Speech perception in children: effects of speech processing strategy and residual hearing


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SUMMARY

The ability of implanted children to adapt to different speech processing strategies has been demonstrated for the Nucleus implant system. Children previously experienced with the Multipeak speech processing strategy, were able to gain significant improvements in consonant, word and sentence perception using the Speak speech processing strategy, suggesting some degree of neural plasticity in neural-auditory coding. Of 192 implanted children with different degrees of preoperative residual hearing, 65% were found to obtain significant scores on open-set speech materials using electrical stimulation alone. Those children with more residual hearing had a greater probability of achieving open-set understanding, and at a minimum level, perceived high frequency consonant information which would not have been available through conventional hearing aids.

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INTRODUCTION

The ability of children to benefit from the Nucleus 22-channel cochlear implant has been shown in a number of studies which evaluated speech perception, speech production and acquisition of language (Dawson et al, 1992, 1995; Geers and Moog, 1994; Tye-Murray et al, 1995). In each of these studies, children were evaluated using the Multipeak speech coding strategy, implemented in the Spectra-22 speech processor. More recently, the Speak speech processing strategy has been implemented by Cochlear Limited in the Spectra-22 speech processor. Results obtained with experienced adult users showed that they were able to change to the new speech processing strategy, and showed significant benefits, particularly in the presence of background noise (Skinner et al, 1994). However, a large proportion of the adult implant population are postlingually deaf, having learned language through normal hearing. In contrast, a significant proportion of the paediatric implant population are congenitally deaf, and have learned to listen through their implant. Therefore, the ability of implanted children to benefit from the Speak speech processing strategy required evaluation, particularly in regards to the neural plasticity required to adapt to a different sound.

The ability of adult implant users to adapt to improved speech processing strategies has resulted in a continuing increase in mean speech perception scores (Clark et al, 1995). Recent clinical results show that postlingually deaf adults starting with the Speak speech processing strategy have performed almost at ceiling in tests using electrical stimulation alone. These results have led to evaluation of benefit from implant use in severely hearing-impaired adults. Similarly, pressure from parents of severely hearing-impaired children to ascertain whether their children would benefit more from hearing aids or cochlear implants has also grown. Although all implant candidates receive a hearing aid trial as part of the preoperative program, young children may take many months to adapt to the auditory input provided before any benefit is evident. To evaluate the potential for individual children with different levels of residual hearing to benefit from cochlear implants, a retrospective analysis has been conducted on the paediatric population of the Melbourne and Sydney Cochlear Implant Clinics.

MATERIALS AND METHODS

In the first study, twelve children (seven from the Melbourne Cochlear Implant Clinic and five from the Sydney Cochlear Implant Clinic) were assessed over a 2 year period, using the Multipeak, and then the Speak speech processing strategy. During the first period, four separate evaluations with Multipeak were conducted, using open-set sentence tests, in both quiet and noisy conditions (+15dB signal-to-noise ratio). The children were switched to Speak, and a further eight evaluations were conducted with Speak at three weekly intervals. The children were then switched back to Multipeak for a further evaluation. Subsequently, the children were evaluated after an additional twelve months of using the Speak speech processing strategy.

In the retrospective study of the paediatric population, the first 192 children who received cochlear implants in either the Children's Cochlear Implant Centre (NSW) in Sydney, or the Royal Victorian Eye & Ear Hospital in Melbourne were analyzed. All of these children have been implanted with the Nucleus 22-channel cochlear implant. The children were grouped into four classes according to their preoperative aided residual hearing thresholds (tab. 1). Hearing Class 1 representing those children with no aided responses, and Hearing Class 4 representing those children who had aided thresholds within the limits of the 70dB speech spectrum up to 2kHz. Given the heterogeneous nature of the paediatric population in regards to age and linguistic abilities, a new open-set speech perception test was appropriate for and had been conducted with all children. For this reason, the speech perception test results for the children were categorized according to the seven-step scale developed by Dowell et al, 1995 (see tab. 2). In that scale, Speech Perception Category 1 represents sound detection alone when using electrical stimulation alone. Speech Perception Categories 6 and 7 represent different performance levels of open-set speech perception using electrical stimulation alone.
RESULTS AND CONCLUSIONS

Figure 1a and 1b show mean speech perception scores for the 12 children using Multipeak and Speak. As shown, there was a significant (p<0.05) increase in mean scores with the Speak speech processing strategy. The increase in score was greater in the condition of poor signal-to-noise ratio. Mean scores continued to show an increasing trend with additional experience with the Speak speech processing strategy. Scores for evaluations conducted with Multipeak prior to the change to Speak, and subsequently at the change back to Multipeak were not significantly different for any of the twelve children. Eleven of the twelve children showed a significant increase in score when using Speak as compared with Multipeak. The twelfth child showed no significant difference between Multipeak and Speak. All twelve children opted to continue to use the Speak speech processing strategy following conclusion of the evaluation period.

These results suggest that hearing impaired children who had learned to listen primarily through the Nucleus cochlear implant using the Multipeak strategy were able to adapt to the different sound and information presented through the Speak speech processing strategy. This suggests a degree of neural plasticity in processing auditory information, and an ability to use new cues to assist with understanding of speech. The results which showed increased benefits in poor signal-to-noise ratio are of particular significance, as implanted children are often in situations of high background noise in the school classroom, particularly those children integrated classroom settings.

Table 3 shows the analysis of results for the retrospective study of pediatric populations. As shown, the largest proportion of children were in Hearing Class 1 (51%), followed by Class 2 (37%) and 3 (38%). The least number of implanted children were in Hearing Class 4 (19%). Overall, 65% of the 192 children were found to be able to achieve some open-set understanding of words (i.e. Speech Perception Categories 5, 6 and 7).

Speech Perception Category was found to be variable for the children in Hearing Class 1. A number of children were in all Speech Perception Categories 1 through 7. Similarly, children in Hearing Class 2 were spread across Speech Perception Categories 1 through 7. In Hearing Class 3, all but 1 child were in Speech Perception Categories 4 through 7, while all children in Class 4 were in Speech Perception Categories 4 through 7. This

Table 3. Number of children from each of four Hearing Classes in each Speech Perception Category (n = 192).

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<tr>
<th>Hearing Class</th>
<th>Category 1</th>
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Figure 2. Percentage of children in each Hearing Class with open-set speech perception.

Figure 2 shows the percentage of children in each of the Hearing Classes 1 through 4 who achieved open-set speech perception. As shown, a significant proportion of children in each of the hearing classes were able to achieve open-set speech perception. However, there is a marked trend in the results showing that the probability of achieving open-set understanding increased for those children with more residual hearing, and was highest for those children in Hearing Class 4 (90%).
The results for the retrospective study suggest that children with higher levels of residual hearing (i.e., severe-to-profound hearing loss) are good candidates for cochlear implants, and that they would appear to be able to access acoustic information from their cochlear implant which is not available from conventional amplification. Possible explanations for the good benefits achieved with this group could be the presence of more residual ganglion cells, or some pre-patterning of the auditory system through use of aided residual hearing pre-operatively.

REFERENCES


Author/s:

Title:
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Date:
1997

Citation:

Persistent Link:
http://hdl.handle.net/11343/26979

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Speech perception in implanted children: effects of speech processing strategy and residual hearing