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Journal of Educational Audiology: Ten Years in Review

Erin C. Schafer, Ph.D.
University of North Texas
Denton, Texas

Cynthia M. Richburg, Ph.D.
Indiana University of Pennsylvania
Indiana, Pennsylvania

Andrew B. John, Ph.D.
University of Oklahoma Health Sciences Center
Oklahoma City, Oklahoma

Karen L. Anderson, Ph.D.
Pediatric & Educational Audiology Consulting
Minneapolis, Minnesota

Susan Naeve-Velguth, Ph.D.
Central Michigan University
Mt. Pleasant, Michigan

Claudia D.L. Updike, Ph.D.
Ball State University
Muncie, Indiana

This article is a showcase of titles and abstracts seen in the *Journal of Educational Audiology* over the past ten years (2000-2009). The purpose of this compilation is to illustrate the diversity of article topics. In addition, this article documents some of the changes in technology, theories, and implementation of therapies/protocols over the past decade.

Introduction

Over the past ten years, publications in the *Journal of Educational Audiology* provided a wealth of information related to management, testing, counseling, and amplification of children who have normal hearing, hearing loss, or other auditory disorders. To provide the journal readership with an overview of these informative papers, the Journal Committee has compiled a table of publications sorted by topic and provided reprints of the abstracts from manuscripts published from 2000 to 2009. Articles may be listed more than once in the table because many publications related to more than one topic in educational audiology (e.g., FM systems and auditory processing disorders). The Journal Committee hopes this information will be helpful to educational audiologists and other professionals who serve and conduct research with children who have normal hearing, hearing loss, or other auditory disorders.

2000 - Volume 8

♦Adolescents' Attitudes toward Their Peers with Hearing Impairments (Stein, Gill, & Gans)

A questionnaire was distributed to 80 adolescents with normal hearing to determine whether gender and/or the presence of a classmate with a hearing impairment affected attitudes toward socialization with, appearance of, and achievement of peers with hearing impairments. While some negative attitudes continue to exist toward those with hearing impairments, the degree of negativity appears to have decreased compared to some studies conducted in the 1980's. These results suggest that educational programs should be continued to be implemented in the homes and at school to further improve acceptance of children with hearing impairments.

♦Current Practices in Classroom Sound Field FM Amplification (Crandell & Smaldino)

It has been amply demonstrated that sound field FM amplification, or sound reinforcement, systems can improve speech perception, reading/spelling ability, behavior, attention, psychosocial function, on-task behaviors, and psychoeducational achievement in children. To date, however, there exists a paucity of empirical data on the clinical practices of audiologists in recommending, dispensing, installing, and measuring the efficacy of such technology. The purpose of the present investigation was

Table 1. Overview of 2000 to 2009 Journal of Educational Audiology Articles Sorted by Topic

Topic	Author(s)	Year	Issue	Title
Auditory Processing Disorder & Auditory Neuropathy/ Dys-synchrony	English	2001	9	Assessing auditory processing problems in the school setting
	Blumsack	2001	9	Auditory processing assessment in children: Towards a dual approach
	Keith	2002	10	Standardization of the Time Compressed Sentence Test
	Garfinkel	2003	11	Educational testing for auditory processing: A retrospective study
	Friederichs & Friederichs	2005	12	Electrophysiologic and psycho-acoustic findings following one-year application of a personal ear-level FM device in children with attention deficit and suspected central auditory processing disorder
	Gustafson & Keith	2005	12	Relationship of auditory processing categories as determined by the Staggered Spondaic Word Test (SSW) to speech-language and other auditory processing test results
	Plyler et al	2005	12	Auditory neuropathy/dys-synchrony with secondary loss of otoacoustic emissions in a child with autism
	Updike	2006	13	The use of FM systems for children with attention deficit disorder
	Hurley et al	2007-08	14	Click ABR characteristics in children with temporal processing deficits
	Strange et al	2009	15	Exploring the usefulness of Fisher's Auditory Problems Checklist as a screening tool in relationship to the Buffalo Model Diagnostic Central Auditory Processing Test Battery
Behavioral/Speech Measures	Kuk & Ludvigsen	2001	9	Verification of nonlinear hearing aids: Considerations for sound-field thresholds and real-ear measurements
	English	2001	9	Assessing auditory processing problems in the school setting
	Stewart	2003	11	The Word Intelligibility by Picture Identification Test: A two-part study of familiarity and use
	Naeve-Velguth et al	2005	12	Child distress and the use of a teddy bear model during preschool audiologic screenings
	Gustafson & Keith	2005	12	Relationship of auditory processing categories as determined by the Staggered Spondaic Word Test (SSW) to speech-language and other auditory processing test results
	Prendergast	2005	12	Use of the California Consonant Test with children
	Freyaldenhoven & Smiley	2006	13	Acceptance of background noise in children with normal hearing
	Cienkowski et al	2009	15	The Word Intelligibility by Picture Identification (WIPI) Test revisited

to examine current practices among audiologists regarding sound field FM technology. Specifically, a 20-iteam questionnaire was sent to 916 audiologists. Responses were received from 241 audiologists for a return rate of 26%. Theoretical and applied applications of the survey results are discussed.

♦A Cross-Case Study of Audiologic Services Delivered to Students in Four Different Demographic Settings (Byrne, Cordell, & Lehnerer)

A negative outcome of the decentralization of students who are deaf or hard of hearing may be the unavailability of school personnel knowledgeable about the maintenance of amplification devices and the provision of appropriate Audiologic services in school settings. The purpose of this study was twofold: first, to compare the consistency of data regarding audiologic practices and procedures in a variety of school settings within a single state, with policy and procedures stipulated in IDEA 97 and the State Plan; and second, to provide a model for gathering data that will enable local educational agency administrators to make informed policy decisions in special education settings. Field-based data identified specific information and procedures across individual school programs that were inconsistent with state and federal documents. Also, a key factor associated with programs that were highly consistent the State Plan and IDEA 97 was the employment of an educational audiologist who played an active role in direct service provision, in-service training of personnel, and supervision of services provided by others.

♦Efficacy of Using Teachers as Identifiers of Hearing Problems (Kernan, Church, & Martin)

Although most school children are routinely screened for hearing impairment across their academic careers, schools and parents rely on teachers to make referrals when they suspect a hearing problem. To explore the reliability of this referral process, six first-grade educators were asked to identify students in their classrooms who were not likely to pass a hearing screening. They identified 27 children in all, and then completed SIFTER screeners for each one. One hundred and five pupils from their collective classes were screened at 500-6000Hz at 15dB HL, bilaterally. Results show that teachers' identification rates were 17% sensitive, but 70% specific: that is, they were generally inaccurate in identifying children who would not pass a hearing screening, but among those they did identify, they were generally correct. SIFTER results are also discussed.

♦ "Can You Hear Me?"A Longitudinal Study of Hearing Aid Monitoring in the Classroom (Langan & Blair)

Research articles cite the alarming statistics that, without a daily hearing aid check, 50% of hearing aids worn by school children are malfunctioning on any given day. Analysis of hearing aid monitoring data kept over a seven-year period at one elementary school supports the value of daily monitoring, finding on 5.5% of hearing aids malfunctioning when a child entered his or her classroom in the morning. This malfunction rate was reduced to less than 1% by the time class instruction started when simple troubleshooting procedures were implemented (e.g. readjusting settings or replacing a weak or dead battery). This study suggests that a comprehensive hearing aid monitoring system can effectively eliminate the problems reported the literature. Recommendations for hearing aid monitoring are presented.

♦The Development and Validation of an "Intelligent" Classroom Sound Field Frequency Modulation (FM) System (Lederman, Johnson, Crandell, & Smaldino)

The adverse acoustical environments often found in classrooms have led to the proliferation of small sound reinforcement systems currently referred to as "sound field amplification systems." Previous studies detail how speech perception is negatively affected by variable background noise conditions created by poor acoustics, room heating/cooling systems, noisy audiovisual and computer equipment, and other noise generated both inside and outside the classroom. Available manual adjusted sound field systems do not address the fact that background noise levels and a teacher microphone input levels often levels often change throughout the day in a classroom. This article will report on the development and field evaluation of adaptive signal-processing technology that "listens" to the classroom's changing background noise, automatically adjusting the sound field system's output in order to maximize signal-to-noise ratio and speech intelligibility. Field test data demonstrated positive effects of this adaptive signal processing technology on speech perception.

♦AudiSee: An Auditory-Visual-FM System (Gagne)

For several years researchers have investigated the various factors that hinder or facilitate learning in classroom environments, especially with respect to students with hearing loss. Everyone agrees on the fundamental communication process inherent to teaching and on the importance of providing good learning conditions in the classroom. This is why many schools rely on new technology such as assistive listening devices (ALDs) like the well-known FM transmissions systems. While these systems overcome some of the obstacles found in classrooms, many students with hearing loss still struggle. However, the recent arrival of new technology, the audiovisual-FM system, provides added benefit to standard audio-only FM systems in that it transmits both audio and visual speech cues, thereby increasing the ability of students with hearing loss to assimilate information.

♦Development of a Teacher Needs Survey to Support Students with Auditory Impairments (Dunay & English)

A "needs" survey was developed for classroom teachers who have students with hearing disabilities including auditory processing disorders. The purpose was to provide a vehicle for teachers to communicate needed support to school speech-language pathologists and/or educational audiologists. Five focus groups, including speech-language pathologists, educational audiologists and a deaf education teacher, contributed to the development of the survey. The survey was sent to 50 classroom teachers who have or have had a student with documented auditory impairment in their classroom. A follow-up interview was conducted with participating teachers to assess the utility of the survey. Results indicated an overall rating of very good to excellent by all respondents. The "Teacher Needs Survey" appears to be successful in identifying and communicating the needs of teachers who have students with auditory impairments in their classrooms in a thorough, quick and simple format for the purpose of obtaining needed support.

2001 - Volume 9

♦A Comparison of the Performance of Classroom Amplifications with Traditional and Bending Wave Speakers (Prendergast)

Classroom amplifications (CA) is used to compensate for the poor acoustics in schools to some degree by amplifying the teacher's voice and projecting it throughout the classroom via loudspeaker(s), thereby improving the signal noise ratio (S/N). A new loudspeaker technology based on bending wave physics is reported to preserve the speech signal with more fidelity and with less loss of power than traditional cone loudspeakers, thus providing an improved signal as well as an improved S/N. This research compared a ca system coupled with either a traditional or bending wave speaker in a classroom on two measures: (a) an octave band analysis of the frequency distribution

Table 1. Continued Overview of 2000 to 2009 Journal of Educational Audiology Articles Sorted by Topic

Topic	Author(s)	Year	Issue	Title
Classroom Acoustics	Anderson	2001	9	Kids in noisy classrooms: What does the research really say?
	Pugh et al	2006	13	Noise levels among first, second, and third grade elementary school classrooms in Hawaii
	Nelson et al	2007-08	14	Background noise levels and reverberation times in old and new elementary school classrooms
	Latham & Blumsack	2007-08	14	Classroom acoustics: A survey of educational audiologists
Cochlear Implants (CI)	McGinnis	2002	10	An electrostatic discharge (ESD) control program for children with cochlear implants
	Schafer & Thibodeau	2003	11	Speech-recognition performance of children using cochlear implants and FM systems
	Anderson et al	2005	12	Benefit of S/N enhancing devices to speech perception of children listening in a typical classroom with hearing aids or a cochlear implant
	Schafer & Kleineck	2009	15	Improvements in speech recognition using cochlear implants and three types of FM systems: A meta-analytic approach
Counseling	Stein et al	2000	8	Adolescents' attitudes toward their peers with hearing impairments
	Crowell et al	2005	12	Use of a self-assessment technique in counseling adolescents with hearing loss: From theory to practice
Early Childhood Intervention (ECI)	Reda et al	2005	12	Impact of the early hearing detection and intervention program on the detection of hearing loss at birth—Michigan, 1998-2002
	Blair & Blair	2007-08	14	Parental perceptions and behavior regarding hearing aid monitoring and maintenance in an early childhood intervention program
Services and Management in Education	Dunay & English	2000	8	Development of a teacher needs survey to support students with auditory impairments
	Takekawa	2007-08	14	Audiology services in Hawaii's public schools: A survey of teachers of the deaf and speech language pathologists
	Richburg & Smiley	2009	15	The "state" of educational audiology revisited
Preparation in Educational Audiology	Beckrow & Nerbonne	2002	10	Preparation in educational audiology: A survey of academic programs in audiology
	Curiel & Nerbonne	2002	10	Preparation in educational audiology: A survey of educational audiologists
	Duncan	2006	13	Application of the auditory-verbal methodology and pedagogy to school age children

and (b) performance by third and fourth graders on a high frequency emphasis, multiple choice speech discrimination test.

♦Effects of Portable Sound Field FM Systems on Speech Perception in Noise (Crandell, Charlton, Kinder, & Kreisman)

The present investigation examined the perceptual benefits of portable, or desktop, sound field Frequency Modulation (FM) systems to more traditional body-worn FM systems. Subjects consisted of 20 adults with normal-hearing sensitivity. Speech perception was assessed by the Hearing in Noise Test (HINT) sentences, while speech spectrum noise served as the noise competition. The HINT sentences were presented to the subjects in three conditions: (1) unaided; (2) portable sound field FM system; (3) body-worn FM with attenuating walkman-style recognition performance in noise compared to unaided listening conditions. However, the body-worn FM systems provided significantly better speech perception in noise scores than the portable technology. Theoretical, educational, and clinical implications of these data are discussed.

♦Coupling FM Systems to High-Technology Digital Hearing Aids (Nelson)

Hearing aids that use digital signal processing can provide desirable features that could not be realized with conventional ear-level analog hearing aids. While children can benefit from these features, the FM system is still the preferred choice for increasing the signal-to-noise ratio in a classroom. By coupling the two systems together, the benefits of both devices can be obtained. When electroacoustic measurements are made with these combined systems, specific procedures need to be followed to ensure reliable and repeatable results. In this article, hearing aid features that affect electroacoustic measurements will be discussed and procedures will be recommended for obtaining the measurements.

Table 1. Continued Overview of 2000 to 2009 Journal of Educational Audiology Articles Sorted by Topic

Topic	Author(s)	Year	Issue	Title
Educational Audiology: General Topics	English & Vargo	2006	13	How is educational audiology being taught? A review of syllabi from Au.D. programs, Fall 2005
	Blood et al	2007-08	14	Job burnout in educational audiologists: The value of work experience
	Smiley et al	2009	15	Problem-solving ability in elementary school-aged children with hearing impairment
	Hurley & Hurley	2009	15	Auditory remediation for a patient with Landau-Kleffner Syndrome: A case study
	Millett	2009	15	Accommodating students with hearing loss in a teacher of the deaf/hard of hearing education program
Electroacoustic/ Real Ear Measurement	Kuk & Ludvigsen	2001	9	Verification of nonlinear hearing aids: Considerations for sound-field thresholds and real-ear measurements
	Wolfe et al	2007-08	14	Clinical evaluation of a verification strategy for personal FM Systems and nonlinear hearing aids
	Naeve-Velguth et al	2009	15	Effect of MicroMLxS Designated Programmable Audio Input (DPAI) and switch settings on FM- and muted-FM transparency for six DPAI hearing instruments
Objective Measures	Friederichs & Friederichs	2005	12	Electrophysiologic and psycho-acoustic findings following one-year application of a personal ear-level FM device in children with attention deficit and suspected central auditory processing disorder
	Plyler et al	2005	12	Auditory neuropathy/dys-synchrony with secondary loss of otoacoustic emissions in a child with autism
	Hurley et al	2007-08	14	Click ABR characteristics in children with temporal processing deficits

♦Kids in Noisy Classrooms: What does the Research Really Say? (Anderson)

The Federal rulemaking agency responsible for implementation of the Americans with Disabilities Act of 1990 has recently sought to define criteria for acoustic conditions to address the needs of persons with disabilities in learning environments. As a result, knowledge of the effects of inadequate acoustic environments on learning has become an increasing interest to groups such as educational administrators, architects, and audiologists. The purpose of this document is to review the body of research applicable to the effects of adverse acoustic environments on children's learning. The direct effects of adverse listening conditions in the classroom will be reviewed. These include the effects of noise on health, the performance of specified tasks, attention, reading ability, and some information on open plan classrooms. This body of research supports the need to address the acoustics of the classroom environment so that all students can learn without detriment from the interfering affects of excessive noise and reverberation.

♦Verification of Nonlinear Hearing Aids: Considerations for Sound-Field Thresholds and Real-Ear Measurements (Kuk & Ludvigsen)

Audiologists have used the behavioral index of the sound-field aided threshold as a tool to verify the performance of linear hearing aids for many years. Its use on nonlinear hearing aids requires a different interpretation and extra precaution. In this paper, we will explore the meaning of the aided thresholds, review the variables that may affects its reliability, and compare its use the real-ear insertion gain measurement.

♦Assessing Auditory Processing Problems in the School Setting (English)

Recently, a consensus conference on auditory processing disorders (APDs) recommended a minimal APD test battery (Jerger & Musiek, 2000). These recommendations were made in the interest of defining a "gold standard" for APD assessment; however, they leave educational audiologists at a disadvantage since these professionals do not have ready access to certain clinical procedures. To meet the high volume of referrals for APD assessments in the school setting, it seems that another, second-tier type of test battery is needed; therefore, an alternative test battery is presented here for consideration. As a type of "silver standard" for assessment, it does not allow for a definitive APD diagnosis; however, it does not provide sufficient information to identify a likely auditory processing problem. A two-dimensional model of auditory processing and an assessment matrix are described to provide an organizational framework for this alternative test battery.

♦Auditory Processing Assessment in Children: Towards a Dual Approach (Blumsack)

The behaviors that are typically assessed in children referred for auditory processing concerns often do not relate directly to the behavioral problems that give rise to referral for evaluation. In order to bridge the gap between diagnostic results and classroom behaviors, the present paper advocates the use of instruments that measure both "auditory system mechanisms and processes" (ASHA, 1996) and communicative performance. Such an approach would be beneficial in the design of intervention for affected children.

2002, Volume 10

♦The Effect of Non-Linear Amplifications and Low Compression Threshold on Receptive and Expressive Speech Ability in Children with Severe to Profound Hearing Loss (Gou, Valero, & Marcoux)

The performance of a hearing instrument during a pediatric fitting must be guided under the provision to optimize the development of speech and language. The implementation of a low compression threshold (CT) within non-linear amplification may provide amplification for soft speech, which is otherwise not audible with linear amplification or with non-linear amplification using a high CT. To demonstrate the usefulness of audibility of soft speech, receptive and expressive speech performance was measured with a group of children with severe to profound hearing impairment. Scores were collected first using the child's prescribed linear hearing instrument and then with a low CT multi-channel non-linear digital signal processing (DSP) hearing instrument. Results indicated an increase in receptive and expressive speech indices using the low CT hearing aid. These findings suggested that children who received this type of amplification during primary intervention benefited from the increased audibility of soft speech in order to enhance speech and language ability.

♦Standardization of the Time Compressed Sentence Test (Keith)

The Time Compressed Sentence Test (TCST) was developed to identify and quantify disorders of auditory processing in children. The test consists of sentences that were time compressed at 0, 40, and 60%. Standardization data was obtained from 13 beta site examiners in 7 states. One-hundred sixty three normally hearing and typically developing children between the ages of 6 and 11 years were administered the test. Statistical analysis of the first 117 children tested found significant differences between the 40% and 60% time compression conditions and for subjects by age. There were also significant differences between right and left ear scores. The implication of these analyses is that is it necessary to interpret findings using tables of norms reported separately for each age and for right and left ears. Descriptive statistics were used to identify "cut-off" scores, and then converted to standard scores and percentiles.

♦Behind-the-Ear FM Systems: Effects on Speech Perception in Noise (Kreisman & Crandell)

The present investigation examined the perceptual benefits of behind the ear (BTE) Frequency Modulation (FM) systems to more traditional body-worn FM systems. Subjects consisted of 20 adults with normal-hearing sensitivity. Speech perception was assessed by the Hearing in Noise Test (HINT) sentences, while speech spectrum noise served as the noise competition. The HINT sentences were presented to the subjects in four conditions: (1) unaided; (2) monaural BTE-FM; (3) binaural BTE-FM; and (4) body-worn FM with attenuating walk-man style headphones. Results indicated that the BTE and body-worn FM systems significantly improved speech-recognition performance in noise compared to unaided listening conditions. However, no significant differences in speech perception were noted between either the BTE or body-worn FM systems. Theoretical, educational, and clinical, implications of these data are discussed.

♦Current Practices in Hearing Conservation Education in Schools (Burns & Tulenko)

Growing national concern prompted Denver area audiologists to include higher frequencies in their testing protocol of middle and high school students. This revealed an alarming number of adolescents with hearing loss in higher frequencies. The need for more hearing conservation education became apparent, and it became important to discover what efforts were already underway and how effective these might be to prevent unnecessary duplication and maximize the use of the most effective programs. The purpose of the study was to find out how widespread hearing conservation education is in schools and to assess the types of school hearing conservation education programs that have been implemented across the United States. An electronic survey was designed and e-mailed to educational audiologists and to others who might provide audiology services or hearing conservation education services in schools in the United States. More than 90 percent of educational audiologists and 80 percent of non-educational audiologists indicated that they felt hearing conservation education is important. However, only 35 percent of educational audiologists said the provide it. Twenty-one percent of non-educational audiologists provide hearing conservation education, but less than 1 percent interact directly with children and adolescents while 45 percent consider themselves a professional resource in this regard. The results of the survey leave little doubt that a large number of our students in the public schools do not have access to hearing conservation education. The findings clearly suggest a need for more direct instruction in hearing loss prevention in public schools.

♦Preparation in Educational Audiology: A Survey of Academic Programs in Audiology (Beckrow & Nerbonne)

A survey of academic programs accredited by the American Speech-Language Hearing Association (ASHA) in audiology was conducted to determine the preparation of students in knowledge and skills targeting the minimum competencies for educational audiologists as established by the Educational Audiology Association (EAA). Responses from 48 programs generally indicate that students receive considerable academic and clinical preparation for those competencies associated with assessment and other mainstream areas of clinical audiology but substantially less preparation in most of the competencies related to audiology within the educational setting. Thus, current programs in audiology do not appear to be preparing graduates any better for employment in the schools than has been reported in the past.

♦Preparation in Educational Audiology: A Survey of Educational Audiologists (Curiel & Nerbonne)

Completed surveys were obtained from 425 educational audiologists concerning the degree of competence each felt he/she possessed in key areas of educational audiology upon graduation. Results indicated generally strong competency ratings for those areas closely aligned with mainstream clinical audiology, but the competency ratings were much lower for aspects directly associated with practicing audiology in the school setting. These results strongly suggest the need for substantial changes in how future audiologists are prepared academically and clinically in educational audiology.

♦An Electrostatic Discharge (ESD) Control Program for Children with Cochlear Implants (McGinnis)

The increasing presence in educational programs of infants and young children with cochlear implants mandates that professionals become knowledgeable about electrostatic discharge (ESD), so that they can provide a safe educational environment for children. An ESD-controlled program presented that is practical and inexpensive for most educational situations. An ESD inservice module for parents and professionals is also presented.

2003, Volume 11

♦A Comparison of Lecture and Problem-Based Instructional Formats for FM Inservices (Naeve-Velguth, Hariprasad, & Lehman)

This study compared the pedagogical approaches of traditional lecture and problem-based learning (PBL) for professional inservice instruction on classroom FM systems. Participants attended either a lecture or PBL instructional session, and each completed a pretest, immediate post-test, and one-week post-test examination of his or her knowledge of three FM systems (Phonic Ear Personal Easy Listener, Phonic Ear FreeEar, Phonak MicroLink). The findings indicated that the PBL group's post-instruction scores were significantly higher than those of the lecture group. These data and other findings are discussed in terms of the potential effectiveness of PBL as an instructional model for FM inservices.

♦Speech-Recognition Performance of Children Using Cochlear Implants and FM Systems (Schafer & Thibodeau)

Sentence recognition was evaluated for ten children with cochlear implants (CIs) in quiet, noise, and in four FM system arrangements: desktop soundfield, body-worn, miniature direct-connect, and miniature cord-connect. The CI speech processors remained at user settings during testing, and the children adjusted the volume controls on the FM receivers to comfortable levels while listening to running speech. No significant differences were found in thresholds for speech-weighted noise obtained across the four FM system arrangements, which suggested that the children were able to adjust the volume settings on the FM system receivers to relatively equal perceptual levels. When listening with their implant alone, the children's sentence recognition was significantly affected by the presence of the background noise. The use of all four FM system arrangements resulted in significantly improved performance in noise relative to the implant-alone condition. There were no significant differences in average speech recognition scores across the FM systems.

♦ Educational Testing for Auditory Processing: A Retrospective Study (Garfinkel)

Although school-based audiologists frequently assess auditory processing problems in children, there is a lack of standardized educational guidelines for auditory processing referrals. The American Speech-Language-Hearing Association (ASHA; 1996) statement on auditory processing provides definitions of auditory processing and the characteristics presented by children with auditory processing disorders. The procedures used to refer and test children suspected of auditory processing disorders within an educational system vary by state and by personnel providing these services within the school systems. There is little research on how educational teams decide which children should receive educational assessments for auditory processing problems. The purpose of this study was to determine if school districts followed recommended referral procedures when referring students for auditory processing evaluations.

Results revealed that school districts were following most of the recommended procedures for making auditory processing referrals in the two years studied. A retrospective analysis of student records indicated that school districts were meeting

Table 1. Continued Overview of 2000 to 2009 Journal of Educational Audiology Articles Sorted by Topic

Topic	Author(s)	Year	Issue	Title
Frequency Modulated (FM)/ Infrared Systems	Lederman et al	2000	8	Development and validation of an "intelligent" classroom sound field frequency modulated (FM) system
	Gagne	2000	8	AudiSee: An auditory-visual-FM System
	Prendergast	2001	9	A comparison of the performance of classroom amplification with traditional and bending wave speakers
	Crandell et al	2001	9	Effects of portable sound field FM systems on speech perception in noise
	Nelson	2001	9	Coupling FM systems to high-technology digital hearing aids
	Kreisman & Crandell	2002	10	Behind-the-ear FM systems: Effects on speech perception in noise
	Naeve-Velguth et al	2003	11	A comparison of lecture and problem-based instructional formats for FM inservices
	Schafer & Thibodeau	2003	11	Speech-recognition performance of children using cochlear implants and FM systems
	Taub et al	2003	11	Reducing acoustic barriers in classrooms: A report comparing two kindergarten classrooms in an inner-city school
	Anderson et al	2005	12	Benefit of S/N enhancing devices to speech perception of children listening in a typical classroom with hearing aids or a cochlear implant
	Friederichs & Friederichs	2005	12	Electrophysiologic and psycho-acoustic findings following one-year application of a personal ear-level FM device in children with attention deficit and suspected central auditory processing disorder
	Flynn et al	2005	12	The FM advantage in the real classroom
	Edwards & Feun	2005	12	A formative evaluation of sound-field amplification system across several grade levels in four schools
	Updike	2006	13	The use of FM systems for children with attention deficit disorder
	Wolfe et al	2007-08	14	Clinical evaluation of a verification strategy for personal FM systems and nonlinear hearing aids
	Schafer & Kleineck	2009	15	Improvements in speech recognition using cochlear implants and three types of FM systems: A meta-analytic approach
	Naeve-Velguth et al	2009	15	Effect of MicroMLxS Designated Programmable Audio Input (DPAI) and switch settings on FM- and muted-FM transparency for six DPAI hearing instruments

many of the 10 goals for student referral set forth by the Lincoln Intermediate Unity (LIU) #12 Task Force on Auditory Processing. Most of the referred children met the basic requirements of having intelligible speech, normal hearing, being in academic struggle, and completion of the Instructional Support Team process, completion of a psychoeducational evaluation and completion of the LIU #12 checklist for auditory processing referrals. Areas that still need improvement include completion of a full speech and language evaluation prior to the referral to the audiologist and the Instructional Support Team's use of prescreening forms.

♦The Word Intelligibility by Picture Identification Test: A Two-Part Study of Familiarity and Use (Stewart)

The Word Intelligibility by Picture Identification (WIPI) Test was published as a means to "assess the speech discrimination ability of hearing impaired children" (Ross & Lerman, 1970). The WIPI remains a popular test among pediatric audiologists, even though many of the pictures now appear out-of-date and several illustrations seem insensitive to our current social mores. None of the drawings reflect the racial diversity of the American population. In this two part pilot study, the WIPI was presented to a group of 16 normally hearing five- to eight-year old children, two boys and two girls at each level, to determine if they had difficulty indentifying any test pictures or vocabulary. The data showed that the six- to eight-year-old children had little difficulty recognizing the test pictures or vocabulary. Children in the five-year-old group demonstrated a considerable number of errors. Eight of the 150 test items were missed consistently across all age groups. Additionally, an on-line survey was disseminated to approximately 800 audiologists to examine how they currently use the WIPI test. Results confirmed that the majority of pediatric audiologists who responded to the survey use this test. These audiologists indicated that they chose the WIPI more often than any other closed-set word recognition test. However, a substantial number of audiologists reported that they varied their test presentation from the protocol outlined by Ross and Lerman.

♦A Checklist/Protocol for Audiologists: Is This Hearing Aid Appropriate for This Individual? (Palmer)

After reading news of exciting advances in hearing aid technology many patients, parents, and educators are asking the question "Is this hearing aid appropriate for me/my child?" The audiologist is challenged with answering this question from four constituencies: 1) patients or parents of children seeking an appropriate hearing aid solution; 2) a physician posing the question about one of his/her patients; 3) educational audiologists guided by legislation or guidelines that recommend testing of each child's hearing aid once per year resulting in a report documenting the adequacy of the fitting; and 4) health professionals such as speech-language-pathologists, occupational therapists, and physical therapists whose treatment may depend on or be modified by the individual's ability to hear. Four primary hearing aid fitting goals are identified and a test protocol is suggested to evaluate whether these goals have been met by an individual's current hearing aids. A case is presented to illustrate the protocol and provide discussion related to the possible results of the assessment and subsequent actions that might be recommended.

♦Reducing Acoustic Barriers in Classrooms: A Report Comparing Two Kindergarten Classrooms in an Inner-City School (Taub, Kanis, & Kramer)

A project was undertaken to demonstrate the effects of sound-field amplification on learning in a low socioeconomic urban classroom environment. The results of testing for identifying children who are at risk for academic difficulty as measured by the Preschool S.I.F.T.E.R. and phonological awareness as measured by the TOPA (Kindergarten Version) for two kindergarten classes were compared. Implications of these findings are presented.

2005, Volume 12

♦Child Distress and the Use of a Teddy Bear Model during Preschool Audiologic Screenings (Naeve-Velguth, Griffin, & Lehman)

Clinical experience suggests that young children may become distressed when undergoing otoscopy and tympanometry, two procedures routinely performed as a part of pediatric audiologic screenings. If a child's distress is moderate or extreme, it may result in behaviors that are disruptive to testing, cause parent upset, or interfere with the parent education component of the screening session. Research suggests that child distress may be reduced when healthcare practitioners prepare children for upcoming procedures by first demonstrating these procedures on a medical doll or stuffed animal. The present study compared child behavioral distress during routine audiologic screenings for two groups of children: Those for whom otoscopy and tympanometry were modeled on a teddy bear prior to testing and those for whom these procedures were performed without a teddy bear model. The results indicated that a greater number of children who saw a teddy bear model were relatively less distressed during otoscopy and tympanometry, as compared to a group of children for whom a teddy bear was not used. The use of a teddy bear model was specifically associated with fewer children being physically restrained and more children smiling, as compared to children who were tested using standard clinical procedures. The inclusion of a teddy bear added no more than 30 seconds of modeling time to the screening session, did not lengthen the actual period of otoscopic and tympanometric assessment, and did not negatively affect test outcomes. The application of these findings to hearing screening and other pediatric audiological procedures is discussed.

♦Benefit of S/N Enhancing Devices to Speech Perception of Children Listening in a Typical Classroom with Hearing Aids or a Cochlear Implant (Anderson, Goldstein, Colodzin, & Inglehart)

Speech perception can be improved for children with hearing loss using signal-to-noise ratio (S/N) enhancing devices. Three experiments were performed with 28 participants, age 8 to 14 years using hearing aids or a cochlear implant. Participants repeated HINT sentence lists in classrooms with a typical level of background noise and reverberation times of either 1.1 seconds or 0.6 seconds. In addition to personal amplification, the types of devices used were a classroom sound field system, a desktop personal sound field FM system, and a personal FM system linked to hearing aids or cochlear implant. The speech perception results of the three experiments support the use of a desktop or personal FM system by children with hearing loss who are auditory learners whether a poor or acceptable level of reverberation is present. Based on the results of this investigation, providing classroom sound field amplification as a means to benefit speech perception of students with mild to profound bilateral hearing loss who are successful learners in the mainstream appears to be an unjustified practice for approximately 80% of students with hearing loss. Approximately 20% of participants did benefit by least 5% in word recognition score improvement from classroom sound field amplification over use of their personal devices alone. Performance scores of these participants indicated an additional 5% or greater benefit to word recognition when using desktop or personal FM as compared to their scores using classroom sound field. Results indicated that 64% of participants believed that the personal FM device provided easiest listening with either the personal FM or desktop FM being preferred for use by 26 of the 28 participants.

