Recent advances in cochlear implant provision & technology

Andreas Büchner

Department of Otorhinolaryngology, Medical University of Hannover
(Chairman: Prof. Prof. h. c. Dr. med. Th. Lenarz)

hno mhh

DHZ Deutsches HörZentrum Hannover

VIANNA

MHH Medizinische Hochschule Hannover

Outline

1) The „classical“ indication for cochlear implants:
   A device for the profoundly deaf.

2) Broadening the inclusion criteria:
   The combination of electric and acoustic hearing.

3) The growing together of hearing aid and cochlear implant technology.

Cochlear Implants: From basic research…

Jack Urban, House Ear Institute

… to real world products.

20 years – a long time ago?

1995 BMW Z3

CI Indication Criteria 20 years ago…

bilateral profound hearing loss,
PTA > 100 dB HL (National Institute of Health, 1995)

no open-set speech recognition ability with hearing aids

In the US, children had to be at least 2 years of age to be implanted

Avg. score monosyllables in 1995 at MHH: 19,4%

1994 Clarion 1.0 speech processor

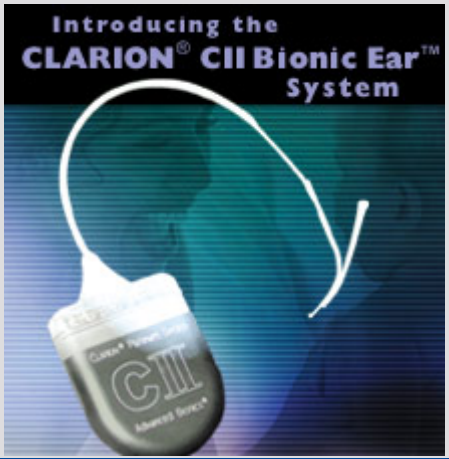
CI Indication 2000 / 2001

Some speech perception with hearing aids (<30% monosyllabic words)

PTA > 70 dB HL
(Lenarz, Balkany, 2001)

Platinum Series Speech Processor

In the US, children had to be at least 12 months of age to be implanted



Avg. score monosyllables in 2001 at MHH: 38,5%

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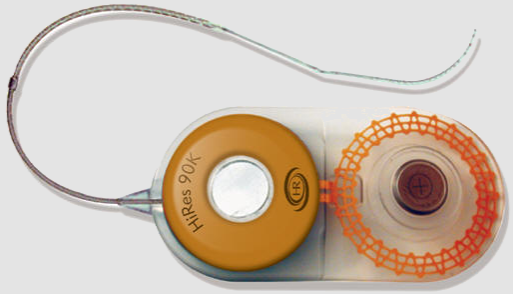
CI Indication 2007

„Integrated Care“ contracts with selected health insurance companies:

- PTA secondary (but poorer than 50 dB)
- Monosyllables up to 50% (best aided @65 dB)

(Contract btw. Medizinische Hochschule & Techniker KK, Dec. 2006)

Auria BTE



HiRes 90K Cochlear Implant

Avg. score monosyllables in 2007 at MHH: 51,1%

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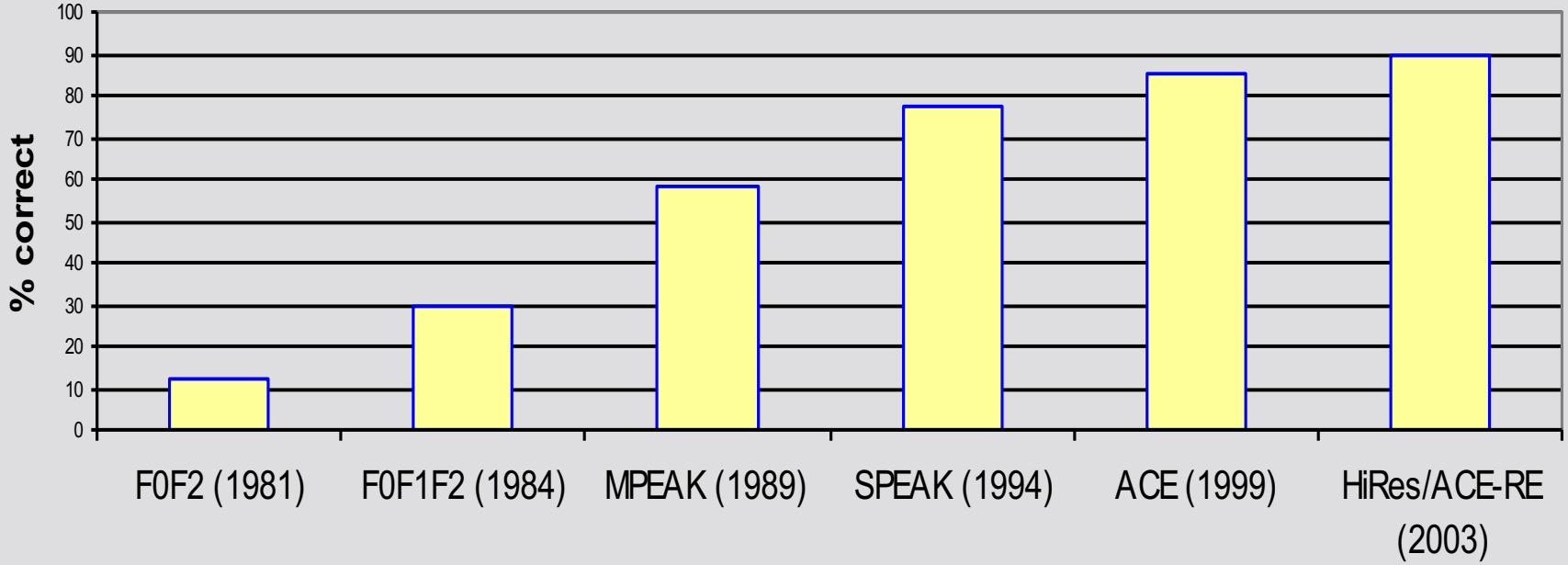
Signal processing in Cochlear Implants has come a long way



