Guidelines for the Audiologic Assessment of Children From Birth to 5 Years of Age

About This Document

This guideline document is an official statement of the American Speech-Language-Hearing Association (ASHA). The ASHA Scope of Practice in Audiology states that the practice of audiology includes providing services to individuals across the entire age span from birth through adulthood. The Preferred Practice Patterns are statements that define universally applicable characteristics of practice. The guidelines within this document fulfill the need for more specific procedures and protocols for serving children from birth to 5 years of age with hearing loss across all settings. It is required that individuals who practice independently in this area hold the Certificate of Clinical Competence in Audiology and abide by the ASHA Code of Ethics, including Principle of Ethics II Rule B, which states "Individuals shall engage in only those aspects of the profession that are within their competence, considering their level of education, training, and experience."

The Guidelines for the Audiologic Assessment of Children From Birth to 5 Years of Age were developed by an American Speech-Language-Hearing Association (ASHA) working group and adopted by the ASHA Legislative Council (LC) in November 2004. Current members of the working group responsible for the development of the guidelines include Pam Mason, ex officio; Allan O. Diefendorf, coordinator; Kathryn L. Beauchaine; Patricia Connelly; Robert J. Nozza; Jackson Roush; Diane L. Sabo; Anne Marie Tharpe; and Judith E. Widen. Susan Brannen, vice president for professional practice in audiology (2000–2003) and Roberta Aungst, vice president for professional practice in audiology (2004–2007), were the monitoring vice presidents.

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Scope

American Speech-Language-Hearing Association (ASHA) guidelines on audiologic assessment of children from birth through 36 months of age (ASHA, 1991) were developed to facilitate audiologic evaluation of children who were either identified through screening programs or referred directly to audiologists for hearing assessment. Moreover, the assessment guidelines were developed pursuant to screening guidelines (ASHA, 1989) and the Joint Committee on Infant Hearing (JCIH) 1990 Position Statement (JCIH, 1991). Over the past decade, the emphasis on universal early detection of hearing loss in infants has grown considerably. Research findings coupled with early hearing detection and intervention practice trends and improvements in screening technology have influenced and resulted in updates of screening guidelines (ASHA, 1997a; JCIH, 1994, 2000). Accordingly, ASHA determined that the 1991 audiologic assessment guidelines also should be updated. Therefore, the scope of this document has been specifically focused on family-centered, culturally competent assessment from birth to 5 years of age, with consideration of auditory evoked potentials, behavioral audiometry, otoacoustic emissions (OAEs), acoustic immittance procedures, developmental screenings, and functional assessment.

In developing these guidelines, the ASHA Working Group on Audiologic Assessment of Children recognizes the complex and multidimensional nature of the auditory system, human hearing, and hearing loss. The committee also recognizes that the success of universal newborn hearing screening (UNHS) has resulted in a rapidly growing need for audiologic care for the pediatric population.

Moreover, the committee recognizes the growing number of infants with multiple developmental disabilities and the resulting challenge of accurately delineating their hearing status.

To achieve improved outcomes from early intervention, audiologic practice patterns must bridge UNHS programs and early intervention programs. Specifically, the JCIH recommends that all infants who do not pass the newborn hearing screening and any subsequent rescreening should begin appropriate audiologic evaluations to confirm the presence of hearing loss before 3 months of age. Furthermore, regardless of prior hearing screening outcomes, all infants who demonstrate delays in speech-language development or present with a risk factor associated with hearing loss, or for whom there is parental concern regarding communication development or hearing, should receive immediate audiologic evaluation. This practice is important for the identification of infants with delayed onset, progressive, or mild forms of hearing loss who may have passed screening in the newborn period (JCIH, 2000).

This document should be regarded as guidelines for practice, not standards. Each child presents unique individual characteristics, shaped by familial roles and culture that may influence an approach to the assessment process. Nevertheless, the specific procedural recommendations provided here are supported by research evidence and cumulative clinical experience. Further study of these guidelines is encouraged to evaluate the efficacy of the procedures and protocols recommended.

These guidelines are intended for audiologists who serve infants and young children suspected of having hearing loss. Given the necessity and importance of multidisciplinary service providers for children and their families, other stakeholders may benefit from these assessment guidelines in the context of early detection and intervention program development.

Introduction

Hearing plays a vital role in the acquisition of speech and language and the achievement of other developmental milestones in young children. When there are concerns regarding a child's hearing or when hearing status is unknown, a comprehensive pediatric audiology assessment is essential. Pursuant to ASHA's screening guidelines (ASHA, 1997a) and the JCIH Position Statement (JCIH, 2000), this report sets forth guidelines for the audiologic evaluation of children who are identified through screening programs or referred directly to audiologists for hearing assessment. The impetus for developing these guidelines is derived from several sources: Public Law 105-17 (the amendments to the Individuals with Disabilities Education Act [IDEA], 1997), a discretionary program to ensure appropriate services for children with special needs from birth through 2 years of age and their parents/caregivers,[1] emphasizes the importance of appropriate assessments provided by qualified personnel. In addition, ASHA's Executive Board approved the establishment of a Working Group on Audiologic Assessment of Infants and Young Children to formulate guidelines on the assessment of hearing

loss in infants. Finally, mounting evidence on the impact of hearing loss on speech-language, social-emotional, cognitive development, and academic achievement supports the need for early identification, complete assessment, and rehabilitation of children with hearing loss (Bess, Dodd-Murphy, & Parker, 1998; Carney & Moeller, 1998; Moeller, 2000; Yoshinaga-Itano & Sedey, 2000; Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998). That is, once a child is suspected of having hearing loss, the diagnostic process, including medical and audiologic assessment, must proceed on a timely basis by well-qualified service providers. When hearing loss is diagnosed, family members must be notified and informed of intervention options. A family-centered and culturally sensitive approach that advocates involvement of the family to the fullest extent they desire must be maintained throughout the process.

The use of any test alone for assessing children's hearing sensitivity is discouraged (Diefendorf, 1998; Friedrich, 1985; Gravel, Kurtzberg, Stapells, Vaughan, & Wallace, 1989). Therefore, ASHA recommends a comprehensive pediatric assessment that includes behavioral, physiologic, and developmental measures. The desirability of using multiple tests in clinical practice is based on the complex nature of the auditory mechanism and the fact that auditory dysfunction may result from pathology at one or more levels. In test battery selection, the audiologist should use test procedures that are outcome-based and cost-effective, and greater weight should be given to the results of those tests for which validity and reliability are highest. Accordingly, the type and number of procedures administered to any child should be dictated as much by the validity and reliability of the results as by any specified assessment protocol (Turner, Frazer, & Shepard, 1984). Corroboration of test results with case history, parent report, and observations of behavior is vital to assessing the functional use of hearing.