Table 1. Continued Overview of 2000 to 2009 Journal of Educational Audiology Articles Sorted by Topic

Topic	Author(s)	Year	Issue	Title
Hearing Aids (HA)	Langan & Blair	2000	8	"Can you hear me?"A longitudinal study of hearing aid monitoring in the classroom
	Nelson	2001	9	Coupling FM systems to high-technology digital hearing aids
	Kuk & Ludvigsen	2001	9	Verification of nonlinear hearing aids: Considerations for sound-field thresholds and real-ear measurements
	Gou et al	2002	10	The effect of non-linear amplifications and low compression threshold on receptive and expressive speech ability in children with severe to profound hearing loss
	Palmer	2003	11	A checklist/protocol for audiologists: Is this hearing aid appropriate for this individual?
	Anderson et al	2005	12	Benefit of S/N enhancing devices to speech perception of children listening in a typical classroom with hearing aids or a cochlear implant
	Wolfe et al	2007-08	14	Clinical evaluation of a verification strategy for personal FM systems and nonlinear hearing aids
	Blair & Blair	2007-08	14	Parental perceptions and behavior regarding hearing aid monitoring and maintenance in an early childhood intervention program
	Auriemmo et al	2009	15	Efficacy of an adaptive directional microphone and a noise reduction system for school-aged children
Hearing Conservation	Burns & Tulenko	2002	10	Current practices in hearing conservation education in schools
	Naeve-Velguth et al	2006	13	Comparison of lecture and computer-based methods for hearing conservation instruction: Implications for secondary education
Hearing Screenings	Kernan et al	2000	8	Efficacy of using teachers as identifiers of hearing problems
	Naeve-Velguth et al	2005	12	Child distress and the use of a teddy bear model during preschool audiologic screenings
	Richburg & Imhoff	2007-08	14	Survey of hearing screeners: Training and protocols used in two distinct school systems

♦Electrophysiologic and Psycho-Acoustic Findings Following One-Year Application of a Personal Ear-Level FM Device in Children with Attention Deficit and Suspected Central Auditory Processing Disorder (Friederichs & Friederichs)

This study examined whether electrophysiological and psycho-acoustic auditory measures would reflect changes following use for one year of a personal ear-level frequency-modulated (FM) device in a group of children with symptoms of central auditory processing disorder (CAPD). Subjects consisted of 10 children aged 7 to 14 years with normal hearing thresholds, suspected CAPD, and additional attention and/or learning difficulties. The children were provided with a personal ear-level FM system which was required to be used mainly during school time for one year. An age-matched control group was also followed over the time period of one year. Results indicated that the children who used the ear-level personal FM device exhibited significantly improved performance on specific tests of auditory function compared to the control group. Furthermore, electrophysiological late event-related potentials revealed significant changes in the experimental group, suggesting an accelerated neuromaturational process when using a FM-device compared to an age-matched control group. Parents and teachers also reported a significant improvement in speech understanding and in overall school performance as well as accompanying conduct behavior in the children who used the FM device. Results of this study suggest that the late auditory event-related potentials are sensitive to changes in clinical development of children using an ear-level FM device. Results also indicate that use of an ear-level FM device results in improved behavioral and electrophysiologic auditory performance.

♦The FM Advantage in the Real Classroom (Flynn, Flynn, & Gregory)

The present study examined the benefits of students using personal FM systems in their own classroom and in the home. Eleven students aged between 5 and 15 years participated in the study. All participants had a sensorineural hearing loss ranging in degree from moderate to profound. During the study, the students used the FM system combined with their hearing aid at school and at home for three months. Performance was documented using measures of oral language comprehension in the student's daily classroom combined with self-report measures obtained from the parents, teachers and students. Results indicated a significant benefit for the use of the FM system combined with the hearing aid over the hearing aid alone in the real classroom. Parents and students reported a significant benefit for use of the FM system at home. Teachers, parents, and students identified an improvement in specific situations of need. This study supports the recommendation of combining a personal FM system with the student's hearing aid to improve speech understanding in school and in the home.

♦Relationship of Auditory Processing Categories as Determined by the Staggered Spondaic Word Test (SSW) to Speech-Language and Other Auditory Processing Test Results (Gustafson & Keith)

In his Buffalo Model, Katz (1992) used primarily scores on the Staggered Spondaic Word test (SSW) to categorize children with auditory processing disorders. From this categorization, speech-language difficulties were predicted and management techniques were proposed within the Buffalo Model. This retrospective study of 159 files examined the relationship among test results on the SSW and other tests of speech-language and auditory processing. Results showed few significant correlations between speech-language and auditory processing measures and separate components of the SSW test. Most of the significant correlations had such low magnitude as to not be clinically significant. Descriptive analysis of reading skills and pitch pattern performance suggested results contrary to the Buffalo Model. The results indicate a lack of construct validity for the Buffalo Model, suggesting that a "cookbook" approach to management using this model should be approached with caution in managing children with auditory processing disorders.

♦A Formative Evaluation of Sound-Field Amplification System across Several Grade Levels in Four Schools (Edwards & Feun)

A formative evaluation was conducted during the 2002 - 2003 school year to determine the degree to which sound-field amplification systems were being implemented in the schools involved in the study and to make improvements/adjustments as necessary. The issues or questions addressed in our evaluation were: 1) How effective was the training provided to the teachers? 2) How often are teachers using the equipment? 3) What effects does using this equipment have on the teachers? 4) What effects does using this equipment have on the students? Two on-site visits were made by an evaluation team to each of the four schools involved in the study during the course of the 2002-03 school year. In addition, a teacher survey was administered at the end of the school year. Results indicated that 95% of the teachers used the sound-field system to some degree. Teachers reported less voice strain, greater clarity of their voices, and improved student attention and participation with use of the sound-field systems. Teachers also identified several areas of needed improvement in the equipment itself and in service-related areas. This study will present these results, along with several recommendations regarding additional equipment needs, training, and need for additional consultation.

♦Use of the California Consonant Test with Children (Prendergast)

The potential advantages of using the California Consonant Test (CCT) (Owens & Schubert, 1977) with children are discussed, followed by reports of two exploratory investigations. In the first investigation, the CCT was administered in classrooms to second, third and fourth graders with normal hearing. The children scored within 13% of an adult control group, suggesting that the CCT was not too difficult for them. In the second investigation, the CCT was administered to 11 children with hearing loss in classrooms with various amplification combinations. Their scores were lower and more variable than the scores of the children with normal hearing, but all scored above chance, suggesting that the CCT was within their capabilities as well. Additional areas of research and uses of the CCT with children are discussed.

♦Auditory Neuropathy/Dys-synchrony with Secondary Loss of Otoacoustic Emissions in a Child with Autism (Plyler, Plyler, & Little)

Otoacoustic emissions are commonly present in cases of auditory neuropathy/dys-synchrony; however, otoacoustic emissions are absent or disappear in approximately one-third of patients with the disorder. Failure to identify AN/AD patients with absent otoacoustic emissions may result in improper diagnosis and management. The purpose of this article is to present findings from a case of auditory neuropathy/dys-synchrony with secondary loss of otoacoustic emissions to increase clinician awareness regarding the relationship between otoacoustic emissions and the disorder.

♦Impact of the Early Hearing Detection and Intervention Program on the Detection of Hearing Loss at Birth—Michigan, 1998-2002 (Reda, Grigorescu, & Jarrett)

The objective of this study was to evaluate the impact of the Early Hearing Detection and Intervention (EHDI) program on the detection of hearing loss (HL) at birth in Michigan. Using EHDI surveillance data for 1998-2002, we calculated screening, referral, and evaluation rates, as well as the rate of enrollment into early intervention (EI) services. We determined that during the 5-year study period, screening rates increased from 22.8% to 92.1%, referral rates declined from 4.7% to 2.8%, and the mean age (and range) at diagnosis of HL decreased (and narrowed) from 6.49 months (range: 0.03-44.27) to 2.65 months (range: 0.07-10.67). The proportion of referred infants with reported re-screening or diagnostic evaluation results remains below 50.0%. Among those referred to EI services with known follow-up, enrollment in services was reported by 74.6%; of these, 48.6% enrolled by age 6 months. Our results suggest that EHDI has improved the detection of HL in the newborn period in Michigan; however, suboptimal reporting threatens the validity of our findings. Continued development of EHDI programs, collaboration with EI providers, and mandated reporting may improve the quality of EHDI data and assure that newborns screened for HL receive appropriate follow-up services.

♦Use of a Self-Assessment Technique in Counseling Adolescents with Hearing Loss: From Theory to Practice (Crowell, English, McCarthy, & Elkayam)

Adolescents with impaired hearing often feel isolated, receiving little support from peers or audiologists. This tutorial describes how educational and pediatric audiologists can use a recently developed self-assessment tool as a counseling strategy when working with the adolescent population. The reader is provided with literature reviews in three topics: Counseling and its application to audiologic practices, the developmental issues of adolescents and the impact of hearing loss during this time in life, and the use of self-assessments as a counseling tool. The final section integrates these topics to demonstrate how a self-assessment designed for teens with hearing loss can provide a counseling framework for educational and pediatric audiologists interested in providing counseling support. Hypothetical scenarios are included in the Appendix to illustrate the use of the self-assessment instrument.

2006, Volume 13

♦The Use of FM Systems for Children with Attention Deficit Disorder (Updike)

This research study was undertaken to evaluate the effects of using FM systems with children having attention deficit disorder. Word recognition ability, attention and listening skills, and academic scores were compared for pre- versus post-FM fitting. Implications of these findings and suggestions for further research are presented.

♦How is Educational Audiology Being Taught? A Review of Syllabi from Au.D. Programs, Fall 2005 (English & Vargo)

Little is known about the nature and extent of educational audiology courses taught in graduate training programs. The two purposes of the present investigation were (1) to determine how many of the 60 accredited Audiology Doctorate (AuD.) programs in the United States include a course in educational audiology in their curriculum, and (2) to summarize the learning objectives from those courses. We learned that slightly more than half of the programs either require a class in educational audiology (N = 25, 42%) or incorporate educational audiology content in other courses (N = 7, 12%). A qualitative analysis of 167 learning objectives from course syllabi indicated a strong consensus across programs regarding expected student outcomes. Educational audiology is now a recognized specialty among many training programs and is being taught with consistency across programs.

♦Comparison of Lecture and Computer-Based Methods for Hearing Conservation Instruction: Implications for Secondary Education (Naeve-Velguth, Locke, Stewart, & Lehman)

Research indicates that children and young adults are at risk for noise-induced hearing loss and can benefit from hearing conservation instruction. The purpose of this study was to examine participant learning about hearing conservation topics, including background information (e.g., anatomy and physiology) and hearing conservation specific content (e.g., hearing loss prevention), as presented through a lecture vs. a computer-based format and assessed by a 20-point post-instruction exam. The results indicated greater learning of background content for lecture instruction, but no difference between instructional modes for hearing conservation-specific material. These data are discussed in terms of implications for secondary education.

♦Acceptance of Background Noise in Children with Normal Hearing (Freyaldenhoven & Smiley)

The present study measured acceptance of noise in 32 children (age 8 and 12 years) with normal hearing sensitivity. Results demonstrated that acceptable noise levels (ANLs) are not dependent on type of noise distraction, gender, or age of the child, at least for children 8 and 12 years of age. Results further demonstrated that ANLs can be obtained reliably in children in 2-4 minutes and are normally distributed. Clinical implications and applications are discussed.

♦Noise Levels Among First, Second, and Third Grade Elementary School Classrooms in Hawaii (Pugh, Miura, & Asahara)

This study examined background and octave band noise levels collected from a combination of 79 unoccupied urban public and private school classrooms in Hawai‘i (island of Oahu). Noise measurements were obtained from first, second, and third grade classrooms and room characteristics were determined for each classroom tested. Measurements were obtained in decibels with the sound level meter weighting switch in “A” position (dBA) and octave band noise spectra were collected to determine Noise Criteria (NC) ratings. Results indicated mean noise levels of all classrooms were above the 30 dBA criterion recommended by the American Speech and Hearing Association (ASHA, 1995), the 20 dB NC rating recommended by the American Speech and Hearing Association (ASHA, 1995), and the 35 dBA criterion recommended by the American National Standards Institute (ANSI, 2002) for educational settings. These findings are discussed.

♦Application of the Auditory-Verbal Methodology and Pedagogy to School Age Children (Duncan)

As children progress through school, the complexity of the linguistic-auditory-cognitive signal increases, requiring the student to process more sophisticated information. Consequently, students with a hearing loss who have developed spoken language through audition must have advanced strategies in place to deal with this mounting challenge. For these students, the auditory-verbal methodology can be a suitable intervention approach. It is important that audiologists understand this methodology whether or not they provide aural (re)habilitation. This paper examines the current principles, teaching behaviors and lesson-planning framework that comprise the application of the auditory-verbal methodology and pedagogy to school age children.

2007/2008, Volume 14

♦Job Burnout in Educational Audiologists: The Value of Work Experience (Blood, Cohen & Blood)

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.

♦Background Noise Levels and Reverberation Times in Old and New Elementary School Classrooms (Nelson, Smaldino, Erler, & Garstecki)

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.

♦Click ABR Characteristics in Children with Temporal Processing Deficits (Hurley, Hood, Cullen, & Cranford)

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.

♦Survey of Hearing Screeners: Training and Protocols Used in Two Distinct School Systems (Richburg & Imhoff)

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.

♦Clinical Evaluation of a Verification Strategy for Personal FM Systems and Nonlinear Hearing Aids (Wolfe, Miller, Swim, & Schafer)

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.

♦Classroom Acoustics: A Survey of Educational Audiologists (Latham & Blumsack)

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.

♦Parental Perceptions and Behavior Regarding Hearing Aid Monitoring and Maintenance in an Early Childhood Intervention Program (Blair & Blair)

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.

♦Different Professionals' Interpretation of a Decoding Deficit in Reading Skills (McNamara, Bailey, & Harbers)

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.

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

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.

2009, Volume 15

♦Improvements in Speech Recognition Using Cochlear Implants and Three Types of FM Systems: A Meta-Analytic Approach (Schafer & Kleineck)

A meta-analytic approach was used to compare improvements in speech recognition of children and adults with cochlear implants (CIs) when using traditional soundfield, desktop soundfield, and direct-audio input (DAI) frequency-modulated systems. There was no significant benefit from traditional soundfield systems when compared to the CIs alone. No significant difference was detected between traditional and desktop soundfield receivers. The DAI receivers provided significantly greater gains in speech recognition when compared to the desktop receivers. According to the results of this analysis, audiologists working with CIs should recommend receivers that directly connect to the CI speech processor (i.e., DAI).

♦Efficacy of an Adaptive Directional Microphone and a Noise Reduction System for School-Aged Children (Auriemmo, Kuk, Lau, Dornan, Sweeton, Marshall, Pikora, Quick, Thiele, & Stenger)

A non-randomized, experimental study utilizing double-blinding was implemented to investigate differences in word recognition performance of school-aged children utilizing adaptive directional microphone and noise reduction (NR) features. Children from two educational facilities participated in this study. Signal-to-noise ratio (SNR) benefit of the adaptive directional system was estimated to be 7.6 dB. No SNR benefit was measured for the NR feature; however, no decrease in performance was observed either. Subjective difficulty for desired sounds originating from various azimuths was not significantly greater in either the adaptive directional or NR modes. Results indicate that for the purposes of improving SNR, adaptive directional microphone systems, but not NR systems, are potentially efficacious hearing aid fitting options for school-aged children.

♦Problem-Solving Ability in Elementary School-Aged Children with Hearing Impairment (Smiley, Thelin, Lance, & Muenchen)

The present study was conducted to evaluate the problem-solving ability of children with hearing impairment. The performance of a group of children with hearing impairment (HI Group) was compared to that of a group of children with normal hearing (NH Group). The participants were asked to solve two types of mathematical problems: those requiring computation alone and word problems requiring the use of both language and mathematical computation. The results of this study revealed that there were no significant differences between the HI Group and NH Group in the ability to solve mathematical equations involving the use of language and mathematical computation problems. Additionally, it was found that problem-solving ability was related to language ability, but not to hearing ability in the children with hearing impairment.

♦The Word Intelligibility by Picture Identification (WIPI) Test Revisited (Cienkowski, Ross, & Lerman)

The Word Intelligibility by Picture Identification (WIPI) test is a widely used test to assess speech recognition for pediatric clients. Since the test was developed over 30 years ago, a number of the pictures are outdated and several test items have been reported to be unrecognizable by children today. The purpose of this study was to evaluate a revised version of the WIPI. The test included modernized items and eliminated pictorial confusions. The result was four revised lists found to be equivalent for a group of children with normal hearing.

♦Exploring the Usefulness of Fisher's Auditory Problems Checklist as a Screening Tool in Relationship to the Buffalo Model Diagnostic Central Auditory Processing Test Battery (Strange, Zalewski, & Waibel-Duncan)

In 1996, ASHA addressed the need for appropriate tools to screen for (C)APD; yet, no universally accepted screening tool has been identified. The purpose of the current study was to determine if Fisher's Auditory Problems Checklist (Fisher, 1976) is a useful screening tool. A Chi Square goodness-of-fit test found that children who scored at or below cutoff on Fisher's Checklist were significantly more likely to receive a diagnosis of (C)APD (X21 = 22.5, $p < 0.05$) based on the Buffalo Model Diagnostic Test Battery. The current study offers preliminary support for the clinical usefulness of Fisher's Auditory Problems Checklist (Fisher, 1976) as a screening tool.

♦Effect of MicroMLxS Designated Programmable Audio Input (DPAI) and Switch Settings on FM- and Muted-FM Transparency for Six DPAI Hearing Instruments (Naeve-Velguth, Miller, & Kujawa)

The first purpose of this study was to evaluate the effect of FM receiver setting (DPAI-yes/2-dot, DPAI-yes/1-dot, DPAI-no/2-dot, DPAI-no/1-dot) on FM transparency, measured as FM offset (in dB), for each of six Designated Programmable Audio Input (DPAI) hearing instruments coupled to one Phonak MicroMLxS FM receiver and one Campus-Sx FM transmitter. The second purpose was to assess the effect of muting the FM microphone (i.e., muted-FM transparency, measured as muted-FM offset, in dB) for each hearing aid and DPAI/dot setting. The results indicated that for five of the six aids, mean three-frequency average (750, 1000, 2000 Hz) FM offset was within FM transparency tolerances (American Academy of Audiology, 2008b) for the DPAI-yes/2-dot, DPAI-yes/1-dot, and DPAI-no/1-dot conditions, but exceeded tolerances for the DPAI-no/2-dot condition. For the sixth hearing instrument, mean three-frequency average FM offset was within tolerances for each DPAI/dot condition. The data of the present study also indicated that mean three-frequency average muted-FM offset was within transparency tolerances for all aids in all DPAI/dot conditions. Implications of these data for FM system management in the schools are discussed.

♦The "State" of Educational Audiology Revisited (Richburg & Smiley)

The Educational Audiology Association conducted a survey of state education agencies in 1990 (Johnson, 1991) to determine the status of audiological services being provided to children with hearing impairments in the schools at that time. A follow-up survey was conducted in 2007 to determine (1) the "state" of educational audiology throughout the United States and (2) if changes have occurred in the delivery of school-based services over the past 17 years. The results revealed that, although some changes have occurred, there have been no substantial improvements in the numbers of audiologists providing services in the schools. In addition, federally mandated guidelines have not provided for universal hearing screenings in every school system, and states have not substantially changed their definition of hearing loss for the purposes of considering a child for special education services.

♦Auditory Remediation for a Patient with Landau-Kleffner Syndrome: A Case Study (Hurley & Hurley)

Landau-Kleffner Syndrome (LKS) is a rare, childhood neurological disorder characterized by a sudden or gradual development of acquired aphasia. This case study offers a unique opportunity to assess the changes in the auditory processing ability of a 12 year old male with LKS after two distinct auditory training programs, Fast ForWord® and Dichotic Interaural Intensity Difference (DIID) training. Improvement in the electrophysiological recordings and the behavioral scores from the Dichotic Digits Test are evidence of the plasticity of the central auditory nervous system and may indicate a viable auditory remediation therapy for persons with LKS.

♦Accommodating Students with Hearing Loss in a Teacher of the Deaf/Hard of Hearing Education Program (Millett)

This article discusses challenges faced by students with hearing loss at the post-secondary level, and presents a model used in the Teacher of the Deaf/Hard of Hearing Education program at York University in Toronto. This program incorporates concepts of universal design and specific strategies to (1) ensure that students with hearing loss can access both curriculum and practicum as fully and easily as students without hearing loss, and (2) provide opportunities to model appropriate teaching practices. The integration of personal and classroom amplification, architectural classroom design, real-time captioning, audiovisual support, ASL interpreters, and use of online technology is described.

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Educational Policy Influences on Educational Audiology: A Review of the Past Decade

Jane B. Seaton, M.S.
Seaton Consultants
Athens, Georgia

Cheryl DeConde Johnson, Ed.D.
The ADVantage- Audiology, Deaf Education Vantage Consulting
Leadville, Colorado

Educational policy can take several different forms ranging from laws, regulations, and court decisions to professional standards and decisions by local and state administrators and school boards. When education laws are enacted, they typically reflect the goals, principles, and outcomes of these various policy groups. Implementing regulations are subsequently developed and adopted to define how the laws are to be implemented. These regulations also provide further clarification by stipulating strategies and services required to meet the intent of the law. Case law adds a further layer of legal interpretation when there is ambiguity or disagreement as to the legal intent or the implementation. Professional standards serve as guidance that also may be reflected in legislation or regulations that can be enforceable as law. While policy decisions by local school systems have to be in accordance with state and federal regulations, litigation usually begins at the local level where it impacts an individual student. However, the local policies typically remain in effect unless challenged under state or federal law. With current trends related to student demographics and increasingly tight education budgets, it is important to be knowledgeable about educational policy decisions that can impact audiology programs and services in the schools. This article provides an overview of policy actions from 2000-2010 that are most likely to influence the practice of educational audiology now and in the near future.

General Education Policy

Although special education policy has provided guidance through definitions and regulations for past and current educational audiology practice, policy decisions within the realm of general education are clearly relevant for the future. With that trend in mind, this review begins with significant issues from general education policy that impact services for students with hearing challenges.

The No Child Left Behind Act (NCLB)

The Elementary and Secondary Education Act of 1965 (ESEA) is a United States federal statute initially enacted on April 11, 1965. The government has reauthorized the ESEA every five years since its inception, and the current reauthorization of ESEA is the No Child Left Behind Act of 2001 (NCLB, 20 U.S.C. § 6301 *et seq*). Primary goals and principles targeted by NCLB include:

- Stronger accountability for results
- Performance goals for states and local education agencies
- Increased flexibility and local control
- Expanded options for parents
- Emphasis on teaching methods that have been proven to work

Implementing regulations for NCLB, adopted in 2008, provided additional clarification regarding assessment, teaching requirements, accountability, and reporting of progress. However, concerns for students with hearing and listening problems that have relevance for educational audiologists remained, such as classroom accommodations, response to intervention, and provision of services to facilitate access to general education for students with disabilities who are not placed in special education. Educational policy related to these areas is discussed in the following sections. More detailed information on the No Child Left Behind Act and its regulations can be found at www.ed.gov/nclb/landing.jhtml

Response to Intervention

This provision has its roots in NCLB to improve classroom instruction. Response to Intervention (RtI) is intended to increase supports for students with specific learning disabilities and behavior problems by increasing the quality of instruction or intervention (e.g., requiring that states establish a process for identifying needs based on students' responses to scientific, research-based intervention). This process requires that before a referral to special education is made, an increasingly intensive series of interventions be provided, and the subsequent progress documented, to assure that the learning problem exhibited by the student is not a result of lack of appropriate instruction. While the RtI process

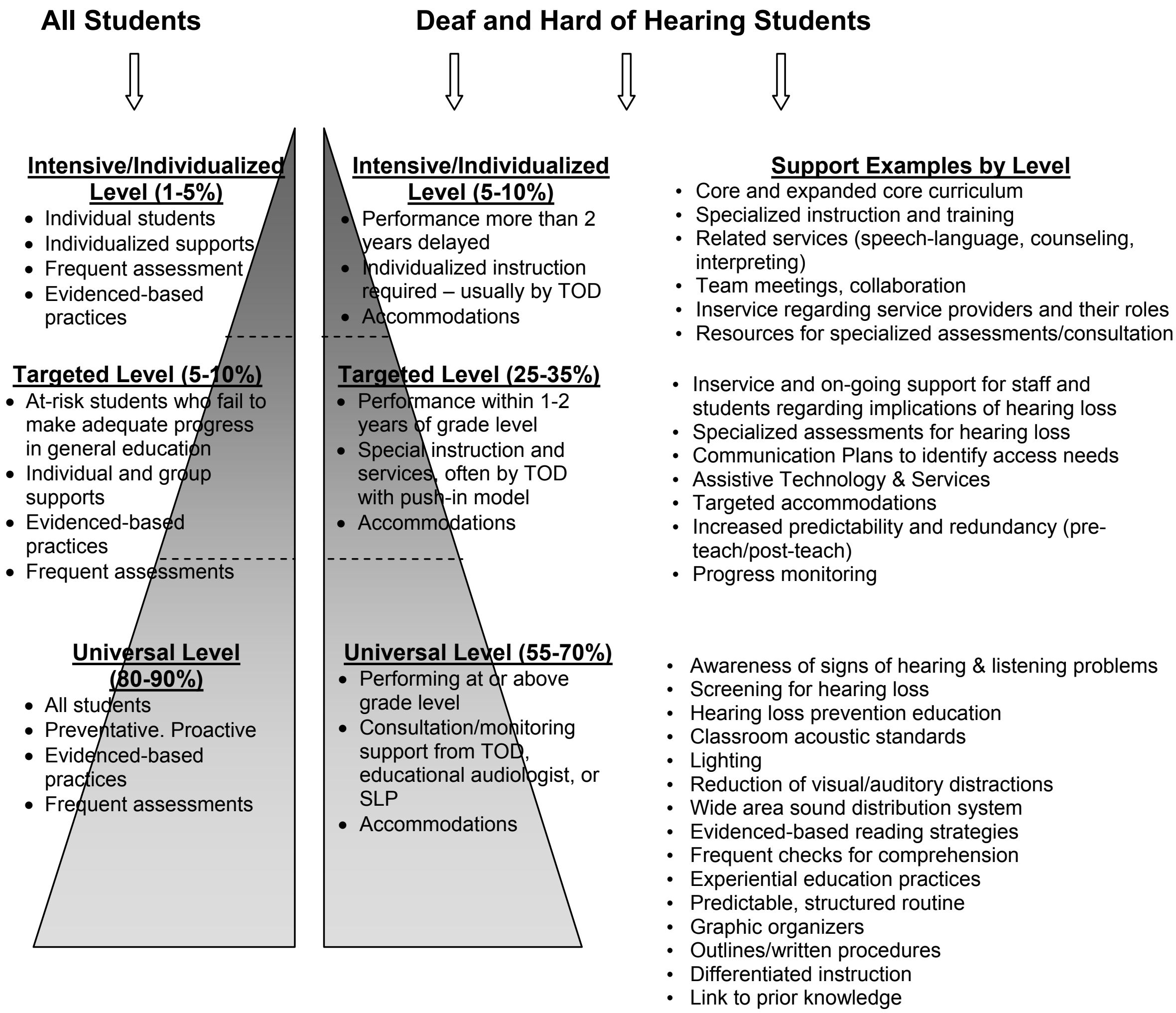

Figure 1. **Response to Intervention model adapted to students with hearing loss with suggested sample supports at each level.**

is not designed for students with sensory, cognitive, or physical disabilities, it does have components that benefit instruction for all children in the general education classroom. These include access to better instruction (scientifically, research-based interventions), access to frequent monitoring procedures to identify how a child is responding to these interventions, and access to instruction that is provided by qualified personnel.

The multi-tiered RtI model should integrate the resources of general education, special education, gifted education, as well as any other school student support programs. For educational audiologists, RtI provides a framework to serve students at all tiers of intervention, regardless of whether they have an IEP, a 504 Plan, or neither. Given the growing number of children with hearing loss who are not eligible for special education due to adequate school performance, the RtI model provides a mechanism to support access and learning needs outside of special education. The increased emphases on research-based interventions that benefit students within the multiple tiers of the model also benefit children with hearing loss and listening problems. This emphasis on effective practices requires frequent monitoring of student progress so that adjustments can be made as soon as it is determined that a student is not making consistent progress.

Figure 1 illustrates a tiered model of services comparing RtI for all students to a suggested model of services for students with hearing loss. Tier 1 describes supports and services for students performing at or above grade level, emphasizing the same prevention proactive approach as Tier 1 for RtI. The goal for these students is to provide supports that will sustain their performance. Tier 2 targets students who are performing within one to two years of their grade level, and Tier 3 targets students who are more than two years delayed. Within this model, interventions such as appropriate classroom acoustics and use of classroom audio distribution systems can be implemented at the Tier 1 core instruction level. Tier 2 adds interventions such as special flexible seating or use of a personal FM system, and Tier 3 adds traditional supports that are typically part of an IEP. Ideally, to support the listening needs of students, audiologists should be involved with school multidisciplinary teams at each of these tiers to ensure that appropriate interventions and accommodations are instituted. IDEA permits states to use up to 15% of their special education funds to support RtI services through Early Intervening Services (EIS). Participation in this program is determined by each state department of education agency. Each state can determine how related services personnel (including audiologists) are involved in the RtI process, either through EIS or some other mechanism. Local school districts may also recognize the benefits of a model founded on prevention rather than failure and provide flexibility for its related services staff to support student at all levels. IDEA does not specifically prevent audiologists from providing support to students who are not in special education. As the use of the school-wide RtI model increases, more will be learned about how general education and special education supports are integrated throughout the tiers of intervention to support students with hearing loss.

Classroom Acoustics

The Architectural and Transportation Barriers Compliance Board (Access Board) received a petition in 1997 from a parent of a child with hearing loss, stating that poor classroom acoustics constituted an architectural barrier to their child's educational opportunities. As a result of this petition, the Access Board and the Acoustical Society of American convened the Classroom Acoustics Working Group to develop guidelines. These guidelines were approved in 2002 as a standard under the American National Standards Institute (ANSI) and Acoustical Society of America (ASA), with the goal that the standard would be adopted by the International Code Committee (ICC) as part of the International Building Code (IBC). An additional acoustical standard was adopted in 2009 for relocatable classrooms (ANSI/ASA, 2009/10). In response to ICC questions, the guidelines were revised as a standard for permanent classrooms and resubmitted to the ICC in 2010. When the standard was not adopted, a petitioning process to the Access Board led to their commitment to develop rulemaking for classroom acoustics standards under the ADA. This process is currently underway. The current standards are located in Text Box 1. The revised standard includes a caveat for children with special listening needs that require a lower reverberation time (RT) be used. Audiology currently lacks a clinical test for identifying individual RT needs. Until such time as a test is developed with norms, a .3 RT for children with hearing loss should be recommended based on current research (Iglehart, 2009; Neuman, Hajicek, & Rubinstein, 2010)

Text Box 1

Recommended Classroom Acoustic Standards for Core Learning Spaces <10,000 ft^3 volume (ANSI/ASA S12.60-2009, 2010)

<u>Permanent Classrooms</u>: Ambient Noise Level: 35dBA/C; Reverberation Time: .6 seconds*

<u>Relocatable Classrooms</u>: Ambient Noise Level: 41dBA/C, 38 dBA/C by 2013, 35 dBA/C by 2017 Reverberation Time: .5 seconds*

*Note: These core learning spaces shall be readily adaptable to allow reduction in reverberation time to .3 seconds to accommodate children with special listening needs.

Classroom acoustics is a foundational responsibility for audiologists in promoting classroom listening. Consider these tendencies: children with hearing and listening problems are primarily educated in regular classrooms, high noise and reverberation levels continue to exist in classrooms, and the use of classroom audio distribution systems as a band-aid to poor room acoustics is growing. These combined issues result in an increase in students that are learning in classrooms with acoustical conditions that may actually exacerbate their listening abilities.

Special Education Policy

As stated initially in this article, audiology has been included in special education legislation prior to the current decade. The following sections on IDEA 2004, ADA 2008, and related legal decisions impacting educational audiology provides an overview of relevant educational policy actions from 2000-2010.

The Individuals with Disabilities Education Act (IDEA 2004)

The Individuals with Disabilities Education Act (IDEA 1997) was reauthorized in 2004 as the Individuals with Disabilities Education Improvement Act and is referred to as IDEA 2004 (20 U.S.C. § 1400 *et seq*). This reauthorization emphasized increased accountability and improved outcomes for students with disabilities and stressed alignment with the educational intents of the NCLB. IDEA 2004 also included an increased emphasis on early intervention, literacy, and research-based instruction. A trend toward increased service to students with disabilities in general education settings is evident throughout many portions of this Act. IDEA 2004 is divided into five parts:

- Part A – General Provisions
- Part B – Assistance for Education of All Children with Disabilities
- Part C – Infants and Toddlers with Disabilities
- Part D – National Activities to Improve Education of Children with Disabilities
- Part E – National Center for Special Education Research

Educational audiology is most involved with Parts B and C, and changes in other parts are not included in this review. Final regulations for Part B were adopted in 2008, and although regulations were drafted for Part C, they were withdrawn in 2009 in anticipation of initiating the Act's reauthorization cycle. As a result, there were no new regulations for serving students from birth to 3 years of age that occurred during the past decade.

Text Box 2

PART B RELATED SERVICES 34CFR300.34
Exception; services that apply to children with surgically implanted devices, including cochlear implants.

(b) Exception: services that apply to children with surgically implanted devices, including cochlear implants.
(1) Related services do not include a medical device that is surgically implanted, the optimization of that device's functioning (e.g. mapping), maintenance of that device, or the replacement of that device.
(2) Nothing in paragraph (b)(1) of this section
  (i) Limits the right of a child with a surgically implanted device (e.g. cochlear implant to receive related services (as listed in paragraph (a) of this section) that are determined by the IEP Team to be necessary for the child to receive FAPE.
  (ii) Limits the responsibility of a public agency to appropriately monitor and maintain medical devices that are needed to maintain the health and safety of the child, including breathing, nutrition, or operation of other bodily functions, while the child is transported to and from school or is at school; or
  (iii) Prevents the routine checking of an external component of a surgically-implanted device to make sure it is functioning properly, as required in §300.113(b).

The definition of audiology as a related service under Part B and Part C did not change in IDEA 2004 and has been used as a basis for EAA's position statement, *Recommended Professional Practices for Educational Audiologists,* adopted in 2009 (see www.edaud.org). However, significant additions were made in the Part B regulations to clarify requirements related to serving students who use cochlear implants. Under §300.34 Related Services, an exception was added (see Text Box 2).

