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Compensation of hearing deficiencies in the inner ear

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The cochlea acts as a non-linear spectro-temporal analyzer that codes the frequency-distribution of the incoming acoustic energy (frequency-to-place transformation). The nonlinearity in the cochlear response to sound is mediated by the outer haircells, which provide a compressive saturating gain characteristics, i.e., a high gain at low input levels that decreases with level. The frequency selectivity of this 'cochlear amplifier' is higher than that of the passive cochlear resonant response, i.e., full gain and compression is applied to prominent spectral peaks only. The maximum gain provided by the cochlear amplifier is generally sought to be reduced in cochlear hearing loss due to a loss of outer haircell function. It is associated with an increased threshold of hearing (loss of sensitivity), a reduced dynamic range between threshold and uncomfortable level ('Recruitment') and a reduction in frequency selectivity. In terms of information processing, the latter effect indicates a loss of channel information capacity, because the waveforms at the different places along the cochlear partition have a stronger correlation than in the healthy cochlea. This means in practice that the response pattern of the healthy cochlea cannot be restored regardless of the type of pre-processing. Adopting the information-theoretic viewpoint, signal processing in hearing aids relies as a consequence of the reduced channel capacity on selecting the relevant information to be transferred through the impaired cochlea. An efficient way to select the relevant information is to enhance speech components by noise reduction (cf. the contribution by J. Wouters to this session). Another means to selecting relevant components is to simulate the cochlear amplifier, in particular its high frequency selectivity. Also, the distinction of relevant and irrelevant components might depend on the actual acoustic scene, emphasizing the need for an intelligent environment classification. This contribution discusses consequences of a reduced channel capacity and possible rehabilitation schemes.

