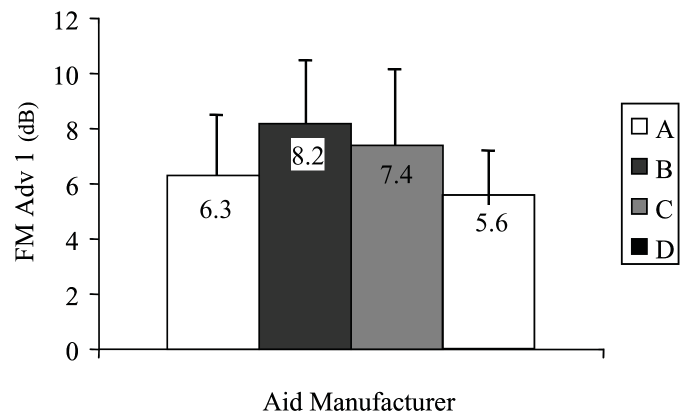


Figure 2 D.

FM Advantage 2: Comparisons across Aids, Manufacturers, and Severities of Hearing Loss

For the 38 conditions in which the ASHA recommended +10 FM advantage was not achieved, the gain of the receiver was increased in an attempt to achieve the desired advantage. The FM advantage measurements obtained after these adjustments were referred to as FM Advantage2. Twenty-five of these conditions did not achieve an FM advantage of +10 dB despite a maximum increase in FM receiver gain. The mean FM Advantage 2 with all aids included was 8.66 dB (SD = 1.92). An ANOVA was conducted for FM Advantage 2 and showed no statistically significant differences ($p > .05$) or interactions among the four main effects (hearing aid manufacturer, hearing aid type, FM system, or degree of hearing loss). The mean FM Advantage 2 is provided for each of the four main effects in Figure 6a-6d.

After the FM Advantage 2 measurements were completed, the change in EIN and THD at 500 and 800 Hz were determined by subtracting measurements from the default setting. The mean increase in EIN following adjustment of the FM receiver gain was 5.6 dB (SD = 4), while the mean increase in the THD was 9.7% (SD = 9.4) and 8.4% (SD = 12.9) at 500 and 800 Hz, respectively. The range of change in the EIN was zero to 15.4 dB, while the range for the change in THD was zero to 42.2% and zero to 48% at 500 and 800 Hz, respectively. An ANOVA indicated no statistically significant differences in the change in EIN or THD from the default setting to the adjusted setting for any of the main effects ($p > .05$).

Discussion

FM Advantage as Measured with ASHA Verification Approach

A commercially available HA analyzer, the Audioscan Verifit, was used to measure the average FM advantage of several contemporary HAs possessing digital signal processing. Measurement of the FM advantage was accomplished using a sequential assessment protocol, as recommended in the ASHA Guidelines for Fitting and Monitoring of FM Systems (2002). The average FM advantage at 1000 and 2000 Hz did not meet the ASHA recommendation of +10 dB for 38 of 46 HA conditions when the FM receiver was set at the manufacturer default settings. No significant differences were detected in the average FM advantage at 1000 and 2000 Hz when the HAs were set for either a mild or severe degree of hearing loss. For the severe hearing loss programming used in this study, the dynamic range (range between threshold and loudness discomfort level) exceeded 30 dB. Therefore, average conversational speech could be amplified within this dynamic range (available headrowom). It is probable that a profound hearing loss, with a smaller dynamic range, would not allow for full audibility of average conversational level or the ability to achieve a +10 dB FM advantage.

No significant difference was detected in the mean FM advantage at 1000 and 2000 Hz between the two personal FM systems or for the various types of HAs that were evaluated (i.e., low-end, high-end, and power aid). There was, however, a statistically significant difference in the mean FM advantage between the various manufacturers of HAs used in this study, which was likely attributable to two factors. First, when evaluated at default settings, the HAs of Manufacturer B had higher FM advantages than the HAs of the other manufacturers. Two of the HAs of Manufacturer B had separate analog-to-digital (A/D) converters for the input from the HA and FM microphones, resulting in independent control of the output of each A/D converter. As such, the HAs were designed to maintain a difference (i.e., 10 dB FM advantage) for conversational speech between the HA and FM microphones. The output is maintained regardless of whether a sequential or simultaneous verification procedure is used. The HAs of the other manufacturers were designed so that the signal from the HA and FM system were processed by the same amplifier. Consequently, the compression of the two signals will likely be different for a nonlinear HA when using a sequential evaluation approach.

Another factor contributing to differences among HA manufacturers was the varying compression characteristics in the HAs. For example, Aid D possessed a relatively low compression threshold and high compression ratio, and it also possessed the lowest FM advantage amongst the four HA manufacturers. Therefore, the amount of compression for the FM signal is greater for this manufacturer compared to the other manufacturers. In a sequential verification approach, the increased amount of compression results in the appearance of a lower FM advantage. In realistic situations, however, the HA and FM system signals will be processed simultaneously, and the same amount of compression will be applied to each. Therefore, the FM advantage obtained when using a sequential test approach for nonlinear HAs may not be representative of what is achieved in everyday listening situations.

One way to achieve the desired +10 dB FM advantage is to use an adjustable gain feature available on some FM receivers. In this study, increasing the gain of the FM receiver occasionally produced detrimental outcomes. For instance, increasing the gain of the FM receiver typically resulted in an increase in the internal noise, which corresponded to the magnitude of the gain increase. Increases in EIN of at least 3 dB were observed in 27 of the 38 hearing aid/FM conditions in which the gain of the FM receiver was increased to achieve the ASHA recommended +10 dB FM advantage. The difference in the EIN following the adjustment in the FM receiver gain ranged from no change to an increase of 26 dB. The mean increase in EIN was 5.6 dB

Figure 3. Mean FM Advantage (Adv) 1 for 1000 and 2000 Hz for each type of hearing aid across four different hearing aid manufacturers (FM receiver set at default settings).

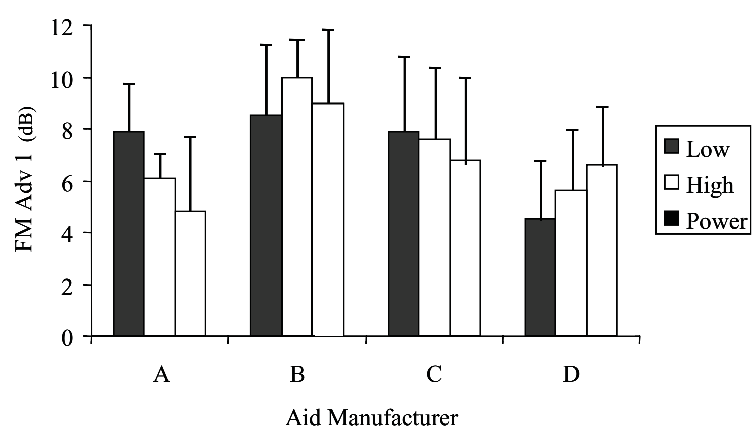
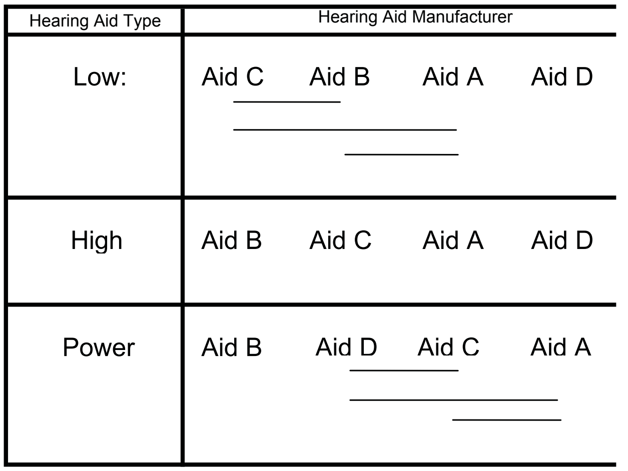


Figure 4. Results of Tukey analysis examining differences between hearing aid manuafacturers across type of hearing aid.



Note. Non-significant differences are denoted by connecting lines

(SD = 5.7 dB). A paired Student's t-test indicated that the difference in EIN measured before and after the adjustment of the gain of the FM receiver was statistically significant ($p < .001$). Larger increases in EIN were typically observed as larger increases in the adjustable gain in the receiver were implemented. This increase in internal noise may affect sound quality and potentially speech recognition in quiet environments. It should be noted that the ANSI S3.22-1996 standard for the measurement of hearing aid performance does express concern with the use of the EIN test with hearing aids possessing nonlinear signal processing. Specifically, the ANSI S3.22-1996 standard suggests that EIN values may be exaggerated when using nonlinear hearing aids. The possibility does exist that a portion of the increase in EIN observed with changes in FM receiver gain may be attributed to the exaggeration associated with nonlinear hearing aids.

Increases in THD were also observed for 31 of the 38 hearing aid/FM conditions in which the gain of the FM receiver was increased to achieve a +10 dB FM advantage. The increase in distortion was most severe when the FM receiver was set to the maximum setting. Also, this increase (mean increase of approximately 9%) often exceeded the acceptable THD level, as recommended by Dillon (2001). Comprehensive evaluation of the performance of an FM system should include not only an electroacoustic analysis but also a biologic listening assessment to check for artifacts or distortion that may elude the electroacoustic evaluation.

Effectiveness of ASHA Guidelines for Hearing Aids with Nonlinear Signal Processing

Several researchers have expressed concern regarding the limitations of using a sequential test protocol, such as the ASHA (2002) procedure, for the evaluation of contemporary nonlinear HAs (Hostler, 2004; Lewis, Feigin, Karasek, & Stelmachowicz, 1991; Platz, 2004, 2006). Indeed, this paper suggests that it is difficult to obtain the recommended 10 dB FM advantage when using the ASHA procedure with contemporary nonlinear hearing aids. Furthermore, attempts to attain the recommended 10 dB FM advantage through increases in the gain of the FM receiver may result in undesirable consequences, such as increases in internal noise and distortion. Finally, investigators have shown that attainment of a 10 dB FM advantage when using the ASHA (2002) procedure may result in an inappropriately high FM advantage in realistic situations (Lewis and Eiten, 2006). Keep in mind that attainment of a 10 dB FM advantage is still a reasonable goal with nonlinear hearing aids coupled to personal FM systems. In fact, Platz (2006) Lewis (2006) both showed that the 10 dB FM advantage is achievable with nonlinear hearing aids when signals arrive at the hearing aid microphone and FM microphone simultaneously. Because of this, there is a need for a new method to assess the FM advantage obtained with nonlinear hearing aids.

Several alternatives have been proposed and focus on simultaneous presentation of test signals to the HA and FM microphones. These arrangements

Figure 5. Mean FM Advantage 1 obtained for two different personal FM systems across frequency with the FM receiver gain set at default settings

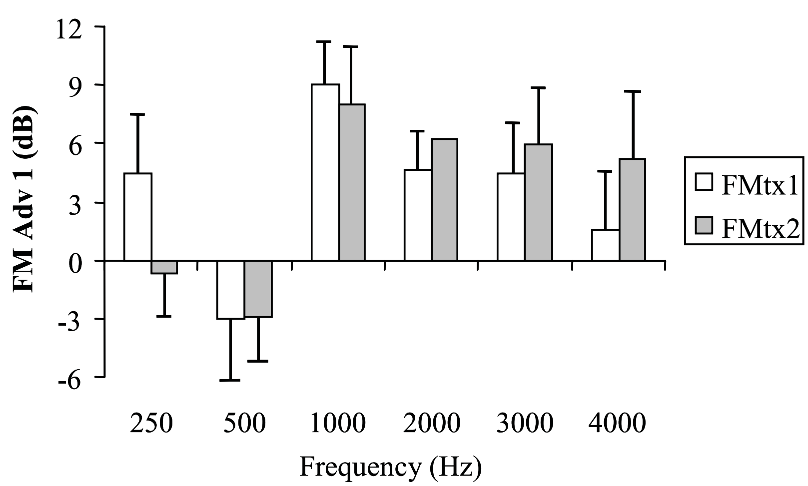


Figure 6. Mean FM Advantage (Adv) 2 for 1000 and 2000 Hz with FM receiver set at the adjusted FM receiver settings for each (a) degree of hearing loss, (b) type of hearing instrument, (c) FM transmitter, and (d) hearing aid manufacturer.

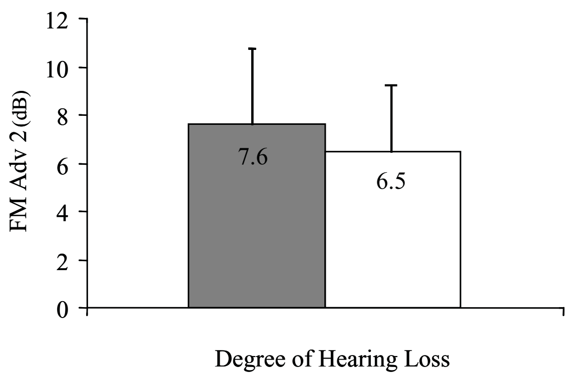


Figure 6 A.

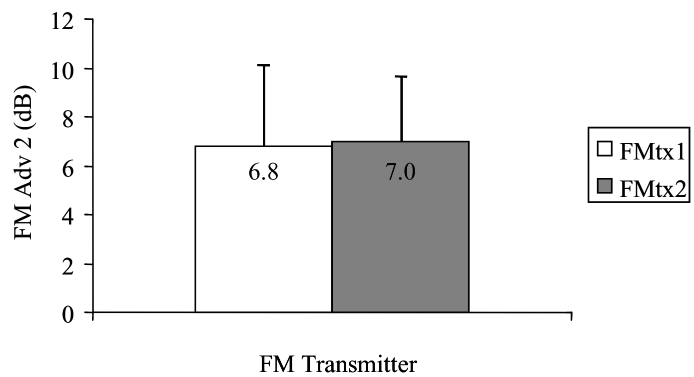


Figure 6 C.

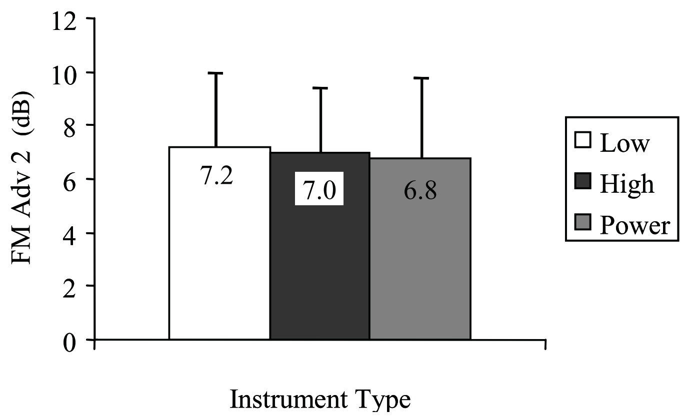


Figure 6 B.

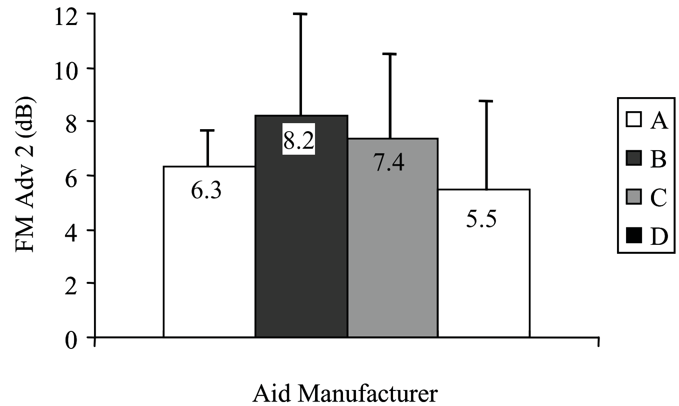


Figure 6 D.

will provide a more valid testing situation and should theoretically result in the same amount of compression at each microphone. Until technology evolves to allow for that type of assessment, other approaches have been proposed.

Lewis and Eiten (2004) described an approach where the output of the HA and FM system are each determined in response to a 65 dB SPL signal. If the output is identical, then inputs to the transmitter and HA microphones are believed to be compressed by the same amount. In contrast, when output differs by more than + 2 dB, the FM advantage setting on the FM receiver should be adjusted until similar output is measured. Then, when the relative distances of the transmitter (3-6 in.) and HA microphone (3 ft.) are in place, an FM advantage should be present. In addition, an FM advantage of +5 dB may be sufficient to allow for a perceptual benefit in noisy environments. Lewis and Eiten compared the ASHA protocol (2002) to the newly proposed protocol for three HAs with different characteristics (A-high compression threshold/ low compression ratio, B-separate processing path for FM system and HA to maintain +10 dB FM advantage, C-low compression threshold/ high compression ratio). When using the ASHA protocol, the FM advantage for the three HAs programmed for a 45 dB HL hearing loss was 8, 10, and 4.5 dB, respectively. When the same HAs were evaluated using the approach suggested by Lewis and Eiten, all three HAs produced a similar output for a 65 dB SPL signal presented to both the HA and FM system microphones. Consequently, in realistic use, the three HAs provided a comparable FM advantage even though they appeared to be very different when using the ASHA approach.

Currently, the verification approach described by Lewis and Eiten (2004) presents an effective and clinically feasible approach for evaluating the FM advantage of personal FM systems coupled to personal HAs. Additionally, Auriemmo, Keenan, Passerieux,

& Kuk (2005) described a well-designed protocol for electroacoustic verification of personal FM systems for use with contemporary digital hearing aids. Finally, Platz (2006) also described an innovative approach to assess the FM advantage of contemporary systems, but the approach requires multiple HA analyzers making it impractical for some audiology clinics. Recognizing the need for new procedures for the fitting and verification of FM systems, an American Academy of Audiology taskforce of researchers in the area of Hearing Assistance Technology (HAT) are in the process of developing new guidelines (Deconde Johnson, Anderson, Boothroyd, Eiten, Gabbard, Thibodeau , 2007). Until the new guidelines are published, the prudent audiologist must continually be aware of contemporary verification strategies for personal FM systems and sophisticated digital hearing aids, as well as changes and improvements in HA analyzer technology that will allow for a more direct assessment of FM performance.

FM Advantage as a Function of Frequency

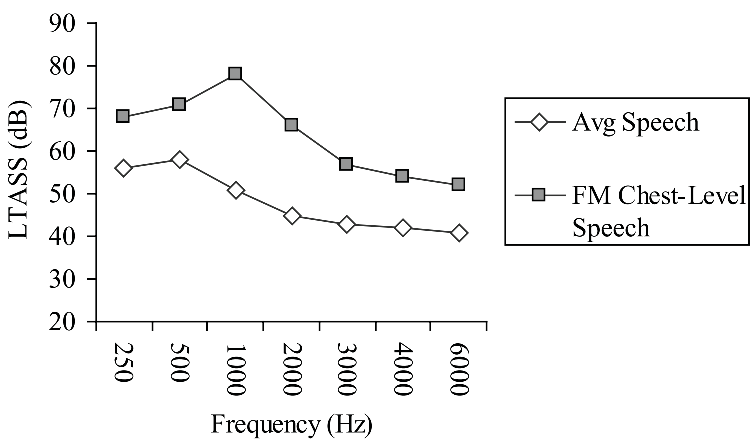
Results of this study showed that FM advantage varied as a function of frequency. Specifically, the FM advantage was greater between 750 and 2000 Hz relative to other frequencies. Differences may be attributed to input level, location of the microphones, and compression characteristics. First, the spectrum of the input stimulus at the two test levels, 65 and 85 dB SPL, is different (see Figure 7). Second, the intensity and the spectrum of the signal are altered at the two microphones because of the relative location of the FM system and HA. Finally, the compression characteristics of the HA will affect the FM advantage measured when using a sequential verification protocol. If compression ratios differ across channels of a nonlinear HA, then the FM advantage will be affected differentially across the frequency range.

In summary, the FM advantage obtained when evaluating contemporary HAs and FM systems with currently available HA analyzers using speech-like signals will vary as a function of frequency. It is most effective to focus FM advantage measurements to a specific area of the spectrum where FM advantages are often higher (750-2000 Hz). As previously noted, for this study, FM advantage was obtained at 1000 and 2000 Hz because the test-retest reliability was shown to be good at those frequencies relative to other frequencies (Lewis, 2006).