Effective assessment includes involving a family in a culturally and linguistically appropriate manner throughout the diagnostic process (Cherow, 1985; Dunst, Trivette, & Deal, 1988; Education of the Handicapped Act Amendments of 1986; Roush & Matkin, 1994). Ultimately, the goal of assessment is to define the type, degree, and configuration of the hearing loss for each ear. With the widespread implementation of UNHS, confirmation of hearing loss will occur at earlier and earlier ages. Consequently, ear-specific information from physiologic measures can serve as the baseline for initiating early intervention decisions. The desire for behavioral hearing test results should not delay the selection and fitting of amplification (hearing aids and FM systems) and other assistive devices, since hearing aid fitting protocols designed for use with infants are now available (American Academy of Audiology [AAA] Pediatric Amplification Protocol, 2003; The Pediatric Working Group, 1996; Seewald et al., 1997; Stelmachowicz, 2000). Accordingly, ongoing assessment is viewed as an integral part of the management process. Furthermore, it should be recognized that single-point assessment does

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[1] *Parent/caregiver* is defined in IDEA as (a) a natural or adoptive parent of a child; (b) a guardian but not the State if the child is a ward of the State; (c) A person acting in the place of a parent (such as a grandparent or stepparent with whom the child lives, or a person who is legally responsible for the child's welfare); or (d) a surrogate parent who has been appointed in accordance with §300.515.

not adequately address the issue of fluctuating and/or progressive hearing loss. In cases where fluctuating and/or progressive hearing loss may be suspected, routine reevaluation in conjunction with otologic management is essential (JCIH, 2000).

Clinical Indicators

Audiologic assessment is indicated for any child from birth to 5 years of age who is at risk of, suspected of, or identified with auditory impairment, disorder, or disability (Joint Audiology Committee Clinical Practice, 1999) including, but not limited to,

- children referred from infant hearing screening or other audiologic screening regarding impairment, disorder, and/or disability;
- children whose parent/primary caregiver, educator, or primary care physician has concern for delayed communication development and/or inconsistent response to auditory stimuli;
- children whose case histories include risk indicators that are associated with delayed onset or progressive hearing loss (JCIH, 2000);
- children whose family history is positive for late-onset hearing loss;
- children with developmental delay;
- children referred from professionals for determination of auditory status;
- children identified with fluctuating or permanent hearing loss; and
- children referred for determination of hearing status as a result of a "refer" result on a pre-K or kindergarten school hearing screening.

Objectives of Assessment

Audiologic assessment for children from birth to 5 years of age is designed to serve the following purposes:

- to determine the status of the auditory mechanism;
- to identify the type, degree, and configuration of hearing loss for each ear;
- to characterize associated disability and potentially handicapping conditions;
- to assess the ability to use auditory information in a meaningful way (functional hearing);
- to identify individual risk factors and the need for surveillance of late-onset or progressive hearing loss;
- to assess candidacy for sensory devices (e.g., hearing aids, hearing assistive devices, cochlear implants);
- to refer for additional evaluation and intervention services when indicated;
- to provide culturally and linguistically sensitive counseling for families/ caregivers regarding audiologic assessment findings and recommendations;
- to communicate findings and recommendations, with parental consent, to other professionals such as the primary care provider (i.e., medical home), medical specialists, speech-language pathologists, early intervention specialists, and appropriate state and local agencies; and
- to consider the need for additional assessments and/or screenings (e.g., speech-language, cognitive, behavioral) based on case history, clinical observations, parental concerns, and reason(s) for referral.

Personnel, Facilities, and Equipment

Audiologic assessment is performed by appropriately credentialed and qualified audiologists who possess a current ASHA Certificate of Clinical Competence where required and/or valid state license where required by law. Audiologists designated to provide assessment and management of infants and children with hearing loss must have the commensurate knowledge, skill, and instrumentation necessary for use with current pediatric hearing assessment methods and hearing

aid selection and evaluation procedures (The Pediatric Working Group, 1996). Facilities that lack the necessary expertise or equipment should establish consortial arrangements with those that do.

Joint Commission on Accreditation of Healthcare Organizations (JCAHO)

Audiologists working in facilities accredited by the JCAHO must adhere to the standards that encompass and govern patient contact (JCAHO, 2002).

Universal Precautions

All procedures must ensure the safety of the patient and clinician, and adhere to universal health precautions (e.g., prevention of bodily injury and transmission of infectious disease). Decontamination, cleaning, disinfection, and sterilization of multiple-use equipment before reuse must be carried out according to facility-specific infection control policies and procedures and according to manufacturers' instructions (ASHA, 1997b; Centers for Disease Control, 1988).

Moderate Sedation

To gain the cooperation of some infants and young children during physiologic assessments of auditory function, sedation may be required. Yet, sedation of pediatric patients has serious associated risks such as hypoventilation, apnea, airway obstruction, and cardiopulmonary impairment. Consequently, sedative medications should only be administered by or in the presence of individuals skilled in airway management and cardiopulmonary resuscitation. Additionally, the oversight by skilled medical personnel and the availability of age- and size-appropriate equipment, medications, and continuous monitoring are essential during procedures and in rescuing the child should an adverse sedation event occur.

The JCAHO has adopted revisions to its anesthesia care standards (JCAHO, 2002), consistent with the standards of the American Society of Anesthesiologists (American Society of Anesthesiologists, 2002). The most current terminology of the American Society of Anesthesiologists has replaced the term *conscious sedation* with the term *moderate sedation*.

Calibration and American National Standards Institute (ANSI) Standards

All measurements of auditory function (behavioral and physiologic) must be completed in a test environment that meets current ANSI standards for background noise levels. Equipment must be maintained according to the manufacturers' specifications and recommendations and calibrated to comply with current ANSI standards. Daily listening checks are particularly important when working with the pediatric population. Documentation of listening checks and periodic electroacoustic calibration should be consistently maintained. When national standards do not exist, as in the case with transient signals used in evoked potential testing or in sound-field audiometry, calibration may be referenced to other published standards, to published data, or to values established by the clinic performing the audiologic tests. Appropriate sound-field calibration is particularly critical in the behavioral audiologic assessment of children who cannot be tested with earphones or with insert phones (Morgan, Dirks, & Bower, 1979; Rochlin, 1990; Walker, Dillon, & Byrne, 1984).

Principles

The recommendations for appropriate assessment procedures are guided by several underlying principles: (a) evidence-based practice, (b) cultural competence, (c) family-centered service provision, (d) documentation, (e) informed consent and privacy protection, and (f) use of accepted standards of terminology.

Evidence-Based Practice

The foundation for these recommendations is evidence-based standards of practice. These guidelines were developed in consideration of and with reference to the following ASHA documents: Preferred Practice Patterns for the Profession of Audiology (ASHA, 1997b); the Joint Audiology Committee on Clinical Practice Algorithms and Statements (2000); the JCIH Year 2000 Position Statement: Principles and Guidelines for Early Hearing Detection and Intervention Programs; Guidelines: Competencies in Auditory Evoked Potentials Measurement and Clinical Applications (1999); and Guidelines for Audiologic Screening (ASHA, 1997a).

