RESULTS FOR CHINESE AND ENGLISH IN A MULTICHANNEL COCHLEAR IMPLANT PATIENT

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A multichannel cochlear prosthesis was implanted in a Chinese patient who suffered from profound sensory hearing loss. The preoperative Minimal Auditory Capabilities (MAC) battery tests in English, as well as an open set bisyllable word test, an open set sentence test, and speech tracking in Chinese indicated significant improvement of speech perception for both English and Chinese after the operation. Substantial understanding of running speech was possible in both languages without the help of lipreading.

At the University of Melbourne Department of Otolaryngology more and more patients with total or profound sensory hearing loss are receiving multichannel cochlear prostheses (Nucleus 22-electrode system) with resulting improvement of hearing ability. One of them was a Chinese patient who could speak both Chinese and English.

One of the characteristics of the Chinese language is the tonal change produced by varying the voicing frequency during a single vowel and thus conveying different meanings. The frequencies of the four tonal changes are flat, rising, falling then rising, and falling, respectively.

It was of great interest to compare the speech perception results for Chinese and English and to ascertain whether our formant-based strategy would be applicable to both languages, especially Chinese, which is both tonal- and formant-based.

PATIENT

The patient in this study was a 19-year-old Chinese man from Malaysia who came to the department for multichannel cochlear implant surgery. He had studied Chinese in primary school and spoke it at home. He had also studied English in high school. He was thought to have Klippel-Feil syndrome and started to lose hearing in the left ear before the age of 8 years. In 1984 he lost all useful hearing in both ears following a bout of mumps. His preoperative pure tone audiogram showed total deafness in the left ear and profound total deafness in the right.

He scored 0% for the Arthur Boothroyd word lists at 120 dB sound pressure level (SPL) in both ears using headphones. Subsequent hearing aid evaluations showed that he could not tolerate a hearing aid in the right ear because of severe recruitment. Promontory testing of the right ear was positive.

A multichannel cochlear implant operation was performed on his right ear in April 1985. During the operation, the round window was found to be obliterated and an opening into the scala tympani of the basal turn was made with a drill. The electrode array was inserted for 22 mm with ease.

Postoperatively all of the electrodes elicited hearing sensations, and the pitch percepts were consistent with the tonotopic organization of the cochlea.

METHODS AND RESULTS

Two months after the operation, a series of tests were performed on the patient. His vowel and consonant recognition was assessed for a series of 11 English vowels and 12 consonants under the following conditions: wearable speech processor plus lipreading (WSP + L), wearable speech processor alone (WSPA), and lipreading alone (LA). The results (Table 1) showed that scores for WSP + L were significantly better than LA, and that remarkably good recognition of

vowels and consonants was possible with sound only.

There were remarkable improvements of all of the scores on the Minimal Auditory Capabilities (MAC) battery tests. Statistically most of the postoperative scores were significantly better ($p < 0.01$) than the preoperative ones.

The patient had several tests of his speech perception performance for English and Chinese. The first test was to see if the patient was able to receive Chinese tonal information that would enable him to recognize differences in meanings. A list of words with tonal changes was constructed and the words were presented at random. It was of interest to compare the results for these tonal changes in Chinese with the results for fundamental frequency changes in English conveying suprasegmental information measured in a question/statement test. The results were 100% (33/33) correct for the Chinese segmental tonal test and 100% (20/20) for the English suprasegmental question/statement test. These good results confirmed that the pulse rate of stimulation was suitable for the representation of fundamental frequency for suprasegmental information in English and for segmental information in Chinese.¹

The second set of tests were open set word recognition tests (Table 2) without lipreading.² We used English monosyllabic words (NU-6, consonant-vowel-consonant) and Chinese bisyllable words (consonant-vowel-consonant-vowel). The results of both words and phonemes showed statistically significant differences ($p < 0.01$) between the scores for English and those for Chinese, the scores for Chinese showing better performance.

The third set of tests were open set Central Institute for the Deaf sentences in English and a Chinese equivalent developed in the department. Without lipreading the results of 84% correct for Chinese (441/523) and 67% correct for English (167/250) indicated that the patient could understand a substantial amount of running speech in both Chinese and English. Again there was a significantly better score for Chinese than for English ($p < 0.01$).

To confirm these findings, speech tracking was carried out both in English and Chinese for LA, for WSP + L, and for WSPA. The results for this test are shown in the Figure. It was difficult in this patient's case to obtain LA scores in English because of his unfamiliarity with many of the words in the passage read. The scores of LA for Chinese averaged ten words/minute and did not increase signifi-

TABLE 1. CORRECT RESPONSES IN ENGLISH VOWEL AND CONSONANT RECOGNITION

	WSP + L		LA		WSPA	
	%	(No.)	%	(No.)	%	(No.)
Vowels (11)	84	(111/132)	76	(100/132)	66	(87/132)
Consonants (12)	95	(136/144)	34	(49/144)	78	(112/144)

WSP + L—wearable speech processor plus lipreading; WSPA—wearable speech processor alone; LA—lipreading alone.

TABLE 2. CORRECT RESPONSES IN ENGLISH AND CHINESE OPEN SET WORD RECOGNITION TESTS WITH ELECTRICAL STIMULATION ALONE

	Words		Phonemes	
	%	(No.)	%	(No.)
English words (CVC)	42	(21/50)	71	(107/150)
Chinese words (CVCV)	63	(79/125)	86	(179/207)

cantly ($p > 0.05$) with time as shown by a regression analysis.

With WSP + L there was a dramatic increase over sessions to 80 words/minute, which is close to the ceiling rate possible with a normal hearing subject. With WSPA the patient also made significant improvement and approached a score of 40 words/minute. If the mean score of LA (10.0) is regarded as the base rate, the mean score of WSP + L (57.9) has a 479% increment.

$$\frac{57.9-10.0}{10.0} \times 100 = 479\%$$

The patient achieved a score of 25 words/minute for speech tracking with wearable speech processor over the telephone (WSP + T). This was slightly less than the score obtained under ideal acoustic conditions, probably caused by some distortion over the telephone.

CONCLUSIONS

1. This patient was able to understand a substantial amount of open set speech without lipreading in both English and Chinese with the multichannel cochlear prosthesis.

2. Speech understanding when using the cochlear prosthesis combined with lipreading was much better than using lipreading alone.

3. The speech-tracking procedure with ongoing speech is a valuable training and evaluation technique for both

Results of speech-tracking tests in English and Chinese. WSP + L—wearable speech processor plus lipreading; WSPA—wearable speech processor alone; WSP + T—wearable speech processor over telephone; LA—lipreading alone.

Chinese and English.²

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