Conclusion

Given the advancement of HAs using digital signal processing, new testing protocols need to be established to account for varied results found using the ASHA protocol (2002). Results of this study show that the desired +10 dB FM advantage was not achieved in many HAs, and large differences were found across different manufacturers. Attempts to obtain a +10 dB FM advantage through adjustments of the FM receiver setting were successful, but often resulted in an increase in the internal noise and distortion. Modern HAs typically possess nonlinear signal processing, and as a result, the FM advantage obtained in a sequential assessment approach using different levels may underestimate the FM advantage obtained during use in most realistic situations. Therefore, these authors believe that clinicians should exercise caution in using the ASHA 2002 procedure for all WDRC hearing aids. Although, several researchers have described alternative approaches to evaluating the FM advantage with contemporary HAs, audiologists and manufacturers must continue to develop and implement clinically practical electroacoustic verification protocols for the assessment of FM performance with modern HAs and personal FM systems.

Figure 7. Long-term average speech spectrum (LTASS) for the average conversational level (65 dB SPL) and FM Chest-level Speech-shaped (85 dB SPL) signal of the Audioscan Verifit.



Acknowledgements

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Appendix
Hearing Aid/FM Technology Conditions

Hearing Aid Manufacturer	Hearing Aid Type	FM System	Hearing Loss
A	High-end Digital	FMTx1	Mild
A	Low-end Digital	FMTx1	Mild
A	Power Digital	FMTx1	Mild
A	High-end Digital	FMTx2	Mild
A	Low-end Digital	FMTx2	Mild
A	Power Digital	FMTx2	Mild
B	High-end Digital	FMTx1	Mild
B	Low-end Digital	FMTx1	Mild
B	Power Digital	FMTx1	Mild
B	High-end Digital	FMTx2	Mild
B	Low-end Digital	FMTx2	Mild
B	Power Digital	FMTx2	Mild
C	High-end Digital	FMTx1	Mild
C	Low-end Digital	FMTx1	Mild
C	Power Digital	FMTx1	Mild
C	High-end Digital	FMTx2	Mild
C	Low-end Digital	FMTx2	Mild
C	Power Digital	FMTx2	Mild
D	High-end Digital	FMTx1	Mild
D	Low-end Digital	FMTx1	Mild
D	Power Digital	FMTx1	Mild
D	High-end Digital	FMTx2	Mild
D	Low-end Digital	FMTx2	Mild
D	Power Digital	FMTx2	Mild
A	High-end Digital	FMTx1	Severe
A	Low-end Digital	FMTx1	Severe
A	Power Digital	FMTx1	Severe
A	High-end Digital	FMTx2	Severe
A	Low-end Digital	FMTx2	Severe
A	Power Digital	FMTx2	Severe
B	High-end Digital	FMTx1	Severe
B	Low-end Digital	FMTx1	Severe
B	Power Digital	FMTx1	Severe
B	High-end Digital	FMTx2	Severe
B	Low-end Digital	FMTx2	Severe
B	Power Digital	FMTx2	Severe
C	High-end Digital	FMTx1	Severe
C	Low-end Digital	FMTx1	Severe
C	Power Digital	FMTx1	Severe
C	High-end Digital	FMTx2	Severe
C	Low-end Digital	FMTx2	Severe
C	Power Digital	FMTx2	Severe
D	High-end Digital	FMTx1	Severe
D	Low-end Digital	FMTx1	Severe
D	Power Digital	FMTx1	Severe
D	High-end Digital	FMTx2	Severe
D	Low-end Digital	FMTx2	Severe
D	Power Digital	FMTx2	Severe

Classroom Acoustics: A Survey of Educational Audiologists

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An electronic survey of 34 educational audiologists was conducted to obtain their perceptions regarding classroom acoustical conditions in their schools. Respondents indicated that 1) walls in their schools were constructed mainly of drywall and/or cinder blocks, 2) there was an approximately even distribution of carpet, vinyl, and area rug flooring, and 3) typically there are multiple windows without closed drapes. Commonly reported noise sources were unattached desks and chairs, frequent use of overhead projectors, and one or more classroom computers typically running during the school day. A large majority of the respondents reported that the HVAC systems were, in their opinion, loud enough to make listening to the teacher difficult, but noise from external sources (such as road traffic and aircraft noise) was reported to be less of a concern.

Introduction

It is widely recognized that acoustical conditions in the classroom play an important role in the learning process. Most daily instruction is verbal, and it is important for students to be able to hear their teachers, for teachers to be able to hear their students, and for students to be able to hear one another. Young students are particularly vulnerable to poor acoustics (Craig, Kim, Pecyna-Rhyner, & Bowen-Chirillo, 1993; Elliot, 1979; Johnson, 2000; Soli & Sullivan, 1997; Stelmachowicz, Hoover, Lewis, Kortekas, & Pittman, 2000; Talarico, Abdilla, Aliferis, Balazic, Giaprakis, Stefanakis, Foenander, Grayden, & Paolini, 2007).

A recent review of the literature concerning maturation of the human auditory system indicates that the nervous systems of young children are in the process of maturing throughout the first twelve years of life (Moore & Linthicum, 2007). During early childhood (ages 2 to 5 years), there is increased dendritic arborization and axonal maturation in the deep cortical layers (Moore & Guan, 2001). In later childhood (ages 6 to 12 years), there is continued axonal maturation in the superficial cortical layers (Moore & Guan, 2001). Evidence indicates that children are less sensitive than adults with respect to detecting small differences in acoustic cues (Elliott, 1986; Sussman & Carney, 1989), and they exhibit greater difficulty than adults in recognizing speech in reverberant conditions (Finitzo-Hieber & Tillman, 1978). Evidence also indicates that speech recognition in noise and reverberation may not mature until the middle to late teenage years and that development is different for different components of speech (Johnson, 2000). In addition, children lack adequate knowledge of their language to "fill in" when a portion of a message is unclear or missed. The acoustical quality of a classroom is even more critical to students with disabilities such as hearing impairment and learning disabilities and to students for whom English is a second language (Bradlow, Kraus, & Hayes, 2003; Crandell & Smaldino, 1996; Finitzo-Hieber & Tillman, 1978; Nabelek & Pickett, 1974).

Two characteristics used to assess acoustical conditions in the classroom are the level of background noise and the amount of reverberation. Background noise, which can be defined as unwanted sound that interferes with one's ability to hear a desired signal, can be generated from a variety of sources such as the heating and air conditioning (HVAC) system, computers, outside traffic, aircraft, and/or railroad noise, shifting chairs in the classroom, overhead projectors, and sounds made by the students themselves. Additionally, when students work in small groups, overall noise levels increase by 10dB (Picard & Bradley, 2001).

Another important consideration for classroom acoustics is reverberation. The term, reverberation, refers to the reflection of sound off of surfaces in the classroom and the resultant persistence of that sound after it has been emitted. Early sound reflections can enhance the audibility of the teacher's words, but late reflections smear phonemes and decrease audibility

(Boothroyd, 2004). Reverberation is measured in terms of reverberation time (RT) which is the amount of time required for a 60dBSPL sound in a specified space to dissipate. Long reverberation times contribute to poor listening conditions. It is important to note that combined excessive background noise and excessive reverberation have a synergistic effect on interference with speech understanding (Picard & Bradley, 2001).

The difference between the intensity of the signal (teacher's voice) to the intensity of the background noise is called the signal-to-noise ratio (SNR). When this ratio is small (e.g. +12dB or poorer), listening conditions can interfere with word understanding (Finitzo-Hieber & Tillman, 1978). Typical classroom SNRs have been estimated to be in the range of +3 to +9.5dB (Houtgast, 1981). Teachers sometimes attempt to improve the SNR by increasing their vocal intensity (signal). However, increasing vocal intensity can have deleterious effects on the teacher's vocal health. For example, teachers have a significantly higher risk of absence from work and doctor's visits related to voice-related problems (Allen's study, as cited in Anderson, 2001; Calas, Verhulst, & Lecoq, 1989; Gotass & Starr, 1993; Smith, Gray, Dove, Kirchner, & Heras, 1997; Urutikoetxea, Ispizua, & Matellanes, 1995).

One way to improve the SNR is to use systems that amplify the teacher's voice and deliver the amplified sound through classroom loudspeakers (sound field), desktop speakers, and/or personal hearing aids. However, evidence suggests that classroom speakers may not be beneficial for students who wear hearing aids when classroom acoustical conditions are poor (Anderson & Goldstein, 2004; Anderson, Goldstein, Colodzin, & Iglehart, 2005).

In 1994, the American Speech Language and Hearing Association (ASHA) published guidelines regarding acoustical conditions in classrooms (ASHA, 1995). These guidelines recommended that noise levels in unoccupied classrooms be 30dBA or less and that the reverberation times be 0.4 seconds or less. In 2002, the American National Standards Institute (ANSI) adopted guidelines for classroom acoustics in which unoccupied classroom noise levels were recommended to be 35dBA or less, and reverberation times were recommended to be 0.6 seconds or less (ANSI, 2002). The ANSI standards are intended for use in the design of new classrooms and in the renovation of existing classrooms.

One approach to evaluating classroom acoustics entails direct measurement of classroom background noise, reverberation, and speech intelligibility. There have been studies of classroom acoustics in many settings including daycare centers (Truchon-Gagnon & Hetu, 1988), preschools (Porter & Dancer, 1998) and college classrooms (Addison et al, 1999) (see Picard & Bradley, 2001 for a review). In one study by Knecht, Nelson, Whitelaw, & Feth, (2002), noise levels and reverberation times were measured in 32 unoccupied elementary classrooms in eight different public schools. When the HVAC system was turned on, recorded noise levels averaged 49.7 dB(A), and when the HVAC system was turned off, the average noise level was 39.8 dB(A). Both values exceed ASHA and ANSI recommendations. Approximately 41% of the rooms exceeded the maximum ANSI recommended reverberation times (Knecht et al., 2002). Similarly, high noise levels have been observed by many other investigators (e.g. Bradley, 1986, Johnson, Stein, Broadway, & Markwalter, 1997; Pekkarinen & Viljanen, 1991; Picard & Bradley, 2001; Slater, 1968), even in classrooms used for students who have hearing impairment (Bess, Sinclair, & Riggs, 1984) and in rooms used for speech-language therapy at Head Start centers (Porter & Dancer, 1998). It has been noted that HVAC systems are an important source of noise in the classroom (Knecht et al., 2002; Siebein, 2004), but high background noise levels have also been measured in schools in temperate climates in which other characteristics of classroom construction, such as open windows and doors, played an important role in classroom acoustical conditions (Polich & Segovia, 1999; Pugh, Miura, & Asahara, 2006).

Surveys can also provide valuable information about classroom acoustics, because this method yields information about a large number of schools. In 1995, the United States General Accounting Office conducted a survey to assess the physical and environmental conditions of a random sample of facilities directors and central administrators at approximately 10,000 schools representing over 5,000 school districts. The responders to that survey indicated that approximately 28% of schools in the United States have unsatisfactory conditions with respect to noise control.

Classroom noise was also found to be a concern in a recent survey of 2,036 British school-aged children in which children were asked to rate their ability to hear the teacher (Dockrell & Shield, 2004). With a rating scale in which a rating of 1 indicated hearing "very well" and a rating of 5 indicated hearing "not at all", children in their second year of school (6-7 year olds) averaged difficulty ratings of 2.29 when the teacher was talking and moving, 2.47 when a classmate was speaking, and 2.70 when children were making noise outside. In general older children (ages 10 to 11 years) reported less difficulty hearing than the younger children.

Educational audiologists are uniquely qualified to evaluate classroom listening conditions, but, to date, no survey has been conducted to obtain information regarding their observations. Educational audiologists are likely to visit a larger variety of classrooms than a typical teacher or student would visit, and they have an educational background in acoustics and in hearing impairment. The purpose of the present study was to solicit information and observations from educational audiologists in order to add to our understanding of existing classroom acoustical conditions.

Method

Participants

Participants were self-reported educational audiologists who subscribe to the Educational Audiology Association (EAA) listserv. There are approximately 384 EAA listserv subscribers. (This estimate is based upon information provided by the EAA.) Participants were recruited through an email announcement on the listserv. They were assured of anonymity, and no identifying information was gathered. A total of 39 people accessed the questionnaire. Of those who did so, 34 participants indicated that they were currently working as audiologists in an educational setting in the United States and completed the remainder of the questionnaire.

Procedures

The questionnaire consisted of 30 multiple choice questions and one open-ended question. The first five questions called for respondent demographic information that did not compromise anonymity (e.g. questions asking if the respondent is currently employed as an educational audiologist, total number of years of experience as an educational audiologist, etc.). The next two questions concerned the schools about which responses were made. That is, one question called for the grade levels (i.e. elementary, middle, high school) and a second question asked for a description of the classrooms (i.e. self-contained, open-plan, portable). Because of survey formatting constraints, classroom features and characteristics (e.g. room construction materials, windows, noise sources, etc.) were grouped in lists in the subsequent three questions, and respondents were asked to check all that apply. Additional questions called for respondent opinions and experiences of reports of problems or concerns (i.e. noise from the heating, ventilation, and/or air conditioning [HVAC] system, classroom noise, vocal problems, etc.) that may have been expressed to the respondent by others such as students or teachers. Finally, the survey included questions about signal-enhancing devices, measurement of classroom noise levels and reverberation times, and requests for acoustical accommodations. The open-ended question asked respondents to list any other concerns that they may have about classroom acoustics issues in their schools. The complete survey is provided in the Appendix.

Prior to application for Auburn University Institutional Review Board approval, the survey questions were previewed by three educational audiologists to judge the ease of use of the questionnaire. The survey was modified on the basis of their comments regarding question clarity and survey length. The base structure of the survey was created using Flashlight Online, which is hosted by the CTL Silhouette system at the Center for Teaching, Learning, and Technology at Washington State University in Pullman, Washington.

List owner permission for posting of information regarding the survey was obtained from the EAA. Participants were contacted via the EAA listserv, where they accessed the anonymous, online questionnaire at a website address provided in the recruitment email message. Respondents who provided services at more than one school were instructed to select one of the schools and to base their survey responses on that school. Participants submitted their responses electronically.

The final questionnaire and the research protocol were approved by the Auburn University Institutional Review Board.

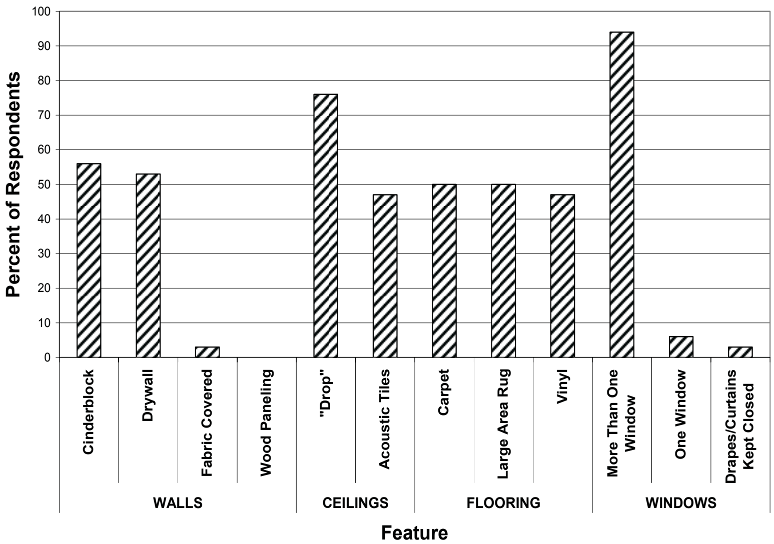
Results

Classroom Characteristics

Respondents were asked to select one of their schools and to answer all questions about that school. Thirty-two percent of the selected schools included 6th through 8th grade; 26% included grades 9th through 12th grade. Ninety-seven percent of the schools selected included kindergarten through 5th grade. Some schools included more than one category.

All respondents reported that the majority of the classrooms in the school they selected were "self-contained"(meaning not open-plan design), and all respondents reported that fluorescent lighting was used. Respondents were provided with lists of classroom characteristics which may be found in a classroom. They were asked to indicate all of the features that are typical in the majority of the classrooms in the school that they had selected. The most common wall materials were reported to be dry wall and cinder block, and 76% of respondents reported dropped ceilings and more than one window in the classroom. Three percent of the respondents reported that drapes or curtains were maintained in a closed position over windows. Respondents were

Figure 1: Percent of Respondents Reporting Feature Typical in Majority of Classrooms



asked to select all kinds of flooring that were typical in the majority of classrooms at their selected school. Selections indicating carpet, vinyl, and area rugs were approximately evenly divided. Ninety-four percent of respondents reported that the majority of classrooms in their school contained posters, pictures, artwork, and bulletin boards, etc. on the walls. Response results concerning typically reported features are shown in Figure 1.

Noise Sources in the Classroom

Ninety-seven percent of all respondents reported that chairs were not attached to desks, and 91% reported that at least one computer was turned on in the classroom throughout the school day. Sixty-two percent of respondents reported that use of an overhead projector for instruction was typical in a majority of classrooms. These data are shown in Figure 2.

Forty-nine percent of the respondents indicated that a closed classroom door was typical in the majority of classrooms for their school. Open doors can also be a source of noise, as they may allow sounds from the outside to reach the classroom.

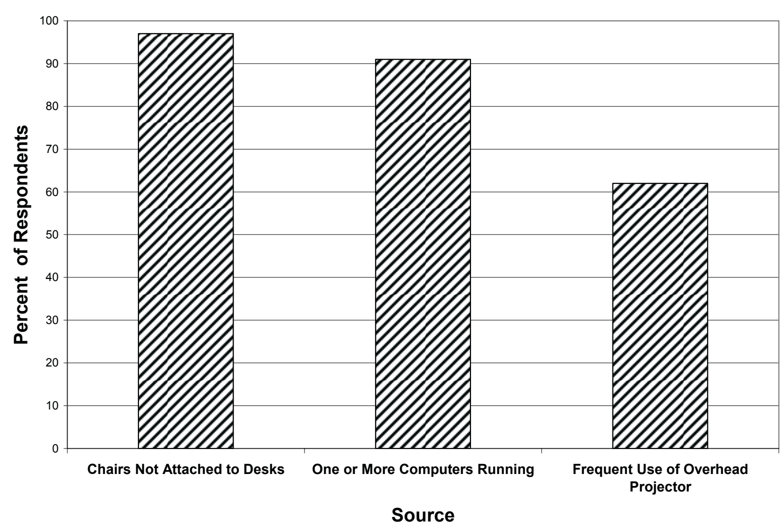
Respondent Perceptions and Opinions

Respondents were asked if, in their opinion, the HVAC system in any classroom in the school they selected was ever loud enough to make listening to teacher instruction difficult. The response was "yes" for 79% of the responses. Respondents were also asked if they had concerns about external traffic noise from cars, trucks, aircraft, or construction work interfering with teachers' instruction in the classroom. The response was "no" for 79% of the responses. Forty-four percent of the respondents reported being aware of a student reporting difficulty hearing teacher instruction in the classroom due to internal and/or external sources of noise. Forty-four percent of the respondents also indicated awareness of teacher-reported vocal problems or vocal stress resulting from having to raise his/her voice in order for students to hear classroom instruction over noise.

Measurement of Noise Levels and Reverberation

Seventy-six percent of the respondents indicated that they have access to a sound level meter to measure noise levels. Of the respondents who indicated that they have access to a sound level meter, 59% indicated that they use the meter to measure noise levels as part of their duties. In response to a question that asked if any of the recorded noise levels were ever at a level that caused the respondent concern that the noise may be interfering with daily classroom instruction, 86% of those participants responded affirmatively. In response to questions regarding reverberation times, 88% of respondents reported being unsure about or having no access to equipment used to measure reverberation times, and 97% reported being

Figure 2: Percent of Respondents Reporting Noise Source Typical in Majority of Classrooms



unsure or having no knowledge of any professional measurement that had been performed to determine reverberation times in the classrooms. (However, in the open-ended section of the questionnaire, one respondent reported calculating estimated reverberation times.)

Classroom Acoustics and Individualized Education Program (IEP) Recommendations

Respondents were asked if acoustical improvements (e.g. window drapes or carpet installation, placement of tennis balls on chair legs, implementation of an FM system) were common requests at IEP meetings for students with hearing impairment. Forty-four percent of the respondents replied affirmatively. Of those respondents, 47% indicated that these requests were always implemented.

Signal-Enhancing Devices

Sixty-five percent of the respondents indicated that signal enhancing systems (i.e. sound-field FM systems or personal FM systems) were implemented only when there is a child with hearing loss in the classroom, and 29% of the respondents indicated that signal-enhancing systems were also implemented in classrooms without students with known hearing loss. Seventy-three percent of the respondents indicated that the majority of teachers always use the system, and 24% of the other respondents indicated that the majority of teachers use the system only when they feel it is really needed.