Cultural Competence

The importance of considering the impact on and/or influence of a family's cultural background should be held paramount during the assessment and intervention process. Potential linguistic and cultural barriers to interacting with families must be addressed and overcome at the outset of the relationship to ensure effective communication and follow-up. Culturally and linguistically appropriate modes of communication (i.e., manually coded languages, interpreters/translators) should be used during all aspects of assessment, outcomes, and management (Scott, 2002).

Family-Centered Service Provision

Families should be actively involved in the assessment process to the extent they desire and to the extent feasible given the nature of the audiologic test procedure. The audiologist must engage the family in the case history and testing session(s), and the family must fully participate in deciding on intervention strategies. The family's rights (including informed consent and confidentiality issues), reasonable expectations, reasonable needs, and preferences are paramount and must be considered.

Documentation

Documentation must be contemporaneous with each visit or interaction to provide a complete and cogent archive of the child's audiologic history. Documentation of assessment must address assessment procedures used, interpretation of test results, type and severity of the hearing loss, and associated conditions (e.g., medical diagnosis, disability, home program). In addition, documentation must contain pertinent background information and specific recommendations. Recommendations may address the need for further assessment, follow-up, or referral. When treatment is recommended, information must be provided concerning the required frequency, estimated duration, type of service, and place of service (e.g., individual, group, home program; ASHA, 1997b). Patient records and student education records should follow a documentation standard and be in full compliance with the Health Insurance Portability and Accountability Act (HIPAA, 1996 [PL 104-191]) and the Family Educational Rights and Privacy Act (FERPA [20 U.S.C. 1232g; 34 CFR Part 99]). A FERPA regulation protects the privacy of student educational records and applies to all schools that receive funding under an applicable program of the U.S. Department of Education.

Requests for a child's records must respect a parent's right to confidentiality and protected health information mandates, and require necessary and appropriate informed consent.

Informed Consent and Privacy Protection
Requirements for privacy protections in electronic records and data management, and in all other documentation and communication (e.g., HIPAA, FERPA, and JCAHO), must be ensured. The audiologist is responsible for obtaining/confirming informed consent or informed parent/legal guardian permission. However, extant state statutes, regulations, or institutional policies may supersede this recommendation.

Terminology
A *disorder* is any anatomic abnormality or pathology. It may or may not result in a change in function of a given organ or organ system. *Impairment* is any loss or abnormality of psychological or physiological function. It implies that some functional aspect of an organ, system, or mechanism is outside the normal range. A *disability* is any restriction or lack of ability to perform an activity by an individual (resulting from impairment). A *handicap* is the difficulty experienced by an individual as a result of an impairment or disability and as a function of barriers (e.g., communication, structural, architectural, attitudinal), lack of accommodations, and/or lack of appropriate auxiliary aids and services (e.g., amplified telephone handset, assistive listening device) required for effective communication. As currently defined, persons with disabilities may find themselves in handicapping situations due to specific environmental restrictions or social expectations.

Audiologic Assessment Procedures

Audiologic assessment of infants and young children includes a thorough case history, otoscopy, and behavioral and physiologic measures. Because children undergo rapid sensory, motor, and cognitive development, and because some children will present with multiple developmental problems, it is vital that assessment tools are appropriate for the neuro-developmental state of the young child. In addition to the assessment of peripheral hearing status, it is essential for audiologists working with infants and young children to consider the functional implications of hearing loss. As is feasible within the time constraints of clinical practice, assessments of speech perception ability, and screening for communication skills, cognitive development and social-emotional status should be included as part of the pediatric test battery. Such assessments and screenings are consistent with the objective of formulating recommendations and making additional referrals as needed.

A thorough assessment of hearing may require multiple sessions. Thus, serial evaluations may be necessary to develop reliable profiles of hearing status and developmental abilities. Prolonged delays between assessments should be avoided. During the assessment process, the audiologist may be formulating a working diagnosis of the child's audiologic status while developing initial management options.

Ear-specific assessment is the goal for both behavioral and physiologic procedures because a unilateral hearing loss, even in the presence of a normal-hearing ear, may place a child at significant developmental and/or educational risk (Bess, 1982;

Bess, Klee, & Culbertson, 1988; Bovo et al., 1988; Oyler, Oyler, & Matkin, 1988). Therefore, determining hearing sensitivity for each ear is important for establishing supportive evidence for medical/surgical diagnosis and treatment, selecting amplification when appropriate, establishing baseline function, and monitoring auditory status when progressive, fluctuating, or late-onset hearing loss is suspected. When air-conduction thresholds obtained by behavioral methods are found to be abnormal, estimates of bone-conduction sensitivity should be completed. Effective masking of the non-test ear should be used as necessary. Insert phones are recommended unless contraindicated when testing infants and young children.

Acoustic stimuli used for behavioral assessment should provide frequency-specific information regarding auditory sensitivity. Therefore, responses to pure tones, FM tones, or narrow bands of noise should be obtained in behavioral testing of children regardless of the response levels obtained to broadband signals (e.g., speech). When using narrowband noise, the bandwidth must be sufficiently narrow to ensure accurate determination of frequency-specific thresholds. Because high-frequency spectral energy above 1000 Hz is critical to speech perception, audiologic assessment of children should always include test stimuli that allow the clinician to evaluate hearing sensitivity within the high-frequency range. At a minimum, thresholds should be obtained at 500 Hz and 2000 Hz for each ear to allow for the selection of appropriate amplification (The Pediatric Working Group, 1996).

It also is recommended that frequency-specific stimuli be used when comprehensive auditory brainstem response (ABR) testing is undertaken. At a minimum, responses to low- and high-frequency stimuli should be obtained for each ear to estimate audiometric configuration. High-frequency assessment should be completed using a 2000-Hz tone burst (The Pediatric Working Group, 1996) and low frequencies should be assessed using a 250- or 500-Hz tone burst (Stapells, Gravel, & Martin, 1995; Stapells & Oates, 1997). The use of click stimuli alone is not sufficient for the estimation of audiometric configuration (Balfour, Pillion, & Gaskin, 1998; Stapells, 1995; Stapells & Oates, 1997).

