Cochlear implants are often an important treatment for profoundly hearing-impaired, postlingually deaf adults.

Evaluation of different cochlear implants

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A center for the evaluation of different cochlear implants has been established at the University of Iowa. Our studies focus on the information provided by different types of cochlear implants and the neurophysiological and psychophysical abilities of profoundly impaired auditory systems.

Types of devices tested

We have evaluated 5 different types of intracochlear implants: the single-channel 3M/House device, the single-channel 3M/Vienna device, the 21-channel Nucleus Corporation device, the 4-channel monopolar Symbion device and the 4-channel bipolar device from San Francisco.

Our patients are evaluated with tests that are computer-controlled. Our test battery includes laser videodisc and audiovisual tests of phoneme and sentence recognition. Patients are not allowed to practice the test items, nor are the items repeated. The test items are presented at 73 dB SPL.

Patients

Patients implanted at the University of Iowa are postlingually deaf adults who cannot benefit from a hearing aid, i.e. they must have <8% word recognition on a 50-item NU-6 test and show no statistically significant improvement in lipreading on the Iowa Medial Consonant Test [1]. Five of our patients use the 3M/House device, 3 use the 3M/Vienna device and 7 the Nucleus device. Patients were originally implanted with the 3M/House device until the 3M/Vienna device, and more recently the Nucleus device, became available. We could not obtain reliable results in 2 other patients implanted with the 3M/House device [2]. Two other patients with the 3M/Vienna device are no longer using their implants. One of these patients had no hearing sensation upon electrical stimulation and the other had a hearing sensation only at very high levels of current, which we decided were unsafe.

We have also tested 13 patients who were implanted elsewhere. These include one Nucleus patient, 11 Symbion patients and one patient with the San Francisco device. These patients were thought to be representative users of these devices.

Results

This brief communication does not allow a discussion of all the results. Nonetheless, we shall make some general comments and highlight important areas.

Most of our implanted patients are able to recognize some everyday sounds, although performance varies markedly from patient to patient. Patients generally improve their test performance after using their implant at home for several months [3]. Most of the patients are also able to make some distinction of phonetic stress and intonation, which can convey information such as accent and emotion. While very few implanted patients score perfectly, most have a success rate of between 60 and 80% when asked to identify whether an utterance is a question or a statement, or whether a sentence was spoken by a male or female speaker. The noise/voice test (Minimal Auditory Capabilities [MAC] battery) presents both naturally spoken sentences and amplitude-modulated noises [4]. Surprisingly, very few patients are able to correctly label the stimuli as either noise or voice 100% of the time.

Figure 1 shows the results of a 4-choice spondee test performed in quiet and in background noise, with a speech-to-noise ratio of 10 dB. Nearly all patients had difficulty in noise. However, the Symbion patients showed some resistance to the noise. This was consistent with our observations of the patients' activities: as they moved to rooms with different levels of background noise, they frequently adjusted their processors to optimize speech understanding. Patient 7 (Nucleus) is the only one in this series using the new Nucleus processor which codes F1 information in addition to amplitude, F0 and F2. This patient also shows some resistance to the effects of noise.

One of the most important benefits of the cochlear implant is the increased ability to lipread. All of the patients show an improvement in sentence un-