Two other sections of the Part B regulations (§300.113 Routine checking of hearing aids and external components of surgically implanted medical devices, and §300.5 Assistive technology device) were modified to ensure that school systems were *not* responsible for the maintenance or replacement of the internal portions of a cochlear implant, but *were* responsible for daily checks of the external portions to ensure that the device was functioning properly. These changes in the law resulted from case law decisions (discussed below) regarding services to students who use cochlear implants and serve as an example of how court decisions can influence legislation.

Text Box 3

Consideration of special factors 34CFR300.324(2)(iv)
…the IEP Team shall consider the communication needs of the child, and in the case of a child who is deaf or hard of hearing consider the child's language and communication needs, opportunities for direct communications with peers and professional personnel in the child's language and communication mode academic level, and full range of needs, including opportunities for direct instruction in the child's language and communication mode; and consider whether the child needs assistive technology devices and services. (Authority: 20 U.S.C. §1414(d)(3)(B)(iv, v)

An additional issue that can impact home use of hearing assistance technology is addressed in IDEA 2004. Regulations Section 300.106 Assistive technology (b) states, "On a case-by-case basis, the use of school-purchased assistive technology devices in a child's home or in other settings is required if the child's IEP Team determines that the child needs access to those devices in order to receive FAPE." (Authority: 20 U.S.C. 1412(a)(1), 1412(a)(12)(B)(i). IDEA 2004 also includes a new section on special consideration by the IEP team when developing IEPs for students, including those who are deaf or hard of hearing (see Text Box 3).

New regulations allowing 3-year re-evaluations (20 U.S.C. § 1414 (a)(2)(B)(ii) and the requirement for team member attendance at IEP meetings, unless excused (20 U.S.C. § 1414 (d)(1)(C)(i-iii), are two issues that have generated much discussion among educational audiologists. Readers are encouraged to check with their state's implementing regulations for IDEA 2004 to see how these regulations are being interpreted for their specific situations. Recommendations documented in the student's IEP are key to both of these issues, and whenever there is a concern that a student needs to be seen more often than is the norm, the educational audiologist should make every effort to be an active participant in the IEP process.

One last area of interest to educational audiologists is the addition of the section on early intervening services. This new section in IDEA 2004 states that school districts may use up to 15% of their Part B funds to provide services for students who need academic and behavioral assistance, but have not been identified as needing special education services (20 U.S.C.§ 1413(f). This, again, is an attempt to prevent placement in special education programs for students whose academic challenges could be addressed within the general education environment, and, unlike Section 504, the early intervening section does provide for some financial support. Additional information on these topics and others is available through Topic Briefs prepared by the Office of Special Education Programs (OSEP) that can be accessed at www.ed.gov/policy/speced/guid/idea.

The Americans with Disabilities Act (ADA)

One additional piece of relevant legislation was amended during the past decade. The ADA was enacted in 1990 to provide protection from discrimination based on disability. Modeled after the Rehabilitation Act of 1973, the ADA replaces the word "handicap" with "disability" and pertains to all employers, not just those receiving federal funds. Covered disabilities include physical conditions affecting mobility, stamina, sight, hearing, and speech as well as conditions such as emotional illness and learning disorders. The Act includes five sections (called Titles) covering employment, public services and transportation, public accommodations and commercial facilities, telecommunications, and miscellaneous provisions. The ADA was amended in 2008, as the Americans with Disabilities Act Amendments Act (ADAAA), providing an expanded interpretation of disability. The requirements of ADA for schools are the same as Section 504 of the Rehabilitation Act of 1973 and, therefore, while these amendments did not require the U.S. Department of Education to amend its 504 regulations, the expanded definition of disability may result in an increase in the number of 504 plans whose needs may have been previously handled under health care plans. In addition, as a result of the ADAAA of 2008, Section 504 clarified that determinations must be based on the child's disability as it presents itself without mitigating measures. The ADA Accessibility Guidelines (ADAAG) serve as the basis for standards issued by the Departments of Justice and Transportation to enforce the law. Schools must comply with the requirements of ADA by providing appropriate accommodations and accessibility for all individuals with disabilities, including its employees and the public. Additional information on the ADA can be accessed at www.ada.gov, the U.S. Department of Justice ADA home page.

Case Law

Case law is determined through the rulings of a court, from local circuits up to the Supreme Court. The U.S. Supreme Court rulings determine the law of the land. The next highest level is the U.S. Court of Appeals, whose decisions are binding over the courts in states contained within their district. While not binding on states outside the district, decisions from U.S. Courts of Appeals may be used as "persuasive authority" in cases being argued in other circuits. Local courts and due process decisions can set precedents and be quoted in other case briefs. The Office of Civil Rights (OCR) rules on cases that are filed through their office. These rulings also have national implications. The U.S. Department of Education provides further legal interpretation through the Office of Special Education Programs (OSEP). Clarification and interpretation of federal regulations are made through letters of policy clarification written in response to specific inquiries made by state education officials, parents, or other pertinent parties.

The following case summaries are presented in order of the year of the latest court ruling available. Where multiple citations are provided, more than one source was used for background information and/or there were several levels of appeal for the case. See Text Box 4 for a list of acronyms used in these case summaries.

Text Box 4

Case Law Summary Acronyms

ALJ	Administrative Law Judge
AVT	Auditory Verbal Therapy
EI	Early Intervention
FAPE	Free Appropriate Public Education
IEE	Independent Educational Evaluation
IEP	Individualized Educational Plan
IFSP	Individualized Family Service Plan
IHO	Impartial Hearing Officer
CI	Cochlear Implant
LEA	Local Educational Agency
LRE	Least Restrictive Environment
LSS	Local School System
SLP	Speech-Language Pathologist
TOD	Teacher of the Deaf and Hard of Hearing

<u>**Cases Filed Under IDEA:**</u>

• ***Holmes v. Millcreek Township School District,* 205 F.3d 583 (3d Cir. 2000).** This case involved a student with severe hearing loss who used hearing aids and sign language interpreter services in his general education classroom under an IEP that was developed with assistance from an IEE completed by Western Pennsylvania School for the Deaf. Parents wanted same IEE process for re-evaluation and reimbursement by the LEA. The LSS offered a re-evaluation completed with the assistance of the school district interpreter. Local due process ruled for reimbursement, but did not rule on the appropriateness of a re-evaluation. The decision was appealed and reversed on "legal error." The parents prevailed in an appeal to the U.S. District Court for attorneys' fees, prior court costs, and IEE costs. The school district appealed again, and the District Court of Appeals upheld the award of attorneys' fees, but reduced the amount since it felt the family had contributed to "protracted proceedings" and should share in the costs. The reimbursement for the IEE costs was reversed since the LEAs re-evaluation was not shown to be inappropriate.

• ***[Student] v. Branford Board of Education*, Order 01-320 (2001).** This case involved a four-year-old child with a CI and history of AVT provided under Part C of IDEA. The AVT was continued at the LSS's expense under the IEP when the child turned three. The child was placed in a private mainstream preschool at the parents' expense rather than the LSS non-categorical preschool class for students with disabilities, but the parents did request that the LSS provide an FM. The LSS maintained their preschool provided FAPE and refused to provide FM for this student in a private school. The hearing officer ruled in favor of the parents and ordered the provision of FM, reimbursement for continued AVT, and payment of private school tuition.

• ***D.D. v. Foothill SELPA* 38. IDELR 29 (CA 2002).** This case involved a sixteen-month-old child initially served in the home by a TOD and an SLP provided by SELPA (Special Education Local Plan Area) under Part C. SELPA proposed to continue the same services after the child received a CI. Parents requested placement at a private oral school, where staff were experienced in serving students with CIs and included two full-time audiologists. The ALJ ruled that the program developed by the staff of the early childhood program could not provide an appropriate EI program for this child because the staff did not have sufficient training to work with cochlear implants. The LSS claimed that the private school provider could not meet all of the needs on the child's IEP and that the private school setting violated natural environment requirements of Part C. The ALJ ruled in favor of the parents and ordered the SELPA to pay for the private school placement.

• ***Stratham School District v Beth and David P.*, 38 IDELR 121 (D.N.H. 2002); 103 LRP 4317 (02-135-JD, 2003 DNH 022).**** This case involved a three-year-old using a CI with an IEP that included services from a TOD and an SLP and objectives based on the use of the CI. The parents requested reimbursement for mapping co-payments and transportation costs to the CI center in a neighboring state. The school district refused stating the CI and associated costs were a medical, not educational, expense. The hearing officer ruled in favor of the parents, and on appeal by the LSS, the lower court decision was upheld in U.S. District Court. The higher court ruling confirmed that "…the educational methodology chosen for [the student] includes the use of the CI as a necessary part of the FAPE provided…Under these circumstances, the mapping services necessary for the use of [the student's] CI are related services within the meaning of the IDEA." (**Note: This was a precedent-setting case involving audiology services that resulted in changes identified previously in IDEA 2004 Regulations [34CFR §300.34(b); §300.113(b)].)

• ***W.F. v. Flossmoor SD* 38 IDELR 50 (IL 2002).** This case involved parents who unilaterally placed their four-year-old son with a CI in a private oral/aural day school after the LSS offered placement in a classroom that used total communication. Due process was filed for FAPE and retroactive and prospective reimbursement. The IHO ruled that the private school placement should provide FAPE for this student for at least one more year (because of his CI) and rebutted this case as a methodology issue. The parents were awarded reimbursement for both tuition and transportation costs.

• ***Avon Local School District,* 38 IDELR 254 (SEA 2003) (Ohio).**** This case involved parents who initiated due process when their school system refused reimbursement for costs associated with the mapping of their four-year-old daughter's CI. The IHO cited the Stratham School District Decision (above) and ruled in favor of the parents stating, "A properly functioning CI is necessary for [student] to enable her to have access to a FAPE…School District is responsible for the costs of mapping and audiological testing services for [student]." (**Note: Ruling made prior to the adoption of IDEA 2004 Regulations.)

• ***S.H. v. State-Operated School District of the City of Newark*, 336 F.3d 260 (3d Cir. 2003).** This case involved a three-year-old child with a severe to profound hearing impairment placed for two years in an out-of-district public school for children who are deaf and hard of hearing (based on her needs and a lack of FAPE in her home district). The LSS then recommended a placement change to a self-contained program within a mainstream school justified by LRE. The parent requested a due process hearing, and after hearing testimony, the ALJ ruled that the LSS program did not provide FAPE for this child. The LSS appealed, was upheld by Magistrate Judge Opinion, and was adopted by the U.S. District Court. The case was heard by the U.S. Court of Appeals, and the judgment of the District Court in favor of the school was reversed.

• ***[Student] v. Encinitas Union ESD,* 2645 (CA 2003).** This case involved an eight-year-old student with a CI previously diagnosed with Landau-Kleffner syndrome. The initial IEP called for the parents to train the staff in the CI maintenance and to provide FM, but auditory goals were not specified. The parent sought help from a private audiologist and SLP, and then filed due process for reimbursement from the LSS. The IHO ruled in favor of the parents and ordered the development of auditory goals and training of an instructional aide for monitoring the equipment.

• ***Megan C. v ECI LifePath Systems* (ECI Docket No. 001-ECI-0803) (Texas, 2004).**** This case involved the parents of a two-year-old with a CI who initiated due process for reimbursement for mapping expenses, related audiological testing, and associated travel expenses under Part C of IDEA. The IHO cited Stratham and Avon School District Decisions (above) and ordered these costs be covered and included in the IFSP as EI services under IDEA. (**Note: Ruling made prior to the adoption of IDEA 2004 Regulations.)

• ***Missouri Department of Education v. Springfield R–12*, 358 F.3d 992 (8th Cir. 2004).** This case involved a child with vision and hearing deficits initially placed within the local school district. After increasing behavioral problems, residential placement was recommended. The state public residential school denied acceptance, and the parents placed their child in an out-of-state school for the blind and then requested reimbursement for costs. When challenged through a local due process hearing, the panel agreed that the local district should reimburse the parents. The decision was upheld on appeal in two different District Courts.

• ***Shapiro v. Paradise Valley Unified School District No. 69*, 152 F.3d 1159 (9th Cir. 1998); *Shapiro v. Paradise Valley Unified School District No. 69*, 317 F.3d 1072 (9th Cir. 2003); *Shapiro v. Paradise Valley Unified School District No. 69*, 374 F.3d 857 (9th Cir. 2004).** This case involved a seven-year-old deaf student with a CI placed at a private residential oral school for a 3-year study, tuition-free. The parents requested continued placement, and the LEA decided to start a local oral program. The parents objected since the program was not yet in place and filed due process while placing the student back at the private school. The LEA developed an IEP based on the private school data only without parents or current teaching staff present. Several levels of hearings and appeals made differing decisions on reimbursement and FAPE, but ultimately the U.S. District Court of Appeals affirmed and upheld the earlier rulings for the parents, stating FAPE was provided by the private school. The parents were awarded reimbursement for school costs and attorneys' fees.

• ***C.M. v Miami-Dade County School Board* (2003); M.M. ex rel. C.M. v School Board of Miami-Dade County FL 437 F.3[rd] 1085 (11[th] Cir. 2006).** This case involved the parent of a four-year-old child with a CI who sought reimbursement for AVT while the child attended a private school. The ALJ ruled there was no jurisdiction for the parents' claim because the child was never enrolled in the public school, and failure to offer AVT was not a denial of FAPE. The District Court dismissed the case because IDEA does not permit challenges to an IEP on the basis that it is not the most desirable program. The U.S. Court of Appeals upheld the decision for dismissal on the basis of failure to state a viable claim for relief under IDEA.

<u>Cases Filed Under 504 and OCR Rulings:</u>

• **K.S. v. George West ISD (TX 2001).** This case involved a ten-year-old student with bilateral mild conductive loss. The LSS provided an FM and preferential seating under the 504 plan. The parents filed due process for FAPE. The IHO dismissed the case saying the student's impairment did not adversely impact educational performance, thus the student did not qualify for IDEA.

• ***Cave v East Meadow Union Free SD*, IDELR 92 (2[nd] Cir, 2008); *Cave v. East Meadow Union Free School District*, 514 F.3d 240 (2d Cir. 2008); *Cave v. East Meadow Union Free Sch. Dist.*, 47 IDELR 162, 480 F.Supp.2d 610 (E.D. N.Y. 2007), aff'd, 49 IDELR 92, 514 F.3d 240 (2d Cir. 2008).** This case involved a high school student using bilateral CIs with an IEP that provided for a sign language interpreter, TOD support, a notetaker, classroom amplification, closed-caption systems, and preferential seating. The school district denied the request for the student to bring a service dog to school at the recommendation of the Section 504 team (this recommendation was also not on the student's IEP). The parents filed a suit in the U.S. District Court under Section 504 and ADA to force the district to allow the student to bring his service dog to high school classes. The Court determined that the parents did not "exhaust their administrative remedies" under IDEA and dismissed the case for lack of jurisdiction under ADA and Section 504.

• ***J.W. v. Fresno Unified SD*, 50 IDELR 42, (E.D., CA 2008).** This case involved a student with a hearing disability on a 504 Plan. A California District Court agreed with the school district dismissing this case because the student could not seek the legal remedies of the IDEA when he alleged that he had not been provided with a FAPE. Section 504 does not focus on the needs of the student based on his educational performance (i.e. FAPE), but on the access to educational services (i.e. absence of discrimination based on disability).

• ***OCR 2003 Ceres, CA Unified School District*, 39 IDELR 221.** This case involved the parent of a student with identified hearing impairment who contended that the child's classroom teacher did not use an FM device as required by the student's IEP. The IEP called for the teacher to wear the device 90 percent of the instructional time, as a means of communicating with the student. OCR determined that the teacher had experienced intermittent problems maintaining and using the unit. However, evidence confirmed that the school's principal took steps to identify and correct the problem. The principal, along with a resource specialist instructor, met with the teacher to ensure she understood how to use the device and was aware of the requirements of the child's IEP.

<u>Other Cases:</u>

The following cases are recent Supreme Court cases not involving hearing impairment, but whose decisions have implications for all cases brought to due process under IDEA.

• ***Schaffer ex rel. Schaffer v. Vance,* 2 Fed. Appx. 232 (4th Cir. 2001); *Weast v Schaffer ex rel. Schaffer,* 377 F.3d 449 (4th Cir. 2004); *Schaffer ex rel. Schaffer v. Weast,* 546 U.S. 49, and 126 S. Ct. 528 (2005); *Schaffer ex rel. Schaffer v. Weast*, 554 F.3d 470 (4th Cir. 2009).** This case started with an ALJ's decision that parents, who had challenged a local school system's program as not being sufficient to meet their son's needs, were required to prove the program's inadequacy. This case regarding "burden of proof" was appealed, re-appealed, and ultimately heard by the U.S. Supreme Court. The justices held that the party seeking relief bears the burden of proof in states that do not already place the burden of proof on one party or the other (in the latter, they chose to defer to state statute).

• ***Forest Grove SD v. T.A*., 9th Cir. (2008); 557 U.S._ (2009).** This case involved a student initially found not eligible for services under IDEA or 504 from the LSS. The parents placed him into a private school, then sought reimbursement. The IHO ruled in favor of the parents and ordered payment by the LSS. The decision was appealed to the Federal District Court, who set aside the award citing that IDEA 1997 barred reimbursement for students who had never been in special education. The Court of Appeals reversed this decision and remanded to the 9th Circuit, who ruled in favor of the parents. The Supreme Court heard this case to resolve the split in District decisions and ultimately ruled that IDEA 2004 does permit reimbursement under these circumstances. The case was remanded back to the District Court to determine the amount of the award.

Summary of Case Law

The preceding examples do not provide an exhaustive list of cases involving students who are deaf and hard of hearing, but they are considered representative of those due process cases filed over the past decade. It is apparent that audiology typically is not the primary issue, with the exception of the cases dealing with mapping and maintenance of a cochlear implant. More often cases deal with placement and services providing a free appropriate public education, defined, ironically, by the 1982 U.S. Supreme Court decision in *Board of Education v. Rowley*, regarding a student with a hearing impairment. The majority of the cases included above concern students who use cochlear implants, a trend that has increased during the past decade.

Regardless of the issue, however, these cases remind us that the IEP is the key for clarifying needs that define FAPE for individual students. With options for mediation and a mandatory resolution session that offer opportunities to resolve disputes prior to due process hearings under IDEA 2004 [§1415(f)(1)(B)], hopefully the number of due process hearings will decrease in future decades. Hopefully more students will receive appropriate services in a timely manner *without* court intervention.

Readers are referred to resources listed at the end of this article, as well as sites such as www.Findlaw.com, www.Versuslaw.com, and the *Individuals with Disabilities Education Law Reporter (IDELR)* for more information on the cases summarized above and other due process proceedings of interest.

The Evolving Role of the Educational Audiologist

Changing demographic characteristics of students with hearing loss in the last decade are having a significant impact on the role of educational audiologists. These trends include fewer students with hearing loss being educated under IDEA, more students with hearing loss on 504 Plans, students in rural areas with hearing loss not having consistent support from a teacher of the deaf, students with listening problems benefitting from accommodations, increasing hearing technology options, and more reliance on hearing instruments and hearing assistance technology. Educational audiologists are in a position to support students in all of these situations and, increasingly, they should be the "go to" professional to assure access accommodations to support classroom listening and to help monitor developmental and educational benchmarks. As special education policy becomes more integrated with general education policy, so must services.

Internet Resources

- **www.access-board.gov/acoustic** - Access Board website with progress report on state and local action, links to ANSI/ASA standard, technical assistance documents, and other resources.
- **www.ada.gov** -U.S. Department of Justice ADA home page.
- **www.agbell.org/** -Links to selected due process decisions and case proceedings (click on topic under Advocacy section).
- **www.ceasd.org/position_papers.shtml** -Conference of Educational Administrators of Schools and Programs for the Deaf website with links to position papers related to impact of IDEA and NCLB on students who are D/HH.
- **http://clerccenter.gallaudet.edu/Clerc_Center/Information_and_Resources/Info_to_Go/Laws.html** -Information on IDEA, NCLB, Rehabilitation Act of 1973, and ADA pertinent to D/HH.
- **www.dredf.org** -Website for Disability Rights Education and Defense Fund, Inc. with information and multiple links relating to IDEA, ADA, and Section 504.
- **www.ed.gov/about/offices/list/ocr/504faq.html** -FAQ document revised to clarify Section 504 requirements for elementary and secondary students and incorporate relevant information on ADAAA of 2008.
- **www.ed.gov/nclb/landing.jhtml** -Information site for No Child Left Behind with links to legislation, state information, and related resources.
- **www.edlawrc.com/special_education.htm** -Education Law Resource Center site with multiple links covering and comparing IDEA, IDEIA, and Section 504.
- **www.eduref.org/cgi-bin/print.cgi/Resources/Reference/Law/Education_Law.html** -The Educator's Reference Desk with multiple links to internet sites and organizations dealing with education law.
- **www.handsandvoices.org** -Web home for Hands and Voices organization with links to legal information and articles covering services to children who are deaf and hard of hearing.
- **http://idea.ed.gov/** -Dept. of Education website that provides information on IDEA 2004 legislation and implementing regulations for Part B. Includes links to IDEA topic briefs, as well as other news information and resources for technical assistance.
- **www.letthemhear.org/articles** -IDEA 2004 special education web resource center for parents and professionals (need to register to access full articles & selected case law).
- **www.listen-up.org** -Site specific to hearing disabilities; link to "Your rights" provides archived information on legal decisions and policy letters.
- **www.nad.org/issues/education/k-12** -Access to IDEA, Section 504 & NCLB information, Bill of Rights for D/HH Children, NAD Position Statements, as well as links to selected case law.
- **www.nasdse.org** -Resources from the National Association of State Directors of Special Education, including special education, deaf education and response to intervention.
- **www.nectac.org/idea/idea.asp#regs** -National Early Childhood Technical Assistance Center website with information on current IDEA legislative and regulatory activity and links to OSEP policy letters and performance data.
- **www.wrightslaw.com** -Excellent site maintained by attorney parents with multiple links to legal information and educational case law for parents with children with disabilities (majority of legal information concerns children with autism, but relevant legal information for any disability category).
- **www.wrightslaw.com/info/sec504.summ.rights.htm** -Overview of Section 504 & ADA with comparisons to IDEA 2004; links to information brief, "Section 504, ADA, High Stakes Testing, and Statewide Assessments."

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Reliability of the Self-Assessment of Communication-Adolescent (SAC-A)

Kelli Wright, Au.D.
Northeast Ohio Au.D. Consortium
Akron, Ohio

Kris English, Ph.D.
University of Akron
Akron, Ohio

Judy Elkayam, Au.D.
Low Incidence Cooperative Agreement
Mt. Prospect, Illinois

Self-assessments give audiologists the opportunity to discuss comprehensive rehabilitation issues, including perceived impact of hearing loss on communication and social-emotional well-being. Until recently, few self-assessments existed for use with adolescents who are deaf or hard-of-hearing. In 2003, Elkayam and English modified a pre-existing questionnaire to create the Self Assessment of Communication-Adolescent (SAC-A), a 12-item survey with three subcategories: Hearing & Understanding, Feelings about Communication, and Other People. For a questionnaire to be clinically useful, it must be both psychometrically valid and reliable. Face validity for the SAC-A is high, as rated by a panel of pediatric audiology experts. The purpose of the present study was to evaluate reliability of the SAC-A. Twenty students between the ages of 11 and 19 years with educationally-significant hearing loss completed the SAC-A on two occasions. Pearson product-moment correlation for test-retest reliability was adequate (.76) for the total SAC-A. Internal consistency reliability, as measured by Cronbach's alpha, was determined to be acceptable (.85) for the first test session. Because correlations for test-retest and internal consistency were both satisfactory, the SAC-A can be considered a psychometrically reliable measure when used as a discussion tool for hearing disability and handicap in adolescents. Continued research is needed to determine if the SAC-A may be used as a measure of treatment efficacy for this population.

Introduction

By nature of professional training, audiologists are uniquely qualified to provide counseling regarding hearing loss (Clark & English, 2004). This responsibility is twofold. Both informational and personal adjustment counseling are necessary for comprehensive care. Informational counseling focuses on facts and content, while personal adjustment counseling encompasses psychological, social, and emotional challenges. Personal adjustment topics are sensitive, and many audiologists feel inadequate addressing them (Clark & English, 2004).

Self-assessments which examine issues of disability, handicap, or both can be used to initiate personal adjustment conversations. Questionnaires used as counseling tools provide a relatively nonintrusive means of stimulating conversation (Elkayam & English, 2003). In this format, patients are able to express worries and difficulties safely (Kopun & Stelmachowicz, 1998; Mendel, 1997). By addressing the emotional aspects of hearing loss, personal adjustment counseling can enhance patient quality of life and adjustment to hearing impairment (Clark, 1994; Mendel, 1997).

At present, almost all hearing disability/handicap self-assessments are designed for adults, e.g., Hearing Handicap Inventory-Adults (HHIA; Newman, Weinstein, Jacobson, & Hug, 1990), the Self Assessment of Communication (SAC; Schow & Nerbonne, 1982), and the Abbreviated Profile of Hearing Aid Benefit (APHAB; Cox & Alexander, 1995). Surveys regarding children's hearing disability/handicap also exist; however, they were either designed primarily for younger children (e.g., The Listening Inventory for Education [L.I.F.E.; Anderson & Smaldino, 1998]; Children's Peer Relationship Scale [English, 2002]) or they collect information from adults rather than from the child (e.g., Children's Auditory Performance Scale [CHAPS; Smoski, Brunt, & Tannahill, 1998]; Screening Instrument for Targeting Educational Risk [S.I.F.T.E.R.; Anderson & Matkin, 1989]).

Because adolescents experience life with hearing impairment differently from adults and children, they too could benefit from a unique disability/handicap questionnaire. To address this need, Elkayam and English (2003) designed the Self-Assessment of Communication –Adolescent (SAC-A). This short 12-item questionnaire evaluates three subcategories: Hearing & Understanding, Feelings about Communication, and Other People. Personal adjustment counseling can be facilitated through discussing a teen's responses to the SAC-A.

Hearing Disability and Handicap in Adolescence

For teenagers, the communicative challenges of hearing loss and resultant emotional and social sequelae can be especially challenging (Crowell, Hanenburg & Gilbertson, 2009). Peer rejection and low self-esteem are pervasive issues for students with hearing loss (Cappelli, Daniels, Duriex-Smith, McGrath, & Neuss, 1995). In fact, poor self-concept among hearing impaired youth seems independent of the degree of hearing impairment. Bess, Dodd-Murphy, and Parker (1998) analyzed the academic and social-emotional functioning of 1200 children with mild hearing loss. Despite their mild hearing thresholds, these children exhibited more self-esteem troubles than their peers.

Social interactions can be limited for teens with hearing impairment due to delay in communication skills and ability to understand others' feelings and perceptions (Clark & English, 2004). In general, youth with hearing loss describe themselves as having more difficulty making friends (Loeb & Sarigiani, 1986) and integrating into a social mainstream (Israelite, Ower, & Goldstein, 2002). Many do not have opportunities to interact with others like themselves, which can lead to feelings of inadequacy and detachment (Fusick, 2008). Social isolation can be even more intense for mainstreamed children with profound hearing loss who use American Sign Language (ASL; Mathos, 2005). Development of self-identity (Israelite et al., 2002; Ladd, Munson, & Miller, 1984; Stinson & Liu, 1999) and overall happiness (Kent & Smith, 2006; Risdale & Thompson, 2002) are related to the quality of peer interactions for students with hearing loss.

Due to the varied psychosocial and emotional difficulties associated with being deaf or hard of hearing, teen life satisfaction can be adversely affected. A 2004 study by Gilman, Easterbrooks, and Frey compared life satisfaction of 88 hearing impaired youth in residential and day schools to a control group of 71 normally hearing peers. Using the Multidimensional Students' Life Satisfaction Scale (MSLSS; Huebner, 1994), they found that youth with hearing impairment expressed lower life satisfaction than their peers with normal hearing. Friendship satisfaction was influenced the most by hearing status, but many domains were affected (Global, Family, and Living Environments). A recent pilot study investigated the health related quality of life (HRQOL) for children and adolescents with unilateral hearing loss, comparing their self-perceptions with those of parents, peers with bilateral hearing loss, and peers with normal hearing (Borton, Mauze, & Lieu, 2010). With respect to social-emotional well being, both similarities and differences existed between the adolescents' perceptions and those of their parents and peers. Youths' beliefs regarding personal quality of life changed over time and across activities, sometimes varying considerably. Evidence that hearing loss impact is neither static nor predictable should strengthen the desire of audiologists to explore each adolescent's perception of disability and handicap through self-assessments and dialogue.

Adolescents can be challenging to counsel due to their unique developmental characteristics and needs. Teens are usually more apprehensive then adults to discuss their communication problems (Borton, Mauze, & Lieu, 2010; Elkayam & English, 1999). Despite the inherent road blocks, personal adjustment counseling is critical at the adolescent stage. Discussing psychosocial issues can allow a teen to capitalize on self-reflection, hypothetical thinking, and increased problem-solving skills (Petersen & Leffert, 1995). Counseling can ultimately lead to positive changes in behavior or perception (Lukomski, 2007).

Psychometric Evaluation of the SAC-A

The Self-Assessment of Communication-Adolescent is an ideal tool for discussing hearing disability and handicap with teens. For the SAC-A to be considered clinically useful, it must be found to have high psychometric validity and reliability (Nunnally, 1978). Validity determines whether a questionnaire assesses what it intends to measure. The other component of psychometric accuracy, reliability, is the degree of consistency between two or more observations of the same event.

When rated by a panel of pediatric experts (one educational audiologist, one school social worker, and one school administrator/teacher of students with hearing loss), the SAC-A was found to have high face validity (Elkayam & English, 2003). Each expert responded to a three-item questionnaire regarding the validity of SAC-A items. Face validity is described as how well a test appears to measure the domain in which it intends (Carmines & Zeller, 1979). Because the SAC-A was rated as having high face validity, audiologists can be confident that results assess the realms of hearing & understanding, feelings about communication, and other people.

Measurement of reliability is the next element of psychometric evaluation for the SAC-A. Reliability correlations demonstrate how stable responses remain each time questions are given under the same conditions (Carmines & Zeller, 1979). For a self-assessment to measure benefit or assess progress over time, it must have good reliability (Demorest & Walden, 1984).

Two of the most common reliability measures used for health-related questionnaires are test-retest reliability and internal consistency (Demorest & Walden, 1984). Test-retest reliability indicates how well patients maintain their relative score from one test session to another under the same conditions. The amount of time between test and retest must be large enough to minimize the effects of memory on the second administration (Nunnally, 1978). Pearson-product moment correlation (r) is used to calculate test-retest reliability.

As mentioned above, the second reliability measure used for self-assessments is internal consistency. Internal consistency is an estimate of how well items in a group are interrelated (Nunnally, 1978). Cronbach's alpha (α) is calculated for internal consistency. High alpha values provide justification for generalizing an observed score to others in a similar set of items (Demorest & Walden, 1984).

The present study (approved by the Institutional Review Board at the University of Akron) was designed to measure the test-retest reliability and internal consistency of the SAC-A. High reliability and consistency results would provide credibility to this instrument and help to fill the void of self-assessment measures specific to this population.

Method

Participants

Twenty individuals (14 females, 6 males) ranging in age from 11 to 19 years old (mean=16.69 years) participated. Each adolescent had an educationally-significant hearing loss, as defined by the Ohio Department of Education (2008), and received services from educational audiologists.

Participants were recruited from several parts of the United States: 11 from Ohio, 5 from Minnesota, 2 from Illinois, and 2 from Washington (see "Acknowledgements" for names of data collectors). Teens were informed orally and in writing that their participation was voluntary and they could refuse continued participation at any time, per National Institutes on Deafness and Other Communication Disorders (1999) guidelines. Parental consents and participant assents were collected per IRB protocols. All students remained in the study for the entire duration.

Instrument

The Self-Assessment of Communication-Adolescent (see Appendix) is a 12-item questionnaire that explores an adolescent's hearing disability and handicap experience (Elkayam & English, 2003). It was modified from an existing tool for adults (Schow & Nerbonne, 1982). The SAC-A is composed of three domains: Hearing & Understanding, Feelings about Communication, and Other People. For each question, teens are asked to rate the frequency of occurrence for specific behaviors or feelings along a five-point Likert scale ranging from "almost never" (one point) to "almost always" (five points). Higher score values indicate greater perceived disability/handicap.

Procedures

Teens with hearing impairment received a recruitment handout from their educational audiologist inviting them to participate in the study. An unknown percentage of students who were approached regarding the study decided not to participate. After parental consent and participant assent forms were signed, each participant completed the SAC-A using a paper-and-pencil method on two separate occasions. All twenty participants completed the SAC-A in its entirety for both test administrations. The average interval between the first and second session was 19 days (range = 14 to 28 days). Nunnally (1978) suggests that allowing two weeks between test and retest allow for short-term fluctuations in ability and personality to be established.

During both instances, the questionnaire was given in the student's preferred modality (read by the student or signed in ASL by an interpreter). The chosen modality was consistent between test and retest sessions. Participants were given $10 gift cards after they completed the retest administration.

Analysis

Statistics were compiled separately for the total SAC-A and its three subcategories. Descriptive values (mean, standard deviation, and range) were analyzed for both test sessions. Test-retest reliability was calculated using Pearson's product moment correlation coefficient (r). Internal consistency reliability was also evaluated for both test sessions using Cronbach's alpha (α).

Results

Mean, standard deviation, and range for both test sessions are shown in Table 1. The mean scores for total SAC-A and each subcategory were closely related between the two assessments. The variability of responses, as shown by standard deviation, was also similar between test and retest.