When air-conduction thresholds obtained by physiologic methods are found to be abnormal, estimates of bone-conduction sensitivity should be completed (Mauldin & Jerger, 1979; Stapells, 1989; Stapells & Ruben, 1989; Yang, Rupert, & Moushegian, 1987; Ysunza & Cone-Wesson, 1987). However, there are output limitations using bone conduction and transient stimuli (approximately 50 dB maximum output for clicks). If bone conduction is not done and latency information only is used, precipitously sloping high-frequency losses can be confused with conductive losses. Generally, ABRs obtained by bone conduction have longer latencies (Gorga, Kaminski et al., 1993). It is important when doing bone conduction ABRs that attention is paid to ensure adequate pressure of the bone vibrator (Yang & Stewart, 1990) on the mastoid. Care also must be taken to separate the bone vibrator from the electrode due to electromagnetic leakage. Alternative electrode placements such as the earlobe or tragus or the use of tiptrodes should be considered.

Case History

The case history is particularly important because it will often guide the selection of a strategy for the audiological evaluation. Moreover, accurate diagnosis of hearing loss relies on interpretation of a test battery within the context of the child's medical and/or developmental history. Case history information may suggest a need for modification of evaluation procedures. For example, the audiologist may want to include evaluation of the high-frequency region of the cochlea (above 4000 Hz) for a young child with a history of ototoxic drug exposure. Modification of routine assessment procedures also may be necessary when evaluating a child with multiple disabilities. The case history should be recorded using a standard form (see Appendix A).

Otoscopy

Several audiologic assessment procedures require the insertion of a probe into the external auditory canal. Thus, a visual inspection of the outer ear canal should be conducted to verify that there is no contraindication to placing a probe in the ear canal (e.g., drainage, foreign objects, occluding cerumen, atretic canal).

Behavioral Assessment

Behavioral assessment of hearing sensitivity in children is complicated by developmental and maturational factors. It is now known that unconditioned behavioral observation techniques with infants are confounded by poor test-retest reliability, and high inter- and intrasubject variability (Bench, Collyer, Mentz, & Wilson, 1976; Weber, 1969; Wilson & Thompson, 1984). Several studies have shown that once an infant reaches a developmental age of 5–6 months, it is possible to elicit reliable conditioned auditory responses using an operant, visually reinforced behavioral response technique (Moore, Wilson, & Thompson, 1977; Primus & Thompson, 1985; G. Thompson & Wilson, 1984; G. T. Thompson, Wilson, & Moore, 1979; Widen, 1993; Wilson, 1978). Typically, developing children as young as 5 months of age may be conditioned to produce a motor response contingent on the presence of an auditory stimulus (Wilson & Thompson, 1984). The behavior, usually a head turn, is reinforced by an appealing visual display. More recent studies confirm that frequency-specific thresholds may be obtained from infants at developmental levels of 5–6 months, enabling accurate evaluation of hearing sensitivity regardless of type, degree, or audiometric configuration (Bernstein & Gravel, 1990; Diefendorf, 1988, 2003; Gravel, 1989; Gravel & Wallace, 1999; Nozza & Wilson, 1984; Talbott, 1987; Widen et al., 2000). The basic paradigm used in the tangible reinforcement operant conditioning audiometry (TROCA) or visually reinforced operant conditioning audiometry (VROCA) procedure involves a bar press response coupled with either tangible or visual reinforcement. TROCA or VROCA has been shown to be most effective with children between 2 and 4 years of age developmentally, and also is effective with children with mental challenges (Diefendorf, 1988; Wilson & Thompson, 1984). In conditioned play audiometry (CPA), children learn to engage in an activity each time they hear the test signal. When children are taught to perform play audiometry, it is usually not difficult to select a response behavior that they are capable of performing. The challenge in play audiometry is teaching the child to wait, listen, and respond with the play activity only when the auditory signal is audible. From 25 to 30 months, CPA is sometimes possible within the time constraints of clinical activity (Thompson, Thompson, & Vethivelu, 1989). After the developmental age of 30 months, CPA is the method of choice. Because overlap

exists among visual reinforcement audiometry (VRA), TROCA/VROCA, and CPA as suitable techniques with infants and young children, the successful evaluation of a child ultimately depends on the observational skills, interpersonal skills, and experience of the audiologist.

Physiologic Assessment

Physiologic assessment procedures are of particular importance in the audiologic assessment of young children. Measurement of auditory evoked potentials, especially the ABR, can provide accurate estimates of threshold sensitivity. (ASHA, 1999) Consequently, ABR plays an important role in both identification and assessment, particularly with children too young or too developmentally delayed for reliable assessment using conditioned behavioral techniques (Stein & Kraus, 1985).

Subject characteristics and recording parameters are known to influence the ABR. Appendix B provides commonly used recording, stimulus, and analysis parameters. Under good recording conditions, visual detection levels of Wave V are usually within 10 dB of behavioral audiometric thresholds for click stimuli. Data from several studies provide normative data for ABR latencies for infants and children to 3 years of age (Gorga, Kaminski, Beauchaine, Jesteadt, & Neely, 1989; Gorga, Reiland, Beauchaine, Worthington, & Jesteadt, 1987).

The auditory steady-state response (ASSR) is an auditory evoked potential test with emerging clinical applications. It holds promise as a method of estimating frequency-specific hearing sensitivity in patients who cannot or will not provide reliable or valid behavioral thresholds (Cone-Wesson, Dowell, Tomlin, Rance, & Ming, 2002; Dimitrijevic et al., 2002; Vander Werff, Brown, Gienapp, & Schmidt-Clay, 2002). The accuracy of ASSR predictions of hearing sensitivity in infants and young children is an area of active interest at this time (Sininger, 2002). Some concerns about recording artifact under certain stimulus conditions have been expressed (Gorga et al., 2004; Small & Stapells, 2003); research in this area is ongoing and improvements in methodology are expected. As with all developing clinical procedures, audiologists are expected to monitor the literature for methodological improvements in ASSR.

At this time, elimination of the click-evoked ABR is not recommended, as it can provide useful information regarding neural integrity. Assessment of interwave latencies, ear asymmetries, and morphology relative to age-appropriate norms may be completed as part of the ABR evaluation and the information may be used in the context of other clinical and/or medical findings. Children who present with abnormal ABR findings of no response or absence of later waves but robust OAEs should undergo further evaluation to differentiate between cochlear and neural dysfunction. When the ABR is absent or abnormal, response to both rarefaction and condensation click stimuli should be obtained to evaluate the presence of the cochlear microphonic (CM; Berlin et al., 1998). In these instances, precautions must be taken to distinguish the CM from a stimulus artifact. For example, performing repeated measurements with the stimulus tube open versus pinched should cause the CM waveform to disappear because no signal is reaching the cochlea to generate a CM. If the alternating current (AC) waveform remains, then

it is a stimulus artifact, which results from the electrical signal at the back of the transducer being picked up by the recording electrodes and amplified (Durrant & Ferraro, 1999).