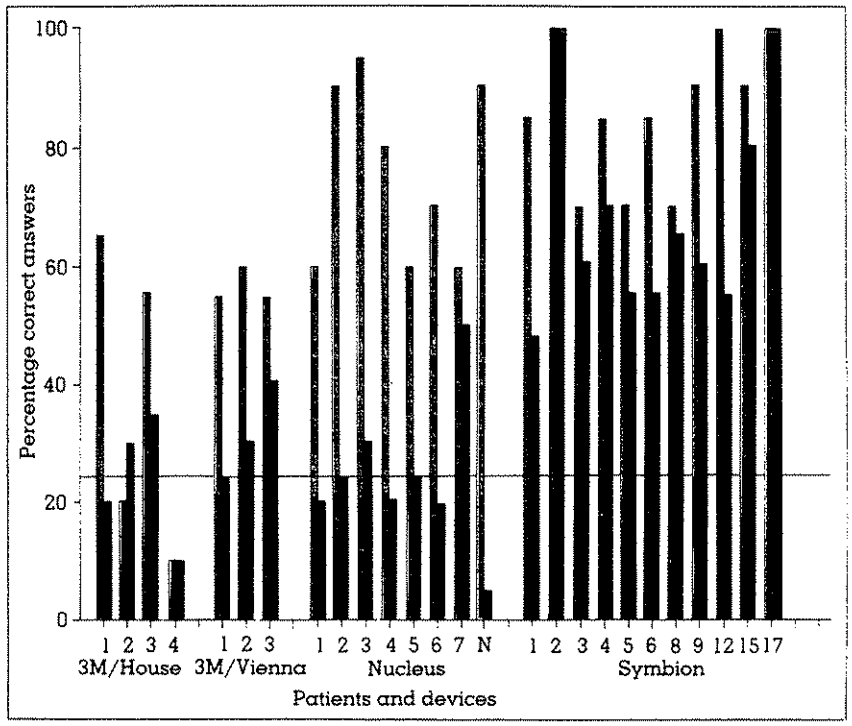

Fig. 1: Results of a 4-choice spondee test performed in quiet (■) and with 10 dB background noise (■). N = Nucleus patient implanted in New York.

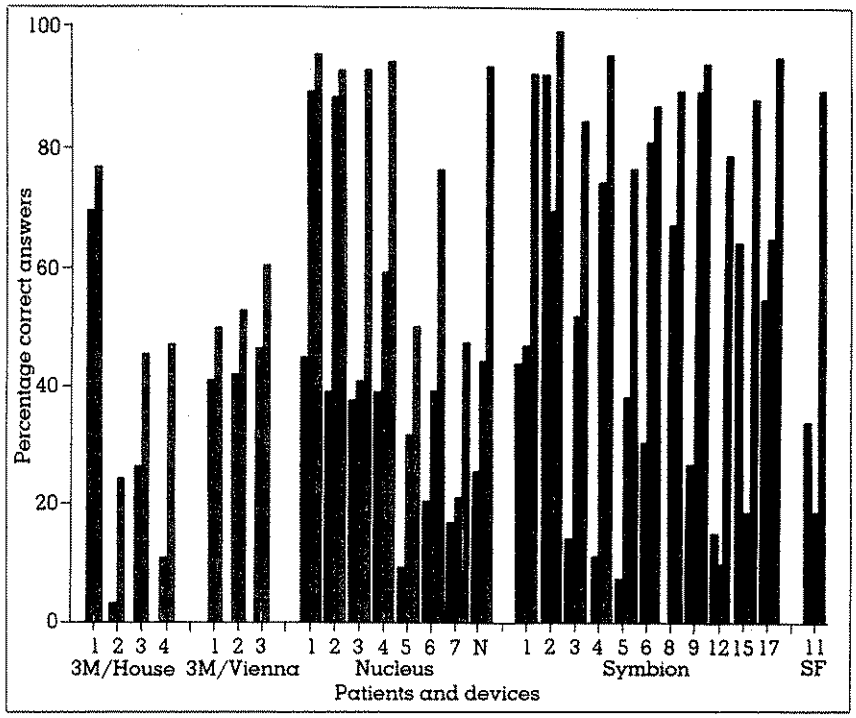

Fig. 2: Results of the Iowa sentence-without-context test in sound-alone (■), vision-alone (■) and sound-plus-vision (■) conditions. N = Nucleus patient implanted in New York, SF = San Francisco device.

derstanding in sound-plus-vision conditions compared to vision-alone conditions (Fig. 2).

Many of our multichannel cochlear implant patients can recognize words that are presented in lists of monosyllabic words and sentences in sound-alone conditions (Fig. 2). This is a remarkable and perhaps a unique advantage of cochlear implants compared to tactile aids. These patients are not receiving regular intensive auditory training, as do most patients with tactile aids. In fact, some of the patients can recognize words within hours of receiving their cochlear implant.

However, it is important to note that the patients who recognize some words cannot always determine whether a stimulus is speech or noise (as previously mentioned for the MAC noise/voice test). This indicates that the patients perceive a very distorted, unclear stimulus. However, even though they do not 'hear' speech that is in any way normal, some can successfully estimate (perhaps guess) individual sounds and words. Our analysis of the consonant and vowel errors suggests that the patients utilize information related to the voicing (fundamental) frequency, the duration of speech components, the envelope and in some cases first and second formant frequency [5].

Conclusion

Cochlear implants are clearly an important treatment for profoundly hearing-impaired, postlingually deaf adults. Patients do not hear speech normally, but many demonstrate the ability to recognize some words without visual cues. One might expect less benefit in prelingually deaf adults. Before implanting young children, it is necessary to first ensure that they have no usable hearing. Careful clinical investigation should be instigated in these cases [6].

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