Table 2 displays the Pearson product moment correlations (r) for total SAC-A and the three subcategories. Nunnally (1978)

Table 1. Mean, Standard Deviation, and Range Associated with Test-Retest Assessment of the Total SAC-A and the Three Subcategories (N=20)

		1st SAC-A	2nd SAC-A
Total SAC-A	Mean	28.9	28.1
	SD	8.6	8.2
	Range	15-45	14-44
Hearing & Understanding at Different Times	Mean	16.6	15.2
	SD	4.5	4.2
	Range	9-23	8-23
Feelings about Communication	Mean	6.2	6.5
	SD	3	3.5
	Range	3-12	3-15
Other People	Mean	6.3	6.2
	SD	2.2	2.5
	Range	3-11	3-11

Table 2. Pearson Product Moment Correlation (r) Associated with Test-Retest Assessment of the Total SAC-A and the Three Subcategories (N=20)

	r
Total SAC-A	0.76
Hearing & Understanding at Different Times	0.70
Feelings about Communication	0.68
Other People	0.83

proposed a correlation coefficient of 0.7 or higher to be considered modest reliability. Using this criterion, the test-retest reliability for total SAC-A was adequate (0.76). Levels of correlation for the subcategories ranged from 0.68 - 0.83.

Cronbach's alpha values are displayed in Table 3 for the first and second test sessions. Alpha values of 0.85 or higher are considered satisfactory in health-related fields for outcome measures (Hyde, 2000). The scale yielded adequate internal consistency with Cronbach alpha values of 0.85 for the first test session and 0.81 for the second.

Discussion

The purpose of the present study was to determine the reliability of the Self Assessment of Communication-Adolescent using a paper-and-pencil method. Degree of correlation for test-retest was adequate for the total SAC-A and its three subcategories.

This finding suggests SAC-A responses are generally consistent between test periods. Internal consistency was high (α= 0.85) for the first test administration. This indicates how well items on the SAC-A are interrelated. The second test had a slightly below adequate alpha value of 0.81. Because test-retest reliability and internal consistency were both sufficient, the SAC-A is considered a reliable measure for personal adjustment counseling of adolescents with hearing loss when used as a qualitative catalyst for dialogue.

There are several possible reasons for the variance in internal consistency between the two test sessions (0.85 & 0.81). Studies of reliability have several opportunities for error. Mood, health, and concentration of the participant can all be factors (Cox & Gilmore, 1990). These variables may be especially important to consider when working with adolescents, given their immature cognitive processing of information and emotion (Weinberger, Elvevag, & Giedd, 2005).

Table 3. Cronbach's Alpha (α) Associated with Test-Retest Assessment of the SAC-A and the Three Subcategories (N=20)

	1st SAC-A α	2nd SAC-A α
Total SAC-A	0.85	0.81
Hearing & Understanding at Different Times	0.74	0.62
Feelings about Communication	0.73	0.81
Other People	0.44	0.74

The sample size for the present investigation was small. This is typical for studies that involve teens who are hearing impaired. Because of the limited number of participants, it was not possible to determine if degree of hearing loss, gender, age, or hearing aid style was a significant factor in the responses given.

Future Studies

Self-assessments are often used as a measurement of treatment efficacy. For the SAC-A to be used this way, further psychometric evaluation is necessary. Outcome measures should have a test-retest correlation of 0.8 or better (Nunnally, 1978). This study found a reliability level close to this threshold, but not quite high enough (0.76 for the total SAC-A). Another analysis, standard error of measurement, should also be calculated for outcome measures (Nunnally, 1978). Standard error of measurement must be low so that changes due to treatment can be accurately documented.

Elkayam and English (2003) suggest that completing the SAC-A in a face-to-face format allows for greater flexibility during the interview. Orally discussing SAC-A questions is also likely to avoid misunderstandings due to poor reading comprehension. When responses are used only for dialogue, rather than treatment efficacy, the need for high reliability is not as pressing. Discussing differences between two SAC-A test sessions allows clinicians to spur conversation and personal adjustment. This opportunity can be used to discover why a teen has varied his or her response. Despite the lesser importance for reliability in dialogue format, it would be valuable to determine the SAC-A psychometric reliability when completed face-to-face.

Psychometric reliability and validity should also be measured for the SAC-A companion questionnaire, the Significant Other Assessment of Communication-Adolescent (SOAC-A) (Elkayam & English, 2003). This assessment allows a friend to answer 12 questions, which mirror those on the SAC-A. The friend is asked to rate his impression of the hearing impaired teen's communication skills, social and emotional well-being. By comparing these two surveys with the patient, clinicians can stimulate discussion and help facilitate the personal adjustment process (Elkayam & English, 2003).

Another suggestion for further study is to compare SAC-A responses for different degrees of hearing loss, gender, or age. Although each teen is unique, small sample sizes may impact the statistical significance of measured differences or make it problematic to account for all variables. A large scale study involving the SAC-A would be very valuable for the field of audiology to increase accuracy of the psychometric data, identify characteristics that may influence adolescent approaches to hearing loss management, and expand audiologists' knowledge about the attitudes and beliefs of adolescents who are hard-of-hearing or deaf.

In conclusion, the acceptable test-retest correlation and adequate internal consistency found in this study attest to the psychometric reliability of the SAC-A. These findings support the use of the SAC-A as a discussion tool for hearing disability and handicap in adolescents. Continued research is necessary if the assessment is to be used as an outcome measure for the adolescent population.

Appendix

Questions from the
SELF-ASSESSMENT OF COMMUNICATION-- ADOLESCENT (SAC-A)
1 = almost never 2 = occasionally 3 = about half the time 4 = frequently 5 = almost always

Please select the appropriate number to answer the following questions:	
1)	Do you experience communication difficulties in situations when speaking with only one other person? (for example, when talking to a teacher or classmate; a clerk at a store; a server at a restaurant; a co-worker or your boss; someone providing information/directions, etc.)
2)	Do you experience communication difficulties when talking with a small group of people? (for example, during holidays or other family gatherings; in language or science labs or in small discussions; while driving or riding in a car; during extracurricular activities like sports, clubs, etc.)
3)	Do you experience communication difficulties when listening to someone speak to a large group? (for example, during class discussions or school assemblies; when taking notes in school; in a house of worship, etc.)
4)	Do you experience communication difficulties while participating in various types of entertainment? (for example, movies, TV, radio/CD's, musical entertainment, plays, shopping, talking with friends, etc.)
5)	Do you experience communication difficulties in situations when other people could also have trouble hearing? (for example, at a noisy party; when there is background noise/music; when someone whispers or is soft-spoken; when someone talks while moving around; from a great distance or outdoors; in the hallways at school before, after, or in between classes; in the cafeteria or gym, etc)
6)	Do you experience communication difficulties when using or listening to various communication devices? (for example, telephone, telephone ringing; doorbell; radio; PA system at school' alarms; computer, etc)
7)	Does your hearing loss interfere with your social life?
8)	Does any problem or difficulty with your hearing loss upset you?
9)	Does the hearing loss keep you from doing things that might be fun?
10)	Do other people ever notice that you have a hearing loss?
11)	Do you feel left out of conversations or do other people become frustrated when talking to you because of hearing problems?
12)	Do people get a wrong impression when they first meet you because of hearing problems?

*Modified, with permission, from *Self Assessment of Communication* (Schow and Nerbonne, 1982).

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Speech Perception in Noise Measures for Children: A Critical Review and Case Studies

Erin C. Schafer, Ph.D.
University of North Texas
Denton, Texas

Children who have hearing loss or other auditory disorders are at risk for educational difficulties, especially when the detrimental effects of an impaired auditory system are combined with poor classroom acoustics. Classroom observations, teacher questionnaires, and speech perception measures in noise may be used to identify children who are at-risk and to evaluate the effects of classroom noise on behavior and performance. Valid and reliable quantification of listening difficulty will provide evidence of a child's need for instructional and communication accommodations, special education support, and hearing assistance technology. Currently, however, no cumulative peer-reviewed publications that analyze speech perception tests in noise for children exist. For this reason, the primary goal of this paper is to provide a critical review of speech perception measures in noise which are designed for young and school-aged children. This review will provide information regarding the sensitivity, validity, and reliability of available measures, as well as discuss advantages and disadvantages of each test for examining pediatric speech perception in noise. In addition, three case studies will demonstrate the clinical utility of two tests for measuring speech perception in noise in a classroom setting.

Introduction

One of the greatest challenges for audiologists is identifying and addressing the deleterious effects of classroom noise and reverberation on speech perception of children who have hearing loss and other auditory disorders (Bradley & Sato, 2008; Jamieson, Kranjc, Yu, & Hodgetts, 2004). Classrooms with poor acoustics are common (Knecht, Nelson, Whitelaw, & Feth, 2002) and rarely meet the guidelines set forth by the American Speech-Language-Hearing Association (2005) or American National Standards Institute (2002) for unoccupied noise levels, reverberation, or signal-to-noise ratios (SNR). Performance decrements in noisy classrooms are even more concerning for young children (i.e., < 5 years) who show significantly worse speech perception in noise than older children (Jamieson et al., 2004). In addition to classroom observations and teacher questionnaires, audiologists may use speech perception in noise tests to identify young and school-aged children who are at high risk for educational difficulties in noisy classrooms. As a result, the educational audiologist must have access to efficient, practical, portable, and sensitive speech-in-noise measures to quantify the behavioral effects of classroom noise. Valid and reliable quantification of listening difficulty often provides evidence of a child's need for instructional and communication accommodations, special education support, and hearing assistance technology (HAT) to enhance the SNR at the child's ear. Furthermore, sensitive speech-in-noise measures provide evidence to document benefits from HAT after it is fit on a child (American Academy of Audiology, 2008).

According to Elkins (1984) and Mendel and Danhauer (1997), sensitive speech perception tests are defined as those having the following characteristics: (1) a clear purpose, (2) identification of individuals for whom the test is designed, (3) evidence of validity, (4) confirmation of reliability through reports of typical variance and equivalent lists, and (5) defined procedures for administration, scoring, and interpretation. The validity and reliability of a test are particularly important because these data provide evidence that the test was constructed carefully and appropriately. Because most speech perception tests already typically address face validity (i.e., appears to be a good measure) and content validity (i.e., has appropriate content/stimuli), the most pertinent forms of validity to examine for this study include construct, convergent, discriminant, concurrent, and predictive validity. Construct validity confirms that a test measures what it is intended to measure. It may be examined through analyses of convergent validity (i.e., correlated to similar measures) or discriminant validity (i.e., not correlated to dissimilar measures). Concurrent validity examines whether a test will show significant differences in performance between groups of listeners that should be different, such as normal hearing and hearing impaired (Trochim, 2005). Although the aforementioned definition will be used for this critical review, concurrent validity may also be defined similarly to convergent validity, where results on the speech perception measure are compared to results on a similar assessment within the same testing period. Finally, predictive validity examines the relatedness of the test to a similar measure at a later time. For example, at a later testing period, the examiners could determine if the results on the speech perception test correlate to listening abilities in noise as reported on a subjective questionnaire.

Reliability, on the other hand, relates primarily to the repeatability of test results, equivalency among test items, and equivalency of lists in the test. Assessments of the latter two types of reliability are particularly important because items on a test, and lists within a test, must be equally intelligible (i.e., understandable) in background noise to allow for similar scores across lists or listening conditions (i.e., with and without HAT). In other words, the test must have inter-item and inter-list equivalence to have good test-retest reliability. Equal intelligibility in noise across test items and lists may not occur by simply equating for intensity or equal average root-mean-square (RMS) amplitude across the stimuli on a test (BKB-SIN, 2005; Nilsson, Soli, & Sullivan, 1994). As a result, most pediatric speech perception tests that are designed for use in quiet conditions do not have equivalent word lists when used with background noise. For example, the word lists for the Word Intelligibility by Picture Identification (WIPI; Ross & Lerman, 1970; Ross, Lerman, & Cienkowski, 2004) are not equivalent in broadband noise (Chermak, Wagner, & Bendel, 1988). Similarly, researchers found lack of list equivalence in noise for the Northwestern University-Children's Perception of Speech Test (NU-CHIPS; Chermak, Pederson, & Bendel, 1984; Elliott & Katz, 1980). Therefore, these tests, or any test that is not designed for use in noise, should not be used for assessing speech perception in noise as they may not allow for reliable comparisons of performance in various test conditions (such as aided and unaided) when using different lists.

Given the detrimental effects of noise on children's performance, the importance of quantifying speech perception in noise is clear. As a result, selection of sensitive speech perception tests is paramount for obtaining valid and reliable data. However, at this time, there are no cumulative peer-reviewed publications that critically analyze the construction and clinical utility of speech perception tests in noise for children. Therefore, the primary goal of this paper is to provide a critical review of speech perception measures in noise specifically designed for young and school-aged children. This review will present information regarding the sensitivity, validity, and reliability of available measures, as well as advantages and disadvantages of each test for examining pediatric speech perception in noise. Additionally, the clinical utility of two of the most sensitive measures for speech perception testing in the schools will be shown through case studies of three children who were assessed with and without frequency modulated (FM) systems.

Method

The speech perception tests in noise included in the critical review were identified through a comprehensive search of the literature using electronic databases (e.g., PubMed, ERIC) and a manual search of references or tests published from January 1970 through March 2010. Speech perception tests had to meet the following three criteria for inclusion: (1) design considerations for testing in noise, (2) stimuli with vocabulary levels appropriate

Table 1. Summary of Speech-Perception Tests in Noise for Children

Test (Acronym)	Ages	Test Description	Advantages	Disadvantages
Bamford-Kowal-Bench Speech in Noise test (BKB-SIN)	5+ years	Modified-adaptive test; Measures SNR loss for sentences in multi-talker babble	High validity, reliability, & sensitivity; may be used with any population; simple administration & scoring; portable & may be used in the classroom; inexpensive; on CD	May have ceiling/floor effects at standard SNRs; only appropriate for school-aged children
Hearing in Noise Test for Children (HINT-C)	6-12 years	Adaptive test; measures 50% correct threshold for sentences in speech-shaped noise	High validity, reliability, & sensitivity; computerized; may be used with any population; multiple languages; simple administration, scoring & interpretation	Expensive; only appropriate for school-aged children; speech-shaped noise may not be as challenging as other noises
Listening in Spatialized Noise-Sentences test (LiSN-S)	6-11 years	Adaptive test; measures sentence-in-noise thresholds for varying noise locations & types of noise	High validity, reliability, & sensitivity; computerized; simple administration, scoring, & interpretation	Only designed for use with suspected APD; may only present under headphones; expensive
Pediatric Speech Intelligibility test (PSI)	3-6 years	Measures percent-correct performance for words and sentences in single-talker competing noise	High validity & reliability, may be used with young children; simple scoring and interpretation; inexpensive; on CD	Complicated administration; may have ceiling/floor effects; single-talker noise may not be challenging; only for young children

Note. APD=auditory processing disorders; CD= compact disc; SNR=signal-to-noise ratio loss for children less than 12 years of age, and (3) availability for purchase. Once a test met the inclusion criteria, all publications related to the construction, validity, and reliability of that same test were identified. Each test was analyzed for its sensitivity using the recommendations by Elkins (1984) and Mendel and Danhauer (1997). Using these criteria, the following areas were addressed for each speech perception test in noise: (1) purpose and population, (2) validity and reliability, (3) administration, scoring, and interpretation, and (4) advantages and disadvantages of using the test in schools. In addition, three case studies were presented where sensitive measures were used to evaluate speech perception performance and potential benefit from FM systems.

Results

Commercially Available Speech-in-Noise Tests

As shown in Table 1, the literature review and manual search resulted in the identification of four speech perception tests in noise, including the Bamford-Kowal-Bench Speech-in-Noise (BKB-SIN) test, Hearing in Noise Test for Children (HINT-C), Listening and Spatialized Noise-Sentences test (LiSN-S), and the Pediatric Speech Intelligibility (PSI) test. Critical reviews for each of these tests will be provided in the following sections. In addition, brief reviews will be presented for three tests that were used in research studies, but are not commercially available for purchase. These tests include the Adaptive Spondee Test (AdSpon), Children's Realistic Index of Speech Perception (CRISP), and the Phrases in Noise Test (PINT).

Bamford-Kowal-Bench Speech-in-Noise Test (BKB-SIN)

Purpose and population. The purpose of the BKB-SIN test (BKB-SIN, 2005) is to determine the listener's signal-to-noise ration (SNR) loss, which is the increase in SNR that is required by a listener to obtain 50% of key words correct as compared to normative data from normal-hearing listeners of the same age (i.e., 5 to 6 years). In other words, using a formula to calculate SNR loss, this test determines the dB difference between a child's SNR for a 50% (SNR 50) correct level and the average SNR of children within a similar age range. The test consists of 18 list pairs (e.g., lists 1a and 1b are to be used together) of 10 sentences each spoken by a male speaker and in the presence of multi-talker babble. The stimuli are presented at pre-recorded SNRs that decrease 3-dB steps from a +21 to a -6 dB SNR. The BKB-SIN test may also be used to evaluate aided benefit, assess performance with directional microphones, and screen for auditory processing disorders. It was designed for children (≥ 5 years) or adults and for populations having normal-hearing, hearing loss (unaided), hearing aids, cochlear implants, and other auditory disorders (e.g., auditory processing deficits).

Validity and reliability. The sentences were determined originally from language samples of young children with hearing loss and are at a vocabulary level of a typical first-grade child (Bench & Bamford, 1979; Bench, Kowal & Bamford, 1979). Although construct validity was not addressed in the BKB-SIN user manual (BKB-SIN, 2005), it was assessed adequately in several publications. For example, convergent validity is shown in a study by Wilson, McArdle, and Smith (2007) who reported that scores on the BKB-SIN are within one standard deviation of scores on the HINT for adults with normal hearing and hearing loss. Discriminant validity was addressed, somewhat, in two studies that evaluated noise tolerance with a measure known as acceptable noise levels (ANL) and speech perception in noise using the BKB-SIN (Donaldson et al., 2009; Schafer & Wolfe, 2008). Both studies confirm that noise tolerance is not significantly correlated to speech perception on the BKB-SIN. These findings are also similar to what is reported for users of hearing aids (Nabelek, Freyaldenhoven, Tampas, Burchfield, & Muenchen, 2006). Concurrent validity is addressed in the user manual (BKB-SIN, 2005) by identifying significant performance differences between adults with normal hearing and cochlear implants, as well as among children with normal hearing in three age groups: 5 to 6 years, 7 to 10 years, and 11 to 14 years. Predictive validity is assessed in the Donaldson et al (2009) and Schafer and Wolfe (2008) studies with statistically significant correlations (i.e., correlation coefficients of 0.60 and 0.46, respectively) between performance on the BKB-SIN and subjective self-assessment questionnaires that measured ease of communication, speech recognition in reverberation, and social and emotional hearing handicap.

Test-retest reliability, as provided in the user manual (BKB-SIN, 2005) was high according to the results of testing 48 children with high levels of education and 44 children from lower-income families. In addition, the authors provided the estimated reliability based on the number of list pairs given. Because root-mean-square (RMS) equivalence of the sentences did not ensure equal intelligibility across the sentences, the creators grouped sentences with similar thresholds and grouped lists into pairs to ensure equivalent difficulty. The final BKB-SIN test provides equivalent list pairs that, according to normative data, do not deviate by more than 1 dB from the grand-average performance across lists.

Administration, scoring, and interpretation. Overall, the administration, scoring, and interpretation are presented clearly in the BKB-SIN manual (BKB-SIN, 2005). The procedures for administration of the test are the same as those used to collect the normative data. The scoring forms are easy to interpret, and the manual provides a chart to calculate the child's SNR loss (i.e., dB difference from children with normal-hearing). Although interpretation for children is not as clear as it is for adults, the creators suggest that SNR losses of children should be evaluated on a case-by-case basis along with supporting data, such as speech, language, and academic skills and learning environment.

Advantages and disadvantages. The BKB-SIN is a sensitive test that has data to support its validity and reliability in each of the critical areas. Because it is recorded on compact disc (CD), it may easily be used in the sound booth or for testing in the classroom using a portable CD player with detachable loudspeakers. There are two CDs provided from Etymotic Research with the stimuli on the same channel (Standard CD) or with the stimuli on separate channels (Split Track CD), which allows for testing with HAT and directional microphones on hearing aids. Another advantage of this test is the use of multi-talker babble, which is more difficult and realistic than most other types of background noise (Sperry, Wiley, & Chial, 1997). Overall, this is a well-constructed, flexible test for use with children.

One minor disadvantage of the BKB-SIN is that the listener could hit ceiling at the poorest SNR on the CD (-6 dB) or floor at the best SNR (+21 dB). However, the manual describes how the SNR can be adjusted to avoid this issue. This may be particularly relevant when testing the benefit of HAT, which can improve performance from the no-FM-system condition by 20 dB (Schafer & Thibodeau, 2006). In addition, the BKB-SIN may only be used for children who have receptive vocabulary levels of a typical five-year-old child, which further limits the appropriateness of this test to school-aged children.

Hearing in Noise Test for Children (HINT-C)

Purpose and population. The purpose of the HINT-C is to assess speech intelligibility and functional hearing of children, ages 6 to 12 years, in quiet and in speech-shaped noise, using an adaptive-testing paradigm to obtain a threshold at the 50% correct level. The HINT-C was developed using a subset of age-appropriate sentences in the HINT (Nilsson et al., 1994) that were separated into ten, ten-sentence lists with similar phonemic content (Nilsson, Soli, & Gelnett, 1996). Children are asked to correctly repeat the entire sentence. When testing in noise, the speech is fixed, typically at 65 dBA, and presented from a loudspeaker at 0 degrees azimuth. The noise, which is matched to the long-term-average spectrum of the sentences, is varied adaptively to find the child's threshold. Noise may be presented from the loudspeakers located at the front (0 degrees) or sides (90 or 270 degrees) of the child. The test was designed for use with any listener including those with normal hearing and hearing loss. The test manufacturer (Bio-Logic) also clearly states that the test may be used to asses speech intelligibility for children who are trying to learn in noisy classrooms, especially those who are English- language learners and those who have learning disabilities, otitis media, hearing aids, and/or cochlear implants.

Validity and reliability. In order to determine which of the sentences from the HINT were age appropriate, normal-hearing children ages 5 to 6 years were asked to repeat them in a quiet listening condition. If a child did not repeat the sentence correctly, it was discarded from the final version of the HINT-C. In terms of construct validity, convergent validity of the HINT-C was shown in the same study as discussed for the BKB-SIN (Wilson et al., 2007), while no evidence of discriminant validity was found. Concurrent validity was addressed for the HINT-C with comparisons between adults with normal hearing and children of different ages. Children, ages 6 to 12 years, showed significantly poorer performance than older children (> 13 years) and adults, and percentile rankings are provided for each age group in each listening condition (Nilsson et al., 1996). In addition, the HINT was shown to differentiate performance between 15 adults with normal hearing and nine adults with bilateral, symmetrical sensorineural hearing losses (Nilsson, Soli, & Sumida, 1995). Similar results are expected for the HINT-C when comparing performance of those with normal and impaired hearing. No direct evidence of predictive validity was found; however, listeners with cochlear implants, who had significantly poorer performance on HINT sentences in noise (fixed intensities) than those with normal hearing, reported significant difficulty listening in noisy situations via subjective questionnaires (Schafer & Thibodeau, 2004). Therefore, a relationship between speech perception performance in noise on the HINT and subjective, real-world difficulties likely exists.

Measures of reliability for the HINT-C are referenced back to the development of the original HINT (Nilsson et al., 1994). During the development of the HINT, test-retest reliability was confirmed by testing 18 adults with normal hearing (Nilsson et al., 1994) who showed average performance that only varied by 1 dB or less across lists. Similar findings were found in a later study (Nilsson et al., 1995). In addition, prior to this testing, the sentences and lists were equated for phonemic content, intelligibility, and difficulty.

Administration, scoring, and interpretation. Initially, the HINT-C was available as hardware and software, or on CD, where the examiner was required to adjust the signal levels manually using guidelines. However, the HINT was recently acquired by another manufacturer (Bio-Logic) and is now only available as a hardware and software system known as HINTPro. This system includes the HINT and HINT-C in 12 languages. When using the computerized format, administration, scoring, and interpretation is clear, understandable, and simple. The examiner is only asked to indicate if the child repeats the whole sentence correctly, and the software adjusts the sentence levels automatically to obtain the 50% correct threshold. All of the information needed for the interpretation of the person's threshold in noise is provided by the computerized program.

Advantages and disadvantages. Overall, the HINT-C has strong data to support its validity and reliability, as well as clear test administration, scoring, and interpretation. The HINTPro, which includes the HINT-C, is a flexible and portable system, which may be used under headphones or in the soundfield. In addition, it includes normative data for conditions with speech and noise from the same loudspeaker (0 degrees azimuth) and speech and noise from spatially separated loudspeakers (speech at 0 degrees and noise at 90 or 270 degrees azimuth). Soundfield testing may allow for assessment of aided benefit with hearing aids, cochlear implants, directional microphones, or HAT (spatially separated loudspeakers for the latter two). One unique aspect of HINTPro is the monitoring of patient reliability during testing. That is, if the child's responses are highly unreliable, testing will be automatically discontinued.

The main disadvantage to the HINTPro is the cost of the computerized system, which is approximately $5,000. This price may limit its use in school districts. Another disadvantage to the HINT-C is the use of speech-shaped noise, which is not as realistic or as challenging as multi-talker babble (Sperry et al., 1997). Finally, the test can only be used for children who have vocabulary levels greater than or equal to a typically-developing six-year-old.

Listening and Spatialized Noise-Sentences Test (LiSN-S)

Purpose and population. The North American LiSN-S is designed to assess a child's abilities to understand speech in the presence of noise arriving from different directions. The speech and noise stimuli are presented via headphones using a computerized program that creates the perception of a three-dimensional acoustic space. The program uses an adaptive-testing paradigm to determine if a child receives an advantage from spatially separated speech and noise sources. The four listening conditions tested include speech presented from the front (i.e., 0 degrees azimuth) and differing types of noise (i.e., noise from same or different voices) presented from varying locations. As the child repeats what he or she hears, the examiner records the number of correctly-repeated words into the program. The test was designed to assess children ranging from 6 to 11 years suspected of having auditory processing disorders. The test can also be used following some type of intervention to examine improvements in this area of binaural auditory processing in noise. Normative data for older children and adults are now available.

Validity and reliability. The sentences for the LiSN-S were written by Australian speech-language pathologists who specialized in the rehabilitation of children with hearing loss (Cameron & Dillon, 2007), and they were constructed according to procedures used to develop the original BKB sentences (Bamford & Wilson, 1979). Construct validity for this test is difficult to examine because it is a fairly new measure and the only adaptive test in noise designed specifically to assess auditory processing disorders. Two initial studies with some evidence regarding convergent and discriminant validity are currently available. An examination of convergent validity was attempted by comparing the normative data from the North American version of the LiSN-S to the normative data from the Australian version of the LiSN-S; however, unexplainable significant differences were found between the two groups of children (Cameron et al., 2009). Discriminant validity was determined in a study by Cameron and Dillon (2008) where children's results on the Australian version of LiSN-S were compared to four other common measures for assessing auditory processing disorders (i.e., Dichotic Digits, Masking Level Difference, Pitch Pattern Sequence, and Random Gap Detection Test). The researchers hypothesized that the LiSN-S examined different auditory processes than the other measures, which was confirmed by a lack of significant correlations (i.e., correlation coefficients ranged from 0.05 to 0.5). Concurrent validity was reported via significant differences across ages of typically developing, normal-hearing children (Cameron & Dillon, 2007; Cameron et al., 2009). In addition, significant performance differences were reported for children with suspected auditory processing disorders and those with no listening difficulties (Cameron & Dillon, 2008). Although no direct measure of predictive validity was found, the Cameron and Dillon (2008) study showed a relationship between performance on the LiSN-S and abnormal auditory behaviors from children with suspected auditory processing disorders.

According to Cameron and colleagues (2009), test-retest reliability of the LiSN-S was fairly high according to testing with 36 children with normal hearing and auditory processing. Correlation coefficients were significant for four of the five testing conditions and ranged from 0.5 to 0.7. List equivalency was also confirmed in this study with 24 children with normal-hearing sensitivity.

Administration, scoring, and interpretation. The administration of LiSN-S is fairly simple in that it only requires the examiner to enter the number of words repeated correctly within each sentence. During the adaptive testing, the noise remains constant (55 dB SPL), and the sentences are adapted to determine a speech reception threshold in noise after presenting 22 to 30 sentences. The testing takes approximately 20 minutes. The LiSN-S uses a unique scoring technique to reduce effects of language, learning, and communication abilities, which involves computing difference scores. These difference scores represent the spatial advantage (i.e., scores with noise at 0 degrees minus scores with noise at $\pm$ 90 degrees), talker advantage (i.e., scores with noise from same talker minus scores with the noise from different talkers), and total advantage. The interpretation of the scores is automated. The computerized program determines if the child's score is within or outside of the normal range when compared to normative data from North American children, and it creates a report (Cameron et al., 2009).

Advantages and disadvantages. The primary advantages of this test are the use of adaptive stimuli, which avoids ceiling and floor effects (i.e., 100% and 0%, respectively) and the computerized administration, scoring, and interpretation. Additionally, the test has strong validity and reliability and may be used for children with suspected auditory processing disorders before and after treatment or therapy. The use of headphones to present stimuli has several advantages when compared to use of loudspeakers because headphones eliminate variability associated with child head movement during testing, remove limits resulting from loudspeaker and listener placement issues in the soundfield, and reduce effects of reverberation.

The primary disadvantages to the LiSN-S is the limited population for which it was designed and the inability to present the test using loudspeakers. The test was not designed for children with hearing loss, hearing aids, or cochlear implants; yet, these populations of children exhibit great difficulty listening in noisy situations. While the use of headphones does reduce variability in several domains, the test would have greater application to other populations if normative data were provided in the soundfield using loudspeakers. Another disadvantage is the price of the program, which is approximately $1,000. Children with suspected auditory processing disorders are only one small group of children served by an educational audiologist. Therefore, the cost of the program may outweigh the benefits of having the test, especially when there are less expensive tests that can be used in the classroom.

Pediatric Speech Intelligibility Test (PSI)

Purpose and population. The purpose of the PSI is to examine diagnostic speech intelligibility of young children, ages 3 to 6 years, using a closed set of monosyllabic words and sentences in quiet and noise conditions (Jerger & Jerger, 1982, 1984). Children are asked to listen to the speech stimulus presented in quiet or in single-talker competing noise. They are then asked to indicate their responses by pointing to the corresponding noun (one of five pictures) or sentence (one of five pictures) depicted on a color picture card. Stimuli may be presented via headphones or one loudspeaker located at 20 cm and 90 degrees azimuth from the child. The examiner uses various fixed signal levels to obtain a performance-intensity function (i.e., performance at various percent-correct scores) in quiet or in noise for dichotic testing (headphones only). The test is designed for young child with normal hearing or hearing loss.

Validity and reliability. The vocabulary for the PSI was developed from language testing and samples of 87 children, ages 3 to 6 years. Construct validity, or more specifically the convergent validity, of this test was difficult to determine because there were no other speech perception tests in noise for children at the time of its development. However, a recent study used PSI to examine the effects of early amplification on speech perception performance in noise of young children with mild to profound hearing loss (Sininger, Grimes, & Christensen, 2010). Although the PSI was not correlated to any of the other measures in the study (i.e., no convergent validity; correlation coefficients ranging from 0.003 to 0.034), this finding was expected because the other measures focused on other aspects of speech perception, production, and language (i.e., speech perception of contrasts in quiet, speech production, and receptive and expressive language). The fact that the PSI was not correlated to these measures shows that it has discriminant validity. Concurrent validity was also confirmed in this recent study because the PSI was able to differentiate between children with good and poorer speech perception in noise. Concurrent validity was also shown via significantly different scores in noise across ages (Jerger & Jerger, 1984) and between children with normal-hearing sensitivity and otitis media (Jerger, Jerger, Alford, & Abrams, 1983). Predictive validity was revealed in the Sininger et al. (2010) study because the age at amplification was a significant predictor of PSI performance. In other words, the PSI was sensitive for identifying the expected effect of more positive outcomes for earlier amplified children.

The reliability of the measure was clearly addressed in the test manual (Jerger & Jerger, 1984). Test-retest reliability was confirmed with 35 children with normal hearing and 18 children with varying degrees of sensorineural hearing loss. Correlation coefficients were high for words and for sentences (i.e., .82 to .96). In addition, equivalence of word and sentence lists was established with children with normal hearing on two occasions. The test developers also examined practice effects with children with normal hearing and concluded that three practice trials would essentially eliminate any influence of practice effects on performance. Inter-item equivalency was also examined in noise, and the words and sentences were found to be equivalently difficult for children in the competing noise.

Administration, scoring, and interpretation. When compared to the previous three speech perception measures, the administration of the PSI is somewhat complicated. The user manual provides step-by-step instructions, but the rules for changing intensities when obtaining the performance-intensity functions are difficult to follow. However, the scoring (i.e., percent correct) and the interpretation are straightforward. Normative data are provided for children with normal hearing, and the interpretation of these data is fairly clear. The Sininger et al. (2010) paper used a modified approach to the PSI by presenting speech from a loudspeaker at 0 degrees azimuth and noise from a speaker at 180 degrees azimuth in quiet and at +10, 0, and -10 SNRs. This testing technique may be easier to administer clinically; however, the applicability of the normative data may be influenced by using different loudspeaker arrangements and conditions from the original design.

Advantages and disadvantages. The primary advantage to this test is that it may be used with younger children, ages 3 to 6 years. In addition, the use of closed-set materials and administration of the practice lists prior to testing addresses issues related to speech intelligibility (i.e., production) and vocabulary level. The original test was available on cassette tape, but it is now available on CD along with the manual and picture cards from Auditec (www.auditec.com). Finally, the PSI appears to be well-constructed, and there is adequate data to support its reliability and validity.