OAEs also expand the pediatric audiology test battery by providing a physiologic means of assessing preneural auditory function (Gorga, Neely, Bergman et al., 1993; Kemp, Ryan, & Bray, 1990; Norton & Widen, 1990). The presence of OAEs is consistent with normal or near-normal hearing thresholds in a given frequency region. Although relations exist between OAEs and behavioral thresholds (Gorga, Neely, & Dorn, 2002; Gorga Stover, & Neely, 1996; Martin, Ohlms, Franklin, Harris, & Lonsbury-Martin, 1990) and there has been improvement in strategies for predicting thresholds using OAEs (Boege & Janssen, 2002; Gorga, Neely, Dorn & Hoover, 2003), variability among individuals suggests that caution should be exercised when attempting to predict behavioral thresholds from OAEs. Because OAEs are generated in the cochlea, they provide information that further defines auditory system integrity and sensitivity. Used in conjunction with ABR, OAEs are not only useful in the differential diagnosis of cochlear hearing loss but also in the identification of children with neurological dysfunction.

Transient evoked OAEs (TEOAEs) are elicited following either a click or transient stimulus (TEOAE), whereas distortion product OAEs (DPOAEs) are elicited following stimulation with two tones. TEOAEs typically are measured in response to a click at approximately 80 dB pSPL (78-82 dB SPL). Although the click stimulus is a broadband stimulus that is not frequency-specific, the response is analyzed in the frequency domain, thus providing information across frequencies from 500 to 5000 Hz, although test performance is best for mid-to-high frequencies. Probe fit can affect the spectrum of the click stimulus in the ear canal. The stimulus spectrum, as measured in the ear canal, should have equal intensities across the frequency range. However, in neonates, this cannot be achieved and the stimulus typically has more high-frequency energy (Norton et al., 2000). In common clinical practice, TEOAEs need to be present above the noise floor by at least 6 dB and/or have a reproducibility of greater than an established percentage at defined frequencies. For example, Kemp et al. (1990) recommended a minimum of 50% reproducibility for determining response presence, and Prieve et al. (1993) found 70% to be a reasonable expectation when coupled with an overall minimum amplitude (wideband) of 6 dB SPL. For narrow frequency bands, levels of 3 dB above background noise may give reasonable assurance of a TEOAE response for that frequency region alone (Norton et al., 2000). Hussain, Gorga, Neely, Keefe, & Peters (1998) provided an approach in which data from normal and from impaired ears were used to develop diagnostic criteria, thus explicitly taking into account the fact that responses from normal and impaired ears are not completely separated for any criterion value. It should be noted that in the presence of very low noise levels, a low-level TEOAE response could result in an OAE-to-noise ratio (SNR) that exceeds passing criteria. A diagnostic approach in which SNR is used to establish the reliability of the measurement, followed by a clinical decision based on response level, might avoid diagnostic errors associated with very low noise levels.

DPOAEs are measured in response to two tones (primaries) that interact to produce nonlinear distortions in the cochlea. DPOAEs are measured at the frequencies of the distortion product $2f_1 - f_2$ for each stimulus tone pair. The stimulus tones are

designated by f_1 for the lower frequency tone, f_2 for the higher frequency tone, and L_1 and L_2 for the lower and higher frequency intensity levels, respectively. The two tones typically are selected so that the frequency ratio between the tones (f_2/f_1) is 1.22, which is known to produce the largest ($2f_1 - 2f_2$) distortion product at most test frequencies in humans. Data from several studies suggest that the primaries should be unequal and of a moderate level (e.g., $L_1/L_2 = 65/55$ dB SPL) to most accurately classify auditory status (e.g., Stover, Gorga, Neely, & Montoya, 1996). Response presence can be determined by examining response level or by examining the response level relative to the noise floor (SNR). SNR has generally good performance for identifying ears with normal cochlear function, but because it depends on the level of the noise as well as OAE level, the same potential problem mentioned above regarding use of SNR with TEOAEs also exists for the DPOAE. Gorga et al. (1997) provided an interpretative approach for DPOAEs that is similar to the one described by Hussain et al. (1998) for TEOAEs. It recognizes the fact that there is no criterion value that will separate normal or impaired function without error. However, their approach provides a means for determining the level of confidence with which any measured response indicates normal or impaired hearing. In their application, SNR is used to first determine that a response was reliably measured. If the SNR indicates that a reliable response was measured, DPOAE level is then used to determine auditory status.

Schemes for trying to determine the degree of hearing loss and/or for predicting thresholds using DPOAEs have been investigated (Boege & Janssen, 2002; Dorn et al., 2001; Gorga et al., 1996, 2002, Gorga, Neely, Dierking, Dorn, Hoover, & Fitzpatrick 2003; Martin et al., 1990). Although some strategies have met with success, variability is such that threshold predictions should be viewed cautiously. In some approaches, predictions of behavioral thresholds from DPOAE thresholds require the measurement of DPOAE levels for several stimulus levels (i.e., DPOAE input-output functions). It may be difficult to obtain these data routinely under some clinical conditions.

Acoustic Immittance. Acoustic immittance measures are an integral part of the pediatric assessment battery. Clinical decisions should be made based on a quantitative assessment of the tympanogram, including consideration of equivalent ear canal volume, peak compensated static acoustic admittance, tympanometric width or gradient, and tympanometric peak pressure. The components of the immittance test battery, alone or in combination, have been used for many years to evaluate middle-ear function and to screen for middle-ear effusion (MEE; ASHA, 1997b). The acoustic reflex may provide supplemental information relevant to the functional status of the middle ear, cochlea, and brainstem pathway. Together, these measures are fundamental components of the pediatric audiology test battery. For neonates and young infants, however, optimal clinical procedures for application of tympanometric and acoustic reflex measurements are not well defined (ASHA, 1994; McMillan, Bennett, Marchant, & Shurin, 1985; Sprague, Wiley, & Goldstein, 1985). Under the age of approximately 4 months, interpretation of tympanograms and acoustic reflex findings may be compromised when a conventional low-frequency (220- or 226-Hz) probe tone is used (Paradise, Smith, & Bluestone, 1976).

A higher probe-tone frequency (e.g., 1000 Hz) appears to provide a more valid indication of middle-ear function (ASHA, 1988; Bennett & Weatherby, 1982; Himelfarb, Popelka, & Shannon, 1979; Holte, Margolis, & Cavanaugh, 1991; Marchant et al., 1986; Margolis, 1978; Margolis & Hunter, 1999; Margolis & Popelka, 1975; Weatherby & Bennett, 1980) and normative data for 1000-Hz tympanometry are now available for neonates and young infants (Margolis et al., 2003). Likewise, wideband acoustic reflectance (Keefe, Gorga, Neely, Zhao, & Vohr, 2003) may prove to be valuable as a clinical tool, especially in assessing middle-ear status in young infants, but further investigation is needed. The limited clinical guidelines for high-frequency tympanometry should not preclude their application in the pediatric test battery. However, thoughtful interpretation of test results must be made in combination with other clinical findings.