Open-Ended Question: Reported Concerns and Comments

There were 6 comments made in response to the open-ended question regarding other concerns about classroom acoustics issues in their schools. These comments were unique, and there was no common theme. One comment concerned resistance by "poorer districts" to address classroom acoustics issues. Another comment indicated that the respondent was not viewed by the administration as an appropriate person to raise concerns about classroom acoustics. A third respondent reported the existence of classrooms that are designated "self-contained" but have moveable walls through which sound can be heard from adjacent classrooms. One comment concerned a particularly responsive school that has led the way for improved classroom acoustics at the other two elementary schools in the district. One of the remaining responses concerned the lack of access to equipment to measure reverberation time, but the respondent reported using measurements and calculations as a substitute for equipment. Finally, one respondent reported that acoustical improvements such as tennis balls on chair legs or an FM system were common in IEPs but that carpeting and drapes were not common. This respondent also noted that expensive, new hand dryers in bathrooms were causing loud broad spectrum noise to be heard in the classrooms even though the classroom doors were closed.

Discussion

The responses in the present survey provided perceptions and observations by educational audiologists regarding classroom acoustics. Nearly half of the respondents reported being aware of student and teacher problems related to classroom acoustics. Many respondents reported access to and use of sound level measurement equipment to measure classroom noise levels, but reported measurement of reverberation time was rare.

The present results add to information currently available in the literature by providing a first-hand report of classroom acoustical conditions by educational audiologists who visit many classrooms and are qualified to evaluate listening conditions. Through direct measurements, previous studies have shown that ANSI and ASHA guidelines for noise levels and reverberation times are frequently exceeded (e.g. Knecht et al., 2002), and the responses in the present study suggest a widespread presence of features known to contribute to these conditions. In the present study, the HVAC systems were widely reported to be a concern, and this concern has been supported by studies in which direct measurements were made of HVAC systems (e.g. Knecht et al., 2002; Siebein, 2004) and found to contribute significantly to measured noise levels. It is of interest that, in the present survey, external noise (from traffic, etc.) was not reported to be a concern, and that this result contrasts with direct measurement studies in temperate climates where windows are frequently kept open for ventilation (Polich & Segovia, 1999; Pugh, et al, 2006).

It has been suggested that improvement in classroom acoustics requires that educational administrators, school board members, and legislators recognize and understand that poor classroom acoustical conditions interfere with the learning process (Anderson, 2004). The respondents in the present survey indicated their awareness of student and teacher concerns regarding classroom acoustics. It is reasonable to suggest that educational audiologists such as those who responded in the current study can contribute important information to school decision-makers when classroom acoustics issues are considered.

It is noteworthy that many of the respondents reported that they measure noise levels, but very few reported measuring reverberation times. It may be that educational audiologists would benefit from training opportunities regarding reverberation time measurement and/or calculation.

Certain limitations in the present study should be noted. The sample size in this study was small. In addition, respondents to the present survey were self-selected and may not be representative of all educational audiologists, particularly since participation required the use of computers and participants were contacted via the EAA listserv to which all educational audiologists do not subscribe. Also, because of the way the electronic survey was conducted, there is no way to determine if one person submitted more than one survey form or to ensure that the demographic information was accurate. However, it is important to note that no incentives were provided to respond to the survey, and there was no reward for false responses and/or multiple questionnaire submission. Finally, there is no way to verify the accuracy of the information provided. With regard to the survey questions, it may have been useful, in retrospect, to obtain information regarding rooms other than classrooms (e.g. physical education facilities, music rooms, shop classrooms), and to obtain information, if possible, about build dates of the schools and typical teaching styles (e.g. use of learning stations, group learning, teacher movement in the classroom).

Teacher concerns reported in the present study suggest that future research designed to obtain teacher perceptions would add a useful perspective regarding classroom acoustics. Studies of student ratings of classroom listening conditions have been conducted (Dockrell & Shield, 2004; Kennedy, Hodgson, Edgett, Lamb, & Rempel, 2006), but there is very little information available about the teachers' perceptions and experiences.

In summary, the results of the present survey indicate the reported perceptions and concerns of educational audiologists regarding classroom acoustics in schools where they work. The reported perceptions are consistent with a large body of research. It is possible that this report will be useful to educational audiologists and/or educational decision-makers in their efforts to improve the listening environments for students in their schools.

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APPENDIX

Classroom Acoustics Survey for Educational Audiologists

The purpose of this survey is to gather subjective impressions of currently-employed educational audiologists working in school settings about classroom acoustics issues. ALL answers given in this survey will be kept completely anonymous with no personal, identifying information attached. Please click the "Submit" button when you have completed the survey questions. THANK YOU FOR YOUR PARTICIPATION!

1. Are you currently employed as an audiologist for a school or other educational setting? (* If your answer is "no", you have completed the survey. Please do not continue answering the remaining questions and click "Submit" at the end of the survey.*)
   - ☐ Yes
   - ☐ No

2. What degree(s) have you attained? Please mark all that apply.
   - ☐ Bachelor's degree
   - ☐ Master's degree
   - ☐ Doctor of Audiology (Au.D.) degree
   - ☐ Doctor of Philosophy (Ph.D.) degree
   - ☐ Doctor of Education (Ed.D.) degree
   - ☐ Other doctorate
   - ☐ Other degree

3. How many total years have you provided audiological services in schools or other educational settings?
   - ☐ Less than 5 years
   - ☐ 5—10 years
   - ☐ 11—15 years
   - ☐ 16—20 years
   - ☐ 21—25 years
   - ☐ More than 25 years

4. How many total years have you worked as an audiologist overall?
   - ☐ Less than 5 years
   - ☐ 5—10 years
   - ☐ 11—15 years
   - ☐ 16—20 years
   - ☐ 21—25 years
   - ☐ More than 25 years

5. In which country do you currently provide audiological services for a school(s)?
   - ☐ United States of America
   - ☐ Canada
   - ☐ Mexico
   - ☐ Puerto Rico
   - ☐ Other

6. PLEASE ANSWER ALL REMAINING QUESTIONS ABOUT THE SCHOOL AT WHICH YOU ARE CURRENTLY EMPLOYED TO PROVIDE AUDIOLOGICAL SERVICES. IF YOU PROVIDE SERVICES AT MORE THAN ONE SCHOOL, PLEASE CHOOSE ONE OF THE SCHOOLS TO ANSWER ALL QUESTIONS ABOUT THAT SCHOOL. (PLEASE REMEMBER THAT ALL ANSWERS WILL BE KEPT COMPLETELY ANONYMOUS WITH NO PERSONAL, IDENTIFYING INFORMATION ATTACHED.) The school that you will be referring to when answering all the questions to this survey accommodates which grade level(s)? Please mark ALL choices that most closely represent the school's grade levels.
   - ☐ Elementary school (approximately Kindergarten through 5th grade)
   - ☐ Middle or junior high school (approximately 6th through 8th grade)
   - ☐ High school (approximately 9th through 12th grade)

7. Most classrooms in the school for which I work are:
- ☐ "Self contained", individual rooms in a fixed building
- ☐ "Open plan" arrangement in a fixed building, where many classes share the same open space
- ☐ "Portable" classrooms/trailers

8. THE FOLLOWING THREE QUESTIONS ARE SUBDIVIDED TO DESCRIBE CHARACTERISTICS OR FEATURES WHICH MAY BE FOUND IN A CLASSROOM. PLEASE MARK ALL CHOICES THAT APPLY TO YOUR SCHOOL. Which features are typical in the MAJORITY of classrooms in the school for which you work?
- ☐ Walls are made mostly of drywall material
- ☐ Walls are made mostly of cinder blocks
- ☐ Walls are mostly covered in wood paneling
- ☐ Walls are mostly covered with fabric
- ☐ Bulletin board is on at least one wall
- ☐ Posters, pictures, or artwork are on the walls
- ☐ "Drop" ceiling (grid-like ceiling panels)
- ☐ Acoustic tiles, which dampen sounds, on ceiling or walls

9. Which features are typical in the MAJORITY of classrooms in the school for which you work? Please mark ALL choices that apply.
- ☐ Fluorescent lights
- ☐ Desks with chairs that ARE attached to them (CANNOT separate the chair from the desk)
- ☐ Desks which have chairs that are NOT attached to them (CAN separate the chair from the desk)
- ☐ Tennis balls (or similar items) have been cut and placed on the bottom of chair legs
- ☐ No window(s) in the classroom
- ☐ One window in the classroom
- ☐ More than one window in the classroom
- ☐ Drapes or curtains are kept closed over windows

10. Which features are typical in the MAJORITY of classrooms in the school for which you work? Please mark ALL choices that apply.
- ☐ Carpet flooring
- ☐ Vinyl flooring
- ☐ Area rug (large rug) on the floor
- ☐ Classroom doors are kept closed while students are in the classroom
- ☐ Overhead projector is used frequently by the teacher for instruction
- ☐ One or more computer is turned on in the classroom throughout the school day
- ☐ Signal enhancing devices, such as sound-field FM systems, are implemented (teacher uses a microphone and speakers are in place throughout the classroom)
- ☐ Portable signal-enhancing devices, such as portable FM systems, are implemented (teacher uses a microphone and the student uses a personal speaker that is placed on the student's desk)

11. In your opinion, is the heating, ventilation, and/or air conditioning (HVAC) system in any classroom ever loud enough to make listening to teacher instruction difficult?
- ☐ Yes
- ☐ No

12. If you answered "yes" to the previous question (#11), have you expressed your concern about the HVAC system to the school administration?
- ☐ Yes
- ☐ No
- ☐ I did not answer "yes" to the previous question

13. Have YOU ever had concern about external traffic noise from cars, trucks, aircrafts, or construction work interfering with teachers' instruction in the classrooms?
- ☐ Yes
- ☐ No

14. If you answered "yes" to the previous question (#13), have you ever expressed your concern to the school administration?

- ☐ Yes
- ☐ No
- ☐ I did not answer "yes" to the previous question

15. To your best knowledge, has any TEACHER ever expressed concern about outside noise from cars, trucks, aircrafts, or construction work interfering with classroom instruction?

- ☐ Yes, the teacher expressed concern to me.
- ☐ Yes, the teacher expressed concern to the school administration.
- ☐ Yes, the teacher expressed concern to both me and the school administration.
- ☐ No teacher has expressed any concern.

16. To your best knowledge, has any TEACHER reported vocal problems or vocal stress as a result of having to raise his/her voice in order for students to hear classroom instruction over noise?

- ☐ Yes, the teacher reported to me.
- ☐ Yes, the teacher reported to the school administration.
- ☐ Yes, the teacher reported to both me and the school administration.
- ☐ No teacher has reported any problems.

17. To your best knowledge, has any STUDENT ever reported having difficulty hearing teacher instruction in the classroom due to internal and/or external sources of noise?

- ☐ Yes, the student reported to me.
- ☐ Yes, the student reported to the teacher.
- ☐ Yes, the student reported to the school administration.
- ☐ No student has reported any difficulty.

18. To the best of your knowledge, are signal-enhancing devices, which amplify teachers' voices, promptly provided by the school system for students with hearing loss (i.e., sound-field FM systems or personal FM systems - where the teacher uses a microphone and there is at least one speaker provided for the child or speakers throughout the classroom)?

- ☐ Yes, signal enhancing systems are implemented only when there is a child with hearing loss in the classroom.
- ☐ Yes, but signal-enhancing systems are also implemented in classrooms even if there is not a student with known hearing loss.
- ☐ No
- ☐ Not sure

19. To your best knowledge, if a signal-enhancing system is put into place, do the majority of teachers seem to comply with using the system (for example, actually uses the microphone and reports problems with the speakers)?

- ☐ Yes, they always use it.
- ☐ Yes, but they use it only when they feel it is really needed.
- ☐ No, they never use it.
- ☐ Not Sure

20. To the best of your knowledge, are acoustical improvements in the classroom common requests in Individualized Education Program (IEP) meetings for students with hearing impairment (for example, carpeting is put into the classroom, drapes are hung, an FM system with a microphone is implemented, tennis balls are put on the bottom of chair legs, etc.)?

- ☐ Yes
- ☐ No
- ☐ Not Sure

21. If you answered "yes" to the previous question (#20), are these IEP requests for acoustical improvements in the classroom accommodated?

- ☐ Yes, always
- ☐ Sometimes
- ☐ No, never
- ☐ Not sure
- ☐ I did not answer "yes" to the previous question

22. If you answered “yes” or “sometimes” to the previous question (#21), are acoustical improvements made in what you consider to be a timely manner?

- ☐ Yes, always
- ☐ Sometimes
- ☐ No, never
- ☐ Not sure
- ☐ I did not answer "yes" or "sometimes" to the previous question

23. Do you have access to a sound-level meter to measure noise levels?

- ☐ Yes
- ☐ No
- ☐ Not sure

24. If you answered “yes” to the previous question (#23), do you ever measure noise levels using a sound-level meter in any classroom as part of your job duties?

- ☐ Yes
- ☐ No
- ☐ I did not answer "yes" to the previous question

25. If you answered “yes” to the previous question (#24), are any of the recorded noise levels ever at such a level that is causes you concern that the noise may be interfering with daily classroom instruction?

- ☐ Yes
- ☐ No
- ☐ I did not answer "yes" to the previous question

26. To the best of your knowledge, does any other professional (such as an acoustical engineer, etc.) ever measure noise levels using a sound-level meter in the classrooms?

- ☐ Yes
- ☐ No
- ☐ Not sure

27. Do you have access to equipment used to measure reverberation time in the classrooms?

- ☐ Yes
- ☐ No
- ☐ Not sure

28. If you answered “yes” to the previous question (#27), do you ever measure reverberation time in any classroom as part of your job duties?

- ☐ Yes
- ☐ No
- ☐ I did not answer "yes" to the previous question

29. If you answered “yes” to the previous question (#28), are any of the recorded reverberation times at such an amount that it causes you concern that reverberation could be interfering with daily class instruction?

- ☐ Yes
- ☐ No
- ☐ I did not answer "yes" to the previous question

30. To the best of your knowledge, does any other professional (such as an acoustical engineer, etc.) ever measure reverberation time in the classrooms?

- ☐ Yes
- ☐ No
- ☐ Not sure

31. Please list any other concerns you have about classroom acoustics issues in the school(s) for which you work that were not specifically listed in this survey. THANK YOU for your participation!

Parental Perceptions and Behavior Regarding Hearing Aid Monitoring and Maintenance in an Early Childhood Intervention Program

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The value of early hearing detection and intervention is significantly undermined when hearing aids fail to perform consistently. A parent questionnaire was developed to investigate parent training and perceived competency in hearing aid care, ownership/use of test kit items, frequency of hearing aid checks, and reasons for not performing hearing aid checks. Thirty-one parent questionnaires were obtained from families of children with hearing aids who were enrolled in the Utah Parent Infant Program. Findings indicate that parents are generally well-equipped with the necessary tools to monitor hearing aid function, but they are not making regular use of these items. Many parents check hearing aids infrequently and/or improperly. Implications and potential solutions are discussed.

When considering the fundamental role of amplification in early hearing detection and intervention (EHDI) services, hearing aid malfunction has the potential to be a major barrier to successful developmental outcomes for the infant/child who is deaf or hard-of-hearing (d/hh). Furthermore, any benefit that might have been derived from EHDI programs could be compromised or nullified by the effect of a malfunctioning hearing aid. Appropriate amplification and consistent auditory stimulation through properly functioning hearing aids are essential to the effectiveness of any early intervention program. Unfortunately, many studies among school age children have indicated that hearing aids often fail to work, or are otherwise sub-par in their performance (Diefendorf & Arthur, 1987; Elfenbein, Bentler, Davis, & Niebuhr, 1988; Elfenbein, 1994; Most, 2002).

In the realm of hearing and hearing aids, it is important for parents to possess knowledge of the developmental impact of their child's hearing loss and the role that amplification can play in helping to compensate for their child's inability to hear. More specifically, parent knowledge of the hearing aid itself, the importance of amplification, and how to monitor, maintain, and troubleshoot hearing aids is essential in ensuring appropriate management of their child's hearing aids. Elfenbein (1994) noted, "although most parents are aware of the need to monitor hearing aids for signs of malfunction, they do not always have the equipment and the skills needed to accomplish the task" (p. 65). Elfenbein (1994) continued that:

> Data from this sample indicate that hearing aid monitoring programs conducted by the parents of preschoolers are inadequate. Only half of the families (N = 15) performed daily hearing aid checks. One third did not own the basic equipment needed to assess battery strength and sound quality. Even those who reported owning appropriate equipment and performing daily checks missed major signs of hearing aid malfunction. (p. 67)

In a study of parental knowledge and understanding of hearing loss and hearing aids, Blair, Wright, and Pollard (1981) found that, according to their criteria, 50% of the parents questioned (N = 96) had little or no knowledge about their child's hearing loss, and 61% had little or no information about their child's hearing aid. These studies clearly highlight the need for proper and effective parent education and training in relation to hearing aids.

In terms of the historical incidence of hearing aid malfunction in children, Diefendorf and Arthur (1987) found an average hearing aid malfunction rate of 29.2% (N = 10) in children 2 to 6 years of age over a period of several months, when gathering baseline data describing hearing aid performance prior to implementing an intervention program. Elfenbein, et al. (1988) reviewed studies of school age children's hearing aid performance over the 20 years preceding their study and found outcomes showing that, depending on the criteria used at any given time, 27% to 92% of children's hearing aids were malfunctioning. Elfenbein (1994) found a 33% (N = 15) incidence of hearing aid malfunction in a study of preschool children ranging in age from 16-54 months.

It is important to consider what can be done to reduce the incidence of hearing aid malfunction. Over the years, two important principles for reducing hearing aid malfunction have emerged: daily monitoring checks and parent/teacher education. Blair and Langan (2000) conducted a longitudinal study analyzing seven years of classroom hearing aid monitoring data for preschool, elementary, and junior-high children (N = 158). They found that with the use of daily monitoring checks, an average of 5.5% (range 3.0% to 10.9%) of hearing aids were malfunctioning when children entered the classroom each morning. Furthermore, they found that the average incidence of hearing aid malfunction was reduced even more, to less than 1%, once daily hearing aid checks were performed. The study by Diefendorf and Arthur (1987) considered the effects of daily monitoring and parent education on reducing hearing aid malfunction. The authors evaluated hearing aid malfunction rates in children before and after a parent training program and found that the average incidence of hearing aid malfunction had been reduced from 29.2% to 5.6%. Outcomes suggest that parents who better understand their child's hearing loss and the importance of amplification will be more likely to carry out daily hearing aid checks and see to their child's auditory needs.

The incidence of hearing aid malfunction, as well as the need for effective parent education and training with regard to hearing aid monitoring and maintenance, is well documented. Programs in early intervention provide parents with information about how to check hearing aids and teach parents the importance of care and maintenance of these instruments (Watkins, 2004). However, there is no research that has explored how well parents are using the information they obtain from a parent advisor concerning hearing aid care. The purpose of this study was to obtain a better understanding of parental perceptions and behavior with regard to (1) training and competency in hearing aid care, (2) ownership and use of a test kit, (3) frequency of hearing aid checks, and (4) reasons for not performing the hearing aid check. The understanding of this information is critical for early intervention programs. Therefore, the purpose of this study was to answer questions concerning parental knowledge and behavior relative to their children's hearing aids. These topics and questions included:

1. Hearing aid test kits: Contents and use. Do parents of children enrolled in the Utah Parent Infant Program (PIP) own a hearing aid test kit, and how frequently do they use its contents?
2. Hearing aid maintenance: Checks and cleanings. How frequently do parents enrolled in the Utah PIP check and clean their child's hearing aids?
3. Parent perceptions: Training and abilities. Do parents feel confident in their training and abilities relative to hearing aid monitoring and maintenance, and for what reason might they not check their child's hearing aids daily?

Method

Subjects

Data collection for the study was provided by five of the seven parent advisors (PAs) for the Logan, Ogden, Salt Lake, and Provo regions in the state of Utah. These five PAs served a total of 36 families with children who were d/hh and wearing hearing aids. Children ranged from 5 to 35 months (average 22 months) of age. Enrollment in the PIP ranged from 2 to 35 months (average 12 months). Parent reports on how recently hearing aid training had been administered ranged from 1 to 24 months (average 8 months).

Procedure

Prior to beginning the study, PAs were provided in-service training regarding the data collection protocols. This training was provided by either the primary investigator or the program director. The items on the questionnaire were explained in detail to the PAs. The PAs were instructed to deliver the questionnaires to the parents and have the parents read the questions while the PAs were present. Then the PAs were to answer any questions about the questionnaire that the parents might have raised. PAs were responsible for the distribution and collection of the parent questionnaires and an informed consent form.

