AUDIOLOGICAL ASSESSMENT OF PROFOUNDLY HEARING-IMPAIRED CHILDREN

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The design of an audiological assessment protocol for profoundly hearing-impaired children may be divided into three areas. First, accurate estimation of hearing loss includes the behavioral measures of unaided and aided thresholds and the objective measures of electrocochleography and auditory brain stem response. The reliability of these measures for the accurate diagnosis of a profound to total hearing loss is discussed. Second, speech perception includes the measure of perception in the audition alone, vision alone, and audition plus vision conditions. Test material should include speech features, words, and sentences. Factors influencing the choice of material are the developmental age of the child, the method of educational instruction, speech and language skills, and vocabulary limits. Third, psychophysical properties of residual auditory skills include measures such as frequency, intensity, and duration difference limens. These skills may be compared to those elicited through other sensory channels, such as visual and tactile. Other important factors that should be considered are the psychological well-being of the child and family, family motivations and expectations, and educational requirements.

The audiological assessment of the profoundly hearing-impaired child is becoming increasingly important in the selection of the most appropriate sensory devices. These devices include high gain hearing aids, tactile and electro-tactile aids, and cochlear implants. This paper proposes three areas of investigation that are important in the audiological assessment protocol for device selection.

The first area of investigation concerns the accurate estimation of hearing thresholds. Behavioral pure tone audiometry is usually less reliable for children below 3 to 4 years of age than for children above this age. Northern and Downs¹ have suggested that responses for the younger children may be approximately 25 dB above true thresholds. The sophistication of the procedure and the ability of the child to respond are dependent on a number of factors. These include the developmental and chronological age, interest in the procedure, prior auditory experience, test environment, stimulus characteristics, and status of motor and perceptual abilities.² Also important in cases of acquired losses are the years of profound loss and the age of the child at the onset of the impairment. Failure to consider these factors may result in inaccurate behavioral threshold estimations before sensory device fitting. For example, it has been reported during postoperative assessment that some preschool-aged children provided with single-channel cochlear implants were able to respond more consistently to acoustic stimulation in the nonimplanted ear fitted with a hearing aid than they were preoperatively.³ This may suggest that, preoperatively, insufficient attention was directed toward the elicitation of consistent and realistic estimations of thresholds in these children.

Objective estimations of hearing thresholds should include electrocochleography (ECoG) and auditory brain stem response (ABR) audiometry. Both have some limitations for the full assessment of children. First, the characteristics of stimuli commonly used, for example broad band clicks, do not provide information concerning discrete frequencies usually assessed in behavioral audiometry. Second, ABR or ECoG electrical potentials may be approximately 20 dB above the behavioral thresholds because of difficulties in identifying the response waves.⁴ Rickards⁵ has demonstrated frequency-specific electrical potentials to amplitude-modulated and frequency-modulated tones; thus an estimation of discrete frequency thresholds may be obtained. Nowosielski and Redhead⁶ have demonstrated an effective technique for the use of high intensity signals, up to 115 dB hearing threshold level (HTL), in ECoG recordings. A piezoelectric tweeter housed in an electrostatically shielded cover and a different method of needle anchorage

have been used to overcome some signal and noise difficulties usually associated with high intensity stimulation.

The second area for investigation is concerned with the measurement of the contributions of the acoustic signal to speech perception. This is particularly important for the estimation of the communication handicap imposed by a profound loss. For this purpose, stimuli should be presented in the audition alone, vision alone, and audition plus vision conditions because these represent the more common speech signal channels available to the hearing-impaired child.⁷ The contributions of acoustic and visual speech signals have been frequently assessed by the use of these three conditions. For example, in the perception of vowels by hearing-impaired children it has been demonstrated that some patients were able effectively to combine acoustic and visual parameters, whereas others were not.⁸ In respect to speech perception in the audition alone condition, some profoundly hearing-impaired children can perceive a significant proportion of phonological features in the speech signal.⁹ Boothroyd¹⁰ has also suggested that children with hearing thresholds up to 110 dB HTL have useful hearing for both speech perception and production when used in an effective training program. The training program itself is an important contributor to the development of these skills with the sensory device.^{11,12}

A large selection of stimuli is available for the assessment of speech perception by hearing-impaired children. For example, consonant and vowel confusion studies provide information concerning phoneme discrimination. The monosyllable-spondee-trochee (MST) discrimination test¹³ measures syllable pattern categorization and within-pattern discrimination. Bamford-Kowal-Bench sentences¹⁴ provide a measure that reflects on the communicative perceptual skills of a child. However, the significance of the results is often limited by the material used. For example, within-pattern discrimination for the MST test may be dependent on pattern categorization skills. Vowel and consonant confusion studies may not necessarily reflect on the communicative perceptual skills of the hearing-impaired child. The choice of materials is also governed by the same factors that influence the estimation of behavioral thresholds. In addition, other factors should also be considered. First, the speech and language skills of the child would influence the choice of stimuli and the test administration. Second, vocabulary size may restrict the choice of test items because all stimuli should be within the limits of the child. Third, the method of educational instruction is important because experience with acoustic and visual speech signals influences the child's abilities to perform speech tests in these

modalities.

The third area for investigation is concerned with the measurement of the psychophysical properties of residual auditory skills. For instance, frequency difference limens may be used to suggest that the behavioral thresholds reflect tactile rather than auditory responses.¹⁵ Other properties concerned with intensity and temporal integration may also be included; for example, amplitude difference limens for the former and gap detection¹⁶ and numerosity skills¹⁷ for the latter. These can be studied in respect to the relationship between speech perception and psychophysical properties¹⁸ and in relation to performance in other modalities, such as tactile and visual.

The data collected by these assessments would provide information that assists in the selection of the most appropriate sensory device for the profoundly hearing-impaired child. Also, information for the effective auditory management of the child in an educational training program would be available. Other factors relevant to the implementation of auditory management would include the psychological and neurological status of the child, family motivations and expectations with the sensory device, and the speech and language requirements of the child within the educational setting.

Careful audiological assessment and management over a realistic time period would provide an indication of the speech perception skills of the child and indicate the usefulness of the sensory device fitted. The change to other devices, such as different hearing aids, tactile or electro-tactile aids, or cochlear implants could be suggested after effective assessments with the fitted device. Family and teachers would also be more informed of the device options available to the profoundly hearing-impaired child as a consequence of the interpretation of data from these assessments.

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