ASHA guidelines (ASHA, 1997b) include suggested data-based criteria for tympanometric screening for middle-ear disorder (Nozza, Bluestone, Kardatzke, & Bachman, 1992, 1994; Roush, Bryant, Mundy, Zeisel, & Roberts, 1995), which also are applicable to assessment of middle ear disorders in a diagnostic setting. Because most instrumentation available uses acoustic admittance rather than acoustic impedance as a measure of immittance, the recommended values in the guidelines and in the referenced literature for peak immittance are in millimhos (mmhos). When a quantitative assessment of a tympanogram is used, care must be taken to ensure that there is correspondence between the graphic representation and the absolute quantities indicated. With children, there sometimes are irregularities in the tympanogram shape (due to movement artifact, swallowing, vocalizing) that may be mistaken for a tympanometric peak by the instrument and can cause the absolute values that are provided to be misleading.

In addition, ear canal volume should be noted and taken into consideration when interpreting tympanograms. For example, equivalent ear canal volumes for ears with an intact tympanometric membrane in children between 1 and 7 years of age range between 0.3 and 0.9 cc (5th and 95th percentile). Ear canal volumes for ears with a patent PE tube in the tympanic membrane for children between 1 and 7 years of age range between 1.0 and 5.5 cc (5th to 95th percentile).

Protocols

In keeping with family-centered service provision, it is recommended that parents or care providers accompany infants and young children throughout the assessment process. When appropriate, family members should be included in the assessment not only as providers of information but as participants in the process (Matkin, 1994).

Assessment Protocol for Children Who Are Chronologically/ Developmentally Birth Through 4 Months of Age (Age Adjusted for Prematurity)

At these very young ages, or for children with severe developmental delays or multiple health conditions, the suggested methods for comprehensive assessment rely primarily on physiologic measures of auditory function: ABR [and/or ASSR] using frequency-specific stimuli are used to estimate the audiogram; ABR using click stimuli is used to assess VIIIth nerve integrity. OAEs and acoustic immittance measures are used to supplement and corroborate the evoked-potential findings. The results of these physiologic measures should always be considered in combination with case history, parent/caregiver report, and behavioral observation

of the infant's responses to a variety of auditory stimuli. The behavioral observation is intended for corroboration of parent/caregiver report of the child's auditory behavior rather than for threshold estimation.

Case History. See Appendix A.

Otoscopy. The purpose of otoscopy in this population is to ensure that there are no contraindications to placing an earphone or probe in the ear canal. Additionally, visual inspection for obvious structural abnormalities (e.g., ear pits, ear tags, atresia, and lowset ears) of the pinna and/or ear canal should be included. Because of the size and anatomy of the newborn ear, it may be difficult to identify the tympanic membrane or any landmarks.

Physiologic Assessment.

ABR Testing for Threshold Estimation.

- Stimuli: Frequency-specific stimuli (tone bursts of low, mid, and high frequency).
- Transducer: Insert earphones are recommended, unless contraindicated, for air-conduction testing. A bone-conduction transducer will be needed if air conduction is elevated (i.e., if air-conduction thresholds are greater than 20 dB nHL, bone-conduction testing should be completed to assess the type of hearing loss).
- Protocol: Responses should be attempted down to 20 dB nHL. Definition of threshold should be attempted in at least 10-dB steps. Recording epochs of 20–25 ms are necessary for adequate ABR threshold detection measures in infants, especially when tonal stimuli are used.

ABR Testing for Measuring VIIIth Nerve Integrity.

- Stimuli: Click stimuli at a high level (e.g., 70 dB nHL) will be adequate in most situations to identify Waves I, III, and V. If no response is obtained at the maximum output level, obtain one run of rarefaction clicks and one of condensation clicks to distinguish between cochlear and neural dysfunction. Use a catch trial (i.e., no signal) to rule out a stimulus artifact that may be misinterpreted as the CM.
- Transducer: Insert earphones.
- Protocol: Compare interpeak latencies with corrected age norms.

Many children in this age group can be tested during natural sleep, without sedation, using sleep deprivation with nap and feeding times coordinated around the test session. However, active or older infants may require sedation to allow adequate time for acquisition of high-quality recordings and sufficient frequency-specific information.

OAEs.

- Limited
    - TEOAE: One level (e.g., 80 dB pSPL) click stimulus should be completed. Normal distributions for this condition for normal hearing are documented in the literature (Hussain et al., 1998), or
    - DPOAE: One level of L_1 and L_2 65/55 dB SPL at least at four frequencies. Normal distributions for this condition for normal hearing are documented in the literature (Gorga et al., 1997).
- Comprehensive
    - TEOAE: Two levels (e.g., 80 dB pSPL and a lower level) may be completed and/or one level using click and multiple frequencies for stimuli, or
    - DPOAE: Use of three levels (e.g., 65/55 and lower levels, as shown by Kummer, Janssen, & Arnold, 1998; Kummer, Janssen, Hulin, & Arnold, 2000) should be completed to obtain DPOAE input-output functions, or at one level for multiple (more than four) frequencies, or
    - Comparison of TEOAE (e.g., single level, single stimulus) and DPOAE (e.g., single level): The TEOAE is a better predictor of low-frequency hearing sensitivity and the DPOAE is a better predictor of high-frequency sensitivity (Boege & Janssen, 2002; Gorga Neely, Dorn, & Hoover, 2003).

Acoustic Immittance Assessment.

- Probe tones equal to or greater than 660 Hz should be used because of the poor validity of tympanometry when using a low-frequency probe tone with this age group and the demonstrated diagnostic value of tympanometry with a high-frequency probe tone

Behavioral Assessment. The high inter- and intrasubject variability in responses has ruled out behavioral observation procedures for estimating hearing thresholds in infants 4 months of age and younger (Hicks, Tharpe, & Ashmead, 2000; G. Thompson & Weber, 1974). There is some benefit, however, in observing auditory behaviors of young infants, because behavioral responses provide information on how infants respond to auditory input. Any behavioral observation assessment is intended for corroboration of patient/caregiver report of the child's auditory behavior rather than for threshold estimation.

Development Screening and Functional Auditory Assessment. Portions of developmental scales may be useful in assessing prelinguistic communicative behavior and determining the need for developmental evaluations. An example of an appropriate screening tool is the Early Language Milestone Scale (Coplan & Gleason, 1993).

Assessment Protocols for Children Who Are Chronologically/ Developmentally 5 through 24 Months of Age (Age Adjusted for Prematurity)
Case History. See Appendix A.

Otoscopy. If there is reason to believe that a thorough otoscopic examination will result in an inability to continue with behavioral testing (i.e., the child will become distraught), then a limited inspection consisting of visual inspection of the entrance to the ear canal will be sufficient prior to insertion of insert earphones. However, a complete otoscopic examination is recommended prior to immittance testing, OAE testing, or the insertion of probe microphones.