In total, 34 parent questionnaires were completed and returned, but only 31 were judged eligible for inclusion in the study. Three questionnaires were not used for the following reasons: (1) one child refused to wear his aids, appeared to do well without them, and recent behavioral testing indicated normal hearing; (2) one questionnaire was completed by someone other than the child's parent/guardian and the responses were not consistent; and (3) one child had a unilateral hearing loss and wore only one aid on an infrequent basis.

Questionnaire

A questionnaire consisting of 20 questions was developed by the first author and subsequently reviewed by two other audiologists. The revised questions were then reviewed by the Parent Infant Coordinator for the Utah School for the Deaf and modified to be more understandable for the parents. Finally, a pre-questionnaire was sent to three parents, outside of the geographical area where the data for this study were collected, asking for their input on clarifications or modifications. Once this process was completed, the final questionnaire (see Appendix A) was sent to the participants of this study.

The questions were written in a multiple-choice format, with opportunities for parents to include additional information, if they chose to do so. Question 17 asked, "Is there any other information about your child's hearing aid/s that you would like to know?", and Question 18 asked, "What are the most frequent problems that you encounter with your child's hearing aid/s?" These were the only two open-ended questions on the questionnaire.

Results

Hearing Aid Test Kits: Contents and Use.

Parents were asked if they own a hearing aid test kit. Of the 31 study participants, 30 (96.7%) responded that they owned a kit. Of these, all 30 reported they owned a battery tester, all but one (96.7%) owned a hearing aid stethoscope, 24 (77.4%) owned an air-bulb, 22 (71.0%) a dri-aid kit, and 22 (71.0%) owned a wax brush. Of the 30 parents who reported that they owned a battery tester, the majority (N= 17, 56.7%) reported that they used it more than once a week (see Table 1). For the ten parents who owned a battery tester but did not report using it one day or more a week, five parents reported why they did not use this tool: two parents were not aware that they owned a tester until they answered the questions in the questionnaire, the other three parents reported that they only tested the battery when they suspected the battery was dead.

Of the 29 parents who indicated that they owned a hearing aid stethoscope, only five reported that they used it on a daily basis, and approximately half (N = 15, 51.7%) reported that they used it 2-3 days a week or less (see Table 1). Three parents reported using their hearing aid stethoscope less than once a week. Of these, one reported using it "as needed," one indicated that it was used when a dead battery was suspected, and one parent reported never using the stethoscope at all.

As may also be seen in Table 1, of the 24 parents who owned an air bulb and of the 22 who owned a dri-aid kit, more than half (N = 17 and N = 12, respectively) used them at least once a week. Seven of the 24 parents (29.2%) who owned an air bulb reported their frequency of use of this tool as "other." Of these seven, two said they never used it, four used it less than once a week, and one reported having lost it. Of the 22 parents who owned a dri-aid kit, ten indicated they used it less than once a week. Of these, seven reported that they had never used it (one parent indicated that she was not aware of what it was until the time of this study), and three indicated that they used it as needed (but less than once a week). Finally, of the 22 parents who indicated that they owned a wax brush, the majority (N = 17, 77.2%) reported that they used it once a week or more. Of the remaining five parents who reported "other" for their frequency of use, three indicated using it less than once a week (but as needed), and one indicated that the brush had been lost.

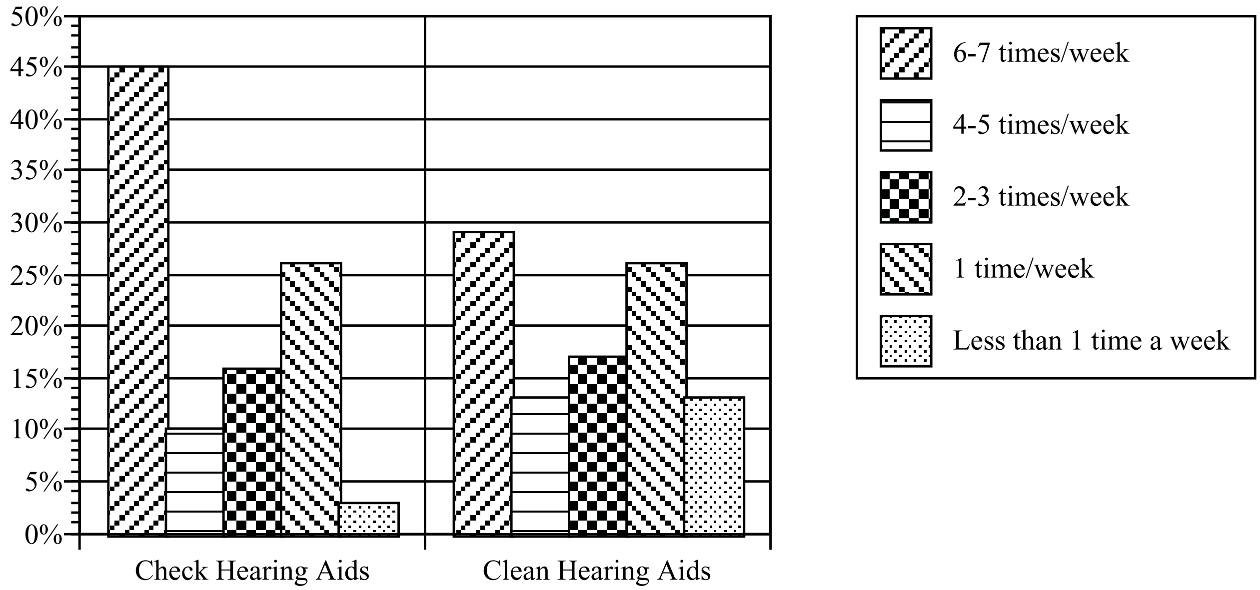
Hearing Aid Maintenance: Checks and Cleanings.

When asked how many times a week parents check their child's hearing aids, 14 parents (45.2%) indicated they do so daily, three parents (9.7%) reported checking the hearing aids at least 4-5 days a week, five parents (16.1%) reported checking their child's aids at least 2-3 days a week, and eight parents (25.8%) checked the aids only once a week. One parent reported checking the hearing aids less than once a week and only when they were not working (see Figure 1).

Table 1. Frequency of test-kit item use, as reported by parents.

	Daily	4-5 days /week	2-3 days /week	1 day /week	Other
Use of battery tester (N = 30)	6	3	8	3	10
Use of HA stethoscope (N = 29)	5	6	3	12	3
Use of air bulb (N = 24)	3	2	5	7	7
Use of dri-aid (N = 22)	3	1	1	7	10
Use of wax brush (N = 22)	9	0	4	4	5

Figure 1: The frequency of hearing aid checks and cleaning, as reported by parents.



The responses from parents who reported checking their child's hearing aids daily were examined more closely. Five of these parents reported daily use of the battery tester, two parents used it 4-5 days a week, two parents used it 2-3 days a week, three parents used it once a week, and two parents reported using it as needed. Similar results were found with the use of the listening stethoscope: five parents used it daily, two parents used it 4-5 times a week, two parents used it 2-3 times a week, and two parents reported using it as needed. Only three of the 14 parents who indicated that they checked the hearing aid daily were found to use the stethoscope and battery tester in conjunction daily.

When asked about cleaning practices during the week, nine parents (29%) indicated they clean their child's hearing aid daily, while four parents (12.9%) cleaned the hearing aid at least 4-5 times a week. Five of the parents (16.7%) cleaned the hearing aids at least 2-3 times a week and eight of the parents (25.8%) cleaned the aids once a week. Four parents (12.9%) cleaned the hearing aids less than once a week, but "as needed," and one parent reported cleaning the aid every other week (see Figure 1).

Parent Perceptions: Training and Abilities.

The questionnaire addressed specific questions concerning parents' perceptions regarding the training they received about hearing aids and their confidence and ability to work with hearing aids (see Appendix A). As described earlier, the parents were given some forced choices to describe their perceptions.

When parents were asked to rate how adequately they had been instructed to perform a daily hearing aid check (very poor to very well), 29 parents (93.5%) rated their training as either "very well" or "good," with the remaining two parents (6.5%) rating their training as either "poor" or "OK." When asked about the adequacy of instruction provided on cleaning a hearing aid, 29 parents (93.5%) again rated their training as either "very well" or "good," with two parents indicating their training as being either "OK" or "poor."

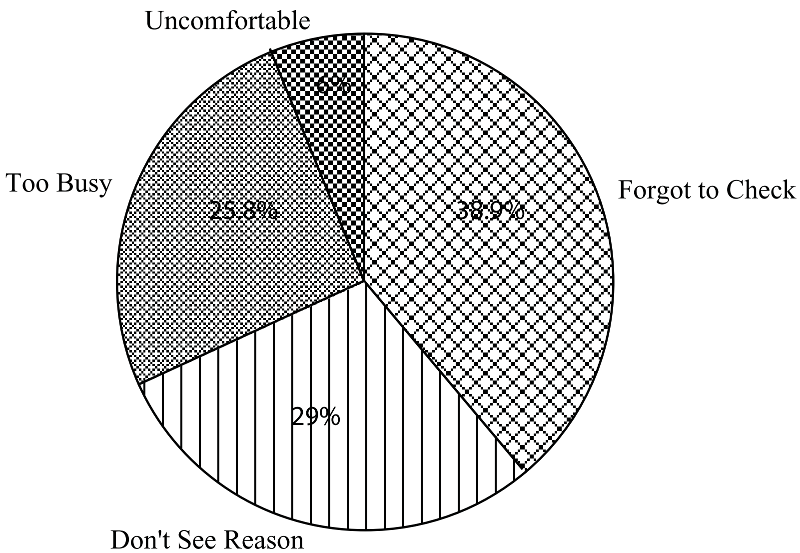
When parents were asked what percentage of the time they believed their child's hearing aids were working properly, 27 parents (87.1%) reported that they estimated good functioning 90% of the time or more. The remaining four parents (12.9%) included one parent who rated performance at 75%, and three parents who rated performance at 50%.

When parents were asked to rate how comfortable they felt checking their child's hearing aids, 28 parents (90.3%) reported feeling either "very comfortable" or "comfortable." The remaining three parents (9.7%) rated their comfort level for checking their child's hearing aids as "OK."

When asked about how much more training in hearing aid monitoring, care, and troubleshooting they needed, 15 parents (48.4%) responded that they needed no more help, 12 parents (38.7%) indicated that a brief overview would be helpful, and two parents (6.4%) indicated that comprehensive training would be helpful.

Finally, when asked what reason(s) parents might not check or clean their child's hearing aids on a daily basis, 12 parents (38.7%) reported that they meant to, but often forget to check, nine parents (29.0%)

Figure 2: Parents' reasons for not checking and cleaning their child's hearing aids daily.



reported that they did not see the reason for having to check and clean the aids daily, eight parents (25.8%) reported they are too busy and cannot find the time, and one parent indicated that he/she still did not feel comfortable with the task (see Figure 2).

Discussion

This study was completed with only 31 parents in the state of Utah. The results of this research cannot be generalized to a larger population and needs to be replicated to determine if these findings are representative across the United States. Utah, however, has had a parent-infant home intervention program for many years and represents the kind of parent advisor program that exists in many other states. Although this study is based on a small sample of parents with children who wear hearing aids, these findings and conclusions are important for all audiologists and parent advisors to read and consider.

Hearing Aid Test Kits: Contents and Use.

The first research question asked, "Do parents of children enrolled in the Utah PIP own a hearing aid test kit and how frequently do they use its contents?" Responses from thirty of the 31 parents indicated that they had a hearing aid trouble shooting kit, and every parent in the study reported having received some kind of training on hearing aid care and maintenance. However, some of the parents did not have some of the basic tools necessary for hearing aid monitoring and maintenance: 29% of parents did not own a wax brush, another 29% did not own a dri-aid kit, 23% did not own an air bulb, 6% did not own a hearing aid stethoscope, and 3% were without a battery tester. No parent should be without any of the above items, nor should they be unfamiliar with their use or the reasons for using them. It was interesting to discover that even when parents owned the basic tools, they did not always make good use of these items. Only 16% of parents reported using their hearing aid stethoscope daily, and only 19% reported using their battery tester daily. These results suggest that families do not understand the importance of daily hearing aid checks. Audiologists, parent advisors, and others who work with families need to help them understand the importance of this practice.

Hearing Aid Maintenance: Checks and Cleanings.

The second research question asked, "How frequently do parents enrolled in the Utah PIP check and clean their child's hearing aids?" Results from this question reveal that parents are not checking and cleaning their child's hearing aids as frequently as hoped. The number of parents reporting that they cleaned their child's hearing aid daily was only 29%. In the case of cleaning hearing aids, it is difficult to state that hearing aids must be cleaned daily; children vary in their wax production, how much they perspire, etc. Therefore, cleaning should occur as needed, and not necessarily daily; however, the value of the hearing aid check is that a thorough examination can help determine when cleaning is necessary, as well as, when the hearing aid is not functioning properly.

These data reveal that some of the parents who check the hearing aids daily do not appear to be doing so thoroughly. For example, one of the parents that reported doing a daily check did not own a hearing aid stethoscope. Only five of the 14 parents that checked the hearing aid daily reported use of the battery tester, and results on the use of the stethoscope were similar with only five parents reporting daily use. Furthermore, of these 14 parents, only three reported daily use of the stethoscope and battery tester together. It appears that in many instances, the hearing aid check performed by parents who monitor them daily is nothing more than a "whistle check" (i.e. cupping the hearing aid in the hand and causing it to feedback to determine whether or not it is turned on).

This finding leads to the concern that the parent definition of "daily hearing aid check" may be different from the professional definition.

What parents do in a hearing aid check and what audiologists/parent advisors recommend are sometimes very different because in some parents' minds it appears that the "whistle check" is sufficient. It is, therefore, important to be more descriptive/ detailed in follow-up sessions with parents. If audiologists or parent advisors ask the parent, "Are you checking the hearing aids?" the response will likely be "yes." However, the quality and frequency of the hearing aid check remains unknown unless the professional probes further.

It appears that confusion regarding the purpose of the stethoscope exists for many of these parents, since only 16% of the respondents reported its daily use. Two parents' comments particularly exemplify this confusion. When asked about the frequency with which they used the stethoscope for checking their child's aids, one parent reported using it only weekly, but that (s)he would stick the hearing aid up to his/her ear daily. Another parent said (s)he tried it once, but stopped because the purpose was not clear.

The need for a hearing aid stethoscope is especially important for parents of infants, since sound quality from the hearing aid needs to be consistent. The likelihood that an aid could be damaged and producing distorted or inadequate sound is great, since infants tend to tamper with hearing aids by taking them out, giving them to the dog, sucking on them, or abusing them in a variety of ways. Without consistent listening checks, parents, audiologists, and parent advisors cannot be certain that children are hearing clear and consistent information from their hearing aids.

A similar problem exists with the battery tester because parents are not using it enough (19% daily). Two parents' comments best exemplify this lack of use. One parent reported that (s)he uses it less than once a week, "only when we suspect a battery may be dead." The second parent explained, "I don't test them. I just change them every two weeks. I just found out that I do have a battery tester." Parents need to be told that although a hearing aid's battery life is typically two weeks, this is a generalization and not an absolute truth. The amount of gain required from the hearing aid, length of use each day, the age of the batteries, and normal random variation in battery life will affect how long a battery lasts. Parents need to be instructed that the real value of a battery tester is not in determining if a battery is dead. Its value is in determining if the charge is too weak and not likely to last the entire day. Regular battery testing is about being both corrective and preventative. A simple daily battery check will ensure the parent that the child's aids have sufficient power to last the day, whereas, a "whistle check" cannot provide this guarantee.

Parent Perceptions: Training and Abilities.

The final research question, "Do parents feel confident in their training and abilities relative to hearing aid monitoring and maintenance, and for what reason might they not check their child's hearing aids daily?" helps to identify perhaps the biggest problem: parents do not understand the critical importance of hearing aid maintenance. Parents view what they are doing as adequate, when in reality more is needed. Audiologists and parent advisors have not sufficiently stressed the importance of the daily hearing aid check. If parents understood that hearing aid monitoring and maintenance could be the difference between success and failure in their child's developmental outcomes, they would likely take hearing aid care more seriously. Audiologists and parent advisors need to teach correct concepts clearly, strongly, and more frequently.

Based on the data in this study, parents have established poor routines in the care of their child's hearing aids, given the infrequency of checks and the inconsistent use of the prescribed tools. The data also reveal that while most of these parents believe they received sufficient training, their actual performance indicates they did not always understand their training or the audiologist/ parent advisor failed to convey the training's importance. In most cases, parents know how to check and clean the aids, but as professionals, we have not given them a sufficient reason to make it a priority.

In future studies, it would be useful to look at the practices of audiologists and parent advisors with regard to their methods for training and follow-up, especially as they relate to parental hearing aid monitoring and maintenance. Perhaps it is appropriate to consider a new approach for instructing parents. The call for better teaching and more frequent follow-up could be addressed through the development of an instructional DVD, which could include demonstrations, research, and parent testimonials. Reading materials written in such a way that parents can understand them need to be provided. In addition, professionals could develop brochures, pamphlets, or informative websites that parents would access after instruction has been provided in the home.

Conclusion

A question that needs to be answered is, "What is best practice with regard to hearing aid monitoring?" Certainly a daily hearing aid check using the battery tester and listening stethoscope would be ideal, but is this realistic, or even necessary? The best way to answer this question is to look at previous literature, which states hearing aids that are properly monitored on a daily basis function better. A hearing aid check utilizing a battery tester and hearing aid stethoscope is something that could be done quite easily. This is a quick and simple routine that should be integrated into parents' daily activities. The time between hearing aid checks should never span more than two days. Parents will only take the task seriously if they are given sufficient reasons. This can be done through effective and regular follow-up and training. The parent who checks his or her child's hearing aids daily with a listening stethoscope and battery tester will be able to recognize even the most subtle changes in the aid's performance and will be more adept at monitoring its performance and detecting problems.

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Appendix A
Parent Questionnaire

Date: ______ Participant Number __________

Please answer the questions listed below. We appreciate your help in gathering information about hearing aids and their care and maintenance.

