IN15

ADVANCES IN COCHLEAR IMPLANT SPEECH PROCESSING

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Our early research emphasized there was a restriction on the amount of speech and other acoustic information that could be transmitted to the nervous system by electrical stimulation of the auditory nerve. It also showed the need to use multiple-channel stimulation, and minimize channel interaction. As a result our research over the last 30 years has been directed towards optimizing the information presented to the auditory nervous system. This has involved extracting the energy of the first and second formants (F0/F2-WSP II; F0/Fl/F2-WSP III; Multipeak-MSP) as well as the outputs of high band pass fixed filters (Multipeak - MSP) and coding these outputs as cochlear place of stimulation. The voicing frequency was coded as rate of stimulation. Our most recent speech processing strategy (SPEAK) extracts a specified number of maximal outputs from a series of band pass filters, rather than selecting the peaks of energy which was the case with the other strategies. The voltages from the maximal outputs are used to stimulate appropriate electrodes on a place coding basis. The stimuli are presented at a constant stimulus

rate to reduce channel interaction. Voicing is conveyed as amplitude variations.

Increasing the amount of spectral information extracted and presented on a place coding basis has led to a marked increase in speech perception scores in postlinguistically deaf adults. The mean open-set CID sentence scores for electrical stimulation alone on unselected patients attending the Cochlear Implant Clinic of the Royal Victorian Eye and Ear Hospital have increased from 16% for F0/F2, to 36% for F0/F1/F2, to 56% for Multipeak, and to 86% for SPEAK at six months or less postoperatively. As a result of these improvements the mean speech perception scores for a multiple-channel cochlear implant have become better than those for a number of severely deaf people using a powerful hearing aid. We have also shown (van Hoesel and Clark, 1995) two microphones and an adaptive beamformer can improve the perception of speech in noise, and the mean open-set sentence score in four patients with the SPEAK strategy was 43% compared to a control of 9% for a very adverse noise condition of a 0dB signal-to-noise ratio.

An alternative multiple-channel strategy the Continuous Interleaved Sampler (CIS) presents the outputs of six or more fixed filters on a place coding basis at high constant stimulus rates. The published data on a clinical trial of 64 patients using CIS (Kessler et al., 1994) showed a mean open-set CID sentence score of 60%, and the results for SPEAK presented to the FDA by Cochlear on 51 patients were 71%. These data suggest that the extraction of spectral maxima is important for speech processing.

The speech perception abilities of 202 children from 14 months to 18 years using SPEAK from the clinics in Melbourne and Sydney have been assessed, and 62% have varying degrees of open-set speech recognition using electrical stimulation alone. Our studies have also shown that children (up to the age of 14 years in the study) have been able to successfully convert from the Multipeak to SPEAK strategy and receive more speech information. In addition, we have demonstrated that severely-profoundly deaf children (with some limited hearing) achieve mean open-set speech perception scores that are better than those from profoundly deaf children.

To explore further speech processing strategies, Cochlear Limited, in cooperation with the Cooperative Research Centre (CRC) for Cochlear Implant Speech and Hearing Research, has developed a more advanced receiver-stimulator (CI-24M) that will allow more channels to be used at higher stimulus rates. CI-24M has telemetry so that electrode impedances and auditory nerve compound action potentials can be recorded. This facility together with a flat profile makes it suitable for implantation in infants. This receiver-stimulator is part of the Nucleus-24 system which includes both body worn (SPrint), and ear level (ESPrit) speech processors.

REFERENCES

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