The administration of the test is not as simple as other tests, and the suggested loudspeaker arrangements in the manual may limit the applicability of the test for determining benefit from HAT and directional microphones. However, the equipment set-up described in the Sininger et al. (2010) study would address this issue. It is also possible that the use of a single competing talker may not adequately predict common listening situations where more than one talker is present. Finally, the use of fixed signal levels in some of the conditions may lead to ceiling and floor effects. This issue is addressed partially by always using a variety of SNRs for each child, if time permits. On the other hand, use of several SNRs would increase administration time and might lead to issues with attention span.

Tests Developed for Research Studies

As shown in Table 2, the literature review identified three additional tests that were developed for use in research studies, which are not currently available for purchase (i.e., not sold commercially). These include the Adaptive Spondee Discrimination (AdSpon) Test, Children's Realistic Intelligibility and Speech Perception (CRISP) Test, and the Phrases in Noise Test (PINT).

Adaptive Spondee Discrimination Test (AdSpon) and Children's Realistic Intelligibility and Speech Perception Test (CRISP)

The first two tests, the AdSpon (Galvin, Hughes, & Mok, 2010) and the CRISP (Litovsky, 2003, 2005), both used a computerized four-alternative, forced-choice paradigm with simple spondees in the presence of noise. In both of these tests, children were asked to indicate the spondee they heard on a computer screen, and both used an adaptive-testing technique to obtain a speech-in-noise threshold at the 79.4% correct level. The AdSpon spondees were presented in the presence of speech-shaped noise, and it is unknown whether the examiners equated the spondees for intelligibility or average RMS. The speech was presented from a loudspeaker at 0 degrees azimuth, while the noise was presented from a loudspeaker ± 90 degrees azimuth. Galvin and colleagues (2010) used the AdSpon stimuli with children older than 10 years. No validity or reliability data were discussed. The CRISP was used in conjunction with various types of noise for research purposes (Litovsky, 2005; Litovsky, Johnstone, & Godar, 2006), but the same phrases were used in each study and were equated for average RMS. Speech was presented from a loudspeaker at 0 degrees azimuth, while noise was presented from a loudspeaker to the front, right, or left side of the child. This test was designed for children 4 years and older. No reliability or validity data were found for this test either. One major concern about these two tests is related to the intelligibility of the phrases in the various background noises. As mentioned previously, equating for RMS does not ensure equal intelligibility in noise. Scaling procedures or adjustments must be made to ensure equal intelligibility in any type of background noise, especially when using adaptive procedures to find a threshold in noise.

Table 2. Summary of Research-Based Speech Perception in Noise Tests for Children

Test (Acronym)	Ages	Test Description
Adaptive Spondee Discrimination test (AdSpon)	≥ 10 years	Computerized adaptive test; measures 74.4% correct threshold for spondees in speech-shaped noise at ± 90 degrees azimuth; children selects spondee on computer screen
Children's Realistic Intelligibility and Speech Perception test (CRISP)	4+ years	Computerized adaptive test; measures 74.4% correct threshold for spondees in various types of noise at 0, +90, -90 degrees azimuth; children selects spondee on computer screen
Phrases in Noise Test (PINT)	3+ years	Modified-adaptive test; measures 50% correct threshold for simple phrases in classroom noise at 180 degrees azimuth; child repeats phrase or acts it out with a doll

Phrases in Noise Test (PINT)

The PINT consists of ten simple closed-set phrases (equal duration) about body parts (e.g., brush his teeth) with four-classroom noise that is equated to the long-term average RMS of the phrases (Schafer, 2005). It may be used with children as young as 3 years of age (Schafer & Thibodeau, 2006). The intensity of the phrases was determined carefully using intensity-scaling procedures similar to those used for the development of the HINT (Nilsson et al., 1996). The slightly revised version of the test consists of six different lists of 24 randomly-selected phrases that are presented at 57 dBA and classroom noise that automatically adapts in 3-dB steps from a -18 to a +12 dB SNR. The children are asked to repeat the phrases, as well as act them out with a doll and several related objects (e.g., comb his hair). Each list takes approximately three minutes and yields a 50% speech-in-noise threshold. Previous data support convergent validity of the PINT threshold to thresholds obtained using an adaptive-testing technique for a similar test (HINT; Nilsson et al., 1996). In addition, the test has concurrent validity because it detects substantial performance differences between children with normal hearing and those with cochlear implants (Schafer, 2005) and between conditions with and without FM systems (Schafer & Thibodeau, 2006). The PINT is currently being revised, and normative data are being collected from children with normal hearing and hearing loss.

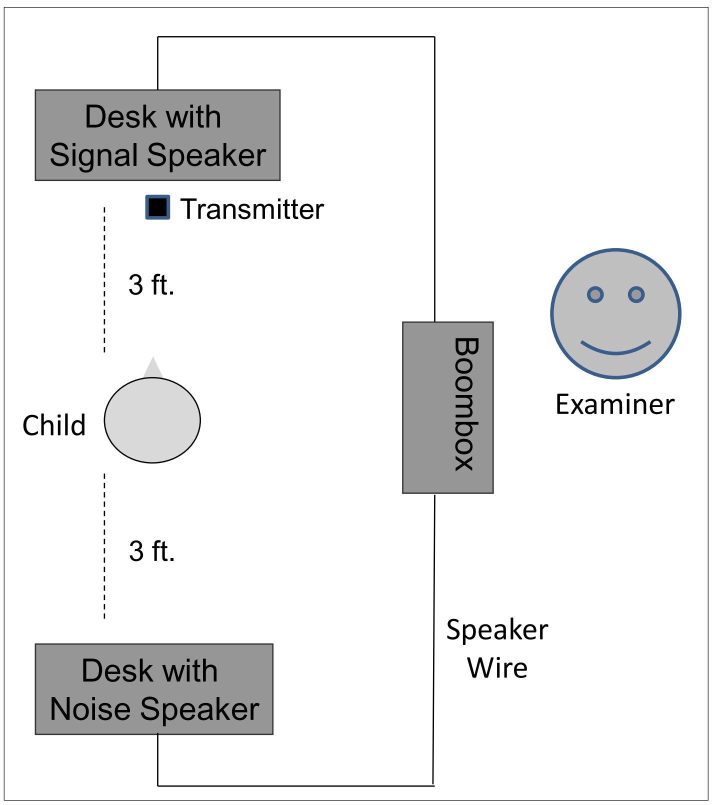

Figure 1. Simple equipment arrangement for conducting speech perception testing in noise in a classroom.

Case Studies

The first two case studies provide a summary of assistive technology evaluations to determine educational need for HAT in the classroom. These case studies provide representative examples of how speech perception measures in noise may be used as part of a functional evaluation for an FM system. Both evaluations included speech perception tests in noise with the BKB-SIN, classroom observations, and teacher questionnaires. As shown in Figure 1, the speech perception testing was conducted in the child's primary classroom using a simple soundfield arrangement. The BKB-SIN is presented via a portable CD player (e.g., Sony CFD-ZW755), two single-coned loudspeakers, and speaker wire to allow for a distance of three feet from the child's head. The levels of the loudspeakers are calibrated in dBA using an inexpensive sound level meter (e.g., Radio Shack Digital Display Sound Level Meter). When the FM system is in use, the transmitter lapel microphone is suspended six inches from the center of the single-coned loudspeaker. Boom or cheek transmitter microphones are placed three inches from the signal speaker. The examiner sits nearby to control the portable CD player and to record the child's responses on the scoring form. The third case study was conducted in a clinical environment to determine performance in noise and differences between two FM-system conditions.

Case One

Jim is a second-grade student who qualified for special education with learning disability and emotional disturbance eligibilities. An assistive technology referral was generated to evaluate his educational need for an FM system.

A hearing screening revealed normal-hearing sensitivity from 500 to 4000 Hz bilaterally. A functional evaluation was conducted and included teacher interviews, questionnaires, classroom observation, and speech perception in noise. Teacher interviews identified concerns about his inability to listen, focus, and participate in structured activities within the classroom. Teacher reports on the Screening Instrument for Targeting Educational Risk (S.I.F.T.E.R.; Anderson, 1989) questionnaire showed that he was at risk in the area of communication. During a classroom observation, Jim had some difficulty with directions and independently following along with the lesson. He required frequent one-on-one assistance from the teacher. In addition, he watched the actions of other students to follow class activities and transitions. He was seated with his back toward the whiteboard and teacher.

Jim's speech perception performance in noise was evaluated in his general education classroom using the BKB-SIN. His performance was assessed with and without a personal FM system (i.e., Phonic Ear Easy Listener and headphones) that was obtained from the school district's pool of back-up FM equipment. In the no-FM condition, the SNR associated with 50% of key words correct was +13.5 dB, which indicates a SNR loss of 12.7 dB. According to the BKB-SIN manual, children his age score an average of 0.8 dB (critical difference level of 3.5 dB), which suggests that he performs significantly worse than children his age when listening in noise. In addition, he will require an even better SNR than +13.5 to hear the full message from the teacher (i.e., greater than 50% of words) in a typical classroom. With the personal FM system set to a comfortable volume, Jim's performance at the 50% correct level improved to +7 dB. As a result, the FM system significantly improved his performance relative to no-FM performance; however, his performance is still well below average scores of peers in his age group.

Given the results of the speech perception testing in noise, teacher observation/questionnaires, and classroom observation, Jim has educational need for an FM system at school. A personal FM system (i.e., Phonak Edulink receiver) was recommended during direct instruction in his academic classes (i.e., math, reading, language arts). In addition, Jim would benefit from preferential seating in the classroom away from noise-producing equipment and with his body facing toward the whiteboard and teacher.

Case Two

Sam is a sixth grader with a bilateral mild-to-moderate sensorineural hearing loss in the right ear and moderate-to-moderately severe sensorineural hearing loss in the left ear. He wears his hearing aids during direct academic instruction, but not during his other classes. He receives some academic support (i.e., tutoring) in math, reading, and language arts. At the time of the evaluation, he did not qualify as a special education student with speech or auditory impairment. Special education teachers generated the assistive technology referral to determine if he had educational need for an FM system.

A functional evaluation was conducted and included teacher questionnaires, a classroom observation, and speech perception testing in noise. The S.I.F.T.E.R. questionnaires from his teachers indicated that he was at-risk in the areas of academics, attention, communication, and class participation when compared to peers. His teachers believed that an FM system could facilitate better attention and focus during class and ease his frustration. The observation revealed a non-carpeted classroom with hard-surfaced walls. One outside wall was near a busy road, and road noise was audible in the classroom. Sam sat at the front of the classroom during the lecture, but he moved to other desks when working collaboratively with peers. He required frequent direction to follow along with the teacher's lesson.

The BKB-SIN was used to measure Sam's speech perception in noise in his primary classroom. In a condition with his hearing aids, Sam required a +15.5 dB SNR to obtain 50% of key words correctly, while the average score for normal-hearing children his age is -0.9. Therefore, Sam's performance was significantly worse than normal-hearing children his age. When using a loaner FM system and his personal hearing aids (i.e., Phonic Ear Easy Listener with neckloop), his performance on the BKB-SIN improved to +10.5 dB, which indicated a significant improvement in performance with the FM system relative to the no-FM condition.

The results of the speech perception testing, teacher questionnaires, and classroom observations indicated educational need for an FM system during direct instruction. Other recommendations included continued preferential seating in the classroom and full-time use of the hearing aids.

Case Three

Sarah is a six-year-old child using a unilateral Advanced Bionics cochlear implant with an ear-level Auria sound processor. Her mother requested an appointment at the University of North Texas Speech and Hearing Center to determine if her school-issued personal soundfield FM system (i.e., Phonic Ear Toteable) was providing optimal benefit in noise. Sarah reported that she did not use her personal soundfield FM system consistently at school, especially during circle and center times in her Kindergarten classroom.

Speech perception testing in noise was conducted in the sound booth using the equipment arrangement shown in Figure 1. The PINT was used to determine Sarah's speech-in-noise threshold in three conditions: (1) cochlear implant alone, (2) personal soundfield FM system, and (3) personal FM system electrically coupled to the implant sound processor (i.e., Phonak MLx-S receiver and Campus S transmitter). Based on data published by Schafer and Thibodeau (2006), significant differences are indicated when there is a difference of 3.2 dB between two listening conditions.

In the cochlear-implant-alone condition, Sarah required a +10.5 dB SNR to repeat half of the phrases correctly. The personal soundfield FM system improved her threshold to +1.5 dB, while the personal FM system resulted in a threshold of -9 dB. Although the personal soundfield system significantly improved performance relative to the cochlear implant alone, the personal, electrically-coupled system had a clear and significant advantage over the soundfield system. Following the evaluation, a personal FM system was recommended for use at school. The personal system resulted in significantly better thresholds in noise than the personal soundfield system, and it provided Sarah more consistent access to the signal from the FM system when she was involved in listening to the teacher during centers or circle time.

Recommendations and Conclusions

The measurement of speech perception in noise provides individualized information regarding a child's ability to function in a noisy classroom. This measure may be used in conjunction with teacher questionnaires and classroom observations to provide a functional assessment in the child's customary learning environment. Specifically, speech perception testing in noise allows educational audiologists to quantify educational need for special education services and HAT (i.e., FM systems). Unfortunately, according to this critical review, there are only four published speech perception tests in noise that were designed for children and three additional tests that were used for pediatric research studies.

All of the published tests have high sensitivity, validity, and reliability, but they differed in presentation format, advantages, disadvantages, and clinical utility for schools. When purchasing a test for use in a clinical setting with a sound booth, the HINT-C has several advantages over other tests, including multiple languages and computerized administration and interpretation. However, it is an expensive test that utilizes speech-shaped noise. The cost of the test and use of a noise type that may not relate closely to the noise encountered in the classroom may limit its applicability for school-based audiology services. Similar to the HINT-C, the LiSN-S test has several advantages, including the ability to measure effects of type of noise and location of noise (i.e., 0 versus 90 degrees azimuth) and computerized administration, scoring, and interpretation. On the other hand, it was only designed for use with headphones and for children who have suspected auditory processing disorders. The PSI is a less expensive alternative to the aforementioned tests, but it may only be used with young children and has several disadvantages over other measures (Table 1), including ceiling and floor effects. Given these findings, the BKB-SIN appears to be the most viable choice for measuring speech perception in noise with school-aged children in the sound booth or in the classroom (Figure 1). It is fairly inexpensive and has straightforward administration and scoring. The possibility of ceiling and floor effects are addressed by using a modified-adaptive testing approach and an adjustable range of SNRs. As shown in these case studies, this test has been used successfully in the classroom to identify educational need and to examine benefits of FM systems for improving speech perception in noise. For younger children, the PSI is the only option at this time; however, normative data collection for the PINT is currently in progress. It is expected to be available for purchase within the next two years. In addition, it is possible that the other research-based tests, the AdSPON and CRISP, will also be available in the near future.

The results of this critical review highlight the significant need for additional sensitive tests to assess children's speech perception in noise. Specifically, there are very few tests that were designed for young children who have several special testing considerations (i.e., vocabulary, attention span, closed/open set). Although there are several published tests for young children (i.e., WIPI, NU-CHIPS), these tests were not designed for use in noise and, therefore, do not have equivalent word lists in the presence of background noise.

Although this critical review focused on speech perception in noise, which is at the identification level of Erber's hierarchal levels of auditory-skill development, it would also be beneficial for audiologists to have access to sensitive tests in noise at other levels including detection, discrimination, and comprehension (Erber, 1982). Assessment along the auditory-skill continuum will help determine educational need for children with a wide range of abilities and levels, as well as help to focus on auditory goals for the speech-language pathologist or educator. The only test commonly used to assess these hierarchal auditory skills in school-aged children - the Test of Auditory Comprehension (TAC; Trammel, 1981) - is no longer published, presents auditory stimuli via cassette tape, and may have outdated vocabulary, picture response options, and stimuli. In addition to these issues, the normative data from the 1980s are no longer applicable for children with newer digital hearing aids and cochlear implants who may have benefited from early hearing detection and intervention. As a result, future pediatric research should focus on the development of a hierarchical battery of tests for young and older school-aged children that includes speech perception measures in noise, as well as more sophisticated levels of auditory-skill development.

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A (C)APD Screening Instrument for The Buffalo Model Diagnostic Test Battery

Meghan Lyn Pavlick, Au.D.
Philadelphia Ear, Nose, and Throat Associates
Philadelphia, Pennsylvania

Thomas R. Zalewski, Ph.D.
Jorge E. González, Ph.D.
Mary Katherine Waibel Duncan, Ph.D.
Bloomsburg University of Pennsylvania
Bloomsburg, Pennsylvania

The Buffalo Model Questionnaire (BMQ) is the screening tool developed for use in conjunction with the Buffalo Model diagnostic test battery. However, there is little empirical evidence of the relatedness of findings across these two measures. The purpose of this study was to explore whether such relatedness exists. A Chi Square Test for Independence showed significant relatedness between findings from the BMQ and the outcomes of the Buffalo Model diagnostic test battery. Findings support the use of the BMQ as a screening tool only when used in conjunction with the Buffalo Model diagnostic test battery.

Introduction

The definition of central auditory processing proposed by the American Speech-Language-Hearing Association (ASHA; ASHA, 2005a) broadly states that it is the efficiency and effectiveness with which the central nervous system (CNS) utilizes auditory information. A more narrow definition refers to central auditory processing as the perceptual processing of auditory information in the CNS and the neurobiologic activity that underlies the processing and gives rise to electrophysiologic auditory potentials (ASHA, 2005a). Central auditory processing includes the following mechanisms and processes responsible for the following skills: (a) sound localization and lateralization, (b) auditory discrimination, (c) auditory pattern recognition, (d) temporal aspects of audition, including temporal resolution, temporal masking, temporal integration, and temporal ordering, (e) auditory performance with competing acoustic signals (including dichotic listening), and (f) auditory performance with degraded acoustic signals (ASHA, 1996; ASHA, 2005a). Children exhibiting auditory problems in a school setting as a result of the skills listed above are usually referred to a speech-language pathologist to determine the need for services (DeBonis & Moncrieff, 2008). A speech-language pathologist uses language assessment tools to determine if there is an auditory deficit (DeBonis & Moncrieff, 2008). However, the use of a language assessment tool may result in the misdiagnosis of the auditory deficit. Therefore, the use of a screening tool specifically designed to identify a central auditory deficit would allow the speech-language pathologist to develop a more efficient and cost-effective diagnostic and intervention plan.

In 1996, ASHA identified the need to establish guidelines to screen children who may be at risk for a (central) auditory processing disorder ([C]APD). In response to ASHA's call for the development of effective (C)APD screening tools, Katz introduced the Buffalo Model Questionnaire (BMQ). The BMQ was developed by Katz based upon his experience with (C)APD (Katz, 2006, 2008). He incorporated the behavioral characteristics frequently exhibited by individuals diagnosed with (C)APD into the BMQ (Katz, 2006, 2008). Therefore, this screening tool is not a product of the Buffalo Model, rather, it is the result of the search for an effective screening tool for (C)APD that is based upon a seasoned clinician's/researcher's experience and knowledge (Katz, 2006, 2008). Currently, there is minimal empirical research documenting the relatedness of findings from the BMQ and the Buffalo Model diagnostic test battery, also developed by Katz (1992). This study was an examination of the relatedness of findings across these measures.

To better guide clinicians working with individuals with (C)APD, two models (Bellis/Ferre & Buffalo) have emerged based on academic and language difficulties, as well as audiological outcomes (Jutras et al., 2007). Although they are different, the Buffalo Model and the Bellis/Ferre Model utilize similar terminology and neuroanatomical correlates for the disorder (Jutras, et al., 2007). For instance, the Buffalo Model categorizes results of audiological (C)APD assessment data into four categories of deficit (decoding, tolerance fading memory, integration, and organization) to individualize a management plan (Katz, 1992). The Bellis/Ferre Model consists of three primary categories (auditory decoding deficit, prosodic deficit, and integration deficit) with two subcategories (associative deficit and output-organization deficit) to classify (C)APD (Jutras et al., 2007). It should be noted that neither model is based on peer-reviewed data (Jutras et al., 2007).

The Buffalo Model diagnostic test battery consists of several tools to evaluate various components of auditory processing, including decoding, integration, organization, and memory. A weakness of the Buffalo test battery is the absence of a temporal measure. Although ASHA (2005a) includes temporal processing as a skill to be evaluated as part of a (C)APD evaluation, it does not require all skills to be evaluated during every (C)APD diagnostic battery. The use of a diagnostic model does not prevent clinicians from including additional tests outside the model of choice into the evaluation session. If a temporal processing disorder is suspected, clinicians can and should supplement the Buffalo Model diagnostic test battery with a tool that evaluates this skill. The Staggered Spondaic Word test (SSW) is the primary diagnostic procedure of the Buffalo Model (Katz & Tillery, 2005), and it is also the most sensitive test of the battery (Katz & Marasciulo, 2001). The other diagnostic tests are the Phonemic Synthesis Test (PST) and W-22 Speech-in-Noise test (S/N: Sparks, 2000). According to Katz (2007a), the three independent tests provide greater diagnostic power when used together. When all three tests are used in conjunction, the battery has a 96% sensitivity rate (Katz & Marasciulo, 2001). Independently, the sensitivity and specificity of the SSW has been found to be 85% (Katz, 2008). It should be noted, however, that when the tape-recorded version of the SSW was updated to a digital format, the background tape noise was removed. Yet, the background noise generated by the tape was determined to be an important factor in the sensitivity of the test and returned to the digital recording of the test (Katz, 1998a).

Katz (1968) suggested that the SSW differentiates individuals with and without central auditory processing disorders. Arnst (1981) found that the SSW was a fairly simple task for 86 normal-hearing adult listeners with no history of central auditory dysfunction. This group achieved a mean correct score of 98.4% on the SSW. This provides evidence that the SSW has strong specificity, as long as peripheral hearing loss has been ruled out (Katz, 1998a). Yet some research states the SSW is resistant to mild, and possibly moderate, peripheral distortions (Katz, Basil, & Smith, 1963). Arnst (1982) conducted a study wherein 50 male subjects with bilateral symmetrical sensorineural hearing loss were given the SSW. The mean pure-tone average (PTA) was 33.8 dBHL for the right ear and 34.2 dBHL for the left ear. Analyses showed that for those subjects with hearing better than 40 dBHL, the correlation was greater than 0.82; however, for those subjects with a hearing loss greater than 40 dBHL, the correlation was poorer than 0.82 (Arnst, 1982).

The linguistic load of the SSW test may influence the outcome of the test. However, a student with Spanish as his first language with two and a half years of enrollment in an English language learning school program was evaluated for (C)APD using the Spanish and English versions of the SSW, which resulted in the same outcome (Lucker, 2003). This indicates that the linguistic load of the SSW has minimal influence on the outcome of the test.

On the other hand, the PST is highly predictive of a person's ability to read words (Katz, 1998c), especially when the individual is required to read phonetically rather than using sight reading. Medwetsky (2002a) noted that an individual's phonemic synthesis ability is closely associated with articulation, spelling, and receptive language. Katz and Marasciulo (2001) reported that the PST has a hit rate of 54%, indicating it correctly identifies approximately half of the subjects with a decoding (C)APD. In the same study, the subjects were broken down into two groups; those above and below the age of 10 years. The sensitivity of the PST for individuals under 10 years of age was 54%, and the sensitivity was 55% for individuals aged 10 years old or older (Katz & Marasciulo, 2001). The PST is less sensitive (54% and 55%, versus 85% for the SSW) and the average number of significant findings (i.e., qualifiers) is less when compared to the SSW (Katz & Marasciulo, 2001). Qualifiers are noteworthy actions exhibited by the individuals during testing (Katz, 1998a). These important indicators will provide insight into the limitations, as well as the compensatory actions, of the individual (Katz, 1998a).

The S/N test is included as part of the Buffalo Model diagnostic battery to examine the tolerance aspect of the tolerance-fading memory category (Katz, 2007b). Research examining the S/N test found that 84% of 138 patients seen at Rochester Hearing and Speech Center had significant findings on this test (Medwetsky, 2002b). This may be due to lower order processing skills, while the other Buffalo Model categories represent higher order processing deficits. Katz (1998b) provided a rationale for the inclusion of the S/N test: (1) word recognition test results are normative so clinicians can determine the presence of significant variations; (2) poor performance might be a result of anxiety and/or distractibility, which may suggest the presence of a tolerance fading memory issue, and; (3) poor word recognition coupled with essentially normal hearing may indicate another underlying issue. Rationale number three supports the assumption that S/N testing assesses lower order processing deficits.

Professionals across disciplines use screening tools to determine the need for more extensive and comprehensive diagnostic evaluations. The Teacher's Report Form (TRF), for example, was designed to obtain a qualitative report of children's academic performance, adaptive functioning, and behavioral/

emotional problems (Achenbach, 2006). The TRF has relatively good sensitivity and specificity when used appropriately (Brown et al., 2001; Dunn & Lipkin, 2006). The Child Behavior Checklist (CBCL) is a screening instrument completed by the parents of children at risk for psychological morbidities, including externalizing problems (e.g., behavior problems) and internalizing problems (e.g., anxiety or depression). Nelson and colleagues (2001) found that the sensitivity of the CBCL's Obsessive Compulsive Subscale (OCS), for example, is between 75.3% and 84.9% and the specificity is between 82.2% and 92.5%.

Musiek and Guerkink (1980) stated that information provided by parents could help identify children who should be seen for more comprehensive diagnostic (C)APD evaluations. In addition, many researchers (Domitz & Schow, 2000; Jerger & Musiek, 2000; Katz et al., 2002) have encouraged the use of screening tools when establishing (C)APD evaluation guidelines. Today, hearing healthcare professionals regard screening tools as an essential part of the (C)APD test batteries (Bellis, 2003). The majority of (C)APD protocols use a screening method in the form of a questionnaire or checklist, similar to those of other disciplines. For example, the Willeford (1977) test battery implements the use of the Willeford and Burleigh Behavior Rating Scale to screen for central auditory disorders. This 41-item parent-completed checklist involves using a Likert-type scale to rate children's behaviors that are consistent with (C)APD (Willeford & Burleigh, 1985). Questions on the Willeford and Burleigh Behavior Rating Scale address the child's auditory, academic, and social behaviors (e.g., attention, daydreaming, speech/language therapy). This checklist was originally developed for use in a research project and has not been widely utilized, leaving its sensitivity, reliability, and validity unknown (Willeford & Burleigh, 1985). Therefore, researchers are focused on establishing a more contemporary behavioral checklist for (C)APD.

Bellis (2003) recommends the use of two behavioral checklists, which are known to be helpful in identifying compromised auditory function in children: Fisher's Auditory Problems Checklist (Fisher, 1985) and the Children's Auditory Performance Scale (C.H.A.P.S.) (Smoski, Brunt, & Tanahill, 1992). Fisher's Auditory Problems Checklist was developed to screen children, Kindergarten through sixth grade, in order to collect information about perceived auditory processing problems from various referring sources (i.e., classroom teachers, speech-language pathologists, parents, or other professionals) (Fisher, 1985). This 25-item checklist gathers information about observers' perceptions of children's auditory acuity, attention, attention span, discrimination, short-term memory, long-term memory, sequential memory, comprehension, speech and language problems, auditory-visual integration, motivation and performance. Unpublished data suggest that this checklist is effective in identifying children with auditory perceptual problems who are in need of further (C)APD diagnostic testing (Fisher, 1985). Furthermore, preliminary results support the clinical usefulness of Fisher's Auditory Problems Checklist as a screening tool when used with the Buffalo Model Diagnostic Test Battery (Strange, Zalewski & Duncan, 2009).

The C.H.A.P.S. was developed to systematically collect and quantify the observed listening behaviors of children. This 36-item checklist gathers information about children's listening behaviors in a variety of listening conditions and functions: quiet, ideal, multiple inputs, noise, auditory memory/sequencing and auditory attention span (Smoski et al, 1992). The C.H.A.P.S. may be completed by a classroom teacher, special education teacher, or parent (Bellis, 2003). The individual completing the C.H.A.P.S. is asked to judge the amount of listening difficulty experienced by the child as compared to a "hypothetical reference population." The C.H.A.P.S. subdivides and quantifies listening performance, rendering it useful in prescribing and measuring the effects of therapeutic intervention. It also is useful for early and quick identification of children who should be referred for a diagnostic (C)APD evaluation (Smoski et al., 1992). Research suggests that there is a significant relationship between the six listening conditions as an individual subtest and the overall total score. Previous research also shows that teachers judge the listening characteristics of children diagnosed with (C)APD to be poorer than those of their age-related peers (Smoski et al., 1992).

The Buffalo Model Questionnaire (BMQ; see Appendix) is the only screening tool designed to complement the Buffalo Model diagnostic test battery. The screening measure consists of 48 questions concerning the individual's behaviors, as well as six mitigating factors (Katz, 2006). Typically, a parent reads each question and circles "yes" if the question describes that child's behaviors (Katz, 2004). Katz (2006) noted that the results of both the BMQ and the actual (C)APD diagnosis are relatively close. The questionnaire addresses issues associated with articulation, spelling, oral reading, speech understanding in noise, distraction, ADHD, coordination, sequencing, short-term memory, and other auditory-based tasks (Katz, 2006). The BMQ is an important factor in the (C)APD evaluation in that it gives pertinent information to the tester regarding the child's school and communication problems (Katz, 2004).

In a pilot study of the BMQ, the parents of children who were diagnosed with (C)APD reported a significantly higher number of concerns on the BMQ (M = 18.9; SD = 6.6) compared to children who were not diagnosed with (C)APD (M = 1.3; SD = 1.8) (Katz, 2004). A more in-depth study of the BMQ showed that there is little to no overlap in the number of questions marked "yes" when comparing the (C)APD group to the controls (Katz, 2004).

Katz (2006) also found that the seven most sensitive questions for identifying (C)APD on the BMQ never received affirmative responses from the parents of children without a diagnosis of (C)APD.

Jerger and Musiek (2000) recommend that no matter what diagnostic (C)APD protocol a professional chooses to use, a screening tool is to be used as well. Screening tools are useful in the determination of the need for a more comprehensive diagnostic (C)APD evaluation, which might include, but are not limited to, measures of receptive and expressive language skills, speech production skills, reading, and written language (including phonemic representation), cognition, psychoeducational abilities, medical status, and educational/developmental history (Bellis & Ferre, 1996).

The Buffalo Model Questionnaire (BMQ) is the screening tool developed for use in conjunction with the Buffalo Model diagnostic test battery. Jutras et al. (2007) found the Buffalo Model to be a clinically appropriate and applicable model for (C)APD. Therefore, the use of a valid screening tool that complements the model is important to identify. However, there is little empirical evidence of the relatedness of findings across these two measures. The purpose of the present study was to explore whether such relatedness exists between findings on the BMQ and conclusions based upon completion of the Buffalo Model diagnostic test battery. This study also examined the sensitivity and specificity of this screening tool when used only in conjunction with the Buffalo Model diagnostic test battery.

Method

The charts of all children between the ages of 6 and 13 years old who presented at the Bloomsburg University Speech, Hearing, and Language Clinic for a central auditory evaluation from January of 2006 to January of 2009 were reviewed. Fifty-nine children (Mean = 8.78 years old, SD = 1.99) were included in this study. The majority of study participants were boys (68%). The chart of each participant contained documented evidence of the following inclusion criteria: a complete Buffalo Model Questionnaire (BMQ), a complete Buffalo Model diagnostic test battery (i.e., SSW, PST, and S/N), hearing thresholds less than or equal to 20 dB HL from 500 to 4000 Hz (ASHA, 2005b), healthy and intact tympanic membranes, normal middle ear function as defined by peak static acoustic admittance from 0.25-1.05 mmho, a tympanometric width from 80-159 daPa, and an ear canal volume from 0.3-0.9 cm^3 (Margolis & Hunter, 2000). Children with myringotomy tubes were included since open myringotomy tubes usually indicate a healthy middle ear space. Children with identified learning or reading disorders or attention deficit hyperactivity disorder were included if they received a diagnosis of (C)APD following completion of the Buffalo Model test battery. Children with speech and/or language disorders were included, as well. A family history of hearing loss, chronic ear infections, learning difficulties, reading disabilities, or speech and language issues did not impact an individual's ability to participate in this project.

Children with an IQ of 70 or lower, autism, and/or Fragile X were excluded from the study. Children with histories of traumatic head injury were excluded due to possible damage to auditory structures. Children who had received therapy (e.g., aural rehabilitation or speech therapy) were excluded as therapy has been shown to influence testing outcomes (Katz, 2006).

Given the nominal scales of measurement upon which data were recorded, a Chi Square Test for Independence was conducted to determine whether parents' reports of children's central auditory processing, as measured by the BMQ, were significantly related to findings from a more objective and comprehensive diagnostic test for (C)APD, the Buffalo Model diagnostic test battery. In addition, descriptive analyses determined the sensitivity and specificity of the BMQ.

Results

Descriptive analyses showed that the parents of 77% of participants reported more than eight concerns on the BMQ, suggesting the need for a formal central auditory processing evaluation. Descriptive statistics also showed that 76% of the participants received diagnoses of (C)APD following the completion of the more objective and comprehensive Buffalo Model diagnostic test battery. More specifically, 75% of participants achieved abnormal scores on the SSW, 58% of participants achieved abnormal scores on the PST, and 39% of participants achieved abnormal scores on the speech in noise test.

A Chi Square Test for Independence showed the majority of participants (n = 40) obtained abnormal scores on the BMQ and received a diagnosis of (C)APD based on the Buffalo Model (C)APD test battery (i.e., 68% true positive rate). Furthermore, the analysis showed that six participants obtained normal scores on both the BMQ and received no diagnosis of (C)APD based on the Buffalo Model test battery (i.e., 10% true negative rate). In addition, eight participants obtained abnormal scores on the BMQ, but did not receive a diagnosis of (C)APD based on the Buffalo Model test battery (i.e., 13.5% false positive rate). Finally, five participants obtained normal scores on the BMQ and received a diagnosis of (C)APD based on the Buffalo Model test battery (i.e., 8.5% false negative rate). The Chi Square test (see Table 1) achieved significance (X^2 [1, N = 59] = 7.10, $p < .01$) suggesting that findings from the BMQ are significantly related to findings from the comprehensive Buffalo Model diagnostic test battery.