What is the age of your child? ____ Years _____ Months

How long has your child been enrolled in the Parent Infant Program? ____ Years ____ Months

1. Have you received training for hearing aid maintenance? ¬¬___ Yes ___ No
2. If you answered "yes" to question 1, who provided that training (mark all that apply)?
   a. The audiologist who fit your child's hearing aid
   b. Another audiologist
   c. The Parent Advisor form the Parent Infant Program
   d. Another parent
   e. Other (please specify) ____
3. Please indicate which of these individuals were most helpful to you in providing training on care and monitoring of your child's hearing aids (mark all that apply).
   a. The audiologist who fit your child's hearing aid
   b. Another audiologist
   c. The Parent Advisor form the Parent Infant Program
   d. Another parent
   e. Other (please specify) ____
4. Please indicate how adequately you feel you have been instructed regarding how to perform a daily check on your child's hearing aid/s.
   a. Very well
   b. Good
   c. OK
   d. Poor
   e. Very Poor
5. Please rate how adequately you feel you have been instructed regarding how to clean/maintain your child's hearing aid/s.
   a. Very well
   b. Good
   c. OK
   d. Poor
   e. Very Poor
6. Please rate how adequately you feel you have been instructed regarding how to troubleshoot your child's hearing aid/s.
   a. Very well
   b. Good
   c. OK
   d. Poor
   e. Very Poor
7. Do you own any of the following items?
   a. Hearing aid batter tester ___ Yes ___ No
   b. Hearing aid listening tube (stethoscope)___ Yes ___ No
   c. Hearing aid moisture kit ___ Yes ___ No
   d. Wax brush ___ Yes ___ No
   e. Air bulb ___ Yes ___ No

8. If you own any of the above items, have you been told:
   a. To purchase them ___ Yes ___ No
   b. How and where to purchase them ___ Yes ___ No

9. Please indicate how frequently you use the items listed below when checking or cleaning your child's hearing aid/s.
   a. Hearing aid battery tester?
      (1) 6-7 days of the week
      (2) 4-5 days a week
      (3) 2-3 days a week
      (4) Once a week
      (5) Other (please explain) ____

   b. Hearing aid listening tube (stethoscope)?
      (1) 6-7 days a week
      (2) 4-5 days a week
      (3) 2-3 days a week
      (4) Once a week
      (5) Other (please explain) ____

   c. Hearing aid moisture kit?
      (1) 6-7 days a week
      (2) 4-5 days a week
      (3) 2-3 days a week
      (4) Once a week
      (5) Other (please explain) ____

   d. Air bulb to remove earwax or moisture in earmold or tubing?
      (1) 6-7 days a week
      (2) 4-5 days a week
      (3) 2-3 days a week
      (4) Once a week
      (5) Other (please explain) ____

   e. Wax brush for earwax removal on earmold?
      (1) 6-7 days a week
      (2) 4-5 days a week
      (3) 2-3 days a week
      (4) Once a week
      (5) Other (please explain) ____

10. Do you feel confident that you know how to properly use the items listed below?
    a. Hearing aid battery tester ___ Yes ___ No
    b. Hearing aid listening tube (stethoscope)___ Yes ___ No
    c. Hearing aid moisture kit ___ Yes ___ No
    d. Air bulb ___ Yes ___ No

11. How many times a week do you check your child's hearing aid/s?
    a. 6-7 days of the week
    b. 4-5 days a week
    c. 2-3 days a week
    d. Once a week
    e. Other (please explain) ____

12. How many times a week do you clean your child's hearing aid/s?
    a. 6-7 days of the week
    b. 4-5 days a week
    c. 2-3 days a week
    d. Once a week
    e. Other (please explain) ____

13. How much of the time do you believe that your child's hearing aid/s are working properly?
    a. 100%
    b. 90%
    c. 75%
    d. 50%
    e. 25%
    f. Less than 25%

14. Please rate how comfortable you feel checking your child's hearing aid/s?
    a. Very comfortable
    b. Comfortable
    c. OK
    d. Uncomfortable
    e. Very uncomfortable

15. Please rate your level of proficiency for troubleshooting your child's hearing aid/s
    a. Very proficient
    b. Somewhat proficient
    c. Barely proficient
    d. Less than proficient
    e. Not proficient at all

16. What do you typically do in the event that you find a problem with your child's hearing aid/s?
    a. Call your parent advisor
    b. Wait for your parent advisors scheduled visit
    c. Wait for your next scheduled appointment with your audiologist
    d. Other (please explain) ____

17. Is there any other information about your child's hearing aid/s that you would like to know? (If yes, please indicate what that would be)? ___ Yes ___ No

18. What are the most frequent problems that you encounter with your child's hearing aid/s? (Please specify below)

19. For what reasons might you not check or clean your child's hearing aid/s on a daily basis? (Please check all that apply.)
    a. I'm too busy and can't find the time
    b. I mean to but I often forget to check them
    c. I'm not sure what to do
    d. I don't see a reason for having to check and clean them every day
    e. I've been shown how to check and clean hearing aid/s but I still don't feel comfortable doing it.
    f. Other (please explain) ____

20. How much more training in hearing aid monitoring, care, and troubleshooting do you feel you need?
    a. None, I think I am doing well
    b. A brief review would be helpful
    c. I need comprehensive training
    d. Other (please explain) ____

Different Professionals' Interpretation of a Decoding Deficit in Reading Skills

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An educational profile of a fictitious child with a decoding deficit in reading skills was distributed by mail to audiology, speech-language pathology, and reading specialty professionals throughout the United States. Each participant was asked to review the profile and complete a questionnaire. The survey asked open-ended questions concerning the professional's interpretation of what may be the basis of the child's learning difficulties and the assessment tools needed for an evaluation. This study reviewed each professional's analysis of the possible origin of the learning difficulty and determined if a common response theme emerged from the different professional groups.

The lack of development in auditory discrimination of speech sounds plus the inability to process complex phonological information are common characteristics between dyslexia, a (central) auditory processing disorder ([C]APD), and a phonological awareness deficit. Although these disorders have common characteristics, each may be diagnosed differently depending on the professional who examines the child. For example, a child who has difficulty discriminating speech sounds may be assessed for deficits in (central) auditory processing by an audiologist. If the same child was referred to a speech-language pathologist, testing may concentrate on phonemic awareness abilities or receptive language skills. On the other hand, a reading specialist may suspect dyslexia as the cause. Even though all these professions are looking at the same characteristics, different techniques may likely be used for assessment; therefore, different intervention strategies may be implemented.

In order to understand how speech-language pathologists, audiologists, or reading specialists might assess and treat a child with a decoding deficit, it is important to investigate common characteristics and relationships that phonological awareness and (central) auditory processing may have with dyslexia. It is also important to understand the different approaches that these three professional groups may have when evaluating and treating a child with a decoding deficit.

Dyslexia and the Reading Specialist

Learning disorders and developmental reading disabilities, in particular, are a major educational problem in the United States. Dyslexia is a language disability that not only affects the ability to learn to read, write, and spell by conventional methods, but also affects the ability to communicate in more subtle ways, such as pronouncing words clearly or fully understanding what others say (Gillon, 2004). According to the International Dyslexia Association (IDA, 2000), "dyslexia refers to a cluster of symptoms, which result in people having difficulties with specific language skills, particularly reading" (pg. 1). As a result, dyslexic individuals may have problems in reading comprehension and have an overall reduced ability to relate printed symbols with corresponding auditory properties (Snyder and Mortimer, 1969). Reading problems can interfere dramatically with academic achievement. Snowling (1998) estimated that more than 10% of school-age children experience reading difficulties, with half of these children possibly being dyslexic. Children with dyslexia do not exhibit deficits in intelligence, peripheral hearing, or peripheral vision; rather, they lack sufficiency in the processing of language (Moncrieff, 2005).

As with any other skill deficit, the earlier a child is identified with dyslexia, the better the prognosis he or she will have for developing learning strategies, thereby raising school achievement. Snyder and Mortimer (1969) recommend that a child should be evaluated for dyslexia if his or her reading and writing skills are significantly below grade level in the beginning of second grade. Testing is usually completed by an educational psychologist or a reading specialist. A basic test battery that is productive in identifying dyslexia involves (White, 1983): (a) a case history where the psychologist or reading specialist asks the parents questions directly, (b) administration of an intelligence scale for children, (c) reading and spelling tests, and (d) laterality tests. An example of an intelligence scale would be the Wechsler Intelligence Scale for Children – Revised (WISC-R; Wechsler, 1991). This examination includes (but is not limited to) the subtests of picture completion, picture arrangement, vocabulary, object assembly, comprehension, coding, and digit span. The educational psychologist or reading specialist must also obtain information concerning the technique used by the child to interpret unfamiliar vocabulary words, errors involved while producing those words and comprehension of the material read (White, 1983). Dyslexia cannot be diagnosed based on symptomology alone. Testing must be completed by qualified professionals in order to make a reliable diagnosis (IDA, 2000).

Upon completion of the testing and interpretation of the results, schools can implement academic modifications and interventions to help students with dyslexia succeed (IDA, 2000). Examples of effective modifications would include giving students extra time to complete tasks, allowing students to use taped tests, and providing students help with note taking. Furthermore, a combination of correcting errors in reading, reducing pressure upon the child for academic success, and understanding the child's problem would be a successful approach during treatment (IDA, 2000).

(Central) Auditory Processing and the Audiologist

A (central) auditory processing disorder, as defined by the American Speech-Language-Hearing Association (ASHA; 2005, p. 2), is described as "difficulties in the processing of auditory information in the central nervous system (CNS) as demonstrated by poor performance in one or more of the following skills: sound localization and lateralization; auditory discrimination; auditory pattern recognition; temporal aspects of audition, including temporal integration, temporal discrimination, temporal ordering, and temporal masking; auditory performance in competing acoustic signals; and auditory performance with degraded acoustic signals." Children diagnosed with an auditory processing disorder may present characteristics, such as (a) poor expressive and receptive language abilities, (b) poor reading, writing, and spelling, (c) poor phonemic awareness, or (d) behavioral, psychological, and/or social problems as a result of poor language and academic skills. Not all of these characteristics need to be present in order to indicate a (C)APD, but they do provide reason to suspect a disorder in the central auditory nervous system.

A child must be able to sound out words in order to read fluently, a skill referred to as decoding, or word-attack abilities (Bellis, 2002). A child may be diagnosed with a (C)APD that is characterized by problems with decoding, or word-attack skills, and impact reading abilities. This is described as a decoding deficit and is characterized by a weakness in the ability to discriminate and analyze phonemes (Bellis & Ferre, 1999). This child may experience difficulty auditorily distinguishing phonemic segments within a speech signal, which later may lead to problems making associations between phonemes and graphemes (Richard, 2007). A child with a decoding deficit will spend a great deal of time and effort trying to analyze each letter and word. Therefore, by the end of the sentence, the child may have forgotten what the sentence was about because he or she was devoting time and energy to the decoding process. Thus, reading comprehension may also be affected by (C)APD (Bellis, 2002).

(C)APD can only be formally diagnosed by an audiologist because of the characteristics of the test tools used (ASHA, 2005). A child that is suspected of a (central) auditory processing disorder may complete an evaluation that is designed to tax the auditory system. Therefore, a child should be at least seven years of age and have normal peripheral hearing before a (central) auditory processing evaluation is administered (Johnson, Bellis, & Billiet, 2007). Bellis (2002) recommends that the test battery consists of a case history report and auditory tests including dichotic listening, low-redundancy speech tasks, temporal processing tasks, and perception of nonverbal auditory stimuli. If the scores indicate that the individual exhibits characteristics of a (central) auditory processing deficit, results should be used to determine how that disorder contributes to the difficulties the child may be experiencing at school and home. However, the (C)AP assessment should be part of a multidisciplinary evaluation with a team of educational professionals and should not be the initial or only procedure used when diagnosing a (C)APD (Johnson, Bellis, & Billiet, 2007).

Treatment for a (C)APD may incorporate ways to manage the listening environment and/or specific therapy techniques. Moreover, the appropriate management strategies vary depending on the nature of the (C)APD (Bellis, 2003). For example, children who experience a decoding deficit may have difficulty with low-redundancy speech. These children may benefit from enhancement of the auditory signal through changes in the environment (such as reducing background noise or using a personal or sound field FM system in the classroom). Direct therapy techniques may include auditory discrimination training. Richard (2007) recommends that an hierarchy for auditory processing be considered when determining a treatment protocol for a child with a (C)APD. Treatment and management strategies should include goals for acoustic processing, phonemic processing, and language processing. Acoustic goals would incorporate direct auditory training and signal enhancement strategies. The development of the discrimination of phonemes and their association with graphemes would be utilized to enhance phonemic processing skills. For language processing, the focus would be making connections between auditory information and language.

Phonological Awareness and the Speech-Language Pathologist

Phonemes are the basic units of sounds contained within each word, and therefore, understanding phonemes is a critical part in learning to read successfully (Liberman & Liberman, 1990). In order to associate letters to meanings, phonemic awareness should be intact. While in school, children are introduced to the idea that letters of the alphabet stand for speech segments or sounds (phonics). However, the development of phonics may be impaired without the awareness of these speech sounds (phonological awareness). Without this connection between the basic unit of sounds and their representation to letters, reading cannot occur (Liberman & Liberman, 1990). However, children with deficits in the development of phonological awareness have trouble retrieving this basic phonological representation from their memory. Phonological awareness refers to the ability to understand how speech sounds are used in words. Abilities that rely on phonological awareness include, but are not limited to, phonological manipulation, segmentation, and sound blending (Bellis, 2002). Phonological manipulation involves the ability to manipulate the order of the sounds in a word and determine what the new word would be. Segmentation is the ability to separate out speech sounds in a word, and sound blending is the ability to take separate speech sounds and connect them meaningfully to make a word (Torgesen & Mathes, 2000).

The purpose of testing for phonological awareness is to determine a child's knowledge about spoken sounds in words. Successful reading skills in the early school years have been linked to the development of phonological awareness skills in preschool and first grade (Lonigan, Burgess, & Anthony, 2000). This is why it is important to assess phonological skills early during preschool and kindergarten. A speech-language pathologist has extensive training in phonetics and phonological disorders and would play a key role in the assessment and treatment of delays in phonological awareness (Catts, 1991).

Deficits in phonological awareness result in difficulty performing the tasks described above, and for this reason, teachers need to be aware of educational activities that can help their students recognize phonemes before receiving formal reading training. Once beginning readers have acquired phonemic awareness, further reading instruction will enhance their awareness of language (Liberman & Liberman, 1990). Therefore, phonological awareness is both a requirement for and a consequence of learning to read. It has also been argued that phonological awareness may be improved by the ability to read (Dale, Crain-Thoresen & Robinson, 1995). According to Stackhouse (1997), phonological awareness progresses along a range from implicit to explicit. Syllable segmentation and rhyming are found at the implicit end, while sound segmentation and manipulation are found at the explicit end. Most young children begin developing phonological awareness skills in the implicit end of the continuum before having knowledge of the alphabet (Stackhouse, 1997).

Relationship Between Dyslexia, (C)APD, and Phonological Awareness

The relation between dyslexia, (C)APD, and phonological awareness has been discussed by various sources. Past research provides evidence that the quality of a child's phonological awareness skills has a direct impact on the progression of reading abilities (e.g., Landerl, Wimmer, & Frith, 1997; Porpodas, 1999; Torgesen, Wagner & Rashotte, 1994). Weakness in phonological awareness skills has been seen in children with dyslexia. However, the relationship between (central) auditory processing skills and dyslexia has been more controversial. Tallal, Miller, Jenkins and Merzenich (1997) theorized that a weakness in phonological awareness skills in children with dyslexia is due to an inability to accurately process rapidly changing acoustic signals (such as speech sounds). In short, a deficit in phonological awareness may be more related to a deficit in auditory processing skills (Farmer & Klein, 1995). This has led to more recent theories, such as the temporal processing deficit hypothesis. This theory suggests that children with dyslexia show a general impairment in the processing of rapid auditory stimuli (Hood & Conlon, 2004). Hood and Conlon (2004) assessed temporal order judgment (TOJ) tasks in children to support this theory. TOJ refers to the ability to judge the order of two rapidly presented stimuli, either of auditory or visual nature, which can be verbal or nonverbal (Hood & Conlon, 2004). Visual temporal processing is said to be important in perceiving word formation and encoding letter position, while auditory temporal processing is thought to be necessary for the progression of phonological processing and reading (Hood & Conlon, 2004). Using auditory TOJ tasks for nonverbal tones, Tallal (1980) studied 20 children with dyslexia and 12 children without reading difficulties. It was reported that children with dyslexia were less accurate than children without reading difficulties (controls) for the identification of two brief (75 ms) complex tones for short (8-305 ms) inter-stimulus interval (ISI) trials. Heiervang, Stevenson and Hugdahl (2002) administered a computerized version of Tallal's tone-test, but included trials with longer tone durations (250 ms) and with an increased number of observations for each condition. Their results revealed that children with dyslexia were below the children in the control group when correctly identifying complex tones of short duration presented in rapid succession. Therefore, these results support the findings that there is an auditory processing deficit for the identification of rapid stimuli in children with dyslexia.

Marshall, Snowling, and Bailey (2001) reported that auditory processing deficits contribute to poor phonological ability found in children with reading deficits. It is believed that if poor reading is linked to a deficit in auditory processing, then it may be difficult to distinguish speech sounds and the acoustic changes that occur within those sounds. With well-developed phonological awareness, children are able to generalize from the meanings of words, attend to critical sounds, and as a consequence, understand that letters are the written components of their spoken language (Marshall et al., 2001).

Schulte-Korne, Deimel, Bartling, and Remschmidt (1999) proposed a four-level model of auditory and phonological processing (see Table 1), which incorporates the temporal order/gap detection theory.

Table 1. Hierarchical model of different auditory processing levels in reading and spelling development (Schulte-Korne et al., 1999). *Printed with permission from T. Tschech, Springer Publishing.*

	Processing Level	Paradigm and Measures
Level 1	Pre-attentive and automatic processing of auditory stimuli	Passive oddball paradigm, mismatch negativity
Level 2	Conscious processing of auditory stimuli	Gap detection. Tone and speech discrimination
Level 3	Conscious and cognitive (phonological) processing	Phonological awareness; phoneme counting
Level 4	Spelling and reading	Writing to dictation, word reading

Their model depicts that phonological processing is the most complex level in linguistic processing.

Therefore, while speech perception directly influences phonological awareness, phonological processing directly influences reading and spelling.

Differences in Assessment Procedures used by Each Profession

As stated previously, common characteristics between dyslexia, a (C)APD, and a phonological awareness deficit are seen in the lack of development of auditory discrimination of speech sounds and in the processing of complex phonological information. Even though there is an association between dyslexia, (C)APD, and phonological awareness, these disorders may be assessed by different professionals who may use dissimilar approaches to diagnose the problem. For example, while auditory processing disorders are commonly assessed by audiologists, dyslexia may be diagnosed by various professionals with knowledge in the areas of psychology, reading, language, and education (IDA, 2000). Phonological awareness is commonly assessed by speech-language pathologists, due to their extensive training in the development of the sound structure of language. Speech-language pathologists typically make sound comparisons in different words and have children experiment with phonemes, which includes counting, deleting or adding sounds. Each professional working with a child that has difficulty learning to reading will use a variety of tests in order to make a specific diagnosis. Different professionals analyze and examine children with decoding deficits in different ways. The way that different professionals assess and treat these children can be influenced by the biases of their fields.

Current literature lacks information on the incidence of collaborative efforts between professionals when diagnosing a child with a reading disability. The International Dyslexia Association does promote a comprehensive evaluative process when assessing a child suspected of having dyslexia (Sawyer & Jones, 2008). This approach includes testing for the areas of intelligence, oral language skills, word recognition, decoding, spelling, phonological processing, fluency skills, reading comprehension, and vocabulary knowledge (Sawyer & Jones, 2008). However, IDA does not specify which professional groups should be involved when evaluating each of these areas. ASHA also endorses a comprehensive approach for assessing literacy skills, but goes further to clearly define the need for collaboration with other professionals. ASHA states (ASHA,

2002) that, "roles and responsibilities related to reading and writing in children and adolescents are essentially collaborative in nature. No one discipline owns them. SLPs work collaboratively with families, teachers, and other professionals to meet the literacy learning needs of infants, toddlers, children, and adolescents with and without disabilities" (pg. 2). The Educational Audiology Association (EAA) also encourages audiologists to be part of a multidisciplinary team when evaluating any child suspected of having a (C)APD that may be affecting learning in the classroom (EAA, 1997). The significance of pooling resources when addressing a child with a reading disability is evident when reviewing professional guidelines for reading specialists, audiologists, and speech-language pathologists. However, the extent to which individuals in each of the professions collaborates with other specialists is still unknown.

The purpose of this study was to investigate how audiologists, speech-language pathologists, and reading specialists interpreted an educational profile on a fictitious child with a decoding deficit in reading. The study used a qualitative collective case study approach to examine whether a person's profession influenced how he or she interpreted a set of characteristics for a child with a decoding deficit. Data was reviewed to see if different professions had biases with how they viewed a set of learning difficulties presented about a child. It was thought that professionals' views on assessment and treatment are influenced by the training and experiences promoted by their field of study. The goals of this study were to reveal whether professionals in the fields of speech-language pathology, audiology, and reading specialty (1) are influenced by the philosophy of their professions and(2) would assess and diagnose differently a child with a reading disorder. The study also examined the tendency of those professionals to collaborate with other specialists in the assessment and diagnosis of this complex case study.

Method

Participants

A total of 150 professionals (50 audiologists, 50 speech-language pathologists, and 50 reading specialists) from 34 states were asked to voluntarily participate in this study. Of these, 12 audiologists, 18 speech-language pathologists, and 20 reading specialists completed the questionnaire, giving a 33% response rate. Names for participants from the field of audiology were acquired from the Educational Audiology Association. All of the audiologists held a master's degree or higher and were certified or licensed within their state to practice in their profession. Contact information for speech-language pathologists was obtained from ASHA. The speech-language pathologists who participated also held a master's degree or higher, a certificate of clinical competence with ASHA, and were practicing clinicians in an educational setting. Names of reading specialists were acquired through an internet search of school districts in the United States. Contact information for school districts were acquired through lists provided by each state board of education. Listing of personnel for individual school districts was reviewed and those listed as the district's reading specialist were mailed surveys. Surveys were also disbursed to individuals listed on the web as reading specialists. Credentials for the reading specialists varied with nine holding a master's degree and 13 holding a bachelor's degree. A majority of the reading specialists held a degree in the field of education (N=18), with the remaining two holding degrees in other areas, such as psychology. Two participants did not designate the field for their degree and were eliminated from the study.

Design and Measures

Qualitative methodology was selected for this investigation because of its unique appropriateness in meeting the purpose of this study (i.e., to explore and examine the perceptions of professionals regarding a child with a decoding deficit in reading skills). Miles and Huberman (1994) suggested that a characteristic of qualitative research methodology is that "the possibility for understanding latent, underlying, or nonobvious issues is strong" (p.10). Additionally, qualitative data has the features of richness and holism, which tend to reveal complexity. By analyzing data with a qualitative method, themes emerging from the opinions of various professional groups could be directly identified and compared.

