Signal processing concepts for hearing aids

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Hearing loss consists of a variety of psychoacoustic deficits, few of which are compensated for by existing hearing aids. Frequency dependent amplification, when combined with some form of single band compression, can partially compensate for deficits associated with loudness perception. Dual-band and multi-band compression amplification can more fully restore normal loudness relationships, but may simultaneously increase the difficulties caused by impaired frequency and temporal resolution abilities. Sometimes speech discrimination scores can even be reduced as a result. At least two level dependent response hearing aids are already on the market, and although both are designed on the basis of plausible rationales, they accomplish almost opposite forms of processing! An alternative to multi-band compression is to use multi-band expansion combined with single band compression and linear response shaping in such a way that partial compensation for both loudness and frequency resolution deficits is attempted. Compensation for temporal processing deficits can probably be achieved in only a very rudimentary manner until the time arrives when hearing aids are capable of performing automatic speech recognition by themselves. The talk will ask more questions than it will provide answers, but where possible, will include recorded demonstrations of the processing schemes explained and discussed.

A comparison of methods for estimating hearing aid real ear gain

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The gain of a hearing aid was measured on each of eight subjects using a variety of functional (subjective) and insertion (objective) gain methods. Each measurement was repeated on subsequent days and the hearing aid gain was also determined in several couplers and on KEMAR. The multiple measurements enabled an accurate estimate of the “true” gain of the aid on each subject to be determined. The real ear gain measured by each of the individual methods was then compared with this “true” gain estimate and the relative accuracy of each method was quantified. Of the clinically feasible methods, probe microphone measurement of insertion gain proved to be the most accurate. Few significant differences were found between functional gain and insertion gain. Estimation of real ear gain on the basis of coupler gain appeared to be a reasonable, though not recommended approach.

Speech recognition performance with a two-format coding strategy for a multi-channel cochlear prosthesis

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Over the last two years, a new speech coding strategy (FOF1 F2) has been developed for the Nucleus multi-channel cochlear prosthesis designed to provide information about the first formant, in addition to the second formant and voicing frequency information provided by the “standard” speech processing strategy (FOF2). This strategy uses quasi-simultaneous stimulation of two electrode pairs within the cochlea at the voice pitch rate. The positions of the two sites of stimulation vary independently according to the frequencies of the first and second formants. The amplitude at each site is determined from the first and second formant amplitudes. Seven patients were changed to this strategy and an initial study showed significant improvements in recognition of open set sentence material (from a mean of 30.4% for FOF2 to 62.9% for FOF1 F2) and for speech tracking without lipreading (from 11.8 wpm to 30.5 wpm). Phoneme recognition investigations indicated that: 1) vowel identification was improved due to the addition of first formant frequency information in the new strategy, 2) consonant identification was also improved, due to the extra information provided by the independent variation of the amplitude components. These encouraging results led to the use of the FOF1 F2 strategy for all new patients from April 1985. Results for recorded speech testing (MAC battery) three months after surgery have been compared for 13 patients who used the FOF1 F2 strategy. Significant improvements were observed for the FOF1 F2 group on most of the tests. Mean scores for open set testing were as follows: a) spondee recognition: 13.6% for FOF2 and 26.0% for FOF1 F2, b) CID sentences: 15.9% for FOF2 and 37.8% for FOF1 F2, c) monosyllabic words: 4.9% for FOF2 and 12.4% for FOF1 F2, d) phoneme recognition: 23.1% for FOF2 and 33.4% for FOF1 F2.
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