Descriptive statistics showed a sensitivity rate for the BMQ of 89% (i.e., 40 of the 45 children who received a diagnosis of (C)APD received scores above eight on the BMQ). Descriptive statistics also showed a specificity rate for the BMQ of 43% (i.e., 6 of the 14 children who did not receive a diagnosis of (C)APD received scores of eight or lower on the BMQ).

Chi Square Tests for Independence also were conducted on findings from the BMQ and each of the three tests that constitute the Buffalo Model test battery (i.e., SSW, PST, and S/N). With respect to the SSW, analyses showed significant relatedness with the BMQ [X^2 (1, N=59) = 6.05, p < .05]. With respect to the PST, analyses showed significant relatedness with the BMQ [X^2 (1, N=59) = 5.10, p < .05]. In contrast, analyses did not show significant relatedness between the BMQ and the S/N test [X^2 (1, N=59) = 1.42, p > .05].

Discussion

Previous research on central auditory processing screening tools (i.e., Willeford and Burleigh Behavior Rating Scale, Children's Auditory Performance Scale (C.H.A.P.S.), and Fisher's Auditory Problems Checklist) has shown that the use of behavioral checklists are an efficient and effective way to determine if a child is in need of a more in-depth evaluation for central auditory processing problems (Bellis, 2003; Smoski et al., 1992). The present study attempted to expand the existent literature on the clinical usefulness of (C)APD screening tools by examining the relatedness of the parent-completed Buffalo Model Questionnaire and its companion Buffalo Model diagnostic test battery. A Chi Square Test for Independence performed on data gathered through a retrospective chart review shows that there is significant relatedness between the BMQ screening tool and the diagnosis of (C)APD based on the Buffalo Model test battery. This finding suggests the BMQ is a useful screening tool when paired with the Buffalo Model diagnostic test battery.

Although uniquely prepared to identify and respond to the needs of children who are unable to benefit from traditional formal classroom instruction, teachers are relatively unprepared to identify children with central auditory processing problems (Ortiz, 1992). (C)APD is a disorder not well-understood by mainstream educators (Grant, 2009). Teachers often comment that children who ultimately are diagnosed with (C)APD "hear but do not listen" (Grant, 2009). Given the similar behavioral manifestations of ADHD and (C)APD (Tillery, Katz, & Keller, 2000), teachers may mistakenly refer a child with (C)APD for ADHD testing because of their greater familiarity with and understanding of the chronic neuro-developmental disorder (Boeree, 1999; Jerome, Gordon, & Hustler, 1994; Sasso, et al., 1992; Snyder, Busch, & Arrowood, 2003; Wolraich, Hannah, Pinnock, Baumgaertel & Brown, 1996). Similarly, teachers' prior training and experience with behavior disorders, autism, speech/language disorders, and reading deficiencies may lead to other errant referrals of children with (C)APD (Boeree, 1999), inappropriate treatments, and limited improvement in affected children's academic and social functioning. A (C)APD screening tool, such as the Buffalo Model Questionnaire, may assist educators and other school-based professionals make appropriate referrals for more comprehensive diagnostic testing for (C)APD.

When the referral is made to the appropriate professional initially, across any discipline, there is a greater amount of monetary savings for the parents and schools (Teska & Stoneburner, 1980). Glascoe, Foster, and Wolraich (1997) encouraged the use of parent and teacher reports to screen for (C)APD, in order to maximize the opportunity for a timely, fiscally responsible, and productive response to children's central auditory processing problems. According to Glascoe (2004), approximately 30 to 50 percent of children who are referred for screenings, in general, ultimately receive a true diagnosis of the disorder (approximately one out of every two or three children). This value can vary depending upon the screening tool and diagnostic battery employed. Data from the present study showing the relatedness of findings from the BMQ screening tool and Buffalo Model diagnostic test battery suggested that the BMQ is a useful instrument that can enhance school professionals' ability to make appropriate referrals for (C)APD testing if the Buffalo Model is the battery of choice.

Table 1. Chi Square Test for Independence of the BMQ and Buffalo Model Test Battery

		Buffalo Model Test Battery		
		CAPD Diagnosis	No CAPD Diagnosis	TOTAL
BMQ	Abnormal	**40** (37)	**8** (11)	**48**
	Normal	**5** (8)	**6** (3)	**11**
	TOTAL	**45**	**14**	**59**

Note: Observed frequencies are reported in bold type. Expected frequencies are reported in parentheses.

Average screening costs are significantly lower than the monies needed to compensate for a missed diagnosis (Mehl & Thomson, 1998). Even if various screening tools are completed, the cost of administering screening tools is far more economical than undergoing comprehensive test batteries for all of the possible disorders.

When each of the core tests of the Buffalo Model diagnostic battery were independently analyzed, results of the Chi Square Test for Independence show that the SSW and the PST are significantly related to the BMQ, whereas the S/N test was not. Because the SSW and the PST are tests that are multi-dimensional in their tasks (Katz, 1998a; Katz & Fletcher, 1998) more behaviors addressed on the BMQ will also be seen throughout the diagnostic testing. The S/N test is important in that it establishes a child's ability to discern speech in noise (Heckendorf, Wiley, & Wilson, 1997). However, the S/N test is used to identify a tolerance-fading memory issue, which is one of the four Buffalo Model processing disorder categories. This will result in fewer behaviors on the BMQ that concerns the tolerance-fading memory category. Therefore, the professional should keep in mind that the BMQ will address a multitude of behaviors displayed by the child, and the diagnosis should not depend on the results of only one of the core tests.

Research Limitations

There are several limitations to the current study. First, this study did not use a random sample. The 59 participants included in this study represent all of the children whose adult guardians completed the BMQ upon arrival at the clinic and whose charts included documentation of results from the SSW, PST, and S/N tests. A relatively more random sample could have been generated by randomly and independently selecting 30 participants from the available 59 participants. However, such an approach, which limits the number of study participants, would have decreased the power of the statistical analyses.

Another limitation of this study was the broad age range of participants in the sample. Between the ages of 6 and 13 years, there are numerous developmental differences, including auditory attention and handwriting development (Vuontela et al., 2003). Barnes, Kaplan, and Vaidya (2007) noted a definitive difference in cognitive control in early childhood versus middle childhood, which can affect spatial attention, or attention directed toward a particular location within the visual field (Martinez, Ramanathan, Foxe, Javitt, & Hillyard, 2007). If spatial attention is affected, then auditory attention displayed by a child can also be affected (Andersen, Tiippana, Laarni, Kojo, & Sams, 2009). This was shown by an increased auditory perception in subjects exposed to direct visual attention cues. Ultimately, a deficit in auditory and spatial attention could affect the child's score on the BMQ, as some of the questions refer to the child's attentive behaviors reported by the parent or caregiver. Parents with younger children who are answering the BMQ may indicate more attention issues than parents with older children, which may be a developmental issue rather than (C)APD.

According to Feder and Majnemer (2007), poor handwriting can be an indication of negative academic success and poor self-esteem. Handwriting is a complex occupational task that has various underlying component skills (Feder & Majnemer, 2007), and although it is not addressed extensively on the BMQ, handwriting issues are steadfast indications of integration and organizational issues (Medwetsky, Riddle, & Katz, 2009). Some of the component skills identified in Feder and Majnemar's (2007) study are, but not limited to, fine-motor control, bilateral integration, visual-motor integration, motor planning, in-hand manipulation, proprioception, visual perception, sustained attention, and sensory awareness of the fingers. These component skills are developed sufficiently by age 6 years to complete writing, dressing, and feeding tasks, but they will continue to be refined as the child ages into teenage years (Tervo, 2003). Therefore, there will be developmental differences in handwriting and its component skills in 6 year-old children versus 13 year-old children. As a note, some of the component skills of handwriting are listed as areas of concern on the BMQ (i.e., visual perception, visual integration, and attention). Therefore, some of the overt behavioral symptoms exhibited may be a function of age rather than a processing deficit. It must also be stated, the neurological development of the areas mentioned above may also have an impact on the processing ability.

Another limitation to this study is the inclusion of children reported to have co-morbid disorders. Disorders such as Attention Deficit Disorder (ADD), Attention Deficit Hyperactive Disorder (ADHD), learning disabilities, and even depression can manifest in such a way that mimic signs of (C)APD (e.g., ask for repeated directions, listening difficulty in background noise) (Morlet, 2007; Tillery, Katz, & Keller, 2000). Accordingly, parents of children with ADHD are likely to report more than eight concerns on the BMQ (i.e., a finding that suggests the presence of central auditory processing problem). Given the pervasiveness of ADHD (i.e., three to five percent of school-aged children [Low, 2008]), it is reasonable to assume that one or more of the false positive outcomes in the current study could have been a function of an inappropriate referral of a child with ADHD to the Bloomsburg University Speech, Hearing, and Language Clinic. However, upon reviewing the data, the expected frequency of false positives was more than the observed frequency in this study. Therefore, the chances of this occurring were not likely. The inclusion of participants with co-existing disorders may have resulted in a higher number of parental concerns, which would not have occurred if individuals with co-morbid conditions were not included.

Finally, the relatively small sample size is a limitation of this study. The larger the sample size studied, the more likely the measured findings are representative of the population parameters (Lunsford & Lunsford, 1995). If the current project utilized a larger sample size, the outcomes might be more representative of the (C)APD general population. Because the study was limited to charts available at the Bloomsburg University's Speech, Hearing, and Language Clinic, the overall representation of the general population may have been confounded, due to the given demographics of the rural area. In the future, a sample size drawn from a more global population would be ideal to account for racial, cultural, and socioeconomic differences among groups, as well as for various assessment styles.

Future Research

In addition to providing information about the usefulness of the BMQ, the current research also allows insight into directions for future research. Future research could determine if a relationship exists between the BMQ and the (C)APD categories, as defined by the Buffalo Model (Katz, 1998a). This could guide the clinician in choosing a more efficient and effective test battery. For example, the Phonemic Synthesis Test (PST) is associated with the patient's ability to decode phonemically (Medwetsky, 2002a). If the BMQ reveals that decoding is an issue for the individual, then the PST should be a part of the (C)APD test battery.

The BMQ may also provide information that would suggest completion of testing that is outside the central three diagnostic tests in the Buffalo Model (SSW, PST, and S/N) (Katz, 2007a). Although the Competing Environmental Sounds Test (CES) was part of the original Buffalo Model test battery, more recent literature primarily discusses the use of the SSW, PST, and S/N as the current test battery (Katz, 2007a; Medwetsky, 2002a). The CES is a non-linguistic test that examines binaural integration skills of the listener (Chermak, 2001). If the BMQ indicates an expressive language issue, or if an expressive language deficit is observed by the audiologist, the CES would be an appropriate test to administer in addition to the core test battery. The CES removes the expressive language component of a (C)APD evaluation by having the child point to pictures heard under headphones, rather than verbally stating the sounds heard. However, the use of pictures and pointing adds a visual-motor component to the test, which must be taken into consideration. This test is said to be sensitive to cortical lesions (McKay, Headlam, & Copolov, 2000) and examines specifically the auditory areas of the brain. Future research may include examining how the CES and the BMQ are related.

Future research may focus on more discrete age groups (i.e., 6 to 8 year olds, 9 to 10 year olds, and 11 to 13 year olds). This would control for extraneous developmental differences among the current sample. Vuontela and colleagues (2003) found that children in the 9 to 10 year range perform auditory tasks more accurately than 6 to 8 year olds, which indicates that the older age group has improved executive function and memory capacity. This also indicates that auditory processing is related to the neuro-development of the individual. Furthermore, younger children may be behaviorally more impulsive, due to immature cognitive control systems (Vuontela et al., 2003). These children may display aberrant behaviors, such as quick responses, delays, and repetitions, which are important qualitative findings (Katz & Tillery, 2004). In general, qualitative indicators can be used by the examiner to clarify the nature of the deficit. The qualitative scores obtained on the SSW test can be an effective means of validating the parent/caregiver answers on the BMQ. That is, if a reliable parent/caregiver indicates a child exhibits frequent delays on the BMQ, quick responses would less likely be expected on the SSW test.

Another area of future research could determine if the overall number of affirmative responses on the BMQ is important or if a score of eight or greater warrants further testing (Katz, 2006). The cut-off value of eight was determined during initial studies of the BMQ (Katz, 2004). This value has not been studied extensively and would warrant further testing to validate the normative data based on age, gender, and the presence of co-morbid disorders (i.e., ADHD). As a final note, the total score is not always what is most important when analyzing the BMQ. It is imperative to look at responses to each question (Katz, 2004) and to remember that (C)APD is an individualized disorder that must be assessed on a case-by-case basis.

Conclusion

Jerger and Musiek (2000) recommended that audiologists use screening tools to complement (C)APD diagnostic protocols. Currently, there is no universal, empirically-tested screening tool that corresponds to any diagnostic battery. Katz (2006) suggested that findings from the BMQ and Buffalo Model (C)APD diagnostic test battery are related; however, there is limited research available to support this assertion. The purpose of this study was to determine if such relatedness exists. A Chi Square Test for Independence performed on data that were collected through a retrospective chart review showed that findings from the parent-completed BMQ screening tool were significantly related to the diagnosis of (C)APD as determined by the Buffalo Model diagnostic test battery. Data from the present study support the use of the BMQ as an appropriate screening tool only as a complement to the Buffalo Model diagnostic test battery.

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Evaluating the Reliability and Validity of (Central) Auditory Processing Tests: A Preliminary Investigation

Jennifer C. Friberg, Ed.D.
Illinois State University
Normal, Illinois

Tena L. McNamara, Au.D.
Eastern Illinois University
Charleston, Illinois

Twenty-two criterion referenced and standardized tests commonly used to diagnose (central) auditory processing disorders were evaluated for both diagnostic accuracy and test validity. Tests were evaluated for evidence of diagnostic accuracy, level of acceptability of any identified diagnostic accuracy, and test validity for those tests with reported levels of diagnostic accuracy. Criteria for test validity were modified from McCauley and Swisher (1984) and McCauley (1996). Results indicated that 45% of reviewed tests had published evidence of diagnostic accuracy, although only 23% of tests met criteria for acceptable levels of both sensitivity and specificity. Evaluation of test validity indicated strengths in procedural aspects of test administration and weaknesses in various aspects of reliability and validity. Because sufficient evidence to support the reliability and validity of many (C)APD tests is not available in published data, findings indicated a clear need for educational audiologists to make (C)APD test selection decisions with care.

Introduction

The American Speech-Language-Hearing Association (ASHA) has prioritized evidence-based practice for all clinicians. As part of that process, ASHA has demanded that all diagnostic tools be evaluated for their ability to apply appraisal criteria (detailed in relevant research) for the identification of the most valid tools available for clinical use, particularly those used for the purposes of assessment and diagnosis (ASHA, 2005b).

Within the field of audiology, one area of clinical and diagnostic focus is particularly appropriate when considering test validity for the assessment of (central) auditory processing disorders ([C]APD). (Central) auditory processing disorders can be defined 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 (ASHA, 2005a. p. 2).

Historically, there has been significant controversy concerning the assessment of (C)APDs. Central auditory processing abilities are examined by audiologists using a combination of behavioral, electroacoustical, and electrophysiological approaches (ASHA, 2005a). Recognizing behavioral tests as being sensitive to lesions of the central auditory nervous system and important diagnostic data sources (due to the insight they provide into the functional listening abilities of clients), ASHA (2005a) has recommended that behavioral tests be used in conjunction with electroacoustical and electrophysiological measures to diagnose the presence of (C)APD. However, there is little consensus among professionals as to which tests should be utilized within the battery. While the use of electroacoustical and electrophysiological assessment techniques allows for the gathering of information relative to the neural function of the central auditory nervous system (Baran, 2007), electrophysiologic tests are not always readily available for diagnostic purposes. This is due to a lack of resources and equipment. Thus, many clinicians rely on electroacoustical and behavioral tests administered in clinically appropriate settings, as they are more readily available for diagnostic use (Emanuel, 2002; Jerger & Musiek, 2000).

With this in mind, clinicians must give careful consideration to which behavioral measures are most valid for clinical use when determining the presence or absence of (C)APD. With that said, there have been no studies conducted that review the validity of the various tests used in a battery to assess auditory processing abilities. This is despite a documented need for research focused on evaluating the validity and reliability of tests of central auditory function (Bellis, 2003; Keith, 2009a). Rather, several smaller studies have been conducted to look at isolated variables related to a test's validity for various individual (C)APD assessment tools, including the Staggered Spondaic Word Test (SSW; Berrick, Shubow, Schultz, Freed, Fournier, & Hughes, 1984), low- and high-pass filtered versions of the Northwestern University Auditory Test No. 6 (NU-6; Bornstein, Wilson, & Cambron, 1994), Dichotic Digits Test (Kelly, 2007; Musiek, 1983b), Duration Pattern Test (Musiek, 1994), Frequency Pattern Test (Kelly, 2007; Musiek & Pinheiro, 1987b), Auditory Continuous Performance Test (Riccio, Cohen, Hynd, & Keith, 1996), Gaps-in-Noise Test (GIN; Shinn, Chermak, & Musiek, 2009), Random Gap Detection Test (Kelly, 2007), Compressed and Reverberated Words Test (Kelly, 2007), and the Masking Level Difference Test (MLD; Wilson, Moncrieff, Townsend, & Pillion, 2003).

Recognizing the paucity of research, Bellis (2003) indicated that "an understanding of issues surrounding validity and reliability of central auditory function tests is critical in order to determine the clinical utility of specific testing tools" and that the issue of test validity of (C)AP tests is an area of "further, much-needed research" (p. 202). Similarly, Keith (2009a) identified inadequacies within normative data provided for the vast majority of (C)APD assessment tools and indicated that this lack of normative data makes it extremely difficult to accurately judge whether or not a child exhibits a deficit in (C)AP abilities. Some tests' authors suggest that clinicians acquire and develop their own norms when using a particular (C)APD test in order to overcome this assessment challenge (Bellis, 1996; Emanuel, 2002; Kelly, 2007). However, acquiring one's own normative data can be problematic, due to subject variables, divergent testing procedures, and reduced quality control (Katz, Johnson, Brandner, Delagrange, Ferre, King, et al., 2002; Stewart & Kaminski, 2002). As collecting local normative data can be complicated, having well-established, representative, age-appropriate normative data provided by the test's author, test's publisher, or a researcher conducting large-scale research remains the ideal for (C)APD test administration (ASHA, 2006; Keith, 2009a).

It should be noted that within the field of communication sciences and disorders, most studies dealing with test validity have been conducted on tests relative to speech-language pathology. Predominantly, studies focusing on test validity in communication sciences and disorders use the specific psychometric criteria first used by McCauley and Swisher (1984) as the basis for evaluating standardized assessment tools. These criteria have become well established as acceptable and relevant to speech and language assessments. These authors would argue that the criteria are applicable for expansion into other areas of research within the communicative sciences and disorders, including the field of audiology. In fact, the American Educational Research Association (AERA), the American Psychological Association (APA), and the National Council for Measurement in Education (NCME) have collaborated to develop author guidelines for educational and psychological testing. These guidelines have become foundational to assessment practices for a broad range of specialists (AERA, 1999). Within these guidelines, the AERA, APA, and NCME clearly define behavioral tests as multidimensional tools that can be administered across a wide range of content areas to accomplish very similar ends (comparison of test subjects to a normative group or predetermined set of criteria; AERA, 1999). Specifically, these organizations recognize tests of cognitive processing, attention, auditory sensitivity, and "tests requiring reasoning and judgment as they relate to the processing and elaboration of complex sensory combinations and inputs" as having a psychological and/or educational basis (AERA, 1999, p. 123). Many different audiology assessment tools fit this description, including those used for diagnosing (C)APD.

McCauley and Swisher (1984) were among the first researchers in the field of communication sciences and disorders to assess the overall test validity of standardized assessment tools commonly used by practicing clinicians. As part of their research, McCauley and Swisher identified ten specific criteria related to the validity and reliability of standardized tests and applied them to over 30 different language assessment tools to judge the presence and/or absence of these criteria. These psychometric criteria were based on information provided on sample size, the normative sample, item analysis, measures of central tendency, concurrent validity, predictive validity, test/retest reliability, inter-examiner reliability, explanation of testing procedures, and testing qualifications. McCauley and Swisher hypothesized that tests with the most criteria met would be considered the most psychometrically valid of those reviewed and, thus, best for diagnostic use. Rather than identifying strong tests for diagnostic use by speech-language pathologists, this review highlighted the shortcomings of this cadre of tests. Results indicated that many of the assessment tools being used to identify speech and language disorders could not be used with any validity for such a purpose, as only 12 of the 30 assessment tools reviewed met even three of the original ten criteria. The psychometric criteria applied in this study have become the hallmark for assessing test validity to this point in the field of communication sciences and disorders, as they have been used repeatedly for this purpose for the last two decades (Friberg, 2010; Hutchinson, 1996; Mikucki & Larrivee, 2006; Plante & Vance, 1994). Taking the lead from this foundational study (McCauley & Swisher, 1984), several other researchers have conducted in-depth studies of commonly used assessment tools focusing on different aspects of test validity within the fields of audiology and speech/language pathology. These researchers have identified issues related to the composition of normative samples (Pena, Spaulding, & Plante, 2006), use of standardized assessment tools with clients from culturally and linguistically diverse backgrounds (Restrepo & Silverman, 2001; Thomas-Tate, Washington, & Edwards, 2004; Yavas & Goldstein, 1998), and interpretation and application of standardized assessment scores (Pena et al., 2006; Plante & Vance, 1994, 1995). In each of these studies, some threat was found to the test validity of the instrument being used to evaluate an individual's communication skills, indicating that the overall validity associated with scores obtained on many clinically applied behavioral testing instruments remains an area of concern.

Recently, the notion of diagnostic accuracy has been featured in research related to an assessment tool's test validity (Friberg, 2010; Spaulding, Plante, & Farinella, 2006). This shift represents a new direction for researchers studying test validity in communication sciences and disorders because earlier research did not address this notion directly. Diagnostic accuracy refers to the degree with which a given assessment tool is able to diagnose the presence or absence of a disorder accurately. Diagnostic accuracy is of particular concern, as it has been determined that even tests with acceptable levels of test validity cannot always discriminate disordered skills from those considered to be more reflective of typically developing children (Gray, Plante, Vance & Henrichsen, 1999; Plante & Vance, 1994, 1995). To this end, it has been suggested that it might be of greater importance to evaluate the diagnostic accuracy of a particular assessment tool than it is to focus on other psychometric criteria used in the past. The diagnostic accuracy of a test indicates its overall accuracy of diagnosis, and ignoring this variable could lead to the improper identification of a disorder, with children being identified as disordered when they actually have typical functioning or, conversely, identified as being typically developing when a disorder is actually present (Dollaghan, 2004; Spaulding et al., 2006). Consequently, it has been suggested that it is inappropriate to assess the overall test validity of assessment tools for which data related to the diagnostic accuracy of the tests are not reported (Spaulding et al., 2006).

Diagnostic accuracy of a particular assessment tool is often described using two different measures: sensitivity and specificity. Sensitivity is the likelihood that a child who has previously been diagnosed as disordered is found to be disordered when using a different (but related) assessment tool. Conversely, specificity is the likelihood that a child considered to be typically developing in the area being assessed is identified as such, again using a different, but related, test (Dollaghan, 2004; Spaulding et al., 2006). Possessing this information related to the diagnostic accuracy of any particular assessment tool is critical, as lower than ideal levels of either sensitivity or specificity can lead to misdiagnosis, inaccurate eligibility determination, and possibly the provision of inappropriate services. Within the standardization process for assessment tools, sensitivity and specificity are measured by percent, with values indicating the overall accuracy of a particular assessment tool to make a valid diagnosis. Because it is important to ensure diagnostic accuracy, Plante and Vance (1994) and Dollaghan (2004) suggest that the threshold values for acceptable levels of sensitivity and specificity should be 80% or greater (Plante & Vance 1994), indicating that at least 80% of the time, children are correctly diagnosed when a particular assessment battery is administered. Without acceptable levels of sensitivity and specificity, results collected from an assessment tool cannot be considered a valid measure of the child's performance.

A great deal of information on the sensitivity of tests used in the assessment of (C)APD has been based on the performance of adults who have verified lesions in the auditory cortex. For example, a deficit in frequency pattern recognition has been observed in adults with a compromised central auditory system (Musiek & Pinheiro, 1987b). From this data on adults with a damaged auditory cortex, interest arose concerning the prospect of using these behavioral tests in children to diagnose (C)APDs. However, while it is well understood that performance on tests for adults cannot be compared equally to the performance of children, securing children to serve within a normative sample who have no known auditory lesions is not an easy task to accomplish. Thus, in order to accurately diagnose (C)APD in children, weaknesses on behavioral tests must be connected with difficulties that children are experiencing in the classroom. With the understanding that performance on behavioral tests constitutes an important piece of the (C)APD diagnostic puzzle, clinicians must be able to trust the results obtained using these measures. Thus, the presence of acceptable levels of diagnostic accuracy for all behavioral assessment tools does remain the gold standard for accurate (C)APD diagnosis.

Purpose of Research

Research has repeatedly demonstrated that clinicians cannot discount the need to identify strengths and weaknesses relative to a test's validity prior to its use. Such oversight might well lead to inaccurate diagnostic decision making. Additionally, research has suggested that paramount to the notion of test validity, diagnostic accuracy must be a central consideration in the selection of tests meant to diagnose the presence or absence of a particular disorder. Therefore, the current research sought to examine the data provided within examiner's manuals and peer-reviewed, published research for a variety of behavioral (C)APD assessment tools to accomplish the following: 1) identify (C)APD tests that report information related to their diagnostic accuracy, 2) evaluate the acceptability of any diagnostic accuracy evidence found, and 3) assess the test validity and reliability of those (C)APD tests found to have reported levels of diagnostic accuracy.

Method

Selection of Assessment Tools for Evaluation

The purpose of this study was to examine the diagnostic accuracy and test validity of commercially available behavioral tests used to diagnose the presence or absence of (C)APD. Determining which tests to include in this study was complicated in light of the fact that no standard protocols exist for determining which tests should be administered for the most efficient, accurate diagnosis of (C)APD (Emanuel, 2002; Singer, Hurley, & Preece, 1998). In an effort to comprehensively review all relevant (C)APD assessment tools, behavioral tests identified by Chermak et al. (2007) and Emanuel (2002) as being frequently utilized by practicing clinicians were reviewed for this study with few exceptions. Emanuel (2002) found the Rapid Alternating Speech Perception Test (RASP; Willeford, 1976) was commonly administered by clinicians; however, due to recommendations that the RASP not be used secondary to poor quality recordings and norms (Shea & Raffin, 1983), this test was not considered in the present review. Three newly published, standardized (C)AP tests were added for review: the Multiple Auditory Processing Assessment (MAPA; Schow, Seikel, Brockett, & Whitaker, 2007), the SCAN-3 for Adolescents and Adults (SCAN-3:A; Keith, 2009b) and the SCAN-3 for Children (SCAN-3:C; Keith, 2009c). Based on these guidelines, 22 assessments commonly employed by audiologists for (C)APD testing were secured for review. These 22 tests were categorized as either standardized or criterion-referenced, based on the presence or absence of a normative sample.

Fifteen of the 22 selected tests were found to be criterion-referenced. These tests included: the Bamford-Kowal-Bench Speech In Noise Test (BKB-SIN; Etymotic Research, Inc., 2005), Competing Sentences (CS; Willeford, 1977), Dichotic Digits Test (DDT; Auditec, n.d.), Dichotic Digits Test (DDT; Musiek, 1983b), Duration Pattern Sequence Test (DPST; Auditec, n.d.), Duration Pattern Test (DPT; Musiek, 1994; Musiek, Baran, & Pinheiro, 1990), Frequency Pattern Test (FPT; Musiek & Pinheiro, 1987b), Gaps-in-Noise Test (GIN; Musiek, 2005), Low-Pass Filtered NU-6 Test (LPF; Auditec, n.d.), Masking Level Difference Test (MLD; Auditec, 2003), Pitch Pattern Sequence Test-Adult Version (PPS-A; Pinheiro, 1977.), Pitch Pattern Sequence Test-Child Version (PPS-C; Pinheiro, 1977), Quick Speech-in-Noise Test (QuickSIN; Etymotic Research, 2001), Random Gap Detection Test (RGDT; Keith, 2000), and Spondaic Binaural Fusion Test (SBF; Auditec, n.d.).

Seven assessment tools were found as standardized and were selected for review. Four of these tests were identified as being amongst the most commonly administered standardized tests for (C)APD (Emanuel, 2002; Chermak et al., 2007): the Auditory Continuous Performance Test (ACPT; Keith, 1994), Auditory Fusion Test-Revised (AFT-R; Keith & McCrosky, 1996), Selective Auditory Attention Test (SAAT; Cherry, 1998), and the Staggered Spondaic Word Test, 5th Edition (SSW-5; Katz, 1998). As previously stated, three recently published standardized tests were added to those identified as being commonly administered: the MAPA (Schow, Seikel, Brockett, & Whitaker, 2007), the SCAN-3:A (Keith, 2009b) and the SCAN-3:C (Keith, 2009c). While not specifically identified as being commonly administered in their revised form, earlier forms of the SCAN-3:A and SCAN-3:C were identified as commonly administered by clinicians (Emanuel, 2002).

Data Collection and Analysis

A similar process was utilized to review (C)APD assessment tools as was used in previous studies concerning tests from other areas of communication sciences and disorders (Friberg, 2010; McCauley & Swisher, 1984; Plante & Vance, 1994). Initially, two communication sciences and disorders graduate students reviewed each of the assessment tools used in this study to judge the presence or absence of information related to each test's diagnostic accuracy, then to selected psychometric criteria, as appropriate. Both students received a training session with the first author of this study and were provided with guidelines to judge whether tests demonstrated specific criterion at an acceptable level. Trainings for student data collectors were two hours in duration and focused on identification of selected psychometric criteria in sample tests from a related professional field (speech-language pathology). After this initial training session, students were encouraged to contact the authors of this study to resolve any questions that arose in the data collection process.

In completing these analyses, graduate student reviewers consulted the examiner's manual provided as part of each commercially purchased assessment tool studied. The examiner's manuals were critically evaluated to determine whether information was available to indicate the presence or absence of criteria selected for use in this study. Those criteria judged to be present were marked as (+), while those criteria judged to be absent were marked as (-). Immediately, it was evident that few of the test's examiner's manuals contained information relative to the criteria being analyzed because few test manuals contained any evidence of validity as measured by the criteria used in this study. Thus, the authors of this study undertook an extensive literature search to document source data available within original research papers relative to the test validity of (C)APD assessment tools. Searches using the name of each test reviewed and keywords (e.g., [C]APD diagnostic, test validity, diagnostic accuracy, efficiency) were conducted, yielding several studies that could be used for analyses. References cited by authors of the tests were also obtained, which included test protocols and measurements. Information collected in this literature review process was considered in the resulting analysis. Credit was assigned if sufficient evidence indicated the presence or absence of each criterion within a well-executed original research study.

At the conclusion of data collection, all results (from examiner's manuals and from published source data) were pooled and compared for agreement. Initial review of data indicated 97% agreement across raters, as the presence and or absence of each criterion was fairly clear to distinguish for the tests evaluated. Discrepancies (disagreements) amongst data were only found on one criterion (criterion #6, below) from the evaluation of standardized assessments dealing with item analysis. All discrepancies were addressed following procedures reflective of those used in previous research (Friberg, 2010; McCauley & Swisher, 1984). That is, the examiner's manual was revisited by the first author and the student data collector(s) to resolve any disparity in ratings. As a result of this process, three ratings were modified for reporting.

Diagnostic accuracy criteria. Following the initial evaluation of the 22 tests selected for use in this study, those tests found to have no evidence of diagnostic accuracy were reported as such and eliminated from further review. This procedure was consistent with the recommendations of Spaulding et al. (2006), who suggested the inappropriateness of assessing the overall test validity of assessment tools for which data related to their diagnostic accuracy are not reported. Therefore, the tests in which evidence of diagnostic accuracy were identified were further evaluated to ascertain whether each test possessed an "acceptable" level of diagnostic accuracy for clinical use. That is, levels of sensitivity and specificity had to be .80 or greater, in accordance with the recommendations of Plante and Vance (1994) and Dollaghan (2004).

Psychometric validity criteria. Each of the assessment tools with reported levels of diagnostic accuracy were subsequently rated for the presence or absence of specific criteria related to their validity. It was necessary to employ the use of different types of psychometric criteria based on whether an assessment tool was categorized as criterion-referenced or standardized. The following section describes the different criteria utilized to review each of the selected assessment tools.

