EDUCATIONAL ASSESSMENT AND MANAGEMENT OF CHILDREN WITH MULTICHANNEL COCHLEAR IMPLANTS

T. G. NIENHUY, PhD; G. N. MUSGRAVE, PhD; P. A. BUSBY, MA, DIP AUD; P. J. BLAMEY, PhD;
P. NOTT, B APP SC, DIP AUD; Y. C. TONG, PhD; R. C. DOWELL, BSC, DIP AUD; L. F. BROWN, B APP SC;
G. M. CLARK, PhD, FRACS

Funded by a grant from the National Health and Medical Research Council of Australia.

This paper describes the assessment and training program to evaluate speech, language, and communication skills of profoundly deaf children during and after training. Two sensory aids/prostheses are used: hearing aids and the Nucleus multichannel cochlear implant. Using a single-subject time-series experimental design, children's speech, language, and communication skills are assessed. For speech skills, assessment includes formal tests of articulation and intelligibility, syllable stress and process analyses, analyses of suprasegmental features, and voice quality. For general communication abilities, conversational skills with different speakers, story production skills, comprehension and expression of procedural information, discourse skills, and a measure of conversational interaction skills (pragmatics) are analyzed at regular intervals. Regular observations also sample the subjects' mode and frequency of interactions with individuals and groups in the school and home setting. Normative tests and formal analyses of language samples are also used to assess the overall language age of the child, vocabulary size, and kinds of expressive and receptive, syntactic, and semantic ability.

This paper outlines the evaluation and rehabilitation strategies that are being adopted in a current study of the effects of cochlear implantation in deaf children. The work is being undertaken by a multidisciplinary research team based at the University of Melbourne using a smaller version Nucleus Implantable Hearing Prosthesis suitable for children. The implantable prosthesis can allow the delivery of a number of speech-processing strategies. The voicing or fundamental frequency (F0) can be presented to one or more electrodes at the same rate as F0. In addition, the second formant (F2) can be presented to an appropriate electrode. A newer speech-processing strategy, where the first formant (F1) is used to stimulate different electrodes, has been shown to give improved speech perception results in postlingually deaf patients.

Research undertaken with our adult cochlear implant patients has shown that they derive substantial benefit from this device. They can learn to detect and discriminate prosodic information in speech and a wide range of environmental sounds. Furthermore, the special information available with multichannel stimulation provides additional benefit and enables many users to perceive and process speech through hearing alone.¹ These results have encouraged us to plan experimental studies with devices that include totally deaf children.

It has been hypothesized that cochlear implantation is likely to be of maximal benefit to young deaf children. In the early, optimal years for language development between birth and 6 years of age, artificial stimulation of the auditory system may facilitate young children's development of auditory processing skills, their speech production, and their communicative ability.²⁻⁴ It has also been proposed that preadolescents who have developed some verbal communication skills may learn to adapt readily to the speech signal they perceive through cochlear implants.⁵ However, research studies undertaken with children thus far have been unsatisfactorily designed and controlled. These studies failed to provide evidence of the specific benefits derived from these devices because the children have lacked both adequate preoperative assessments and educational evaluation as well as long-term postoperative rehabilitation, evaluation, and appropriate educational and familial sup-

port.^{6,7} If the full potential of the cochlear implant as an aid to communication in deaf children is to be realized, evaluation and rehabilitation must attend equally to analytic, as well as global, skills in speech perception, speech production, language, and communicative development. This process requires long-term cooperation between the child, the parents, the cochlear implant clinic, educators, and rehabilitators.^{3,8}

Our research attempts to meet some of these objections to previous studies by incorporating four features. First, the study uses an experimental design that maximizes the restrictive experimental conditions of small samples of subjects, unexpected contingencies at home and school, the practical limits of child cooperation, and the limited time that the child can spend in the laboratory. Experimental studies of implants in children are subject to a variety of other intervening variables.³ These include the age of the child, emotional factors, neurological status, cognitive development, visual skills, family factors, and educational and other environmental factors.

Furthermore, in assessing a child undergoing intensive diagnostic teaching, observed gains in language and speech function may be a result of teaching, as well as of the prosthesis itself. Therefore, possible training effects need to be considered in evaluating the efficacy of the device. A useful, though not ideal, experimental design is a basic time series or AB single-subject research design.^{9,10} In this design, repeated behavioral observations are made in the preimplant phase to establish a baseline of behavior. In the postimplant phase, multiple observations are repeated, allowing changes in the dependent variable to be observed. Three parameters of preimplant baseline measures can be considered: 1) trends in the baseline — does the level of behavior increase, decrease, or remain stable; 2) absolute or mean overall level of the baseline; and 3) slope of the baseline — at what rate does the baseline behavior change.¹⁰ At least three baseline measures are necessary to demonstrate stability, and the time intervals chosen will depend on the subject and the behavior concerned. In the case of children using cochlear implants, the time lapsing between observations of speech and language should be 4 to 6 weeks, ie, for a recently deafened 4-year-old who would

TABLE 1. SPEECH RECEPTION TESTING

Vowel and consonant confusions
Every 6 wk
Conditions include audition, vision, audition and vision
Stimulus material adapted from MAC battery ¹¹
Performance on BKB sentences ¹²
Every 6 mo
Conditions include audition, vision, audition and vision
Reception of closed-set words
Every 6 mo
Audition only
Stimulus material from NU-CHIPS ¹³

be expected to show developments over this period. A longer period may be necessary, ie, for a 10-year-old who may not show the same rate of development in audition, language, and speech.

