THE EFFECT OF LANGUAGE KNOWLEDGE ON SPEECH PERCEPTION IN CHILDREN WITH IMPAIRED HEARING

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ABSTRACT - Open-set words and sentences were used to assess auditory speech perception of three hearing-impaired children aged 9 to 15 years using the Nucleus 22-channel cochlear implant. Vocabulary and syntax used in the tests were assessed following the initial perception tests. Remediation was given in specific vocabulary and syntactic areas, chosen separately for each child, and the children were reassessed. Two children showed a significant post-remediation improvement in their overall scores on the syntactic test and both perception measures. The third child who was older, had the best language knowledge and the lowest auditory speech perception scores, showed no significant change on any of the measures. Language remediation in specific areas of weakness may be the quickest way to enhance speech perception for some children with impaired hearing in this age range.

INTRODUCTION

Previous research has shown that speech perception abilities of children with cochlear implants vary across a wide range (Cowan et al., 1995; Dowell et al., 1992; Miyamoto et al., 1993; Osberger et al., 1991; Staller et al., 1991). It is therefore important to determine the factors that influence speech perception, and how they interact, so that we can maximise the potential of each child to perceive speech and to develop a competent grasp of language through their audition. It has also been clearly shown that there is a significant gap in language acquisition between most children with a severe or profound hearing impairment and their normally-hearing peers (Kretschmer & Kretschmer, 1986; Paul & Quigley, 1994). Hearing-impaired children have a slower rate of language acquisition, and their overall mastery of the pragmatics, syntax and vocabulary of language is significantly poorer (Geers & Moog, 1995; Moores, 1987). A recent report on the vocabulary of 32 children using a multichannel cochlear implant indicated that the mean rate of vocabulary acquisition post-implantation was equal to the rate for normal children, although the mean rate prior to implantation was less than half the normal rate (Dawson et al, 1995a). In spite of this encouraging result, many of the individual children were still falling behind their normally-hearing peers in word-knowledge and other aspects of language. As speech perception tests are based on language, it would seem logical that deficits in vocabulary or syntactical knowledge may limit children's abilities to use the phonemic information provided to them through their cochlear implant in a meaningful manner for communication. Furthermore, remediation of such deficits should improve children's abilities to use the information provided through their implant and result in improved speech perception scores on open-set tests. Therefore we may in fact be underestimating the potential speech perception abilities of at least some hearing-impaired children. This study examined the effects of remediation of syntactic knowledge and vocabulary on open-set speech perception for three children. Two hypotheses were tested:

1. That open-set speech perception scores are limited by knowledge of vocabulary and syntax.
2. That remediation of vocabulary and syntax will increase open-set speech perception scores.

METHOD

Evaluations

Speech perception and language tests were administered before and after training. Speech perception test materials were presented with live-voice, by a familiar female speaker, at a distance of 1 metre, and at an intensity of 70 dBA. Children wrote their responses for all tests, and no repeats were given. Written responses were required to avoid the problem of subjective interpretation of the children's spoken responses. Profoundly hearing-impaired children commonly have poorly articulated and partially unintelligible speech (Markides, 1970; McGarr & Osberger, 1982). Although the speech of children using cochlear implants has been shown to improve over time, not all children reach a high level of intelligibility (Dawson et al, 1995b; Grogan et al, 1995). Feedback on performance was not provided throughout test procedures. All speech perception testing was conducted in the implant alone condition (A). The test battery comprised:

Test of Syntactic Abilities

The Test of Syntactic Abilities (Quigley et al., 1978) was used to assess syntactical knowledge before and after remediation. Items from the TSA were selected and added to in order to construct a 10-minute written test covering present, present progressive and past tenses, determiners and plurality. Each item was a four-alternative multiple-choice task, and there were 10 items per grammatical construct, making a total of 50 items. The questions were administered using a printed form and answers were written.