The method used was the collective case study, as described by Stake (2000). A collective case study involves the study of more than one case in order to "investigate a phenomenon, population, or general condition" (p. 437). This approach assumes that investigating a number of cases will lead to better comprehension and better theorizing. Miles and Huberman (1994) contend that using collective case studies strengthens the "precision, the validity, and the stability of the findings" (p. 29).

Procedures

An educational profile (Appendix A) of a fictitious child with a decoding deficit in reading skills was sent to randomly chosen professionals in the fields of speech-language pathology, audiology, and reading specialty. The profile was sent by mail to each recipient along with a letter stating that the questionnaires would be confidential and kept in a secure location. Participants could disclose their name and age; however, this was optional. Those who completed the questionnaire were asked demographic information, such as their professional title, degrees earned, and field of certification/licensure. Each participant was asked to review the profile and answer items on a questionnaire. Three open-ended questions were presented (see Appendix B). The first question focused on the professional's interpretation of his or her suspicion about the basis of the child's learning difficulties. The second question centered on the evaluation tools that each professional would consider when assessing this child for a suspected disorder. For the third question, participants were asked if they had any further recommendations. This was included to seek additional information concerning whether or not the professional would refer outside his/her field for further testing or consultation with professionals from other disciplines. A self-addressed, stamped envelope was provided for each participant to return the completed questionnaire.

Data Analysis

A cross-case analysis was used to analyze the data. Miles and Huberman (1994) described cross-case analysis as initially analyzing each individual case as a whole entity. A comparative analysis of all cases was then completed. Studying multiple cases reassures researchers that the events in only one case are not "wholly idiosyncratic" (p. 172). Furthermore, studying multiple cases allows researchers to see processes and outcomes across many cases and to develop a deeper understanding through more powerful descriptions and explanations. A cross-case analysis allowed these researchers to identify similarities and differences for each profession's perspective on how to test and manage a child with a decoding deficit.

Members of the research team reviewed the questionnaires using a coding process to review responses for all three questions. This technique allowed the researchers to merge the data into topics and label these topics with a code (Strauss & Corbin, 1990). Coding assisted researchers to stay close to each participant's views while continually studying the data (Charmaz, 2000). Once each researcher coded the questionnaires, group meetings were conducted to cross-check the coding strategies and interpret the data (Barbour, 2001). The researchers then developed categories across cases and met multiple times in order to refine, add, or delete categories. Once this process was complete, percentages of common response themes were computed based on frequency of their occurance. This method allowed for the emergence of specific and concrete patterns common to sets of cases. Use of this method yielded a rich description of professionals' perceptions from each of the specialized areas of audiology, speech-language pathology, and reading specialty.

Results

Two topics from the questionnaires were analyzed. First, each professional's responses were examined to ascertain what they suspected as being the basis of this fictitious child's reading difficulties. Second, it was assessed whether each professional recommended further collaboration with other disciplines. When presented a description of a child with a decoding deficit, audiologists, speech-language pathologists, and reading specialists generally provided varied interpretations of the possible source of the child's learning problems. This diversity in opinions appeared to be related to each group's professional training

Table 2. Examples of responses referencing the need for a collaborative approach.

Audiologist 1	• Team evaluation would be preferential. Audiologist: Pure tone air and bone conduction, tympanometry, word recognition in quiet and noise, screen for (C)APD. SLP: Language and vocabulary tests. Psych: WISC. LD Specialist: Woodcock-Johnson.
Audiologist 2	• I would want to rule out ADD, APD, or a specific learning disorder. There are many things in the case history that suggest APD. Additionally he may have some type of subtle language delays.
Audiologist 3	• A multi-disciplinary evaluation is in order. I want a full APD eval, rule out ADD, look at language disorders and perhaps executive function concerns. I'd want a psych eval for differences in verbal and performance IQ.
Speech-Language Pathologist 1	• Full evaluation for learning disabilities. Reading specialist evaluation. Audiology referral for full eval or ENT visit.
Speech-Language Pathologist 2	• Refer to Audiologist for a complete workup. Psycho-educational workup.
Speech Language Pathologist 3	• Refer for language testing by certified, licensed speech-language pathologist. See an audiologist if problems are apparent in the auditory processing realm.
Reading Specialist 1	• When I review the client history, I see symptoms that support the possibility of a few different learning difficulties. I would consider: developmental reading disorder, phonological processing disorder, central auditory processing disorder, ADD/ADHD, visual processing issues, and or dyslexia.
Reading Specialist 2	• Need psycho-educational battery. WISC, etc.
Reading Specialist 3	• See an educational diagnostician and have a Wechsler Individual Achievement test (WIAT-II), visual motor, written language test, and full battery of tests to compare strengths and weaknesses.

and scope of practice. Also, there was a tendency for certain professionals, more than others, to pool other resources when evaluating a child with reading difficulties.

Audiologists

Of those surveys returned by the 12 audiologists, eight (66.6%) suspected a (central) auditory processing disorder. All eight audiologists who suspected a (central) auditory processing disorder also cited possible related conditions, such as learning disability or language delay. While all the audiologists recommended a comprehensive hearing evaluation, four (33.3%) did not recommend further testing to rule in/out a (C)APD. All but one audiologist (91.7%) recommended further consultation with multiple professionals from disciplines related to speech and language, educational psychology, reading specialty, learning disability specialty, and neuropsychology. The audiologist who did not recommend a multi-disciplinary approach requested further consultation with a speech-language pathologist. Most professionals in this field precisely recommended some type of comprehensive testing. Table 2 provides examples of statements given by each of the professions on the need for collaboration.

Speech-Language Pathologists

Although a majority of the speech-language pathologists (N=13; 72.2%) suspected some type of deficit in language skills, eight (44.4%) suspected that the child's learning difficulties may also have a (C)APD component. Only two (11.1%) speech-language pathologists inferred that a deficit may exist with phonological awareness/processing skills. Four (22.2%) speech-language pathologists suspected other learning disabilities along with a language disorder or delay. Only four (22.2%) speech-language pathologists surmised that the child may be experiencing a language impairment with no co-morbid conditions. Hearing loss was suspected as the basis of the child's difficulties by one (.94%) speech-language pathologist. Speech-language pathologists also varied in their responses concerning other disciplines that should be involved in the assessment process. Seven (38.9%) of those surveyed recommended a full case study with the involvement of an audiologist, reading specialist, and school psychologist. Nine (50.0%) made no reference to the inclusion of other professionals in the evaluation process for this case. It was suggested by two (11.1%) of the speech language pathologists that the child be seen by an audiologist for a hearing test, but by no other professionals. All but three of the speech-language pathologists (83.3%) recommended various evaluation tools to assess expressive and receptive language skills. Reading specialists' and speech-language pathologists' interpretations relating to the basis for the child's learning difficulties ranged from very explicit theories to a wide range of presumptions (See Table 3).

Reading Specialists

Nine (45.0%) of the 20 reading specialists reported dyslexic tendencies shown in the educational profile. Their descriptions of these tendencies varied from phonics problems to auditory confusion. Two reading specialists (10.0%) made reference to a suspected (C)APD as a possible source for difficulties with reading. Only one (5.0%) of these professionals recommended an evaluation for (C)AP, but there was no specific mention for having an

Table 3. Examples of professionals' interpretations of a child's learning difficulties.

Audiologist 1	• Auditory processing. Language – word retrieval/organizational skills in language.
Audiologist 2	• Hearing loss cannot be ruled out, without comprehensive diagnostic evaluation. If hearing has not been monitored since age 3 – 4, given his history, it's possible a progressive hearing loss or unidentified hearing loss is a factor.
Audiologist 3	• This student's behavior makes him a central auditory disorders suspect with classic decoding symptoms, i.e. problems w/ auditory closure, listening/focusing in noise, hearing fine but not understanding, difficulty with sequential memory, speech-sound discrimination. In addition to decoding problems he may additionally have integration or associative deficits.
Speech-Language Pathologist 1	• Possibly language based learning disability, auditory processing, working memory weakness, or attention deficit disorder.
Speech-Language Pathologist 2	• Perhaps an auditory processing disorder, language delay due to otitis media or hearing loss, or LD for reading/writing.
Speech-Language Pathologist 3	• Suspect poor phonemic awareness skills and language processing delays characterized by difficulties with auditory skills such as memory and receptive language, and the organization of incoming linguistic information. This may account for his failure to remember linguistic units, because he may treat each word as an isolated unit, and therefore unaware of the rules (phonics) that govern their use.
Reading Specialist 1	• Auditory processing may be part of the issue since he has trouble retrieving words. Concentration may be part of the issue since he has trouble organizing his thoughts.
Reading Specialist 2	• This student has numerous difficulties indicating strong dyslexic tendencies. Dyslexics' primary mode of learning is kinesthetic or hands-on learning; therefore, it is natural they will excel in subjects like science and/or math. Due to their inaccurate perception of reality, they are unable to process visual and/or auditory information. This also affects their ability to process sounds which means speech difficulties, as well as an inability to process phonic-based programs.
Reading Specialist 3	• The child is probably a visual-spatial learner. Classes which are structured with less teacher-talk and more visual, experiential learning (such as science) appeal to his learning style and bypass his deficits. This child experienced hearing loss during a crucial language acquisition period, during the ages of 1-3 years. This is most likely a significant contributor to the auditory confusion that he still experiences.

audiologist complete the testing.

Only two reading specialists (10.0%) suspected problems with phonological awareness/processing that inhibited reading skills. However, the inclusion of a speech-language pathologist was not mentioned for the assessment of these skills. When reading specialists questioned dyslexic tendencies, (C)APD, or a delay in phonological awareness as the basis of the decoding deficit, they often associated these disorders with having difficulty in auditory and/or visual processing. Two (10.0%) of the reading specialists referred specifically to the reading disability as a deficit in auditory and visual processing. Other suspicions were stated that the child may have problems with attention deficit disorder (20.0%) and that the child may be experiencing a language-based learning disability (5.0%). Only two reading specialists (10.0%) recommended an evaluation with a multi-disciplinary team. Reading specialists often mentioned the need for multiple evaluation tools, but made little reference to other professionals. Tests that were suggested included (but were not limited to) the Woodcock Reading Mastery Test, Rapid Automatized Naming, Gray Oral Reading, Wechsler Individual Achievement Test, Connor's Continuous Performance Test, and the Woodcock-Johnson Word Attack. Responses from the reading specialists, when compared to audiologists and speech-language pathologists, were often detailed and descriptive, especially when recommending specific test protocols (see Table 4).

Table 4. Examples of recommendations for specific testing

Audiologist 1	• Audiologist: Pure tone air & bone conduction. Tympanometry. Word recognition in quiet & noise. Screen for (C)APD with SCAN • SLP: Language & vocab tests • Psych: WISC • LD Specialist: Woodcock-Johnson
Audiologist 2	• Full diagnostic evaluation to assess peripheral hearing function based on his history of otitis media • Speech and language assessment to evaluate language competencies • WISC-R IV to look at discrepancies between verbal and non-verbal performance • APD screening assessment may be in order to determine candidacy for a diagnostic evaluation • If justification for a diagnostic evaluation for APD is determined, the clinician should choose a battery of tests based on individual complaints and other information provided for this child
Audiologist 3	• Auditory processing evaluation • Speech evaluation • Reading assessment
Speech-Language Pathologist 1	• TOLD-P – all subtests (including supplemental) • EOWPVT – one word picture vocab • TACT – auditory comprehension • Assessment of phonological awareness
Speech-Language Pathologist 2	• Hearing & vision screening • Audiologist to test for CAP-D • OWLS • TACL/TAPS • Cognitive testing w/school psychologist
Speech-Language Pathologist 3	• Audiological exam • The Word Test • Language Processing Test • Perhaps some auditory processing testing
Reading Specialist 1	• When I work with a child such as you described I am given the results from the Woodcock Reading Mastery Test, Rapid Automatized Naming, Woodcock-Johnson Word Attack, Gray Oral Reading, Wechsler Individual Achievement Test, Woodcock-Johnson Comprehension, Connors Continuous Performance Test.
Reading Specialist 2	• I would give an IQ test and look for his overall IQ in relation to his reading/writing performance in order to determine that he is capable of performing at grade level. I would also look at the subtests to determine strengths/weaknesses in sequential thinking versus spatial thinking. I would also give a language test that could identify sequential processing difficulties.
Reading Specialist 3	• Testing done by school psychologist to see if there is a big difference between IQ and academic ability. Send the child to a doctor to rule out any physical problems with the eyes or ears.

Discussion

Audiologists tended to suspect a (central) auditory processing disorder as the basis of the child's learning difficulties (see Figure 1). They also recommended a comprehensive hearing evaluation to rule out otitis media and hearing loss. A majority of the audiologists (91.7%) indicated the importance of referring to a multi-disciplinary team when assessing the educational needs of the child (see Figure 2). In the requests for a team approach, it was common for the audiologist to make a specific recommendation for an evaluation with a speech-language pathologist. However, no audiologist requested the assessment of phonological awareness skills.

Responses from professionals in the field of speech-language pathology were more varied. Speech-language pathologists who responded to the survey most commonly felt that a deficit in language skills may be related to the child's learning difficulties (see Figure 1). Almost half of those surveyed theorized that a (central) auditory processing disorder contributed to the child's academic problems (in conjunction with a language disorder). Since speech-language pathologists typically have children experiment with phonemes in words (Torgeson & Mathes, 2000), it was surprising to find that only two of the speech-language pathologists recommended a test for phonological awareness. It is also interesting to note that half (nine) of the speech-language pathologists reported they would request further

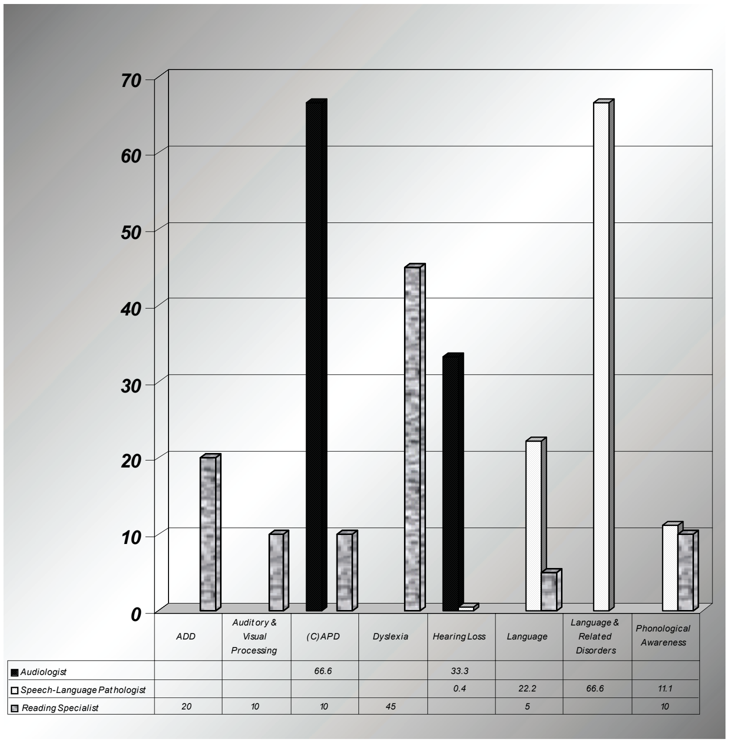

Figure 1. Primary suspected disability related to a deficit in decoding skills.

testing with other professionals while the other half made no reference to outside referrals. Of the half who made recommendations for testing with other disciplines, seven acknowledged the need for a multidisciplinary team (see Figure 2) and eight of the speech-language pathologists specifically included a request for an evaluation with an audiologist.

There were very few trends found in the responses from the reading specialists. Reading specialists had a wide range of theories to explain what contributed to the child's reading difficulties (see Figure 1). Less than half of the reading specialists stated that they suspect the child has some characteristics of dyslexia. This was the only trend noted in the responses of these professionals. Reading specialists were less likely than any other group in this survey to recommend assistance or testing from other professionals in educational-related disciplines (see Figure 2).

In conclusion, several themes were evident from the cross-case analysis. First of all, audiologists were inclined to suspect a (central) auditory processing deficit in this case. Speech- language pathologists did not readily suspect a phonological awareness deficit, but they did speculate that there may be some type of language disorder involved. Reading specialists were more varied in their responses, but generally (65.0%) attributed the learning difficulties to some type of visual and/or auditory processing difficulty.

Second, typical of the closeness of the professional relationship between speech-language pathologists and audiologists, there was a tendency toward cross referrals between these groups. Most audiologists were aware of the need for information concerning the speech and language skills of a child with learning difficulties. Likewise, a significant number of speech-language pathologists were sensitive to information that audiologists could provide when assessing the child; whether it was information about hearing acuity or (central) auditory processing abilities. On the other hand, a number of reading specialists were conservative when it came to collaborating with other professionals. The reading specialists had very specific test protocols for assessing a child with this profile, but there were few referrals made to disciplines outside their own.

The fictitious profile of a child with a deficit in decoding skills was generally interpreted differently by each discipline. However, there was a definite trend for audiologists and speech- language pathologists to make referrals between the two disciplines. Reading

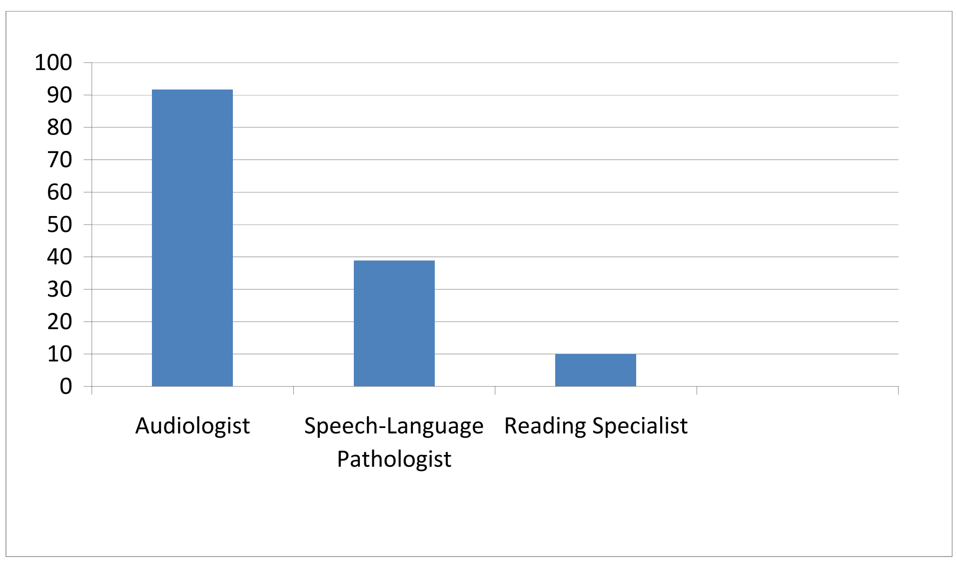

Figure 2. Percentage of professionals from each discipline that specifically indicated the need for a multidisciplinary team assessment.

specialists were least likely to elicit the assistance of other professionals, while audiologists were more ready to request the assistance of other professionals from a wide range of disciplines.

Conclusions and Implications

A collaborative approach is recommended for any child who may struggle with reading (Baran, 2007; Bellis, 2006; Gillon, 2004). This is the only way to delineate the true nature of a learning disability, especially since a child with a decoding deficit in reading skills may be assessed differently by professionals in unrelated fields. The assessment process should include formal and informal measures by an audiologist, educational psychologist, speech-language pathologist, reading specialist, physician, and other relevant educational personnel (Bellis, 2006). Not only should a multi-disciplinary approach be used for the assessment of children with learning difficulties, but a collaborative effort should be included in the treatment and management of these children.

The current study indicates that when given information on a child with a decoding deficit, professionals from different fields may interpret the diagnostic needs of the child differently depending on the biases of their profession. Professionals are influenced by the training and research in their areas and may not be informed about procedures or practices that address the same concerns in other disciplines. In this study, audiologists, speech-language pathologists, and reading specialists (on average) offered a different perspective on the possible cause of a decoding deficit in reading. Also, each group of professionals was inclined to recommend a different battery of tests for assessing the decoding deficit. However, educational audiologists, in general, had a good perspective on the need for a collaborative approach. If a multi-disciplinary approach is used when assessing a child with learning difficulties, then all areas of concern are addressed. Other professionals used in this study did not readily request assistance from other disciplines. Some of the participants in this study may have assumed that a multi-disciplinary approach was already in use with this child. However, this should not be taken for granted and a shared responsibility must be implemented when assessing and treating any child with educational difficulties.