Criterion-referenced tests. McCauley (1996) described guidelines for developers and users of criterion-referenced tests, which identified strengths and weaknesses relative to a given test's design and structure. Specifically, six guidelines related to a test's overall test validity were presented, with suggestions of how test users could look for certain types of evidence to support or refute a particular test's clinical use. These were not hard and fast recommendations, but rather suggestions for clinicians to consider when evaluating diagnostic tests. These guidelines were used to form the foundation from which criterion-referenced tests were evaluated within this current study. To evaluate the qualities of the criterion-referenced tests found to have evidence of diagnostic accuracy, the authors of the current study carefully considered each of McCauley's guidelines and determined what evidence tests would need in order to possess acceptable test validity. Each item of evidence needed by a test was established as a separate criterion, and each criterion-referenced test was evaluated for the presence and/or absence of these separate criteria. Three of McCauley's guidelines were used as specific individual criterion to judge the overall test validity of

Table 1. **Psychometric Criteria used in the Evaluation of Criterion-Referenced Tests**

Criteria #	Description of Criteria[a]
1	Clear definition of test domain, with inclusion of the following information:
	a. Clear definition of behavior assessed
	b. Statement of tasks to be completed
	c. Plan guiding item construction/item analysis
2	Evidence of validity, with inclusion of data reflecting the test's:
	a. Specific criteria for pass/fail scoring
	b. Predictive validity
	c. Concurrent validity
	d. Sensitivity of test
	e. Specificity of test
3	Evidence of reliability, with inclusion of data reflecting the test's:
	a. Inter-rater reliability
	b. Test/re-test reliability
4	Careful description of test takers used in studies of reliability/validity
5	Detailed description of test administration
6	Detailed description of user qualifications

[a] Description of psychometric criteria used for evaluating the test validity of criterion-referenced (C)APD tools is available in McCauley (1996).

each separate assessment tool. The remaining three guidelines were expanded, and in doing so, seven sub-criteria were created. Therefore, a total of eleven distinct criteria were applied to each of the criterion-referenced tests. Table 1 lists each of the criteria used in assessing criterion-referenced tests as part of this current study. These criteria are briefly explained in the following section:

- ***Criterion 1*:** Information should be provided that allows for a clear description of the test's overall scope and structure. Tests were classified as meeting Criterion 1 if information was available related to the following subcriteria: Criterion 1a (provision of a clear definition of the test's purpose/behaviors), Criterion 1b (inclusion of a statement of tasks to be completed as part of the test), and Criterion 1c (provision of a plan guiding item construction/item analysis).
- ***Criterion 2:*** Data should be available to provide evidence of a test's validity prior to its diagnostic use. Tests were classified as meeting Criterion 2 if information was available related to the following subcriteria: Criterion 2a (presence of specific criteria for pass/fail scoring), Criterion 2b (evidence of predictive validity), and Criterion 2c (evidence of concurrent validity).
- ***Criterion 3:*** The consistency and stability of scores obtained on a test over time in various testing situations must be established. Tests were classified as meeting Criterion 3 if information was available related to the following subcriteria: Criterion 3a (test should have a reported inter-rater reliability coefficient of .90 or greater) and Criterion 3b (test should have a test-retest reliability coefficient of .90 or greater).
- ***Criterion 4:*** Each test must provide a thorough description of the test takers who participated in studies of the test's validity. Tests were classified as meeting Criterion 4 if the test provided information for clinicians to review regarding gender, age, grade, socio-economic status, impairment status, and/or geographic distribution of the validation sample.
- ***Criterion 5:*** Each test must provide a clear and detailed description of test administration. Tests were classified as meeting Criterion 5 if the manual provided instructions detailed enough for standard, straightforward administration by a qualified clinician in a manner that is "in compliance with recommended procedures" to "increase the likelihood that the measure will function as intended" (McCauley, 1996, p. 128).
- ***Criterion 6:*** Tests must provide a clear description of the requirements for an examiner to be deemed qualified to administer the test in question. Tests were classified as meeting Criterion 6 if the examiner's manual elaborated on the educational training needed to administer and interpret the results of the test.

Standardized assessment tools. With few modifications, criteria developed by McCauley and Swisher (1984) have been utilized for judging validity of the selected standardized (C)APD assessment tools. Beyond these original ten criteria, one new criterion was added, and one existing criterion was modified. These changes were made to identify threats to test validity more completely, relative to suggestions in recent research advocating for a broadening of focus when considering the test validity of standardized tests. Criteria that remained unchanged from McCauley and Swisher's prior work (1984) are identified and briefly described in Table 2. New and modified psychometric criteria used to review assessment tools in this study are described briefly below.

Clearly defined standardization sample. This criterion was part of McCauley and Swisher's original research (1984), and required that all standardization samples contain information that would allow clinicians to consider the characteristics of the normative sample to ensure that a test that might be administered is representative of the child(ren) to be tested. The importance of a clearly defined standardization sample cannot be understated because test scores obtained from a standardized test (using norms gathered from individuals not reflecting the demographics of the child being tested) cannot be considered a valid representation of strengths or weaknesses with regard to the skill being tested. Furthermore, researchers have stated that "the most compelling [diagnostic] evidence" is found when standardization samples are "broadly representative of the range of individuals about whom the diagnostic decision is to be made" (Dollaghan, 2004, p. 395-6). Thus, a clearly defined standardization sample gives clinicians knowledge of what subgroups of individuals to whom their client(s) will be compared, which will help to inform test selection and ensure a more valid measurement outcome.

Originally, there were only three demographic categories listed as part of this criterion: geographic representation, socioeconomic status, and the communication status of those in the normative group (typical vs. atypical skills; McCauley & Swisher, 1984). These three demographic categories have been expanded to further consider the normative sample for each assessment tool evaluated in this study. Specifically, Spaulding et al. (2006) suggested that any consideration of the normative sample should include the addition of age and gender distribution, as well as ethnic background. Additionally, Entwisle and Astone (1994) indicated that parental education level could serve as an acceptable measure of socio-economic status, as these variables have been found to correlate with one another. Thus, a test was considered to have met this criterion if it provided information about its standardization sample related to geographic representation, socio-economic status representation, gender distribution, ethnic representation, sample +/- impairment(s), and age distribution.

Purpose of assessment tool. Identification of the purpose of an assessment tool has recently been emphasized for a variety of important reasons (Merrell & Plante, 1997; Plante & Vance, 1995; Spaulding et al., 2006). Specific to standardized assessment tools, standardized tests are often administered to document the existence (or non-existence) of a disorder. Similarly, a test might be given in order to quantify the severity of an existing disorder.

A lack of information detailing the purpose of a given assessment tool may compromise the validity of the data collected when the test is administered. Clinicians might make decisions related to eligibility and treatment based on results for a test meant to be used for one purpose that was actually administered to serve an entirely different clinical function. Thus, information related to a test's purpose(s) is a critical component for any assessment tool.

For the purposes of this current review, an assessment tool was considered to have provided an acceptable amount of information related to the purpose of the test if the examiner's manual contained a section outlining the specific purpose(s) of the test in question.

Results

Diagnostic Accuracy

Criterion-referenced tests. Of the 15 criterion-referenced tests reviewed, five tests (CS, Willeford, 1977; DDT, Auditec, n.d.; DPT, Musiek, 1994; FPT, Musiek & Pinheiro, 1987b; GIN, Musiek, 2005) were found to have reported levels of sensitivity and specificity for clinical review. One test was found to have reported levels of sensitivity, but no reported specificity (DD, Musiek, 1983b) and nine other tests (BKB-SIN, Etymotic Research, Inc., 2005; DPST, Auditec, n.d.; LPF, Auditec, n.d.; MLD, Auditec, n.d.; PPS-A, Pinheiro, 1977; PPS-C, Pinheiro, 1977; QuickSIN; Etymotic Research, 2001; RGDT, Keith, 2000; SBF, Auditec, n.d.) were found to have no reported evidence of either sensitivity or specificity in their examiner's manuals or peer-reviewed research publications.

With regard to the level of diagnostic accuracy identified, only the DPT (Musiek, 1994) and FPT (Musiek & Pinheiro, 1987b) were found to have acceptable levels of diagnostic accuracy, as

Table 2. **Summary of McCauley and Swisher (1984) Psychometric Criteria Used For Analysis of (C)APD Assessments**

Psychometric Criteria	Description of Criteria[a]
Adequate Sample Size	Must have at least 100 participants in each comparison subgroup within the normative sample
Evidence of Item Analysis	Test items for the test in question are scrutinized to ensure that they test what they purport to measure.
Measures of Central Tendency Reported	Means and standard deviations of normative sample must be available to allow for flexibility in comparing scores/data within the test in question.
Concurrent Validity is Documented	Results from another, similar, standardized instrument agree with the results obtained from the test in question.
Predictive Validity is Documented	Performance on the test in question is predictive of performance on other, less formal measure (observation, etc.) in a more functional setting.
Test/Retest Reliability is Reported	Ensures that test scores on the test in question are stable over time (correlation of .90 or greater must be reported)
Inter-Examiner Reliability is Reported	Ensures that test scores on the test in question don't fluctuate depending if different clinicians administer the test (correlation of .90 or greater must be reported)
Testing Procedures Explained Sufficiently	Sufficient detail must be provided to ensure that the test can be administered in a way that mirrors test administration for normative sample.
Testing Qualifications Explicitly Stated	Special training/qualifications for test administrators must be clearly stated.

[a] Detailed descriptions of psychometric criteria are available in McCauley and Swisher (1984).

both possessed sensitivity and specificity values of .80 or greater (Dollaghan, 2004). It should be noted that three criterion-referenced tests were reported to have acceptable levels of specificity, but were lacking acceptable levels of sensitivity (CS, Wellford, 1977; DDT, Auditec, n.d.; and GIN, Musiek, 2005). Only one test was reported to have an acceptable level of sensitivity, though no data was available to judge the specificity of the test (DD; Musiek, 1983b).

Standardized tests. Of the seven standardized tests reviewed, three tests (MAPA, Schow et al., 2007; SCAN-3:A, Keith, 2009b; SCAN-3:C, Keith, 2009c) were each found to have reported levels of sensitivity and specificity above .80, indicating acceptable levels of diagnostic accuracy (Dollaghan, 2004). It should be noted that the sensitivity and specificity for the SCAN-3:A and SCAN-3:C were acceptable only at specific cut scores, specified within each test's examiner's manual.

One test (SSW-5; Katz, 1998) was found to have reported levels of specificity, but not sensitivity, and three tests were found to have no reported evidence of diagnostic accuracy published at all (ACPT, Keith, 1994; AFT-R, Keith & McCrosky, 1996; SAAT, Cherry, 1998). Table 3 contains a listing of the tests found to have evidence of diagnostic accuracy, the reported levels of sensitivity and specificity, and the source from which these data were found.

Evidence of Test Validity

A complete accounting of the presence and absence of each selected psychometric criterion can be found in Table 4 (Criterion-Referenced Tests) and Table 5 (Standardized Assessment Tools). The criteria are arranged by assessment tool.

Criterion-referenced tests. Of the six criterion-referenced tests evaluated to determine their level of test validity, no assessment tool was able to meet all 11 criteria applied to them as part of this study. Rather, the six criterion-referenced assessment tools were found to possess a range from three to six of the evaluated criteria, with four tests meeting three criteria (CS, Willeford, 1977; DDT, Auditec, n.d.; DPT, Musiek, 1994; and FPT, Musiek & Pinheiro, 1987b) and one test (GIN, Musiek, 2005) meeting six criteria.

Table 3. **Evidence of Diagnostic Accuracy for (C)APD Assessment Tools**

Name of (C)APD Assessment Tool	Data Source	Level of Sensitivity	Level of Specificity
Competing Sentences (CS)	Schow et al. (2007)	.25	1.0
Dichotic Digits Test (DDT)	Auditec (n.d.)	.30	1.0
Dichotic Digits Test (DD)	Musiek (1983)	.81	Not reported
Duration Pattern Test (DPT)	Musiek (1994); Musiek et al. (1990)	.86	.92
Frequency Pattern Test (FTP)	Musiek and Pinheiro (1987)	.80	.88
Gaps-in-Noise Test (GIN)	Shinn et al. (2009)	.67	.94
Multiple Auditory Processing Assessment (MAPA)	Shiffman (1999)	.83	.85
SCAN-3 for Adolescents and Adults (SCAN-3:A)	Keith, 2009b	.93	.85
SCAN-3 for Children (SCAN-3C)	Keith, 2009c	.90	.83
Staggered Spondaic Word Test, 5th Edition	Berrick et al. (1984)	Not reported	.77

Note: Abbreviations were used to denote the following (C)APD tests: Competing Sentences (CS; Willeford, 1977), Dichotic Digits Test (DDT; Auditec, n.d.), Dichotic Digits Test (DD; Musiek, 1983b), Duration Pattern Test (DPT; Musiek, 1994; Musiek, Baran, & Pinheiro,1990), Frequency Pattern Test (FPT; Musiek & Pinheiro, 1987), Gaps-in-Noise Test (GIN; Musiek, 2005), Multiple Auditory Processing Assessment (MAPA; Schow, Seikel, Brockett, & Whitaker, 2007), SCAN-3 for Adolescents and Adults (SCAN-3:A; Keith, 2009b), SCAN-3 for Children (SCAN-3:C; Keith, 2009c), and the Staggered Spondaic Word Test, 5th Edition (SSW-5; Katz, 1998).

Of the criteria selected for use in this study, criterion-referenced tests were most able to meet standards relative to detailed description of test administration, clear definition of test domain, and careful description of test takers used in studies of reliability and validity. All criterion-referenced tests provided specific criteria for pass/fail scoring. These tests were less successful at meeting criteria relative to evidence of validity, evidence of reliability, and detailed description of user qualifications. None of the criterion-referenced tests provided information relative to predictive validity, concurrent validity, and inter-rater reliability. The majority of data reviewed with regard to the criterion-referenced tests were found within individual test examiner's manuals with the exception of data related to test sensitivity, which was most often reported in published literature (Musiek, 1983a; Musiek, Baran & Pinheiro, 1990; Musiek & Pinheiro, 1987a; Shinn, Chermak, & Musiek, 2009).

Standardized assessment tools. Of the four standardized assessment tools evaluated for test validity within this study, none met all 11 criteria applied to them. Rather, the SCAN-3:A (Keith, 2009b) and SCAN-3:C (Keith, 2009c) each met seven criteria, the MAPA (Schow et al., 2007) met six criteria, and the SSW-5 (Katz, 1998) met five criteria. Of the criteria applied to the standardized tests analyzed in this study, all tests met four criteria uniformly: identification of test purpose, adequate explanation of testing procedures, evidence of item analysis, and reporting of measures of central tendency. Conversely, no test reported data relative to concurrent or predictive validity. Only the SCAN-3:A and SCAN-3:C provided information to clearly describe the normative sample used to standardize the test for clinical use. All data reported for standardized (C)APD assessment tools were found in the test examiner's manuals, with the exception of information relative to the SSW-5, which was found in published research (Berrick et al., 1984).

Discussion

Many audiologists rely on behavioral tests to diagnose (C)APD. Behavioral tests have offered audiologists a fairly inexpensive and readily obtainable means for assessing auditory processing skills, particularly in children (Emanuel, 2002; Jerger & Musiek, 2000). Information from behavioral tests can also provide an understanding of the auditory tasks on which a person may have the most difficulty, as these measures may carry significant meaning for how an individual performs in an everyday listening environment. For these reasons, it is important that clinicians have the opportunity to utilize tests that have acceptable levels of diagnostic accuracy and adequate test validity. The current review of commonly utilized (C)APD assessment tools, both standardized and criterion-referenced, highlights many important considerations for clinicians engaging in such diagnostic endeavors.

It should be noted that for several tests that were analyzed, tests' authors made reference to published literature that offered additional diagnostic accuracy and general psychometric data beyond that provided within the examiner's manuals. In an effort to be comprehensive in this review of (C)APD assessment tools, this information was obtained and included in the study. The question remains, however, whether data reflective of measures of each test's overall validity belongs within the examiner's manual or within outside, refereed research published in relevant journals. McCauley (1996) urges that

Table 4. **Results from Psychometric Analysis of Criterion-Referenced (C)APD Tests**

Criteria Descriptors		CS	DDT	DD	DPT	FPT	GIN
1	Clear Definition of Test Domain						
a	Clear definition of behavior assessed	-	-	+	-	-	+
b	Statement of tasks to be completed	+	+	+	+	-	+
c	Plan guiding item construction/item analysis	-	-	-	-	-	-
2	Evidence of Validity						
a	Specific criteria for pass/fail scoring	+	+	+	+	+	+
b	Predictive validity	-	-	-	-	-	-
c	Concurrent validity	-	-	-	-	-	-
3	Evidence of Reliability						
a	Inter-rater reliability	-	-	-	-	-	-
b	Test/retest reliability	-	-	-[a]	-	-	+[b]
4	Careful description of test takers used in studies of reliability and validity	-	-	-	-	+	+
5	Detailed description of test administration	+	+	+	+	+	+
6	Detailed description of user qualifications	-	-	-	-	-	-
	Total Criteria Met:	3/11	3/11	4/11	3/11	3/11	6/11

Note: Abbreviations were used above to denote the following criterion-referenced tests: Competing Sentences (CS; Willeford, 1977), Dichotic Digits Test (DDT; Auditec, n.d.), Dichotic Digits Test (DD; Musiek, 1983b), Duration Pattern Test (DPT; Musiek, 1994; Musiek, Baran, & Pinheiro, 1990), Frequency Pattern Test (FPT; Musiek & Pinheiro, 1987b), Gaps-in-Noise Test (GIN; Musiek, 2005)
[a] Found in Musiek, Gollegly, Kibbe, and Verkest-Lenz (1991); [b] Found in Shinn, Chermak, and Musiek (2009)

examiner's manuals need to specify not only an accounting of tasks to be accomplished during the administration of a test, but a plan for item construction and analysis, as well. Without this information provided, it is possible that during test administration, a clinician might "misconstrue the test takers' competencies," therefore undermining the usefulness of any results collected within a given test (McCauley, 1996, p. 126). Tests evaluated for this study were varied in their success in including these categories of information within their examiner's manuals. The majority of standardized and criterion-referenced assessment tools provided a clear statement of tasks to be accomplished, yet only the standardized tests evaluated here included information relative to item analysis for consideration. None of the criterion-referenced tests offered this information for diagnosticians. It would seem that, at a minimum, this might be a place to start with revisions of existing (C)APD tests and the introduction of new tests in this area. Publishing the remainder of psychometric data in peer-refereed journals could be deemed as acceptable, so long as clinicians were able to easily identify and secure such research for their review prior to selecting a (C)APD test for administration. It should be noted that Emanuel (2002) found commercially available tests that included detailed administration, interpretation, and scoring procedures as part of the testing package were most widely used for diagnosing (C)APD.

Overall, it would seem that none of the tests evaluated within this study exemplifies a precise diagnostic gold standard for (C)APD, as no test possessed all criteria applied to assess either diagnostic accuracy or test validity. Results from this study highlighted the strengths and weaknesses inherent within each of the tests analyzed. These strengths and weaknesses must be identified in order to inform selection of valid tests for clinical diagnosis of (C)APD. Clinical audiologists have the onus of utilizing evidence-based practices to select diagnostic tools (ASHA, 2005b), yet it is a complicated task to interpret research findings to compare and contrast assessment tools for clinical use. Findings from this research can serve as a starting point for such diagnostic decision making. Knowing the diagnostic accuracy and test validity of assessment tools available for use constitutes the first step in mitigating the threat of clinical misdiagnosis (Plante & Vance, 1994).

Table 5. **Results from Psychometric Analysis of Standardized (C)APD Assessments**

	Criteria Description	MAPA	SSW-5	SCAN-3:A	SCAN-3:C
1	Test Purpose Identified	+	+	+	+
2	Tester Qualifications	+	-	+	+
3	Procedures Explained	+	+	+	+
4	Adequate Sample Size	+	+	-	-
5	Sample Clearly Defined				
	a. geographic representation	-	-	+	+
	b. parent education/SES	-	-	+	+
	c. gender distribution	-	+	+	+
	d. ethnic representation	-	-	+	+
	e. +/- impairment	-	+[a]	+	+
	f. age distribution	+	+	+	+
6	Evidence of Item Analysis	+	+	+	+
7	Measures of Central Tendency	+	+[a]	+	+
8	Concurrent Validity	-	-	-	-
9	Predictive Validity	-	-	-	-
10	Test/Retest Reliability (>.90)	-	-	-	-
11	Inter-Examiner Reliability (>.90)	-	-	+	+
	# Criteria Met (per assessment tool)	6/11	5/11	7/11	7/11

Note: Abbreviations were used above to denote the following standardized tests: Multiple Auditory Processing Assessment (MAPA; Schow, Seikel, Brockett, & Whitaker, 2007), SCAN-3 for Adolescents and Adults (SCAN-3:A; Keith, 2009b), SCAN-3 for Children (SCAN-3:C; Keith, 2009c), and the Staggered Spondaic Word Test, 5th Edition (SSW-5; Katz, 1998).
[a] Found in Berrick, Shubow, Schultz, Freed, Founier, and Hughes (1984).

Data collected were reflective of several key ideas and trends across all assessment tools analyzed. Most notably, less than half of the tests analyzed for this study were found to have any published data reflecting their diagnostic accuracy. ASHA demands that clinicians use evidence-based techniques to diagnose (C)APDs (2005a), and the use of tools that accurately identify the presence or absence of any disorder is fundamental for clinical practice based on research and evidence to support it (McCauley & Swisher, 1984; Plante & Vance, 1994; Spauding et al., 2006).

Looking specifically at test validity, the majority of assessment tools evaluated in this study have acceptable levels of information provided relative to the more procedural aspects of test administration (e.g., clear definition of test domain, detailed description of test administration), yet they lack supporting data relative to the foundational constructs of validity and reliability. These supporting data are the underpinnings of accurate clinical diagnosis (Hutchinson, 1996; McCauley & Swisher, 1984). This lack of support is particularly problematic in light of best practice guidelines from ASHA, which indicate that tests with solid reliability and validity be selected for clinical use (ASHA, 2005b). That said, many audiologists still do not know whether the (C)AP tests they use are accurate for diagnosing the existence of a (C)APD (Chermak et al., 2007).

Thus, data from this study suggest that there is work to be done in critically examining tests commonly used to diagnose the presence or absence of (C)APD. First and foremost, more information is needed for potential test administrators with regard to each test's validity (Hutchinson, 1996). Without knowing that a test can be compared to other, similar tests and activities (concurrent and predictive validity), one cannot possibly measure (C)AP skills precisely. Similarly, tests that lack reliability in the form of inter-rater and test-retest reliability are cause for concern, as there is no confidence that test scores recorded at a particular juncture would hold true over time and administrator. Again, these shortfalls pose a tremendous threat to accurately measuring (C)AP capabilities. Thus, there is a great need for additional research to determine the overall efficacy of those assessment tools that lack test validity and reliability data to support or refute their continued clinical application (Keith, 2009a).

Ideally, the first question audiologists should ask in selecting an assessment tool is whether it is able to accurately diagnose the presence or absence of a disorder. Of the 22 tests selected for evaluation in this study, only seven tests (32%) contain acceptable levels of sensitivity for diagnosing (C)APD while eight (36%) report adequate levels of specificity. This indicates that the majority of tests identified as being the most commonly used tests for (C)APD (Chermak et al., 2007; Emanuel, 2002) lack data related to their diagnostic accuracy. Assessment tools that do not have these data reported in examiner's manuals or in refereed journal articles should be used with the utmost caution, as they might well be inappropriate for use in making diagnostic decisions (Spaulding et al., 2006).

If a selected test possesses adequate diagnostic accuracy, audiologists must then use their clinical expertise to carefully consider that assessment tool's overall test validity (Spaulding et al., 2006). Overall, a guiding principle to direct this selection of assessment tools is the notion that if threats to a test's validity are minimal, the test is likely appropriate to consider for clinical use. The converse is also true; that if threats to a test's validity are large in number, then the test is likely inappropriate for diagnostic use. Audiologists need to undertake (C)APD testing with the understanding that no one assessment tool is likely sufficient for use as a basis for diagnostic decision making (ASHA, 2005a; Emanuel, 2002). Rather, a variety of assessment tools need to be used to confirm the presence or absence of (C)APD, and through interpretation of test data, evaluation of each administered test's validity, and through triangulation of all data (including that gathered from non-behavioral tests), a diagnosis likely can be reached (ASHA, 2005a).

Difficulty in standardizing behavioral tests that assess (C)AP abilities in children can be associated with the complexity of separating auditory processing skills from cognitive and language capabilities. To add to this dilemma, various tests used for evaluating (C)AP have been derived from research on adults with identified pathological conditions in the central auditory nervous system (e.g. Dichotic Digits Test, Duration Pattern Test)). However, in children, additional characteristics such as cognition and language can affect the comprehension of auditory information, making it extremely difficult to extricate auditory processing as a discrete entity (ASHA, 2005). Even with the use of electrophysiologic testing, a general form of learning disability may not be delineated from a specific auditory deficit. Obviously, these factors complicate the process of ensuring strong test validity for (C)APD assessment tools. It is imperative, therefore, that clinicians make certain that accurate diagnoses are made with regard to (C)APD, even in the face of such complications. Knowing the validity of behavioral tests commonly administered as part of the (C)APD battery is a step in the right direction.

In the future, specific questions need to be addressed in order to develop a "gold standard" for (C)APD tests. First of all, a determination must be made relative to which criteria should be used for validating sensitivity and specificity of a test in the absence of a normative group with a known neurological lesion. Additionally, guidelines must be developed to explore the relationship between cognition, language skills, and performance on (C)AP tests. Finally, audiologists must determine the best standard for determining when a child falls within the clinical population for a (C)APD in order to make accurate diagnoses. This research will aid with the third charge, but work is needed to begin to address other identified concern.

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Report on a School Board's Interprofessional Approach to Managing the Provision of Hearing Assistance Technology for Students with Auditory Processing Disorders

Stella Ng, MSc
Thames Valley District School Board &
The University of Western Ontario
London, Ontario, Canada

Vesna Fernandez, MHSc
Brenda Buckrell, MClSc
Karen Gregory, MEd
Thames Valley District School Board
London, Ontario, Canada

The purpose of this article is to describe one Ontario school board's protocol for the provision of hearing assistance technology (HAT) for students with auditory processing disorders (APD). Audiologists are faced with assessment and management challenges surrounding APD. An interprofessional approach is recommended because APD is multi-faceted and complex. Audiologists, speech-language pathologists, psychologists and education professionals play a role in the assessment and management of APD; however, realities of practice often make it difficult to coordinate the efforts of multiple professionals. The Thames Valley District School Board (TVDSB) observed that clinical audiologists alone were left to assess and make recommendations for children with auditory processing challenges. As such, a greater number of students than the Board's staff and budget could manage were receiving recommendations for HAT from their clinical audiologists. The TVDSB needed a way to manage the volume of requests for HAT in such a way that optimally serving student need was prioritized. Thus, the TVDSB APD protocol was developed. This article explains the rationale for the TVDSB APD protocol, its guiding principles, and procedures. The protocol is an interprofessional, evidence-informed approach to managing HAT for APD in the school setting. Two case examples illustrate the protocol at work, and implications and subsequent steps are discussed.

Introduction

The assessment and management of auditory processing is a challenging domain for audiologists, and as such it is often a controversial topic. The following report reflects the perspective from which a school board's auditory processing protocol was designed, explains the protocol's guiding principles and procedures, and discusses how it is implemented by educational audiologists and other health and education professionals employed by the Thames Valley District School Board (TVDSB).

Children who are referred for APD testing often present with multiple concerns, including speech, language, cognition, attention, and learning difficulties (Witton, 2010). Some experts suggest that evaluation for an auditory processing disorder (APD) should occur *in addition to* assessment of other domains (Bellis & Beck, 2000; Bellis & Ferre, 1999). If a child, for example, has a severe speech or language impairment, or an autism spectrum disorder, this could significantly impact the validity of an auditory processing screening tool or some tests in an APD assessment battery (Dawes & Bishop, 2010; Whitelaw, 2003). Thus, recommendations based on the results of an audiologist's APD screening or assessment must be made and interpreted with careful consideration of potential confounds and co-morbidities. Ideally, these recommendations should be made collaboratively with other professionals who have assessed the other domains (American Speech-Language-Hearing Association [ASHA], 2005b; Bellis & Beck, 2000). However, the reality of audiology practice in our local context is that clinical audiologists conduct their assessments and report their results and recommendations. These results and recommendations are shared with parents and relevant agencies and professionals.

Due to time and resource constraints, and limited availability of assessment batteries (Emanuel, 2002), auditory processing assessments conducted in local audiology clinics are not necessarily comprehensive. They are often screenings, which may not meet the criteria of minimal assessment batteries described in the literature (ASHA, 2005a). In and of themselves, screenings or minimal assessments of auditory processing abilities may not be sufficient to inform educational programming or recommendations that translate from a clinical setting to the classroom environment. Depending on a child's needs, a tailored interprofessional approach informed by a combination of assessments, including academics, attention, cognition, language, learning, and speech is recommended for both assessment and management (ASHA, 2005a; Bellis & Beck, 2000; Bellis & Ferre, 1999; Dawes & Bishop, 2010; Jerger & Musiek, 2000; Sharma, Purdy, & Kelly, 2009). Multiple perspectives, including those of professionals working with the student *in the classroom setting,* are most helpful in providing appropriate academic student/patient-centered programming (Bellis & Beck, 2000).

Hearing Assistance Technology for Students with an Auditory Processing Disorder

Clinical audiologists' recommendations for children with auditory processing disorders are considered seriously by TVDSB. A very common recommendation that TVDSB receives from local audiologists is the provision of hearing assistance technology (HAT) for students with suspected APD. HAT refers to personal or sound field amplification systems. Personal HAT typically uses frequency modulation to transmit the teacher's voice to a student-worn receiver. The receiver is either worn at the ear-level (receiver in the ear), or on the body with headphones or earbuds used as transducers. Sound field HAT utilizes one or more loudspeakers to broadcast the teacher's voice to the entire classroom.

We do not rely upon the clinical audiology report as the sole information source upon which to base HAT provision for students with auditory processing challenges. Not all HAT recommendations are appropriate and feasible for all situations; it is important for clinical audiologists to consult with school system staff to ensure that work is accomplished together. Otherwise, parents are placed in the difficult position of managing differing views between clinical and educational professionals. Audiologists must consider each student's individual needs in the classroom, which are sometimes significantly different from how the student presents in the audiology clinic. Thus, clinical and educational audiologists must work as partners in supporting clients/students to ensure client/student-centered best practices are provided.

Funding for Hearing Assistance Technology

Hearing assistance technology in the province of Ontario's public school systems is jointly funded by the individual school board's special education budget and the Ontario Ministry of Education's Special Education Amount (SEA; Ontario Ministry of Education, 2009). School boards are required by the Ontario Ministry of Education to responsibly manage use of the ministry-funded SEA, which funds the purchase and maintenance of equipment essential to students' special education needs. School boards must pay for the first $800 of such equipment from their own budgets, with SEA covering the remaining cost. School boards are asked to develop their own policies and procedures for management of SEA assets, and as such, are held accountable for their use of the funds. Audits are conducted annually by the Ontario Ministry of Education, to ensure proper and consistent use of SEA-funded equipment. The TVDSB staff who manage APD have implemented a protocol to responsibly negotiate the purchase of HAT for students with APD.

Background on Thames Valley District School Board

The TVDSB is a public education provider servicing the London and surrounding area, a district located in Southwestern Ontario. The TVDSB covers 175,000 students in 140 elementary schools and 30 secondary schools. There are approximately 500 students with a peripheral hearing loss on the TVDSB Deaf and Hard of Hearing Program's caseload. The population of students with an APD as identified by a clinical audiologist is estimated at 200, although only half this number results in consultation with speech-language pathology and audiology services throughout a school year. In some cases, students are identified by the clinical audiologist as having auditory processing challenges, but the audiologist makes no recommendations beyond preferential seating and other minor accommodations, which are typically managed at the school level.

The TVDSB employs itinerant teachers of the Deaf and Hard of Hearing (6.5 full-time equivalents) to directly support the students with peripheral hearing loss, in consultation and collaboration with two educational audiologists (sharing one full-time equivalent). The TVDSB employs 35 speech-language pathologists. Each school has at least one Learning Support Teacher (LST), who acts as case manager for students with special education needs. A speech-language pathologist co-ordinates speech, language, and audiology services for the TVDSB, while a special education learning coordinator (a certified teacher) oversees the Deaf and Hard of Hearing program (including the teachers of the Deaf and Hard of Hearing).

Educational audiology in the TVDSB. In Canada, there is currently no standard for assessment and management of APD, although a guideline is in development. In Ontario, educational audiologists do not tend to conduct clinical assessments of hearing or auditory processing. In this article, the terms "clinical audiologist" versus "educational audiologist" are used to differentiate between audiologists who provide clinical services in private practices or hospitals, and audiologists who work in the school system acting as support staff, respectively. Educational audiologists act as liaisons between the clinic and the classroom, and as case managers and consultants within the school system. The purpose of providing the above explanation is to emphasize that educational audiologists in this district are not responsible for the clinical assessment of auditory processing. However, educational audiologists play a leading role in the coordination of efforts to support students with APD.

In our district, auditory processing assessments are often prompted by a physician's referral when parents present concerns regarding school performance, or when they hear about such testing through word-of-mouth or teacher referral. The clinical versus educational audiologist distinction thus presents the challenge of and opportunity for collaboration; efforts must be coordinated between the clinical community and the school board to best support clients'/students' needs. In our school board, the educational audiologist is typically not aware that a clinical APD assessment has been conducted until the assessment is complete and clinical audiology report is received. Despite attempts from both sides to improve the coordination of pediatric audiologic care, particularly in the area of APD, much room for improvement exists. Clinical audiologists must continually strive to remain apprised of the nuances of the TVDSB's protocols, funding schemes, and available resources, and the TVDSB must be transparent and consistent in their message to the clinical community.

Rationale for protocol for provision of hearing assistance technology. Currently in the TVDSB, universal sound field amplification does not exist. That is, classrooms are not equipped with any form of hearing assistance technology unless, (1) an individual student has SEA-funded HAT associated with him/her (due to a hearing loss or APD), (2) a parent or school has obtained HAT for a classroom through their own funding (i.e. personal funds, community sponsored), or (3) unique circumstances exist, such as a HAT supplier trialing HAT systems in a particular school site. Retrofitting sound field amplification in each classroom across the 170 existing schools in TVDSB is not currently planned, nor is universal or mandatory installation of sound field amplification planned for newly-built schools. Thus, the TVDSB's audiology services needed to have a feasible and consistent way to respond to clinical audiologists' HAT recommendations for children with suspected APD.

In 2005, professionals working for TVDSB began to develop a protocol for supporting students with identified auditory processing challenges. Development was motivated by an over 200-student waiting list for either personal or sound field HAT recommended by clinical audiologists. Parents often expected the TVDSB to provide HAT once it had been recommended by the clinical professional. However, due to resource constraints, the school board's audiologists could not possibly keep up with the numbers of recommendations for HAT for children with APD. Note that TVDSB speech-language pathologists' and audiologists' caseloads also include thousands of students with speech or language needs, and hundreds with peripheral hearing losses. Also, it was observed that some students who may benefit most from HAT could be situated far down the waiting list for services. Likewise, students who may perhaps benefit from other forms of support (for example, assistive technology for written language) and/or who may not need support in the form of HAT could be situated at the top of the list. Therefore, the "first-come, first-served" approach was not optimally meeting the needs of students.