Monosyllabic AB Words

Arthur Boothroyd Words (Boothroyd, 1968) were used to test perception of known and unknown vocabulary. The speech perception of each child was tested with AB Words at the start of the study using the complete set of 150 words in fifteen lists. Children were then asked to give a definition of all the words on the lists. Word and phoneme scores were calculated for each child for both known and unknown words. Comparing these scores gave an indication of whether knowing a word had a significant effect on how well it was perceived. The children were then taught the meanings of all the words they did not know, after which speech perception was again assessed on all lists.

Amended Bamford-Kowal-Bench Sentences

The BKB Sentence Test (Bench et al., 1979) provided a basis for individually assessing specific grammatical constructs and evaluating whether perception of these improved after the children had been taught the rules governing their use. The sentence lists were standardised so that each list contained approximately equal numbers of each grammatical construct, all of which were scored as key words. Each child was evaluated with five sentence lists prior to and after training. A total score across five lists was calculated for each grammatical construct.

Subjects

Three children participated in this study. At the time of the study, Child 1 and Child 2 were aged nine, and Child 3 was aged 15 years. Child 1 and Child 2 were implanted under the age of 10, whereas Child 3 was implanted as an adolescent. All three children had a profound hearing loss with no measurable hearing thresholds at 2000 Hz or above and hearing thresholds in excess of 95 dB at 500 Hz and 110 dB at 1000 Hz. All three children consistently wore hearing aids from the time of diagnosis of deafness until the time of implantation. They all communicated orally, although Child 2 also used manual communication and only Child 1 had speech that was intelligible to an inexperienced listener.

Remediation

Areas of greatest need for each child were identified by their scores on the TSA, and by analysis of errors for grammatical constructs in the BKB Sentence Test. Child 1 received remediation on simple present tense, while Child 2 and Child 3 received remediation on the past tense. Each child was seen twice-weekly for 30 mins over a period of 12 weeks. The unknown vocabulary from the AB Word Test was explained by the audiologist and used in meaningful contexts by the children. Games, conversational activities, written activities and role-playing were used to facilitate learning.

Remediation was specifically concerned with improvement of vocabulary and language knowledge, and the use of audition was not emphasised in any way.

Child	Aetiology	Age at Onset of Profound Deafness	Duration of Profound Deafness	Age at Implantation	Duration of Implant Use
1	meningitis	2y	1y8m	3y8m	5y11m
2	congenital unknown	0y	8y2m	8y2m	1y9m
3	congenital rubella	0y	12y	12y	4y

Table 1. History of deafness for each subject in the study.

RESULTS AND DISCUSSION

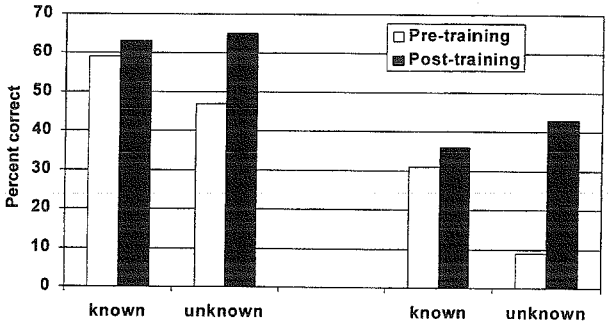

Figure 1. Mean scores for three children on the AB Word Test. Phoneme scores are shown on the left, and word scores on the right. The 'unknown' description refers to words whose meanings were unknown prior to remediation, but known after remediation.

On AB words, initial scores for unknown words were significantly lower than known words for Child 1 and Child 2. They did not know 37% and 42% of the meanings of words respectively. After the vocabulary was learned, scores for unknown words increased significantly ($p<0.001$; $p<0.01$ on a chi-squared test for Child 1 and Child 2 respectively), while scores for known words remained the same. Child 3 knew more words than the other children (31% were unknown before remediation). Speech perception scores for Child 3 did not improve significantly pre to post-training. Chi-squared analysis of the mean data shown in Figure 1 indicated that post-remediation scores were significantly higher than pre-remediation scores, and that the improvement for unknown words was significantly greater than the improvement for known words ($p<.001$ for each comparison, using separate analyses for word and phoneme scores). The fact that scores for known words did not improve significantly while those for unknown words did suggests that remediation of language deficits and not further practice in using their audition affected the children's abilities to use the information provided by the implant.