The following preoperative and postoperative speech reception, speech production, language, and communication observations are to be undertaken in our studies. The final selection of test material is dependent on the age appropriateness and skill levels of the particular child.

Speech Reception. Table 1¹¹⁻¹³ shows the range from which speech reception tests are selected. Tests may be performed every 6 weeks or every 6 months, under audition, vision, or audition-plus-vision conditions, as appropriate. Materials for vowel and consonant confusion tests are adapted from the Minimal Auditory Capabilities Battery (MAC)¹¹ as described by Dowell et al.¹⁴

Speech Production. Table 2¹⁵ summarizes the range of repeated preimplant and postimplant measures that are being undertaken. For efficiency, data are taken either in the course of routine speech teaching (in the case of phonetic level evaluations) or from recordings of the child's running speech made elsewhere in the study.

Language and Communication. Table 3¹⁶ summarizes the range of instruments being employed to develop a global assessment of the child's receptive and productive language and communication skills. The tests are used as appropriate to the child's age and skill level. The evaluations include measures of the child's vocabulary size, early communication skills, and receptive and productive semantic and syntactic abilities, as well as conversational skills and pragmatic development. For the latter areas, an analytic technique devised by Cole and St Clair-Stokes¹⁶ for evaluating conversational styles and pragmatics in parent-child interaction is being employed. Observations of the child communicating with peers at home and at school will also be made.

Second, an ongoing diagnostic teaching approach will be employed by the educator or rehabilitator who is a member of our team. His/her primary role is 1) to carry out the preoperative and postoperative battery of assessments with children who receive cochlear implants, and 2) to develop individualized rehabilitation programs for each child. The children are seen individually for daily sessions of 1 hour's duration throughout the program. This role is considered to be essential in studies of cochlear implantation in children, at least until we determine the effects on progress that are caused by the device and by the training the children receive.

Information obtained from diagnostic teaching sessions

TABLE 2. SPEECH PRODUCTION MEASURES

Assessments
Intelligibility
Voice quality and control
Articulation
Tests
Edinburg Test of Articulation (every 6 mo)
Phonetic and phonologic level evaluations (every 6 wk) ¹⁵
Perceptual ratings*
Functional ratings of prosody
Objective tests of pitch variability, and vocal quality
*Laver J. The phonetic description of voice quality. Cambridge, England: Cambridge University Press, 1981.

should enable us to devise appropriate strategies for developing the child's speech perception skills using cochlear implants. Similarly, an understanding of the properties of electrical stimulation will have implications for the design of the child's speech development program.^{3,15} Details of progress in these areas will furnish valuable data for the experimental evaluation of the device.

Because a more global aim of the implant is to assist young deaf children to develop spoken language skills in the broader context of communication and social development, these areas also require clinical support and evaluation. This study includes measures of emerging expressive and receptive language, including syntax, morphology, semantics, and pragmatics, as well as interactional analyses in different communication settings (with peers, parents and teachers, at home and school), and including signed language use and cued speech where appropriate.

Third, close long-term cooperation is being encouraged between the child's family and the educational and clinical settings in both preimplant and postimplant stages. This should enable rehabilitation and evaluation strategies to be

TABLE 3. LANGUAGE AND COMMUNICATION MEASURES

Receptive (every 6 mo)
PPVT-R
Zimmerman Preschool Language Scale*
Reynell Developmental Language Scale†
Productive
Mean Length of Utterance‡
Type Token Ratio
GAEL-S (every 6 mo)
LARSP (every 6 mo)
Interactional
Conversational analyses
Interaction with mother (every 6 wk) ¹⁶
Interaction with teacher ¹⁶
Story production (with mother and teacher)
Story comprehension (with mother and teacher)
Comprehension of procedural instruction (every 6 mo)

PPVT-R—Dunn LM, Dunn LM. Peabody picture vocabulary test—revised. Circle Pines, Minn: American Guidance Service, 1981. GAEL-S—Moog JS, Geers AE. Grammatical analysis of elicited language. St Louis: Central Institute for the Deaf, 1980. LARSP—Crystal D, Fletcher P, Garman M. The grammatical analysis of language disability: a procedure for assessment and remediation. London: Edward Arnold, 1976.

*Zimmerman IL, Steiner VG, Pond RE. Preschool language scale. Columbus, Ohio: Merrill, 1979.

†Reynell JK. Reynell developmental language scales manual—revised. Windsor, England: NFER-Nelson, 1983.