The TVDSB *does* believe in providing HAT to *appropriate candidates* based on the literature in support of this form of intervention for some individuals with APD (ASHA, 2005a; Johnston, John, Kreisman, Hall, & Crandell, 2009), but must practice within the limitations imposed by resource constraints. The APD protocol was thus developed by a committee comprised of the TVDSB's co-ordinator of speech-language pathology and audiology services (second author), an educational audiologist (third author), and a special education learning coordinator (fourth author). The protocol developers attended workshops about APD, reviewed the available research literature, and considered the local clinical climate and funding schemes within the school board and ministry of education, to create an evidence-informed protocol.

In late 2006, the protocol was piloted, with the first author of this paper (an educational audiologist) taking on the responsibilities of implementing the protocol with an APD committee comprised of five staff members. The APD committee includes members from TVDSB's speech-language pathology and audiology services, psychological services, and special education services administrative team. The following section outlines the TVDSB APD protocol's principles and procedures, followed by two descriptive case examples to illustrate how the protocol is enacted.

Description of the Protocol

Guiding Principles

An important initial point is whether we (the APD committee) should provide personal or sound field HAT to students with APD. We began our protocol with the provision of sound field HAT, with the pragmatic rationale that this equipment benefits the entire classroom rather than just one student with APD. However, as our protocol implementation grew, we transitioned to the provision of personal HAT for three main reasons. First, at the junior or intermediate level (depending on the school), students begin rotary class schedules, moving from one classroom to another for different subjects. Once rotary class schedules begin, the sound field HAT systems are no longer practical. Second, given our accountability to the ministry-funded SEA, we must ensure that the HAT benefits the individual student for whom it is purchased and that the HAT will be used consistently. Personal HAT places a shared responsibility on both teacher and student; the onus placed on the student is informative in confirming benefit and compliance with HAT. Third, we noted that ASHA (2005a) specifically recommends personal HAT because of its documented improvement of signal-to-noise ratio, benefits of which were recently confirmed in a study of personal HAT for children with APD (Johnston et al., 2009).

The TVDSB APD protocol has set out certain criteria that must be met in order for HAT to be pursued for a student with auditory processing challenges. Initially, a student must be identified as struggling in some way that is affecting his/her academic performance. This identification is most commonly instigated by classroom teacher(s) or parent(s) and leads to the formation of the program development team (PDT) and a formal assessment. Auditory processing assessment results suggesting APD must be based on a recent (within one year) formal assessment by a clinical audiologist registered for practice in Ontario. Also, the APD assessment must be completed on a child over the age of 7 years in order for the APD committee to consider provision of HAT (Beck, 2002; Leibold, Yarnell Bonino, & Fleenor, 2007; Pinheiro & Musiek, 1985; Whitelaw & Yuskow, 2006). At the time of the APD assessment, peripheral hearing sensitivity must be documented as normal bilaterally. Note that the TVDSB has a different, simplified procedure for providing amplification for students with peripheral hearing loss as quickly as possible; these students proceed through a different set of steps led by the school's itinerant hearing resource teacher (a teacher of the Deaf and Hard of Hearing). The results and recommendations regarding the APD must indicate the need for accommodations and/or modifications to the student's classroom environment and/or program. Furthermore, regular monitoring of the APD by the clinical audiologist is recommended on an annual basis or as indicated by the clinical audiologist.

The TVDSB APD protocol further specifies that the primary needs of the student must not be the direct result of an *unmanaged* attention deficit/disorder, speech or language delays or impairments, general cognitive functioning deficits, social/emotional difficulties, motor skill difficulties, reading disabilities, learning disabilities, cultural differences, peripheral hearing loss, or behavior disorders. If the PDT has not yet ruled out or identified co-morbidities, they will be identified through the required assessments of the APD protocol. This criterion does *not* preclude students with co-morbidities from receiving HAT support. Rather, if there are concerns in other domains, these concerns must be investigated and addressed in addition to the APD. This requirement ensures that the identification of APD is based on assessments by multiple professionals, that the management of APD does not preclude management of other deficits or disorders, and that provision of HAT is not applied as a "one size fits all" solution (but rather as a student/patient-centered intervention when appropriate).

The TVDSB APD protocol invites information derived from school-based assessments, teacher observations and reports, and parent reports. These data are considered in light of the formal health professional assessment data available to the committee. School-based interventions, supports, and strategies must also be in place when the student has an identified need and when parents wish for their child to receive such intervention. Possible interventions include involvement of the school speech-language pathologist, support through literacy programs, and classroom accommodations and modifications. These interventions are often documented on the Individual Education Plan (IEP). The IEP in the Ontario context is an accountability tool, identifying a student's specific learning expectations and the school's plans to address these expectations through accommodations, modifications, alternative programs, and specific instruction and assessment strategies (Ontario Ministry of Education, 2004). IEPs are mandatory when a student receives any equipment funded by SEA.

Procedures

The Learning Support Teacher (LST) and educational audiologist share the leadership role in the implementation of the APD protocol; the LST co-ordinates activities at the school level with system support staff and the student's caregivers, and the educational audiologist co-ordinates activities at a system level and with community health professionals. If parental consent and desire to proceed has been documented, the following steps proceed with leadership by the school's LST. See Figure 1 for a summary of the steps that are described next. See Appendix A for the checklist of steps that is included in the TVDSB APD protocol for completion by the LST.

Program development team meeting. First, a PDT meeting is called, at which professionals and parents discuss the student's existing assessment results, parental and teacher concerns, and the student's presenting needs. At this meeting, the PDT also discusses strategies that have been attempted to date to support the students' needs. The educational audiologist and LST facilitate this meeting and help the team reach a decision regarding whether or not the APD protocol is the appropriate path to pursue. If it is, then the series of assessments begins, with the LST, speech-language pathologist, psychologist/psychometrist (if indicated), and classroom teacher conducting appropriate assessments as follows.

Assessment. The LST administers the Woodcock-Johnson Tests of Achievement III (WJ-III; Woodcock, McGrew, & Mather, 2001) . The speech-language pathologist conducts a comprehensive speech and language assessment. The psychologist will be consulted to determine if psycho-educational testing is required based on results of the WJ-III, the speech-language pathologist's assessment report, academic achievement, and anecdotal reports. If assessment is warranted according to the psychologist, a psychometrist completes the assessment. The classroom teacher must complete the Children's Auditory Performance Scale (CHAPS: Smoski, Brunt, & Tannahill, 1998). Finally, the LST and classroom teacher rank order a list of behavioral symptoms (see Appendix A) that can help differentiate between attention and auditory concerns (Chermak, Somers, & Seikel, 1998). Furthermore, if there is any observed medical concern, assessments from appropriate medical professionals are recommended to the parents. Once the above assessment data are gathered, the LST submits the package and the student's most recent report card, IEP if applicable, and the checklist in Appendix A to the APD committee for review.

Review. As mentioned previously, the APD committee is comprised of five TVDSB staff members from speech-language pathology (1), audiology (1), psychology (1) and special education (2). The APD committee meets once monthly, at predetermined meeting dates. The committee reviews every file submitted, with

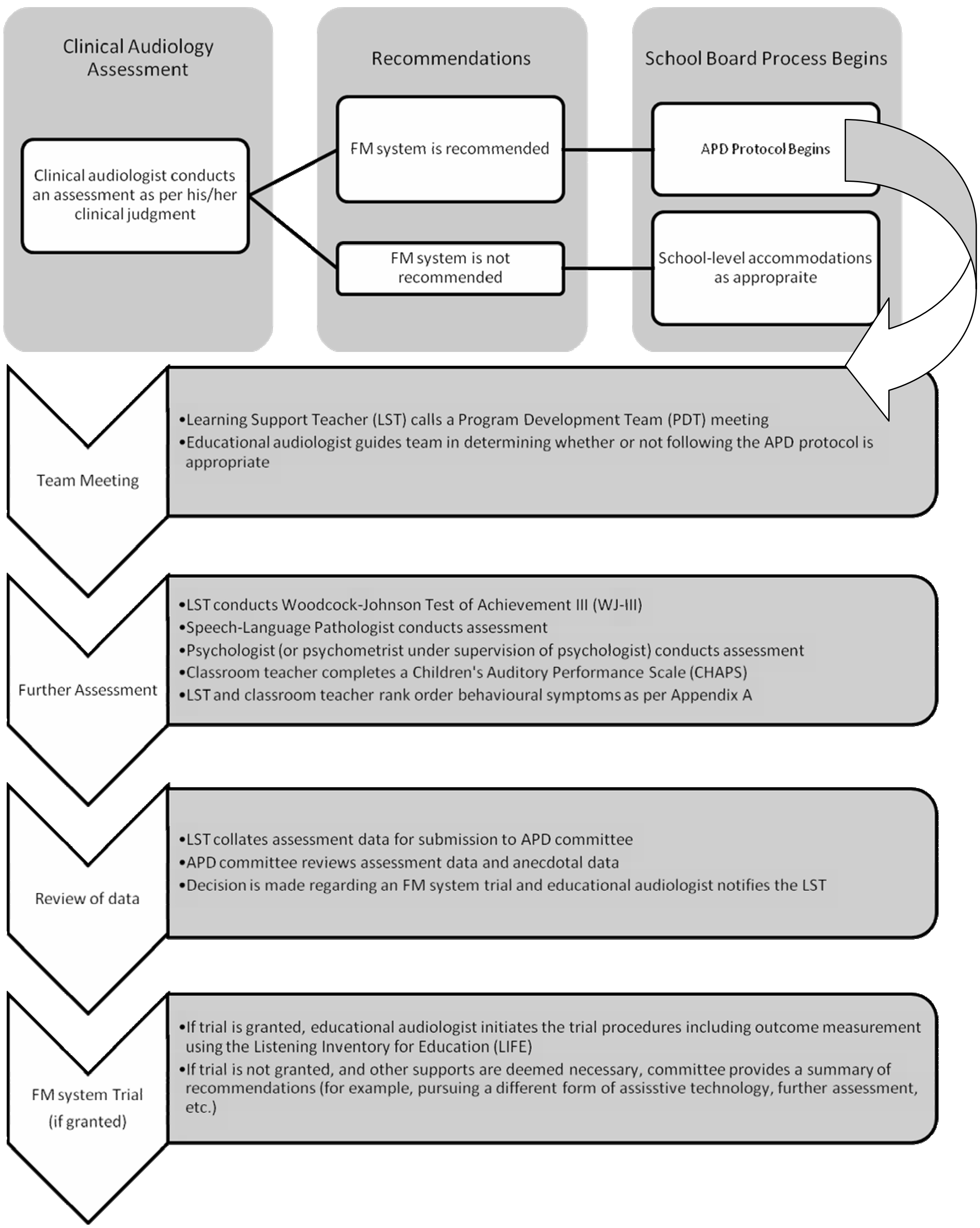

Figure 1. **Procedures of the Thames Valley District School Board's Auditory Processing Disorder Protocol .**

consideration and decision-making taking place as follows.

First, the committee checks that all criteria have been met as outlined above. Second, the committee considers whether or not HAT would be an appropriate form of support for each student. At times, HAT may be contraindicated. For example, we have had cases of students who required personal HAT due to a rotary class schedule, but who were unable or unwilling to use a personal system due to sensory issues relating to an autism spectrum disorder, or due to low self-esteem. Third, the committee seeks to determine if the HAT might be beneficial to the student in terms of improving access to the curriculum or improving academic performance (or both). To determine this point, the committee looks for gaps between assessed ability and academic performance. For example, if a student is assessed as having average cognitive ability and is achieving above average grades without accommodations, then this student would not be prioritized to receive HAT. However, if a student is assessed as having greater ability than he/she demonstrates in classroom performance, HAT might be a consideration to help bridge this gap.

In cases of multiple exceptionalities, the committee also considers other factors, such as whether or not the primary need (for example, attention deficit hyperactivity disorder) has been addressed appropriately in accordance with best practices and parental values. If so, and if the student continues to struggle to follow oral instruction and demonstrates gaps between ability and performance, then HAT may be warranted even if the APD appears to be co-morbid with other deficits or disorders (Updike, 2006).

In rare cases, the results of the APD protocol assessment battery have demonstrated eligibility for intensive support placements that would otherwise not have been identified, or identified at a later date. In these cases, the PDT is referred to procedures for application to these alternative class placements. These cases highlight the importance of the APD protocol or other similar interprofessional approaches to identifying and managing APD. Without a comprehensive assessment beyond the auditory domain, it is possible to misidentify a student with APD or to overlook primary needs.

Generally, students will be denied a trial of HAT if (1) they are performing commensurately with their assessed abilities, (2) it appears that APD, HAT, or both are low on a long list of needs that require attention in priority sequence, (3) if the assessment results as a whole (across professions) do not support the identification of an APD, or (4) if there are contraindicating factors, such as sensory challenges associated with an autism spectrum disorder (Whitelaw, 2003). In the case that a student is *not* given a HAT trial, the committee provides the school team with the rationale for the decision and specific recommendations for next steps. These steps may include further assessments, implementation of existing recommendations, or accessing other appropriate school supports. Program Development Teams may also decide to reapply for HAT in the future if other factors are resolved making HAT an appropriate option.

In summary, the outcome of the APD committee meetings can be one of four decisions: (1) no HAT trial because student is achieving appropriately or overachieving based on assessed abilities, (2) gather further information (e.g. assessment for autism spectrum disorder due to reported symptoms), (3) manage other concerns first, or (4) a trial with a HAT system. Recommendations for next steps are provided in cases of all four types of outcomes.

Hearing Assistance Technology Trials

To date, the TVDSB APD committee has reviewed 65 cases and has approved 35 HAT trials. Sixteen of the 35 approved trials have been successful (note that seven of these trials are ongoing at the time of this report). Success of a trial is determined based on the combined results of an outcome measure completed by both the student and the classroom teacher, and anecdotal evidence gathered from discussions with the LST, classroom teacher, parent/guardian(s), and student. Trials proceed for a minimum of three months up to a maximum of six months.

The educational audiologist monitors trials as follows. First, the educational audiologist convenes with the LST, classroom teacher, parents, and student to determine the most appropriate type of HAT (i.e. personal with body-worn receiver and earbuds, personal with wireless receivers, sound field, sound field with pass-around microphone). Students are allowed to select the color of their system when applicable. A trial of the system is ordered, and the educational audiologist visits the student's classroom to set up the system, fit the system if necessary, verify output levels, and show the teacher(s) and student how to use and care for the system.

Fitting and verification. For personal HAT, listening checks are conducted for each system and the educational audiologist works with the student to informally determine a comfortable listening level for the system. Electroacoustic verification using a hearing aid test system is conducted for the first of any type of HAT being used by TVDSB in order to confirm that the HAT does not exceed maximum output levels (as listed in product specifications). This measure is conducted to ensure that narrowband predicted upper limits of comfort (ULC) for normal hearing thresholds are not exceeded (Scollie et al., 2005). For example, for systems using occluding earbuds, the earbud is coupled to the 2-cc coupler and verification of various input levels, including a maximum power output test, is conducted to ensure that speech signals and maximum output levels are appropriate and safe. This approach is inferred from the evidence for pediatric hearing aid fittings (Scollie et al., 2005); evidence for fitting personal HAT on children with normal hearing is an area of need in our profession. A listening check is performed before fitting an individual HAT system on any child, and fine-tuning or volume adjustments are made based on the student's feedback.

For sound field HAT, the educational audiologist adjusts the system to a level such that the teacher's voice is noticeably and comfortably amplified across all areas of the classroom in which students are seated, without producing any perceptible distortion, reverberation, or discomfort. Sound- level and reverberation-time measurements are not conducted and this is a known weakness; the recent introduction of dynamic sound field amplification systems that adjust output levels based on measured noise levels may warrant consideration in the near future. Note that although listening checks are conducted at the time of fitting or setup, we cannot do much to prevent manipulation of levels by teachers and students beyond providing education.

Counseling, education, and observation. The educational audiologist is available for consultation throughout the trial, responding to any requests from the teacher or student regarding problems or questions. An important consideration is the student's (in cases of personal HAT) and teacher's compliance with use of the system. Compliance is assessed based on student, parent, and teacher report. In addition, informal observation by the LST is conducted. If use of the system is irregular, the educational audiologist will make contact with the student and teacher to determine reasons for lack of use and will address the problems on a case-by-case basis. For example, in cases in which the HAT was in use - but the teacher was often wearing a boom microphone around his/her neck instead of on his/her head - counseling and education are reinforced. Trials can be continued an additional three months with continued and closer monitoring, if necessary.

The education of the classroom teacher and counseling of the student for appropriate HAT use and realistic expectations is crucial to the trial. If the system is not used properly or consistently, the trial is not valid; thus, the LST is relied upon to perform regular check-ins with the classroom, reporting back any concerns to the educational audiologist. Furthermore, these initial discussions allow an opportunity for the teacher or student to disclose any potential factors that may impact the trial, such as a teacher's aversion to wearing the system or a student's sensitivity to sound. Thus, in addition to the formal completion of the outcome measures, the conversations between educational audiologist, LST, classroom teacher, student, and parent(s) weigh heavily into the decision to purchase the HAT or not.

Outcome measurement. Just prior to the trial onset, the educational audiologist or LST administers the pre-trial Listening Inventory for Education to the student (LIFE; Anderson & Smaldino, 1998). The LIFE has been recommended as an outcome measure for HAT benefit and is useful in this context because it allows for measurement of benefit from both student and teacher perspectives (Johnston et al., 2009).

Following the three-month minimum trial period, the classroom teacher completes the post-trial LIFE and the educational audiologist or LST administers a post-trial LIFE to the student. Scores are compared to determine if there was an improvement from pre-trial to post-trial scores. Again, these scores alone are not the determinate of a trial's success, and thus we do not have a set criterion for improvement. We require some improvement in LIFE scores coupled with reports of benefit. In cases of benefit indicated by the LIFE and anecdotal report, the HAT is purchased. In cases where both LIFE results and anecdotal evidence suggest no benefit, the trial is discontinued. In cases where there is contradiction between the LIFE results and anecdotal evidence, we extend the trial by another three months. If the HAT then continues to be used for and by the student, this supports the belief that there is some benefit associated with its use, and the HAT can be purchased. Even when a HAT system's benefit is supported by both LIFE and anecdotal reports, the trial may continue for an additional three months to ensure its continued use before purchasing the HAT.

Summary of trial period process. In summary, LIFE scores, student, parent, and teacher anecdotal reports are considered in determining whether or not a HAT system should (1) be purchased, (2) be continued for another three months, or (3) be discontinued. In cases of a continued trial, the HAT system is purchased as long as HAT use continues regularly for the remaining three months (based on LST observation). If lack of teacher compliance is considered a confounding factor, the HAT system can still be purchased for the student if it is documented that the student does benefit, based on the student version of the LIFE and student self-report. To discontinue a HAT trial, all sources of information must indicate no benefit from the HAT. That is, anecdotal reports from all parties, observations of the LST, and the results of the LIFE must all indicate a lack of benefit in order for a trial to be discontinued at the three-month point. If any one of these information sources suggests benefit, the trial must be continued for three more months. The LIFE is not re-administered during this additional three-month period. The main factor considered in this extended trial period is the continued use of the system.

In order to illustrate the application of this protocol, two case examples will be described below. Specific details (e.g. names, dates) have been omitted to avoid revealing the identity of the professionals and students described. Note that clinical assessments are conducted by different professionals, and in some domains, there is no standard test battery to use across cases; thus, specific tests used may differ across cases. For the auditory processing assessments, all test results provided by the clinical audiologist are outlined. The TVDSB APD committee interprets the results that are provided by community professionals, but cannot dictate what community professionals do. Variation across clinics is a reality that is managed through the interprofessional protocol's broadly scoping review of assessment data. Also, recall that the TVDSB's educational audiologists do not conduct clinical audiology assessments, in part due to the limited amount of time and resources available for such activities, but more-so due to the shared role of the clinical and educational audiologist in this district. The educational audiologist's role in TVDSB is primarily to help schools and families navigate the intersection of the clinical healthcare system and the public education system through educating, liaising, and consulting. HAT verification and outcome measurement is, however, a part of the TVDSB educational audiologist's responsibilities.

Case Examples

Case One

Case One is a male, grade four student. Case One was assessed by a clinical audiologist (normal hearing bilaterally) using the SCAN-C (Keith, 2000) and the Staggered Spondaic Word (SSW) test (Katz, 1962). Results indicated borderline normal performance on the Competing Sentences subtest of the SCAN-C, with an overall composite score in the normal range. However, results on the SSW indicated significant difficulties with tolerance/fading memory, organization, and decoding. Case One's report card showed that he was achieving Cs across subjects. Teachers and parents reported no concerns with attention or behavior. Results of the WJ-III ranged from average to high-average scores across all sub-tests. The speech-language pathologist's assessment indicated no concerns with speech and all language abilities fell in the average to high-average range.

Anecdotally, all teachers involved in the education of this student remarked that Case One put forth considerable effort and was not hyperactive or fidgety, but seemed to struggle to follow along with oral instruction or class discussion, especially when there were sources of auditory distraction. The APD committee concluded that Case One demonstrated some high average abilities on the WJ-III and speech and language assessment, yet achieved only average grades across subjects. Furthermore, Case One demonstrated difficulties with auditory processing as indicated by results of the SSW. Anecdotal evidence supported the potential benefit from HAT.

The APD committee thus decided to trial a sound field HAT, including a pass-around microphone for student participation. Results of the LIFE and discussions with teachers and Case One indicated that the HAT was benefitting Case One. Thus, once the trial period was complete, the HAT was purchased for this student. The classroom teacher and Case One reported that Case One is now more successfully attending to lessons and finds it less onerous to attend to oral instruction and class discussion.

Case Two

Case Two is a male, grade three student. Non-audiology case history will be presented first in this case, due to its impact on the audiologic considerations. Case Two has been diagnosed with Attention Deficit Hyperactivity Disorder for which he is medically treated. Case Two also has diagnoses of Obsessive Compulsive Disorder and an anxiety disorder. Case Two was seeing a speech-language pathologist for therapy for a severe articulation disorder, disordered receptive and expressive language, and disordered phonological awareness. Case Two was seeing an attendance counsellor for significant concerns regarding truancy.

In terms of audiologic assessment, Case Two had normal hearing bilaterally, acoustic reflexes present at 1000 Hz, normal performance on the Competing Sentences subtest of the SCAN-C, and borderline normal results on the other subtests (Auditory Figure-Ground, Competing Words, and Filtered Words). The clinical audiologist noted that scoring the SCAN-C was challenging, due to the lack of intelligibility of Case Two's speech. The clinical audiologist recommended HAT for this student.

The APD committee decided not to trial a HAT. The committee's rationale was that Case Two's challenges did not appear to be the result of APD primarily; many other services and supports needed to be prioritized and ultimately he did not present as a top candidate for provision of HAT. The committee recommended continued implementation of specific recommendations from the psychologist, medical professionals, and speech-language pathologist in addition to the non-technological recommendations from the audiologist (e.g. preferential seating). Note that the APD committee acknowledges that in an ideal situation of *un*limited resources, HAT may indeed have been provided to this student, but such is not reality. The protocol is in place to provide HATs to students with the most potential to benefit, and to provide appropriate recommendations otherwise.

Case Two's father questioned the decision, stating that in addition to the audiologist's recommendation, his son's physician had also supported the HAT recommendation. The educational audiologist addressed the parent's concerns by following up on the case further, including (1) performing an in-class observation, (2) consulting with the pediatrician and psychiatrist involved in Case Two's care, (3) consulting with Case Two's clinical audiologist and school and community speech-language pathologists, and (4) discussing Case Two further with school staff. The in-class observation revealed that Case Two had a high level of educational assistant support; he was taken to a quiet place for one-on-one re-instruction after the teacher taught a lesson, and for individual support with his seatwork. The classrooms in the school were small with no obvious sources of distracting noise (such as traffic or ventilation noise). Also, the classroom was outfitted with tennis balls on the feet of chairs and acoustic ceiling tiles to reduce reverberation. Case Two was seated optimally in the classroom, away from the door/hallway and within three feet in front of his teacher during verbal instruction.

The physicians involved in Case Two's care indicated that they had supported the HAT recommendation solely based on reading the recommendation in the audiology report, but that they felt the primary concerns related to attention, anxiety, and speech articulation. Conversations with the clinical audiologist who made the HAT recommendation confirmed that assessment results were of low reliability given the intelligibility difficulties (hence her cautionary note in Case Two's audiology report); the clinical audiologist agreed that HAT was a low priority relative to the student's other needs. School staff further supported these statements by presenting Case Two's attendance record, which indicated that he was only attending classes on about 50% of school days. On days that Case Two did attend, he spent much of the time in the hallway or principal's office as a result of his anxiety disorder.

The educational audiologist's follow-up actions confirmed the committee's original decision; therefore, a detailed follow-up report was provided to the school and family. The report included the findings outlined above, including further recommendations from the professionals consulted. For example, it was recommended that the speech-language pathologist train Case Two's educational assistant to be able to use daily speech/language strategies and a software program focusing on phonological awareness, in order to provide more intensive and consistent support in this primary area of need. The following recommendations were further emphasized: continue to provide preferential seating, update the student's IEP based on some of the APD committee's recommendations for refinement, continue to work on student's attendance (through attendance counselling), and continue medical management of the medically indicated exceptionalities.

Further Refinement

In 2009, the APD protocol was formally adapted based on feedback generated from the two preceding years of implementation. The following three changes were made to the protocol. First, wording regarding invitation of the educational audiologist to the initial PDT meeting was strengthened, because some schools were submitting their files to the committee without having consulted the educational audiologist. This change was considered important because there are contextual factors that are sometimes difficult to ascertain without direct interaction with the LST and PDT. The educational audiologist's direct involvement provides the APD committee a better understanding of the individual student's unique situation and allows the educational audiologist to facilitate the LST's efforts to navigate the protocol and counsel the parents. Second, wording of the clause on primary needs and multiple exceptionalities was weakened. In the original protocol, this clause stated that a student must not have other exceptionalities or non-auditory factors as his/her *primary* need(s). This clause has been modified to state that a student must not have another *unmanaged* exceptionality as his/her primary need. The APD committee had observed that some schools were interpreting the previous wording to mean that they should not submit to the committee if a child had any co-morbidities and felt that this was misrepresentative of the philosophy of the TVDSB APD protocol. Third, trials for HATs will now typically take place with *personal* HAT systems as opposed to *sound field* HAT systems, which were more commonly trialed in the first two years of the protocol. This change reflects a need to assess benefit to the individual student and not benefit to the teacher or classroom. It was observed that teachers would be more likely and better able to objectively assess benefit for the individual student rather than for the entire class with trials of personal HATs. Following a successful trial, a sound field HAT system may indeed be purchased instead of the personal system, if deemed more appropriate for the student, teacher, and class. Although it would be ideal to provide a sound field HAT for every classroom regardless of APD, the committee is accountable to budgets and resource allocation and must make best use of available funds and resources. Unfortunately, we do not currently have the resources to retrofit thousands of existing classrooms with sound field HAT nor the authority to mandate all future classrooms be fitted with sound field HAT.

Discussion

Implementation Challenges

The implementation of the TVDSB APD protocol has not been without challenges. LSTs are already burdened with many responsibilities, as they are responsible for essentially managing all cases of special education needs within the school. The protocol can be interpreted by some LSTs as placing yet an additional onus on them. Some parents/caregivers do not agree with the school board's internal mechanism to filter HAT recommendations because they perceive the community clinical professional's recommendation as the authoritative directive. However, in attending PDT meetings, the educational audiologist has found that parents tend to come to an understanding that APD is best identified and managed interprofessionally. Although parents seemed more accepting when the process to acquire HAT for children with APD was based on a "first-come, first-served" philosophy (which did not put a committee in place to filter clinical audiologists' recommendations), this former approach meant that some children would virtually never be considered for a HAT because they were behind over 200 other children on a waiting list. We strongly believe that the former approach was a disservice to children since many could have been served by a variety of supports other than HAT, but they would remain unmanaged while waiting for HAT. The current protocol does not aim to impose the TVDSB's judgements on clinical audiologist's recommendations. Rather, it ensures that every student with suspected APD is thoroughly and individually managed and that SEA is responsibly allocated. HAT is not a universal solution for APD or other learning and behaviour challenges, and the current protocol ensures that we do not treat it as a blanket intervention. The clinical audiologist's recommendation for HAT for children with suspected APD serves as an impetus for the school team to investigate further. Thus, the educational audiologist serves as the necessary bridge between the healthcare system and the education system, and further serves as the link between the school teams and the APD committee.

Bridging this healthcare-education gap can be challenging, especially in an area such as APD (for which the clinical community possesses a variety of perspectives). An initial letter in the 2006-2007 school-year and a follow-up newsletter in 2009 were disseminated throughout the TVDSB community of clinicians. An update for clinicians including a list of frequently asked questions will be distributed in early 2011. These communications are intended to inform the community clinicians about the TVDSB APD protocol and explicitly invites feedback and interaction. Face-to-face meetings have also been initiated with the audiology clinics that conduct the most APD assessments. Informal feedback from local clinicians is mixed; many speech-language pathologists support the protocol and its interprofessional stance, while many audiologists disagree with TVDSB's stance that audiologist's recommendations must be considered in light of other assessment data. A significant challenge exists in balancing what audiologists may perceive to be the best practices for children with APD with the realities and complexities of the systems in which we educate children.

One of the strengths of the TVDSB APD protocol is that it manages this "grey zone" of practice by making use of available best practice recommendations (e.g. ASHA, 2005a) while exercising the philosophy of client-centeredness. The TVDSB protocol does not require us to strictly adhere to static rules. Such a philosophy would preclude support for certain students who are appropriate candidates because a static protocol may not be current with regard to the latest available evidence. We acknowledge that the protocol might not be necessary if strong diagnostic criteria existed for APD, or if there were clear evidence-based indicators for the type of intervention or support that would be appropriate for specific profiles of children with APD.

Next Steps

The TVDSB APD protocol is far from perfect or absolute. However, a comprehensive approach to identification and management of children with APD within the TVDSB is surely a better alternative to the former waiting list system. It may be perceived as preferable to the approach some school boards have chosen, which is to limit provision of HATs to children with peripheral hearing loss exclusively. The protocol continues to evolve as new research evidence and technologies emerge, and perhaps as board resources change. The APD committee plans to continue to gather the data from its submissions to continually improve its practices. The data can be analyzed in an attempt to detect any patterns regarding best candidates for HATs, success rates of HAT trials, and academic outcomes for students with and without the HATs (Garfinkel, 2003). Again, challenges exist in reaching this goal given the variability in practices across health professionals. Perhaps as the provincial or national regulations, guidelines, or standards for auditory processing disorders are published, consistency across clinics will enable a more standardized approach to assessing and monitoring auditory processing challenges

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Appendix A

Date: ______________________

Auditory Processing Disorder School Checklist

Name of Student: ________________________ Grade: __________ D.O.B. _____________________

L.S.T. _______________________________ Name of Teacher: ________________________________

Date of last PDT meeting: ____________________ Date of most current IEP report: _____________________

Submit copy of team minutes ☐ Submit copy ☐ (If applicable)

Please complete the following: **Attachments (as required)**

Student struggling academically	☐ i) submit copy of most recent report card ii) submit current DRA level ____________
Student demonstrates normal hearing in both ears	☐
Student is at least 7 years of age	☐
Student demonstrates average non-verbal abilities	☐
C.H.A.P.S. questionnaire complete (submit report)	☐______________________________________
SLP Assessment	☐______________________________________
Academic Assessment (submit WJ-III report)	☐______________________________________

Other disciplines involved:

Medical (e.g. ADHD, developmental delay)	☐
Is the student on medication? (specify)	☐ ______________________________________
ESL	☐
Psychological assessment (if yes, include all reports)	☐______________________________________
Other (specify)	☐_______________________________________

Behavioural concerns - specify

attention	☐
social, emotional	☐
oppositional	☐
anxious	☐
other (specify)	☐_______________________________________

Motor abilities

Gross motor	☐
Fine motor	☐

APD or CAP testing accessible on record (submit report) ☐ Date of Assessment: ________________

Please rank these behavioural symptoms if applicable (where is the most problematic behaviour). Do not include a ranking if the student does not have difficulty in this area. (Rank top 10 concerns with 1 being most severe)

____	inattentive	____	distracted	____	hyperactive
____	fidgety or restless	____	hasty or impulsive	____	interrupts or intrudes
____	difficulty hearing in background noise	____	difficulty following oral instructions	____	poor listening skills
				____	academic difficulties
____	word retrieval problems	____	delayed responses; uses fillers	____	frequently answers "I don't know"or "I forgot"
____	repeats or rehearses comments	____	incomplete sentences		

L.S.T Signature: ______________________________ Principal Signature: _________________________________

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Call for Papers

2011 Journal of Educational Audiology

The Journal of Educational Audiology is now soliciting manuscripts for the 2011 issue (Volume 17). All submissions will be peer-reviewed and blind. *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).

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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.*

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Acknowledgements should appear on a separate page after the tables, figures, and graphs and before the references.

9. References

All references should follow APA manual guidelines, as noted above. References are to be listed alphabetically, then chronologically. Journal names should be spelled out and italicized, along with volume number. Authors should consult the APA style manual (6th ed.) for the specifics on citing references within the text, as well as in the reference list. All citations in the text need to be listed in the References.

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EAA Mission Statement:

The Educational Audiology Association is an international organization of audiologists and related professionals who deliver a full spectrum of hearing services to all children, particularly those in educational settings.

The mission of the Educational Audiology Association is to act as the primary resource and as an active advocate for its members through its publications and products, continuing educational activities, networking opportunities, and other professional endeavors.

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