On the TSA, Child 1 and Child 2 showed significant improvements ($p<0.05$) in post-training scores overall, while Child 3 showed no improvement. This indicates that the remediation was effective in addressing the targeted language deficits for Child 1 and Child 2. The training concentrated on simple present tense for Child 1 and simple past tense for Child 2 and Child 3. Determiners and plurality were

not trained. The results in Figure 2 suggest that the trained tense items improved more than untrained items in the written (multiple-choice) TSA, although there was no statistically significant difference in the improvements observed for tense and other items.

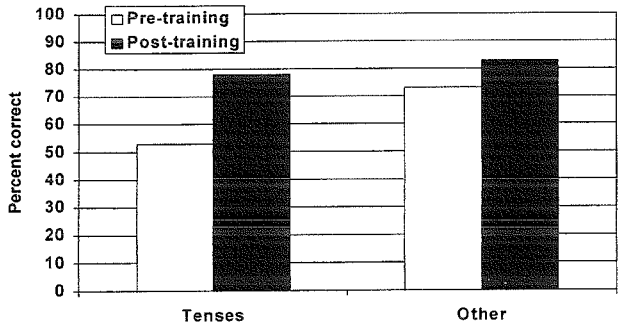

Figure 2. Mean scores on the amended Test of Syntactic Abilities for three children before and after remediation. The bars on the left indicate mean scores for 30 items relating to use of simple present, simple past and present progressive tenses. The bars on the right indicate mean scores for 20 items testing determiners and plurality.

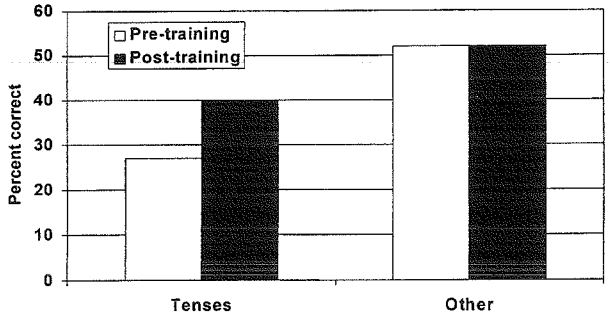

Figure 3. Mean key word scores for three children on the BKB Sentence Test before and after remediation. The bars on the left indicate mean scores for words involving verb tenses. The bars on the left indicate mean scores for other words not involving verb tenses.

On BKB sentences there were significant differences between pre- and post-training scores for Child 1 and Child 2 ($p<0.005$). Child 2 also showed a significantly greater improvement for trained versus untrained grammar constructs ($p<0.01$). Scores for Child 3 were much lower overall than for the other children and, surprisingly, post-training scores for untrained constructs decreased significantly ($p<0.05$). However, it should be noted that Child 3 had better language than Child 1 and Child 2, and poorer speech perception abilities. It seems likely that language was not the limiting factor for Child 3 and thus remediating language did not improve her speech perception scores significantly. The mean scores shown in Figure 3 indicate that the training in grammatical constructs improved perception of key words in sentences which used those constructs that were specifically trained. The improvement

for items involving tense was significantly greater than the improvement for other items not involving verb tenses ($p<.05$).

CONCLUSION

Deficits in language knowledge significantly affected the open-set speech perception scores of two children in this study. Remediation of these deficits significantly improved open-set speech perception. These results suggest a need to include language remediation in cochlear implant habilitation programmes. This also raises a question as to whether reported results may accurately predict the potential speech perception abilities of children with limited language.

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