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## Preliminary Speech Perception Results for Children with the 22-Electrode Melbourne/Cochlear Hearing Prosthesis

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The 22-electrode cochlear prosthesis developed by the University of Melbourne and Cochlear Pty Ltd. has been shown to provide significant speech perception benefits to profoundly deafened adults [1]. More recently, use of an improved Multiplex encoding strategy has significantly improved speech perception performance both in quiet and in noise [2, 3]. Benefits to speech perception in children have not as yet been fully documented, in part due to the shorter history of implant use in children and the smaller overall number of children implanted as compared with adults.

The first implantation of the 22-electrode cochlear prosthesis in a child was carried out in Melbourne in January of 1985. In Melbourne, a 5-year-old child was operated on in April 1986, and a first congenitally deaf child in April 1987. The age of implantation has been progressively reduced, with the first 2-year-old child implanted in Melbourne in 1990. As at January 1992, approximately 1,200 children (under 18 years of age inclusive) have been implanted worldwide with the 22-electrode cochlear prosthesis. Of this number, approximately 50% are under the age of 6 years.

The age of the child, aetiology of the hearing loss, age at onset and duration of the hearing loss, education program attended both prior to and

subsequent to implantation, and parental motivation to assist in habilitation are all factors which may affect an individual child's development and progress with the device. Evaluation of performance in children is complicated by a number of issues, including the effects of delayed speech and language development, and the ability of individual children to perform auditory tests. The measure of performance chosen for any evaluation will also reflect the interests of the particular clinician, for example, effects of device use on speech production may be of interest to the speech therapist, whereas educational progress will be of primary importance to the teacher of an implanted child. However, in choosing an appropriate evaluation test to measure progress with the cochlear prosthesis, it is vital to realize that all measures such as effects of device use on speech production, educational progress, development of language, and effects on social and communication skills depend on the child being able to accurately perceive speech information through her/his device.

### *Method*

Speech perception test results are collected preoperatively and postoperatively in the Melbourne programme. These results serve a number of purposes, including: (1) establishing that the speech processor is functioning properly and is properly mapped; (2) establishing speech perception, speech production and language goals for use in the habilitation programme; (3) establishing postoperative versus preoperative benefits for the child; (4) monitoring continuing improvements in performance over time.

While results of individual tests may be useful for any of these purposes, they are not as appropriate for evaluation of overall performance in groups of children, since the effects of factors such as age, and level of linguistic development cannot be readily controlled. In addition, the importance of patient factors such as duration of profound deafness, experience with the device, or educational placement cannot readily be assessed from individual test results.

In order to address the issue of differing linguistic development and age of children in the programme, a series of six stages or categories of speech perception were established. The individual categories are hierarchically arranged from 1 to 6, and include performance at the levels described as follows: (1) detection of speech sounds including high frequency consonants; (2) discrimination of suprasegmental features of speech, plus 1; (3) discrimination and recognition of vowel sounds, plus 1 and 2; (4) discrimination and recognition of consonant sounds, plus 1, 2, and 3; (5) open-set speech recognition with scores less than 20% for unfamiliar material, plus 1, 2, 3 and 4; (6) open-set speech recognition with scores greater than 20% for unfamiliar material, plus 1, 2, 3, 4 and 5.

These categories were used to analyze speech perception results for 40 children and adolescents implanted with the 22-electrode cochlear prosthesis.

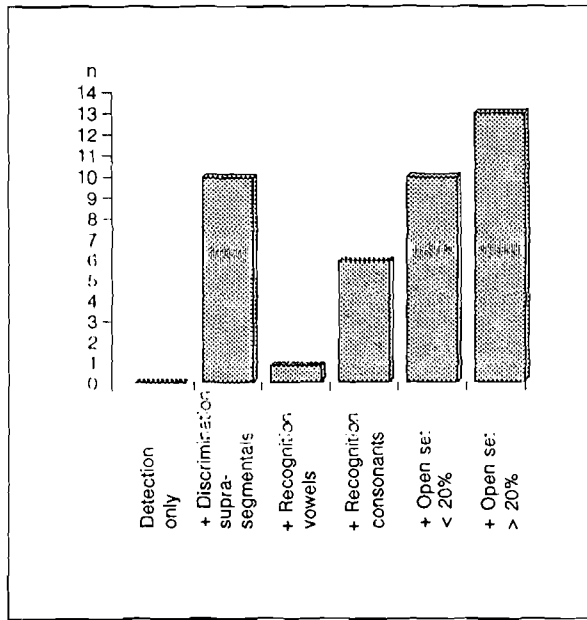


Fig. 1. Speech perception category achieved by implanted children (n = 40).

*Results*

Aetiology of hearing impairment varied across the 40 children and adolescents. A breakdown of hearing loss for the children showed that 24 of the children had congenital hearing losses (resulting from a number of specific aetiologies including: Usher's syndrome - 3, rubella - 2, CMV - 1, idiopathic - 8) versus 16 of the children with an acquired hearing loss (including meningitis - 11, progressive - 3, idiopathic - 2).

In all but 3 cases, the children were using 15 or more electrodes from the array in their programmed map. Of the 3 cases with less than 15 electrodes, 2 had an aetiology of meningitis and one had a congenital.

Figure 1 shows the number of children achieving speech perception results in each of the six speech perception categories. As shown, all children achieve a minimum of category 2 (discrimination of suprasegmentals). In total, 23 of the children, or 58% are in categories 5 and 6, indicat-

ing some open-set speech perception benefits. A total of 13 children, or 33% are in category 6, indicating open-set implant-alone speech perception scores of greater than 20% on unfamiliar material.

### *Discussion*

While this is preliminary data only, a number of interesting findings are evident. First, the majority of children in the programme have a hearing loss due to congenital aetiologies rather than to acquired. This may reflect the epidemiological patterns in Australia and/or the patient selection strategies employed. However, the result differs from the previously held view that the majority of children in cochlear implant programs would have hearing loss due to meningitis.

Previous results with adults [4] have established that the number of electrodes used was a significant factor in predicting scores on sentence perception tests. Analysis of the patient details for the children shows that 37 of the 40 children are using 15 or more electrodes. Although adult data can only be applied cautiously to children, the results suggest that the majority of the children would have enough electrodes for adequate speech perception.

The division of the 40 children into the six speech perception categories showed a number of points. First, no child is achieving only at the level of category 1 (detection of speech sounds). As shown, 58% of the children are achieving some open-set speech perception, placing them in categories 5 and 6. Analysis of contributing factors showed that the majority of children achieving categories 5 and 6 have used the cochlear prosthesis for periods longer than 1 year, and had periods of profound deafness less than seven years prior to implantation. At present, the majority of children in category 2 are those children who have used the device for less than one year. This is encouraging, since it suggests that many of the children currently achieving at the level of category 2 may also reach the open-set levels of category 5 and 6 with additional experience with the device.

More detailed statistical analysis of the results will examine the interaction of speech perception category with a number of factor including duration of profound deafness prior to implantation, number of years of experience with the device, educational placement of the child, age at implant, and residual hearing levels prior to implantation. This analysis

will identify factors important in predicting potential benefits from the device for individual children, and will assist in preoperative counselling and recommendations to parents.

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