‡Brown L. A first language. London, England: Allen and Unwin, 1973.

followed through in these settings and is likely to maximize the benefits the child derives from the implant.

Fourth, the clinical team is seeking to assist in providing information and counseling support to the child's family (and extended family). The important role of the family in the development of a deaf child has long been recognized.¹⁷ When considering a cochlear implant for their child, parents are subject to stresses additional to those already imposed in coming to terms with their child's disability. These are related to decisions about whether to seek an implant while faced with conflicting professional opinion and inaccurate media publicity, to uncertainties about the risks involved, to developing realistic expectations of the implant, to the needs of siblings and extra demands made on parents' time when taking part in the study. Experience also underlines the importance of providing sensitive and detailed explanations and emotional support to the child implantee whose cooperation and positive attitude would be a prerequisite to success.

SUMMARY

This paper presents a summary of the educational assessment protocols and management procedures that have been developed for application to deaf children with the Nucleus cochlear implant.

It is argued that assessment protocols should take into account higher order, intermediate, and lower level skills of children in speech and language production and reception, as well as the ongoing development of general communication skills if the efficacy of the cochlear implant is to be assessed fully.

The test battery considers factors such as a child's previous speech and language training and the language appropriateness of the test material. The battery also includes an assessment of the child's multisensory abilities, including comparisons between auditory-visual, tactile-visual, and visual-only speech perception performance. For linguistic skills, the protocol assesses the child's reception and production skills in speech (segmentals and suprasegmentals), language (syntax, semantics, and pragmatics) and communication (including conversational skills) both preoperatively and postoperatively. This protocol allows for full ongoing assessment, as well as planning for rehabilitative and educational programs.

REFERENCES

1. Millar JB, Tong YC, Clark GM. Speech processing for cochlear implant prostheses. *J Speech Hear Res* 1984;27:280-96.
2. House WF, Berliner KI, Eisenberg LS. Experiences with the cochlear implant in preschool children. *Ann Otol Rhinol Laryngol* 1983;92:587-92.
3. Ling D, Nienhuys TG. The deaf child: habilitation with and without a cochlear implant. *Ann Otol Rhinol Laryngol* 1983;92:593-8.
4. Simmons FB. Cochlear implants in young children: some dilemmas. *Ear Hear* 1985;6:61-3.
5. Eisenberg LS, Berliner KI, Thielemeyer MA, Kirk KI, Tiber N. Cochlear implants in children. *Ear Hear* 1983;4:41-50.
6. House WF, Berliner KI, eds. Cochlear implants: progress and perspectives. *Ann Otol Rhinol Laryngol* 1982; 91(suppl 91):67-73.
7. House WF, Berliner KI, Eisenberg LS. Experiences with the cochlear implant in preschool children. *Ann Otol Rhinol Laryngol* 1983;92:587-92.
8. Schein JD. Cochlear implants and the education of deaf children. *Am Ann Deaf* 1984;129:324-33.
9. Kratochwill TR, ed. Single-subject research: strategies for evaluating change. New York: Academic Press, 1978.
10. McReynolds LV, Kearns KP, eds. Single-subject experimental designs in communication disorders. Baltimore: University Park Press, 1983.
11. Owens E, Kessler D, Telleen C, Schubert E. The minimal auditory capabilities (MAC) battery. *Hearing Aid J* 1981;34:9-34.
12. Bench J, Bamford J, eds. Speech-hearing tests and the spoken language of hearing-impaired children. London: Academic Press, 1979.
13. Elliott LL, Katz DR. Development of a new children's test of speech discrimination. St Louis: Auditec, 1980.
14. Dowell RC, Tong YC, Blamey PJ, Clark GM. Psychophysics of multiple-channel stimulation. In: Schindler RA, Merzenich MM, eds. Cochlear implants. New York: Raven Press, 1985:283-90.
15. Ling D. Speech and the hearing-impaired child: theory and practice. Washington: A G Bell Associates, 1976.
16. Cole EB, St Clair-Stokes J. Caregiver-child interactive behaviours: a clinical procedure for the development of spoken language in hearing-impaired children. *Br J Audiol* 1984;18:7-16.
17. Luterman D. Counseling parents of hearing-impaired children. Boston: Little Brown and Co, 1979.

Minerva Access is the Institutional Repository of The University of Melbourne

Author/s:

Nienhuys, T. G.; Musgrave, G. N.; Busby, P. A.; Blamey, P. J.; Nott, P.; Tong, Y. C.; Dowell, R. C.; Brown, L. F.; Clark, Graeme M.

Title:

Educational assessment and management of children with multichannel cochlear implants

Date:

1987

Citation:

Nienhuys, T. G., Musgrave, G. N., Busby, P. A., Blamey, P. J., Nott, P., Tong, Y. C., et al. (1987). Educational assessment and management of children with multichannel cochlear implants. *Annals of Otology, Rhinology & Laryngology*, January-February, 96(1, part 2, suppl.128), 80-82.

Persistent Link:

<http://hdl.handle.net/11343/27255>