There are inconsistencies in the way that some of these cases may be handled in schools, clinics, or private practices. The manner in which a child is assessed and treated for a learning disability may depend on the professional who sees that child first and whether that professional consults with specialists from other areas. It is imperative that all professional organizations continue to endorse a multidisciplinary approach whenever assessing or treating a child with any type of learning disability. This will insure that all children with educational needs are provided the highest quality services available.

More information is needed on the incidence of collaborative efforts between professionals in different disciplines. This is especially true for those disciplines that assess and treat reading and/or learning disabilities that have overlapping symptomologies. More insight could be given if professionals were asked to analyze and interpret multiple case studies. Specific information on the demographics (without revealing confidential identities) would add to the understanding of the professionals' opinions and practice procedures. Additionally, information on the type of job setting and caseload might show trends in varying work environments.

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Appendix A:

Please read the following information and answer the questions on the attached page.

History

Subject A is currently 8 years, 2 months in age. He attends third grade at a public elementary school. Parents and Teacher report that Subject A has problems following directions and paying attention in the classroom setting. Subject A will often state "I don't get it," when new information is presented for a lesson. The Teacher also reports academic problems with writing skills, word finding abilities, and reading (explaining that phonic skills taught in school are often easily forgotten). Subject A is described as having "good behavior" and is well liked by his peers at school.

Parents report that Subject A has some difficulty telling stories or describing things in a coherent manner. Subject A has some trouble finding appropriate words and keeping thoughts organized when giving a narrative.

Educational history shows that Subject A is working at grade level for mathematics, science, and spelling. It was noted that the science curriculum focused on many hands-on projects. Below average scores were documented for writing and reading.

Medical history was unremarkable with the exception of recurring otitis media (ear infections) from the ages of 1 to 3 years. At age 2, ventilating tubes were inserted which fell out after approximately 11 months. Parents stated that Subject A has not been treated recently for an ear infection. The frequency of the infections has subsided since kindergarten.

Developmental milestones were within the normal range. However, Subject A did not start combining two words phrases until 2 ½ years of age. Parents noted a significant increase in verbalizations once the tubes were inserted.

Appendix B

Questionnaire

Title: ____
Degree: ____
Field of Certification/Licensure: ____
Age (optional) _________

1. From the information presented, what do you "suspect" may be the basis of this child's learning difficulties?

2. What evaluations and specific tests would you recommend to be completed on this child?

3. If a deficit or delay was revealed from these tests, what further recommendations would you make?

Audiology Services in Hawaii's Public Schools: A Survey of Teachers of the Deaf and Speech Language Pathologists

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Hawaii Center for the Deaf and the Blind

**Data collected while author was a student at Central Michigan University*

The Hawaii public school system employs one audiologist for approximately 178,000 students ages 3 through 21. The American-Speech-Language-Hearing Association and the Educational Audiology Association contend that there should be one audiologist for every 10,000 students to adequately deliver services. The purpose of this study was to determine what audiology services are currently being provided in Hawaii's public schools and who, besides audiologists, are performing them. Speech language pathologists (SLPs) and teachers of the deaf (TODs) were identified as the most likely professionals to be providing audiology services to students in the absence of audiologists, and were therefore asked to respond to an online survey of audiology services in the schools. A total of 128 SLPs and TODs completed the survey. Survey results indicated that SLPs and TODs are performing duties that fall under the scope of practice of audiologists. It was determined that employing more audiologists in the Hawaii public school system would improve access to appropriate audiology services to students. Further research in this area could help determine if Hawaii is unique, or if, out of necessity, SLPs and TODs have taken over audiology duties in school systems with less than the recommended 1:10,000 audiologist-to-student ratios.

Introduction

Classroom management for a child with a hearing loss or listening difficulties starts with quantification of the hearing loss or listening problem, assessment of the student's academic performance, assessment of the student's functional skills in the classroom, and determination of individual student and teacher willingness to work together to implement the Individual Education Plan (IEP) recommendations. Audiologists are uniquely qualified to provide important assessment and classroom information to an IEP team for children with hearing loss and listening problems in the public school system. Flexer (1991) states that the ultimate goal of an educational audiologist is to enable children with hearing loss and auditory processing disorders to derive educational benefit from academic instruction. She further states that in order for this to occur, auditory function must be maximized for those students with adequate residual hearing to allow access to language, learning, and life events, as appropriate.

Access to information is essential to learning. In most classroom settings information is presented in an auditory verbal environment (Johnson, 2000; Flexer, 1991). Since the early 1970s, with the passing of major legislation aimed at aiding school students with disabilities, the need for audiological services in the schools has been documented in PL 94-142 and all reauthorizations. Furthermore, studies have demonstrated the need for support services, even for those children with minimal hearing loss, in order to learn and communicate in a mainstream setting (Bess, Dodd-Murphy, & Parker, 1998). It has been stated, "A child's ability to hear influences the development of communication and behavioral skills that affect educational experience and relationships with other people" (Niskar, Kieszak, Holmes, Esteban, Rubin, & Brody, 1998, pg. 1071). There have been numerous studies that put the prevalence of hearing loss in children from 1.9% to over 16%, depending on the criteria used for defining hearing loss. Niskar et. al (1998) reported that information obtained through the Third National Health and Nutrition Examination Survey (NHANES III) indicated that the prevalence of hearing loss of 16dBHL in one or both ears among US children was 14.9% . The majority of the hearing loss was unilateral and slight in severity (16-25dBHL). Even children with these minimal levels of hearing impairment need support in order to access language and learning in the classroom (Bess et. al., 1998; Flexer, 1991).

The issue of minimal hearing loss has

increased the expected numbers of children in need of audiological services and support in school populations (Niskar et.al., 1998; Bess et. al., 1998). Only those with the greatest hearing losses in the severe to profound hearing loss range fall in the 1% to 3% that has resulted in the label of hearing impairment as a low incidence problem. In Hawaii's public school population of approximately 178,000, a prevalence of 14.9% would mean that there are 26,522 students that could be supported in the classroom by an audiologist.

Much of the educational management for children with hearing loss is dictated by federal law under the Individuals with Disabilities Educational Act, and Section 504 of the Rehabilitation Act of 1973. The IDEA has undergone several reauthorizations since the law first passed in 1975 as the Education of all Handicapped Children Act. The most recent reauthorization took place in 2004 as Public Law 108-446.

The Electronic Code of Federal Regulations is reviewed here in relation to audiology services under IDEA 2004. The general definition of eligibility for special education is a child that has been evaluated according to IDEA and been found to have a disability (in this case hearing loss or deafness) who requires, because of this disability, special education and related services to benefit from a free and appropriate public education (Section 300.8[a][1]). Deafness is defined as "a hearing impairment that is so severe that the child is impaired in processing linguistic information through hearing, with or without hearing amplification that adversely affects a child's educational performance" (Section.8 [5]). Hearing impairment is defined as "an impairment in hearing, whether permanent or fluctuating, that adversely affects a child's educational performance but that is not included under deafness" (Section 300.8[3]).

In the case of a child who meets eligibility requirements for special education, audiology services would be available under related services. IDEA (Section 300.34c[1]) states that:

(1) Audiology includes:

(i) Identification of children with hearing loss;
(ii) Determination of the range, nature and degree of hearing loss, including referral for medical or other professional attention for the habilitation of hearing;
(iii) Provision of habilitation activities, such as language habilitation, auditory training, speech-reading (lip-reading), hearing evaluation, and speech conservation;
(iv) Creation and administration of programs for prevention of hearing loss;
(v) Counseling and guidance of children, parents, and teachers regarding hearing loss; and
(vi) Determination of children's needs for group and individual amplification, selecting and fitting an appropriate aid, and evaluating the effectiveness of amplification.

IDEA further states that each school must ensure that hearing aids worn in school by children with hearing impairments, including deafness, are functioning properly (Section 300.113 [a]). FM systems fall under assistive technology. Under this section of the law (Section 300.5), the school must ensure that assistive technology devices (FM systems in this case) are made available to a child if it is required as part of the child's special education, or related services, or supplementary aids and services in the Individualized Education Plan (IEP). There are also services under assistive technology, which include any service directly assisting a child with a disability in the selection, acquisition, or use of any assistive technology (Section 300.6).

A child not eligible for special education services may be entitled to services under the Rehabilitation Act of 1973, subpart D that relates to preschool, elementary, and secondary education programs. The Rehabilitation Act, or Section 504 as it is usually referred to, is an access law with the purpose of preventing discrimination due to disabilities. In general, this Act states that no person who qualifies as handicapped can be excluded from participation in any program or activity which receives federal financial assistance on the basis of their handicap. Under Section 504, a handicap is defined as "any person who has a physical or mental impairment which substantially limits one or more major life activities, has a record of such impairment, or is regarded as having such an impairment" (Section 104.3[h][3][j]). All students who fall under special education will also fall under this act, but not necessarily the other way around.

Services provided under Section 504 include the provision of regular or special education and related aids and services that are designed to meet individual educational needs of handicapped students as adequately as the needs of non-handicapped students are met. The school must ensure that no handicapped student is denied benefits because of the absence of educational auxiliary aids for students with impaired sensory, manual, or speaking skills. Auxiliary aids may include taped texts, interpreters or other effective methods of making orally delivered materials available to students with hearing impairments, readers in libraries for students with visual impairments, classroom equipment adapted for use by students with manual impairments, and other similar services and actions (Section 104.44 [d][2]). Fiscally speaking, the difference between Section 504 and IDEA is that there is no additional funding to support Section 504 services. It is for this reason that many schools will make a student eligible under IDEA whenever possible. Both laws cover a student in extracurricular activities that are sponsored by the school, such as sports. Students with hearing loss or auditory problems that do not qualify for special education services under Hawaii criteria, could receive support from an educational audiologist under the Section 504 law.

Hearing loss is not the only auditory disability assessed by audiologists. Auditory Processing Disorder (APD) refers to the difficulties in processing auditory information in the central nervous system (ASHA, 2005b). APD can result in or be associated with difficulties in learning, speech, language, attention, and social function. APD affecting a child's ability to learn requires comprehensive assessment and intervention by a multidisciplinary team that includes an audiologist. The audiologist can provide information about a student's auditory strengths and limitations and possible learning and teaching strategies for the classroom (EAA, 1997).

There are also the emotional affects of all degrees of hearing loss and processing difficulties. The "hearing aid effect" is used to describe the negative impressions people who see hearing aids have toward the individuals who wear them. In the educational setting this would include teachers, friends, and classmates (Clark & English, 2004). Davis, Elfenbein, Schum, & Bentler (1986) demonstrated that children with hearing loss, especially those who wore hearing aids, were more likely to show aggressive tendencies than their normal hearing peers. They are also more likely to express physical complaints. Parental reports indicated that children with hearing loss were more likely to demonstrate behavioral difficulties and develop social problems of isolation and adjustment to school. This was true of those children with even milder degrees of hearing loss. These reports indicate that there is a need for service provision in the area of psychosocial adjustment for children with hearing aids and hearing loss. Audiologists are trained to work with individuals of all ages who wear hearing aids to overcome some of the issues related to the hearing aid effect, and to educate the professionals who work with children who wear hearing aids in the classroom (Clark & English, 2004).

The acoustical environment in a classroom can have an effect on the academic, psychoeducational, and psychosocial development of children with normal hearing, as well as with children with hearing loss and other disabilities such as APD, learning disabilities, and attention deficits. Children with hearing and listening difficulties are most affected by noise and reverberant listening conditions, the conditions that exist in most classrooms (ASHA, 2005a; Bess, 2001; Berg, Blair, & Benson, 1996; Flexer, Wray, & Ireland, 1989). Even children with mild levels of hearing loss have demonstrated delays in vocabulary development, reading achievement, and problems in behavior and the ability to make friends (Davis et. al., 1986). Children in classrooms for students who are deaf and hard of hearing are likely to utilize amplification devices and FM systems that allow for direct access to the teacher's voice above the background noise. Children with minimal hearing loss are not as likely to have the benefit of an FM system or personal amplification.

A study of noise levels in Hawaii classrooms was recently published (Pugh, Miura, & Asahara, 2006). The study found that Hawaii classrooms are predominantly composed of concrete/hollow tile walls, jalousie windows, tile floors and ceilings with acoustic tiles. Most classrooms do not use HVAC systems, but rely on open and closed windows and fans to control the temperature. The study revealed that the average ambient noise level in empty classrooms was 51.6dBA. The American National Standards Institute (2002) recommends that ambient noise levels not exceed 35dBA. The high classroom noise level reported raises the concern that for children in Hawaii's schools with hearing loss (including minimal hearing loss), APD, and listening problems associated with other disabilities, difficulties in hearing and learning in a typical classroom, without support, likely exist. An educational audiologist is the professional trained to work on solutions to improve classroom learning environments that will provide these children more opportunity to succeed.

National prevalence of noise induced hearing loss (NIHL) in children between the ages of six to nineteen is estimated to be 12.5% (Niskar et. al., 1998). Other studies have documented NIHL in children and adolescents (Peppard & Peppard, 1992; Montgomery & Fujikawa, 1992). Folmer (2006) states that over the last 30 years numerous experts have recommended that hearing loss prevention programs be implemented in the schools. In a study by Chung, Des Roches, Meunier, & Eavey (2005) they concluded many young people are unaware of the hazards of excessive noise exposure and that once educated, children are more willing to take steps to protect themselves. With evidence that even mild hearing losses can have deleterious affects on academic achievement, it is necessary to monitor learning profiles of these students with NIHL. Therefore, the implementation of hearing loss prevention programs is another area where educational audiologists are uniquely qualified to present programs to children in the schools, and/or to support health curricula taught by others.

Hawaii has a Comprehensive Student Support System (CSSS) that identifies five levels of intervention for students (http://www.doe.k12.hi.us/programs/csss). Level One applies to all children that are succeeding in school without any supports. Level Two addresses those students who require some support such as remedial reading, but do not yet require a formal plan of intervention. Level Three applies to those students who require a written plan, such as a 504 or behavioral support plan. Levels Four and Five apply to those students requiring services and supports under IDEA. There are ways to document all service provision needed by students to assist them in succeeding in the classroom. Services from speech language pathologists (SLPs) and teachers of the deaf (TODs) are not likely to take place before a child reaches at least Level Three. Students needing some kind of support service, due to hearing loss or an auditory processing disorder, could receive support from an educational audiologist under the CSSS system at all levels, including Levels One and Two.

In 1991, Johnson surveyed departments of education in 48 of 50 states and the District of Columbia, to determine the number of audiologists serving students, the credentials required of those audiologists, and the criteria for determining if students with hearing loss were eligible for special education services. Johnson found a wide range of educational audiologists employed by school districts in each state, ranging from 0 to 67. At that time there were 529 audiologists employed in 38 states. Johnson also determined that only 13 states were providing audiological services in accordance with IDEA. The data demonstrated that in 1990, only a small percentage of educational audiologists were employed by school systems to provide the services mandated by federal law.

In 2000, Bone reported that the average number of audiologists employed in all 50 states had increased from 13 audiologists per state in the Johnson survey (1991) to 40 audiologists per state. Although this represented a significant increase in the number of educational audiologists serving students in the public schools, it was far short of the estimated 3000 audiologists needed to meet the number recommended by professional organizations (ASHA, 1993; EAA, 1997). However, Bone did conclude that there was a general move in the direction of hiring more educational audiologists, at least in some states.

In 2007, Smiley, McCormick Richburg, & Fullington again surveyed the school systems across the country to determine the current status of audiology services in the schools. They continued to find extreme variability in the roles of educational audiologists and the availability of audiology services in the schools. They were able to report on data from 45 states and the District of Columbia. Their results showed that 468 school districts directly employed at least one audiologist with an average per district of 13 audiologists. An additional 248 districts contracted with audiologists. Although there was some movement in the direction of an increase of the number of audiologists employed by school districts, the ratio of audiologists to the student population fell far short of the 1:10,000 students recommended by ASHA except in five states where the ratio was documented to be 1:10,000 to 1:14,000 students. This information indicates that the mandated audiology services under IDEA are either not being carried out, or they are being carried out by individuals other than audiologists.

The United States Department of Education, Office of Special Education Programs (OSEP) makes annual reports to Congress regarding the services provided under IDEA. Much of the information from this report is available online. A review of the data comparing the number of full time equivalent audiologists (OSEP, 2005a) with the census of school-aged (6-17) children in each state (OSEP, 2005b) provides additional information regarding the ratio of audiologists employed in this country to school-aged children. Four states (Delaware, North Carolina, Iowa, and Maine) employed 1 audiologist for every 10,000 children aged 6-17. An additional three states (New Mexico, Arizona, and Utah) employed one audiologist for every 15,000 children of school age. Four more states (Colorado, Minnesota, Wyoming and Alabama) employed 1 audiologist for every 16,000 children of school age. The average ratio of audiologist to students for all 50 states and the District of Columbia was 1:33,877. Connecticut, Rhode Island and the District of Columbia were reported as not employing any audiologists. Hawaii is listed as employing 1 audiologist for 193,917 children of school age. Only Mississippi had a worse ratio of audiologists to children at 1:248,251.

The Department of Education in Hawaii employs one educational audiologist for the 178,000 students in the school system. The primary responsibility for this audiologist is the assessment of children suspected or known to have hearing loss that may qualify for special education services. This includes students suspected of having auditory processing problems affecting learning. Other audiological roles that are specified in special education law are being carried out by individuals who are not audiologists and have little or no training in audiology. The purpose of this study is to identify the IDEA-mandated audiological services that are provided in Hawaii's public schools, and to determine who is providing these audiological services in the schools.

Method

Subjects

This project included 251 SLPs, 36 classroom TODs (including the teachers at the Hawaii Center for the Deaf and the Blind ASL immersion program), and nine itinerant TODs, all employed by the State of Hawaii, Department of Education. These professionals were identified and surveyed (see Appendix A for complete survey) about the extent to which they are providing IDEA- mandated audiology services. These services are recognized under the scope of practice for an audiologist (ASHA, 2004). Educational levels and continuing education activities of the professionals were a part of the survey. The survey was implemented online at surveymonkey.com, which assured anonymity by removing identifying information. The individual SLPs and TODs were contacted via the Hawaii school system e-mail and invited via cover letter to participate in the survey.

Survey Instrument

The first contact letter was e-mailed on November 19, 2007. The survey was available online between November 19, 2007 and December 3, 2007. A reminder e-mail was sent at the beginning of the second week encouraging those that had not finished the survey to do so.

There were three identical surveys separated by the professions of SLPs, classroom TODs, and itinerant TODs, in order to better identify who was providing mandated audiological services. It should be noted that one of the itinerant TODs is also a certified and licensed audiologist.

Results

Responses to the survey were received from 107 (42.6%) of the SLPs, 14 (38.8%) of the classroom TODs, and 7 (77.7%) of the Itinerant TODs, for a total of 128 complete responses, or a 43.2% response rate. Three surveys from SLPs and two surveys from classroom TODs were not completely filled out and therefore are not reported in these final results. Of the total number of respondents, two hold a doctoral degree, 121 (94.5%) hold a master's degree, and 5 (3.9%) hold a bachelor's degree. The bachelor-level respondents were all TODs, while the doctorate level respondents were SLPs.

The total number of respondents performing hearing screenings sometimes or always was 107 (83.5%). The majority of these individuals, 97.0%, were SLPs. The number of respondents that sometimes or always determine the frequency range, degree, and type of hearing loss was 18 (14.0%). The majority were SLPs, with one classroom TOD reporting that s/he sometimes does this. The number of respondents who reported that they are sometimes or always asked to perform auditory processing assessments was 81 (63.2%). The majority of these individuals were SLPs, but five individuals were itinerant TODs. The number of respondents who reported that they sometimes or always assess students for APD was 45 (35.0%). One of these respondents was a classroom TOD and the rest were SLPs.

Only 76 (59.3%) of the respondents reported that they sometimes or always provide habilitative services to deaf and hard-of-hearing students. Of the 52 (40.6%) who reported that they never provide habilitative services to deaf and hard-of-hearing students, five were classroom TODs. The number of respondents who reported that they sometimes or always provide habilitative services to children with APD was 85 (66.4%), with the majority being SLPs (92.9%). A large percentage (68.0%) of SLPs reported that they provide consultation to classroom teachers, IEP teams, or schools several times a year.