Behavioral Assessment. VRA is the behavioral test of choice.

- Stimuli: Speech and frequency-specific (octave intervals from 250 to 4000 Hz).
- Transducer: Insert earphones are recommended, unless contraindicated, followed by bone conduction as needed; sound-field testing may be necessary or useful with some children (Renshaw & Diefendorf, 1998).
- Protocol: Minimum response levels (MRL) should be obtained for the following stimuli: speech, 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz. The order of stimuli presentation will vary according to the focus of the audiological assessment. One should consider alternating between ears to obtain, for example, an (MRL) for speech in the right ear followed by speech in the left ear, followed by 2000 Hz etc. Numerous options for stimulus start-level, step-size, and start-stop rules are available (Tharpe & Ashmead, 1993; Widen, 1993).

Physiologic Assessment.

Acoustic Immittance Assessment.

- Tympanometry: For most of this age group, a low-frequency (226 Hz) probe tone is appropriate. Between 5 and 7 months of age, there is still a possibility of false-negative tympanograms in ears with MEE according to some studies (Paradise et al., 1976; Purdy & Williams, 2000). Use of a 1000-Hz probe tone for tympanometry in this subset of infants in this age group is recommended when attempting to identify MEE.
- Acoustic reflex thresholds: Acoustic reflex thresholds should be obtained for pure-tone activator frequencies 500, 1000, and 2000 Hz, ipsilaterally. If there is a question of neural pathology, contralateral reflexes should be measured at the same frequencies. Also, absence of acoustic reflexes sometimes can be helpful in the diagnosis of MEE when tympanogram shape is equivocal.

OAEs and ABRs. When behavioral audiometric tests are judged to be unreliable, ear-specific thresholds cannot be obtained, or when results are inconclusive regarding type, degree, or configuration of hearing levels, (evoked) EOAEs and/ or ABR testing should be completed. In addition, if the neurological integrity of the auditory system through the level of the brainstem is in question, ABR testing should be conducted. See the Assessment Protocol for Children Who Are Chronologically/Developmentally Birth Through 4 Months of Age.

Developmental Screening and Functional Auditory Assessment.

Developmental Screening. For this population, a language screening tool such as the Early Language Milestone Scale (Coplan & Gleason, 1993) can be administered as a screen for receptive and expressive language status.

Functional Auditory Assessment. For this population, assessments of auditory skill development such as the Early Listening Function (ELF; Anderson, 2002) or the Functional Auditory Performance Indicators (FAPI; Stredler-Brown & Johnson, 2003) may be appropriate if there are concerns regarding auditory development. For children in this age range with severe-to-profound hearing loss, the Infant-Toddler Meaningful Auditory Integration Scale (IT-MAIS; Zimmerman-Phillips, Osberger, & Robbins, 1998) is an appropriate functional assessment tool.

Assessment Protocol for Children Who Are Chronologically/ Developmentally 25 to 60 Months of Age (Adjusted for Prematurity)

Case History. See Appendix A.

Otoscopy. Otoscopic examination of the external auditory canal (EAC) and tympanic membrane is necessary prior to the audiological evaluation. At the least, verification that the EAC is free of obstructions (e.g., foreign objects, impacted cerumen) and that there is no drainage from the middle ear is essential. To the extent possible, examination of the tympanic membrane with regard to color, position, and abnormalities should be attempted.

Behavioral Assessment. Behavioral techniques, in combination with acoustic immittance measures, are generally sufficient for the comprehensive assessment of hearing for children in this age range. Yet, the abilities of children in the age range from 25 months to 60 months vary widely. The assessment method used is dependent to a large extent on the developmental level of the child (e.g., VRA, TROCA/VROCA, CPA, conventional audiometric testing).

Frequency-Specific Thresholds. See Assessment Protocol for Children Who Are Chronologically/ Developmentally 5 through 24 Months of Age.

Threshold for Speech.

- Speech Awareness Threshold (SAT)
- Speech Recognition Threshold Audiometry (SRT) by identifying pictures of spondee words or using identification of objects or body parts (Ramkissoon, 2001).

Word Recognition Testing.

- Northwestern University Children's Perception of Speech (NU-CHIPS; Elliott & Katz, 1980).
- Word Intelligibility by Picture Identification (WIPI; Ross & Lerman, 1971).
- Minimal Pairs Test (MPT; Robbins Renshaw, Miyamoto, Osberger, & Pope, 1988).

• Pediatric Speech Intelligibility Test (PSI; Jerger & Jerger, 1984).

Although word recognition testing may not be possible with some young children because of their age, degree of hearing loss, or language skills, it is possible to assess speech perception skills in very young children.

Speech Perception Skills. The ability of audiologists to determine if a child's auditory development is at the detection, discrimination, or comprehension stage is important for management purposes:
• Detection (e.g., Early Speech Perception Test [ESP; Moog & Geers, 1990], Ling 6-Sound Test [Ling, 1986]);
• Discrimination (e.g., Screening Inventory of Perception Skills [SCIPS; Osberger et al., 1991], Low-Verbal ESP [Moog & Geers, 1990]);
• Comprehension (e.g., Speech Perception Instructional Curriculum and Evaluation [Moog, Biedenstein, & Davidson, 1995], Mr. Potato Head Task [Robbins, 1994], or following simple commands [Matkin, 1979; Olsen & Matkin, 1979]).

Physiologic Assessment.

Acoustic Immittance Assessment.

• Tympanometry: Tympanograms should be obtained using a low-frequency (226-Hz) probe tone.
• Acoustic reflex threshold: Acoustic reflex thresholds should be obtained for pure-tone activator frequencies 500, 1000, and 2000 Hz, ipsilaterally. If there is a question of neural pathology, contralateral reflexes should be measured at the same frequencies. Also, absence of acoustic reflexes sometimes can be helpful in the diagnosis of MEE when tympanogram shape is equivocal.
• OAE and ABR: OAE and ABR are recommended when the validity or adequacy (ear-specific information) of behavioral test results is limited or if the neurologic integrity of the auditory pathways to the level of the brainstem is in question. When ear-specific information cannot be obtained, EOAE testing should be completed for each ear. If EOAE (TEOAE or DPOAE) responses are not present at expected levels across the frequency range, ABR testing should be conducted. See Assessment Protocol for Children Who Are Chronologically/Developmentally Birth Through 4 Months of Age.

Developmental Screening and Functional Auditory Assessment.

Developmental Screening. For children 36 months of age and older, social skill assessment is an important aspect of development that can be screened using tools such as the Meadow-Kendal Social-Emotional Assessment Inventories for Deaf and Hearing Impaired Students (Meadow-Orlans, 1983). This tool consists of 49 items in five subscales: including social, communicative behavior, dominating behavior, developmental lags, and compulsive behaviors.