The number of respondents who reported that they sometimes or always evaluate, select and fit individual or classroom assistive amplification devices was 31 (24.2%). Only one of the itinerant TODs stated that they never do this; however, 100% of the Itinerant TODs stated that they are responsible for the purchase and maintenance of FM or assistive listening devices in their district. One classroom TOD and 12 (11.2%) SLPs stated that they are sometimes or always responsible for the purchase and maintenance of FM or assistive listening devices. For daily listening checks, 69 (53.9%) of the respondents stated that they sometimes or always perform them or supervise someone who does. Of the classroom TODs, 12 (85.7%) reported that they sometimes or always do this, but two stated that they never do this. Only 35 (27.3%) respondents reported that they perform functional listening assessments sometimes or always, and the majority (85.7 %) were SLPs.

A small group of respondents, 32 (25.0%), the majority of which were SLPs, indicated that they sometimes provide a hearing loss prevention program in the school or district. A little over half of the respondents, 73 (57.0%), stated that they sometimes or always provide consultation to DOE personnel regarding the acoustic environment in a school, district, or classroom. Concerning counseling to students regarding their hearing loss and feelings about hearing loss and amplification, 72 (56.2%) of the respondents reported that they sometimes or always provide this service.

The majority of respondents (53.0%) have not had continuing education in the areas of amplification, minimal hearing loss, or auditory processing disorders in over 2 years. Figures 1-3 detail continuing education by intervals of 0-6 months, 7-12 months, 1-2 years and more than 2 years for SLPs, TODs and Itinerant TODs.

Figure 4 illustrates the caseload ranges and averages for each discipline. There was a wide range of caseloads for the different disciplines, ranging from none to 57. SLP caseloads ranged from 0-25, classroom TOD caseloads ranged from 3-29, and Itinerant TOD caseloads ranged from15-57.

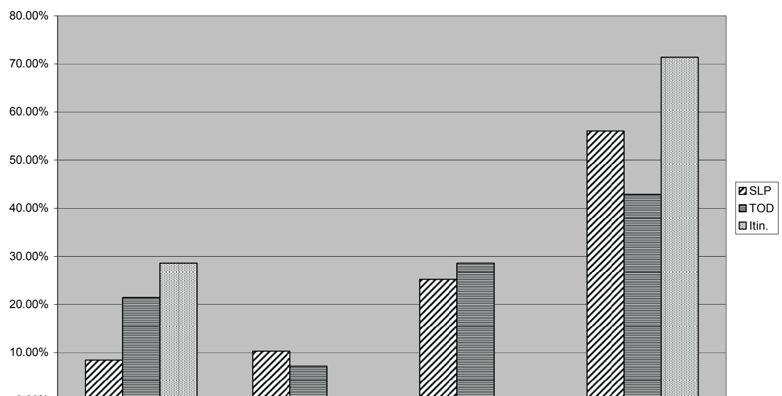
Of all respondents, 41 (32.0%) reported that they always receive adequate support from the DOE audiologist, 65 (50.7%) reported that they sometimes receive adequate support, and 22 (17.0%) reported that they never receive adequate support. The majority of respondents (84.3%) agreed that there is a need for additional audiologists to be employed by the DOE to improve audiological services to students with hearing loss and auditory processing disorders. Only 3 (.02%) disagreed that additional audiologists were needed, while 17 (13.2%) were neutral.

Discussion

There were some problems with the survey in this study. First, some of the questions could have been interpreted in different ways by different respondents. For example, question #3 regarding the determination of frequency range, degree and type of hearing loss could be answered in terms of the interpretation of audiological results provided by an audiologist. The intent of the question was whether or not non-audiologists were conducting comprehensive audiological evaluations on students. In addition, there were two questions regarding the selection and fitting of amplification, one for APD and one for hearing loss. After the review of the individual responses, it was determined that for the most part the same professionals answered these questions the same way. One question regarding the selection and fitting of amplification would have been appropriate. The responses regarding the adequate support by the audiologist could have been affected by the knowledge that the information would be seen by the audiologist. Although no personal information was available to identify respondents, a halo effect in the responses may be present, since 67.0% indicated that they never or only sometimes receive adequate services from the audiologist, and 32.0% indicated that they always receive adequate support. In contrast to this, 84.0% of the respondents stated that there was a need for more audiologists in Hawaii's DOE. If 32.0% feel that they always receive adequate support, then it would be expected that responses from those individuals would be neutral or in disagreement that more audiologists are needed.

Results of this survey indicate that many SLPs in the Hawaii public schools have assumed the role of an audiologist in the determination of hearing loss in students (question 3), the determination of APD in students (question 5), and also in the selection and fitting of amplification for students in the classroom (questions 8 and 12). These practices are clearly outside of the ASHA Scope of Practice for Speech Language Pathologists (2007), which limits a SLP to "the screening for hearing loss or middle ear problems, intervention and support for children with APD; and visual inspection and listening checks of amplification devices". Furthermore, this document specifically

Figure 1. Continuing Education on Minimal Hearing Loss

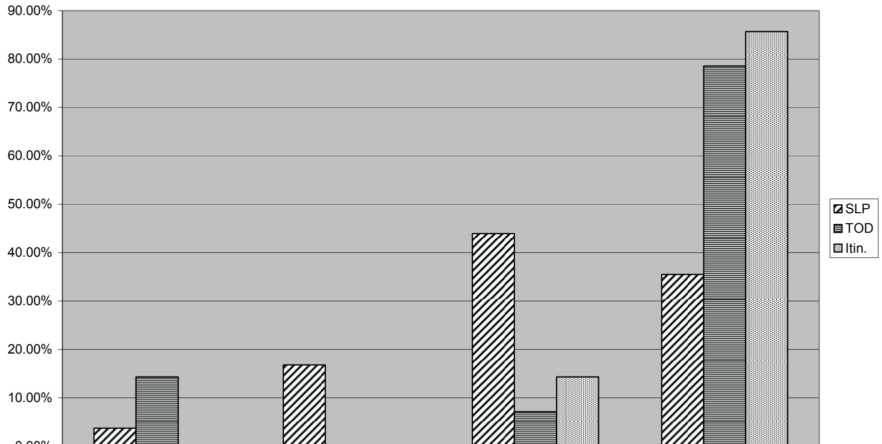


	0-6 months	7-12 months	1-2 years	> 2 years
SLP	8.41%	10.28%	25.23%	56.07%
TOD	21.43%	7.14%	28.57%	42.86%
Itin.	28.57%	0.00%	0.00%	71.43%

states that a SLP's scope of practice does not include "…the selection or fitting of sensory devices used by individuals with hearing loss or other auditory perceptual deficits, which falls within the scope of practice of audiologists" (ASHA 2007, pg. 7). TODs also perform these activities, and their educational background in audiology is usually even more limited than that of SLPs.

It is clear from the results that SLPs and TODs are performing duties that fall under the scope of practice of an audiologist. ASHA states that the practice of audiology includes: "The conduct and interpretation of

Figure 3. Continuing Education on APD



	0-6 months	7-12months	1-2 years	> 2 years
SLP	3.74%	16.82%	43.93%	35.51%
TOD	14.29%	0.00%	7.14%	78.57%
Itin.	0.00%	0.00%	14.29%	85.71%

behavioral, electroacoustic and/or electrophysiologic methods to assess hearing, auditory function, balance, and related systems…". The scope of practice further states that it is the audiologist who "…evaluates, selects, fits, and dispenses hearing assistive technology devices…" (ASHA 2004). This level of expertise helps in the appropriate identification of children with disorders in auditory function, and in the prevention of over-amplification and noise-induced hearing loss in students, or under amplification and the loss of learning opportunities for students who are deaf and hard-of-hearing and students with APD.

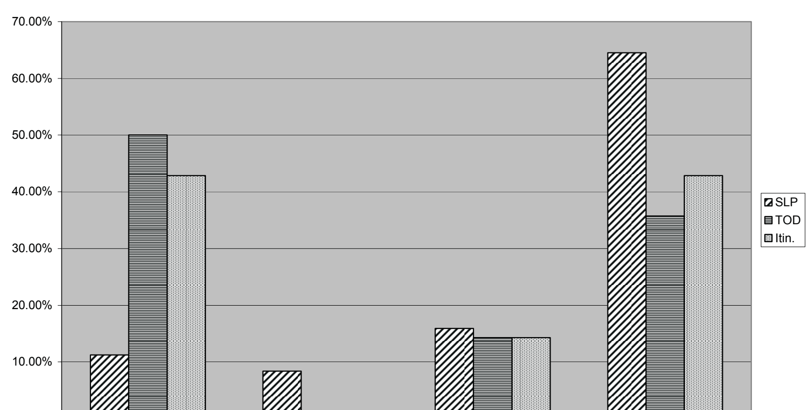
As a result of these survey findings, it is clear that Hawaii's public school children with auditory dysfunction are not receiving audiology services from appropriately qualified professionals (i.e. audiologists) in their school settings. Though the intention is laudable, the individuals who are providing these services are doing so because there is no one else to provide them. Most are not properly trained and, by conducting these services, are violating their professional association's codes of ethics and policies. These SLPs and TODs are providing services outside of their scope of practice. Their administrators are backing them into a corner and forcing them to provide services they are not trained for and should not be doing. By not employing more educational audiologists in the Hawaii school system, the administration is putting employees into a difficult situation, as well as condoning unprofessional and unethical practices. In addition, a significant portion of the IDEA-mandated services are not being provided or are being provided inconsistently. For example, very few respondents reported that they are counseling children about hearing loss and amplification, and less than 25.0% were providing education about the prevention of hearing loss.

The increase in the number of children in the school system with cochlear implants, the increase in the awareness and focus by parents on APD, and the rapid technological changes in amplification devices for the classroom are just a few reasons why audiologic expertise is required to assure proper services. In addition, the dwindling resources to pay for services, necessitates that unnecessary or unsuccessful service be avoided. More audiologists in the Hawaii school system would improve access to appropriate audiology services to the students who need them.

In light of all of the IDEA-mandated audiological services that should be provided in the schools, adequate support cannot possibly be provided by one individual for 178,000 students in Hawaii. SLPs and TODs have taken over some of these services, even though they are not properly trained to do so. Hawaii needs to consider employing, or contracting with, a more appropriate number of audiologists for the student population in order to meet the mandates if IDEA.

In conclusion, while there have been several studies looking at the number of audiologists in the schools, and demonstrating a lack of professionals

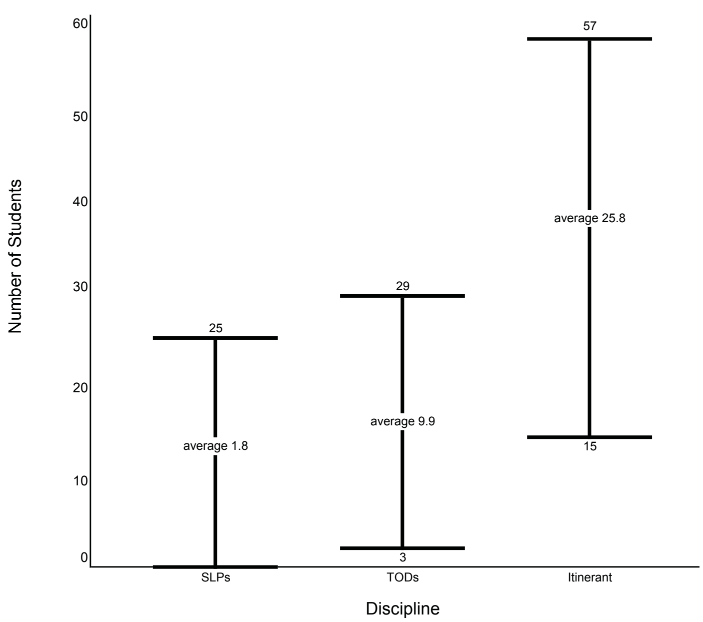
Figure 2. Continuing Education on Amplification Devices



	0-6 months	7-12months	1-2 years	> 2 years
SLP	11.21%	8.41%	15.89%	64.49%
TOD	50.00%	0.00%	14.29%	35.71%
Itin.	42.86%	0.00%	14.29%	42.86%

(Johnson, 1991; Bone, 2000), this is the first study to look at the professionals who are providing the services audiologists should be providing, at least in one state. There is a need for further investigation to determine how this information may be relevant to other states. Is the Hawaii trend toward having SLPs and TODs perform audiological services true in other states and districts as well? If so, what can be done to help meet the gaps in service provision reported? Should audiologists be teaching non-audiologists, such as SLPs and TODs how to perform audiology functions in the schools? These issues need to be addressed by each state to provide the most appropriate services for the students in their school systems.

Figure 4. Caseloads by Discipline



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Appendix A

Survey of Mandated Audiology Services for Children with Hearing/Listening Difficulties

My current position with the DOE is

Speech Language Pathologist (Classroom based Teacher of the Deaf and Hard of Hearing, Itinerant Teacher for the Deaf and Hard of Hearing)

If this is not your current position please contact Kristine Takekawa.

1. What is your highest level of education?
   - ○ Bachelors Degree
   - ○ Masters Degree
   - ○ Doctorate

2. Do you screen the hearing of students?

   ○ never ○ sometimes ○ always

3. Do you determine the frequency range, degree, and type of hearing loss in students?

   ○ never ○ sometimes ○ always

4. Do you provide habilitative services for Deaf and Hard of Hearing students such as auditory training and speech reading?

   ○ never ○ sometimes ○ always

5. Do you provide assessments for auditory processing disorders in students having difficulties in the classroom?

   ○ never ○ sometimes ○ always

6. Are you ever asked to provide assessments for auditory processing disorders?

○ never ○ sometimes ○ always

7. Do you provide habilitative services for children diagnosed with auditory processing disorders?

○ never ○ sometimes ○ always

8. Do you select and fit FM systems to children diagnosed with auditory processing disorders?

○ never ○ sometimes ○ always

9. How often are you asked to consult with a school, classroom teacher, or IEP team regarding auditory processing disorders?

○ never ○ several times a month ○ several times a year

10. Do you perform formal functional listening evaluations for students?

○ never ○ sometimes ○ always

11. Do you determine a child's need for classroom amplification?

○ never ○ sometimes ○ always

12. Do you select and fit classroom or individual assistive amplification devices?

○ never ○ sometimes ○ always

13. Are you responsible for the purchase of FM systems for your school or district?

○ never ○ sometimes ○ always

14. Are you responsible for the maintenance and repair of assistive amplification devices in your district, school, or classroom?

○ never ○ sometimes ○ always

15. Do you perform daily checks to determine if a student's hearing aids are working in school on a daily basis, or do you supervise someone who does?

○ never ○ sometimes ○ always

16. Do you provide a hearing loss prevention program including such things as the anatomy of the ear, noise induced hearing loss and prevention, and other related topics for students in your district, school, or classroom?

○ never ○ sometimes ○ always

17. Do you provide counseling to students with hearing loss regarding their hearing loss, feelings about hearing loss, need for amplification in the classroom, etc.?

○ never ○ sometimes ○ always

18. Do you provide consultation to DOE personnel regarding the acoustic environments in classrooms in your district or school?

○ never ○ sometimes ○ always

19. What is your current case load of students with hearing loss? ________

20. When was your most recent participation in a continuing educational in-service or training on minimal hearing loss and the effects on classroom achievement?

○ 0-6 months ○ 6 months to 1 year ○ 1-2 years ○ greater than 2 years

21. When was your most recent participation in a continuing educational in-service or training on hearing aids and amplification devices and their use with children in the classroom?

○ 0-6 months ○ 6 months to 1 year ○ 1-2 years ○ greater than 2 years

22. When was your most recent participation in a continuing education activity on auditory processing disorders?

○ 0-6 months ○ 6 months to 1 year ○ 1-2 years ○ greater than 2 years

23. Do you receive adequate support from the Hawaii DOE audiologist?

○ never ○ sometimes ○ always

24. Do more audiologists need to be employed by the Hawaii DOE to improve the services to students with hearing loss and auditory processing disorders?

○ agree ○ neutral ○ disagree

Call for Papers

2009 Journal of Educational Audiology

The Journal of Educational Audiology is now soliciting articles for the 2009 issue (Volume 16). All submissions will be peer-reviewed. *JEA* publishes original manuscripts from a range of authors who work with children and their families in a broad variety of audiological settings. One of the primary purposes of the Journal is to provide a forum to share clinical expertise that is unique or innovative and of interest to other educational audiologists. Our traditional focus has been the auditory assessment, management, and treatment of children in educational settings. However, contributors are not limited to those who work in school settings. We invite authors from parent-infant and early intervention programs, as well as clinicians who work with children in related capacities (e.g. Clinical Pediatric Audiologists, Speech-Language Pathologists, Auditory-Verbal Therapists). As the only audiology journal dedicated to a pediatric population, the intent is to reflect the broad spectrum of issues relevant to the education and development of children with auditory dysfunction (e.g. children with hearing loss, auditory neuropathy/ dys-synchrony, or central auditory processing disorders).

Manuscripts may be submitted in one of the following categories:

- Article: a report of scholarly research or study.
- Tutorial: an in-depth article on a specific topic.
- Report: a description of practices in audiology, such as guidelines, standards of practice, service delivery models, survey findings, case studies, or data management.
- Application: a report of an innovative or unique practice, such as a screening program, hearing conservation program, therapy technique or other activity that has been particularly effective.

There are specific manuscript requirements and guidelines for submission posted on the EAA website (www.edaud.org) or you can obtain these by contacting the editor (cynthia.richburg@iup.edu/724-357-5682). The information in the manuscript may have been presented previously, but not published.

Submissions via e-mail to the Editor (cynthia.richburg@iup.edu) are **preferred**. If e-mail is not available, the files may be sent on a CD (no floppy disks, please) via regular mail. Submissions of typewritten manuscripts are also acceptable. Please submit five high-quality completely double-spaced copies of the manuscript to the editor, Cynthia McCormick Richburg, Indiana University of Pennsylvania, Special Education and Clinical Services, 570 S. Eleventh St., Indiana, PA 15705-1087. Questions or comments should also be directed to the Editor (cynthia.richburg@iup.edu/724-357-5682) or one of the Associate Editors, Susan Naeve-Velguth (susan.naeve.velguth@cmich.edu/ 989-774-7292), Patrick Plyler (pplyler@utk.edu/865-974-7588), Erin Schafer (eschafer@unt.edu/ 940-369-7433).

*NOTE: Submissions for the 2009 issue of JEA will be accepted until June 30, 2009. Manuscripts received after that date will be considered for the 2010 issue unless the authors are notified otherwise.

Guidelines for Authors-2009

Journal of Educational Audiology

A Publication of the Educational Audiology Association

Format

All manuscripts must follow the style specified in the Publication Manual of the American Psychological Association (5th edition). Authors should pay special attention to APA style for tables, figures, and references.

Cover Letter

A cover letter should accompany all submissions. The cover letter should contain a statement that the manuscript has not been published previously and is not currently submitted elsewhere.

Author Information Page

The title page should include the title of the article, complete authors' names, and authors' affiliations. This page should include a business address, phone number, and email address (if available) for the corresponding author.

Title Page

This page should contain *only* the title of the article. No other identifying information should be present.

Abstract

The second manuscript page (behind the title page) should contain an abstract not to exceed 100 words

Text

The text of the manuscript should begin on page 3.

Tables, Figures, and Other Graphics

Tables, figures, and other graphics should be attached on *separate pages* and their placement within the manuscript noted (e.g., <<Table 1 here>>). These separate pages should appear after the text and before the acknowledgements.

Acknowledgements

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References

References are to be listed alphabetically, then chronologically. Journal names should be spelled out and italicized. Authors should consult the APA style manual for the specifics on citing references within the text, as well as in the reference list.

Blind Review

All manuscripts will be sent out for blind review. If you have questions about this, please contact the Editor (cynthia.richburg@iup.edu).

Submission of Manuscripts

Submissions of manuscripts via e-mail to the Editor are preferred (cynthia.richburg@iup.edu). Microsoft Word-compatible documents and graphics are preferred. If e-mail is not available, the files may be sent on a CD via regular mail. Submissions of typewritten manuscripts are also acceptable. Please submit five high-quality, completely double-spaced, unstapled copies of the manuscript to Cynthia McCormick Richburg, Indiana University of Pennsylvania, 570 S. Eleventh Street, Davis Hall Room 203, Indiana, PA 15705-1087. Questions or comments should be directed to the Editor (cynthia.richburg@iup.edu/ 724-357-5682) or one of the Associate Editors, Susan Naeve-Velguth (susan.naeve.velguth@cmich.edu; 989-774-7292), Patrick Plyler (pplyler@utk.edu; 865-974-7588) or Erin Schafer (eschafer@unt.edu; 940-369-7433).

Notes:

Notes:


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