Functional Auditory Assessment. Appropriate functional assessment tools for this age range include those that are appropriate for children with minimal or mild hearing losses (i.e., Screening Instrument for Targeting Educational Risk in

Preschool Children; Anderson & Matkin, 1993) or for children with severe-to-profound hearing losses (i.e., the Meaningful Auditory Integration Scale; Robbins, Renshaw, & Berry, 1991).

Outcomes

The expected outcomes of an audiologic assessment of infants and young children include the following:

- Identification of infants and young children with permanent or transient hearing loss, middle-ear dysfunction, or a potential central auditory processing/language disorder;
- Quantification of hearing status based on electrophysiologic, physiologic, and/or perceptual responses to acoustic stimuli;
- Assessment of cochlear, auditory nerve, and/or central auditory nervous system integrity based on electrophysiologic and/or physiologic responses to acoustic stimuli;
- Development of a comprehensive summary of history, physical, and audiologic findings, recommendations, and management;
- Development and implementation of a plan for periodic monitoring and continued surveillance for auditory disorders or impairments based on hearing loss risk indicators or audiometric results;
- Development of a culturally appropriate audiologic (re)habilitative plan to include recommendations for advanced audiologic assessment, medical referral, assessment for sensory aids, auditory assistance devices and systems, aural (re)habilitation assessment and management, speech and language assessment, educational referral/assessment/recommendations, and/or counseling; and
- The provision of family-centered counseling and education to include degree and type of hearing loss; its implications for the child's health, development, communication, and/or education; and associated disability and management/(re)habilitative options.

Follow-Up Recommendations

Based on the Healthy People 2010 goals (U.S. Department of Health and Human Services, 2000), the following should be completed by 3 months of age for infants with **confirmed hearing loss:**

1. Review results of the audiologic assessment, implications of the audiologic diagnosis, and recommendations for intervention with the parents/caregivers, including:
    a. information regarding the need for medical evaluation and diagnosis,
    b. amplification options,
    c. information regarding the importance of early intervention,
    d. information regarding communication options for young children with permanent hearing loss,
    e. information regarding the availability and importance of parent-to-parent support, and
    f. information and referral for funding assistance if necessary.
2. In consultation with the infant's primary care provider (i.e., the child's medical home), refer the infant/family to an otolaryngologist for medical assessment.
3. As appropriate, discuss additional specialty evaluations (e.g., genetics, ophthalmology, child development) with parents/caregivers and the infant's primary care provider.

4. Initiate the amplification process if appropriate and ensure that medical clearance for amplification has been obtained.
5. Refer the family to the community's infant-toddler service coordinator for specific information regarding early intervention options and local resources. If not part of the infant-toddler services referral, contact the educational audiologist in the child's school district.
6. Report, with consent, to the family/caregiver, to the infant's primary care provider, and to the referral source.

The following should be completed immediately after assessment for infants with **hearing within normal limits:**

1. Review results of the audiologic assessment, implications of the audiologic diagnosis, and recommendations for intervention with the parents/caregivers, including:
    a. information about risk indicators for progressive and delayed-onset hearing loss, and
    b. information about typical speech, language, and listening developmental milestones.
2. Report, with consent, to the family/caregiver, to the infant's primary care provider, and to the referral source.

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Name: _____   Date: _____

1. For what reason was this hearing test arranged?   _____

2. Has your child ever had a hearing test?   Yes   No

3. Do you have any concerns about your child's hearing?   Yes   No

4. Does your child seem to hear better on some days than others?   Yes   No

5. Does anyone in the family (sisters, brothers, aunts, grandparents, etc.) have a handicap or problem with language, learning, hearing, speech, etc.?   Yes   No

6. Were there any complications during pregnancy or delivery?   Yes   No

7. Were any of the following present after your child's birth or during the first two months?

   Stayed in hospital after mother   Prematurity
   Birth weight less than 5 lbs.   Poor weight gain
   Did not respond to sounds or people   Appeared yellow
   Was in an incubator or isolette   Infections at birth
   Difficulty breathing   Physical deformities
   High fever

8. What is your child's general health?   Good   Average   Poor

9. Is your child taking any medication now?   Yes   No

10. Has your child ever been hospitalized?   Yes   No

11. Has your child experienced ear infections or other ear disorders?   Yes   No

12. Has your child had any ear surgery?   Yes   No

13. What illnesses has your child had?

   High fever   Dizziness
   Convulsions   Pneumonia
   Measles   Heart problems
   Head or ear injury   Rheumatic fever
   Encephalitis   Allergies
   Meningitis   Asthma
   Tonsillitis   Other: _____

14. Has your child ever received speech therapy?   Yes   No

15. Do you have any concerns about your child's speech and language?   Yes   No

16. Do you have any concerns about your child's physical or mental development?   Yes   No

17. If your child attends school, has he or she repeated any grades?   Yes   No

18. Do you believe your child has any learning problems?   Yes   No

19. What questions would you like to have answered as a result of today's hearing test? _____

   _____

   _____

Appendix A Child Case History

Appendix B Commonly Used Recording, Stimulus and Analysis Parameters

RECORDING EPOCH: A 20–25-ms time window is recommended (a 10-ms window is never appropriate for click or tone-burst ABR thresholds).

FILTERING: High pass: ≤30 Hz (higher cutoffs result in reduced amplitudes and elevated thresholds); low pass: 1000 Hz; slope: 12 dB/octave.

POLARITY: Stimulus presented at a fixed phase.

RATE: Rates of up to 50/s will not seriously increase ABR thresholds. Recommended: 37–41/s). Never use rates that are multiples of 60 Hz.

TRIALS: Average at least 2000 trials per replication. Children with hearing loss may require a higher number of sweeps especially when tone burst stimuli are used. A strategy that averages until a clear response is detected or until a maximum of perhaps 6000 sweeps (before concluding that no response is present) is clinically sound.

REPLICATIONS: Obtain at least two replications (three may be advantageous).

TRANSDUCERS: TDH-39; TDH-49; ER-3A earphones; bone vibrators (these transducers do not transduce energy efficiently for frequencies above about 6000 Hz).

CLICK STIMULUS: 100 _s (amplitude spectra are shaped by the frequency response of the transducer; consequently, a click stimulus has energy in low- and high frequency regions of the audiogram).

TONE BURST: Linearly gated tones ("2-1-2" cycles [rise-plateau-fall]) or five-cycle Blackman tones (no plateau) provide reasonable frequency specificity. Note: For some equipment the tones are set-up in terms of "rise time in milliseconds"; others in terms of "number of cycles".

ANALYSIS: To be considered "normal":

Air conduction:	500 Hz:	30–40 dB nHL
	2000 Hz:	20–30 dB nHL
	4000 Hz:	20–30 dB nHL
Bone conduction:	500 Hz:	20 dB nHL
	2000 Hz:	30 dB nHL
	4000 Hz:	30 dB nHL