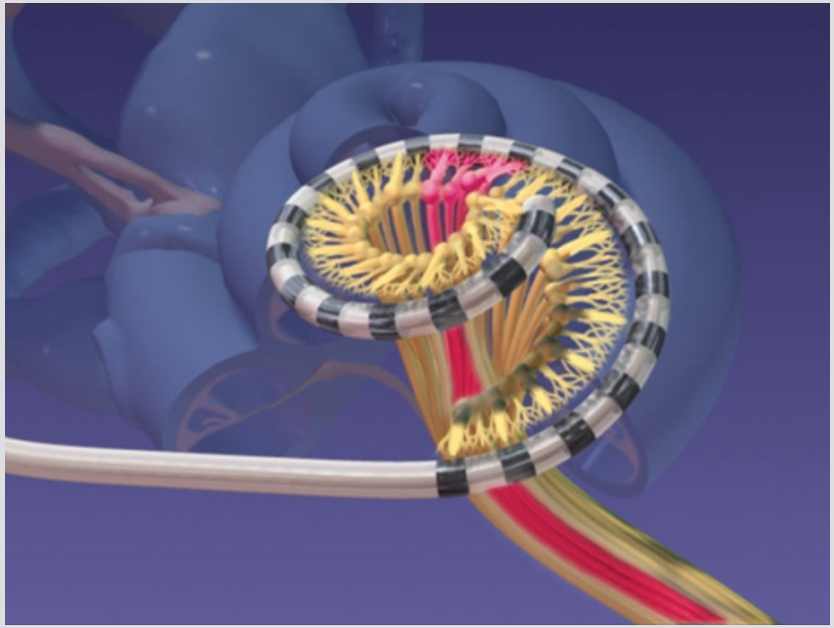
total stimulation rate increased by:

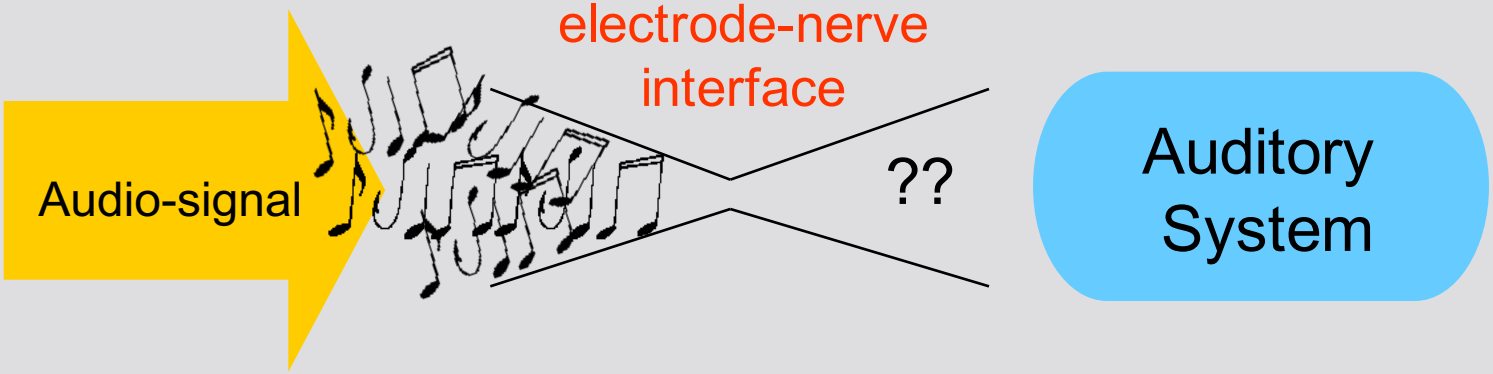
7 x

20 x

100 x

Problem:
The electrode-nerve bottleneck





Intermediate Summary

Cochlear Implants have come a long way:

- from devices for the profoundly deaf to systems for subjects with significant residual hearing

Significant advances have been made in the field of signal processing and stimulation pattern design

Together with these advancements, indication criteria have been more and more relaxed

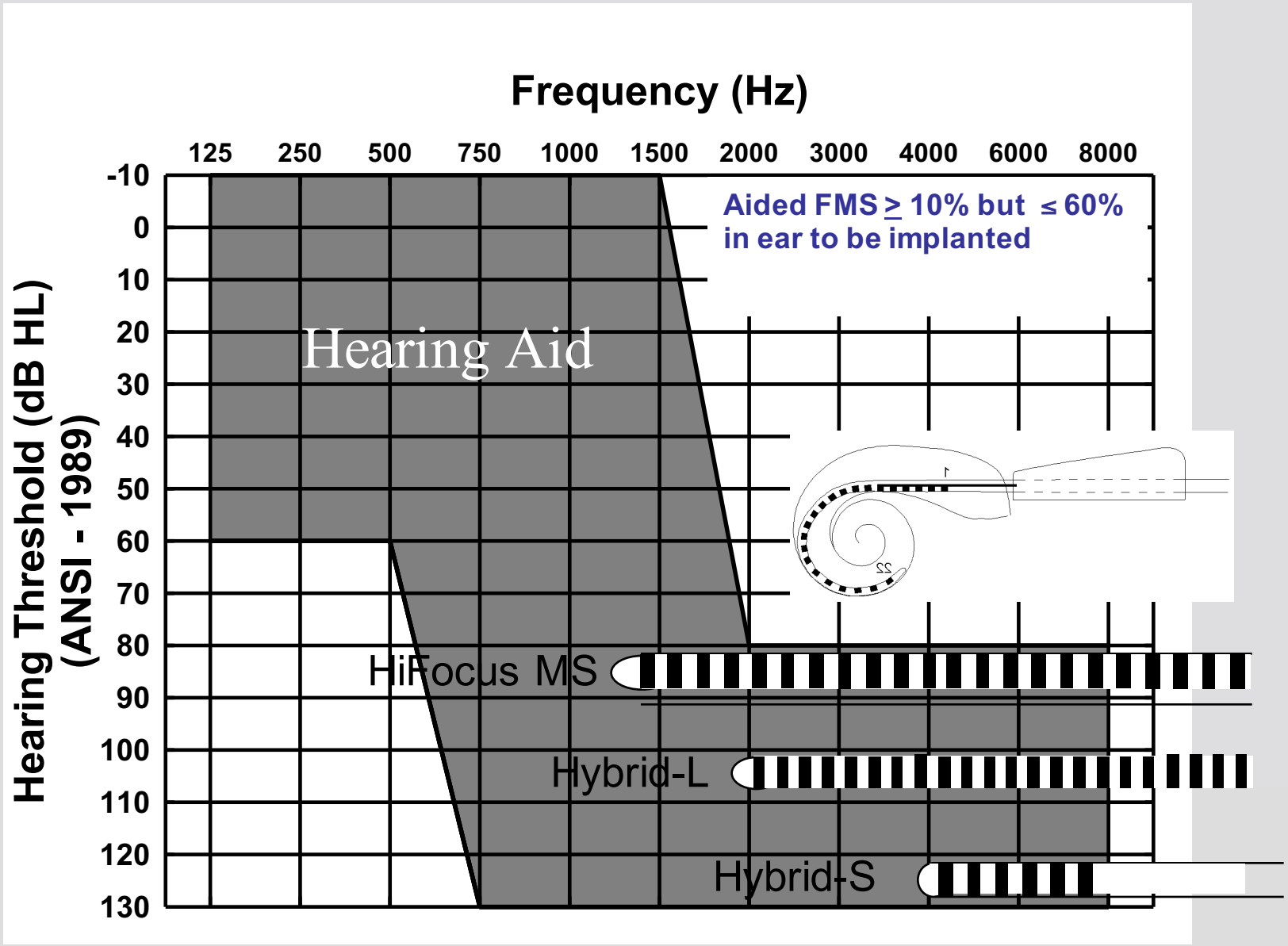
The next level: Electric-acoustic stimulation

MedEl

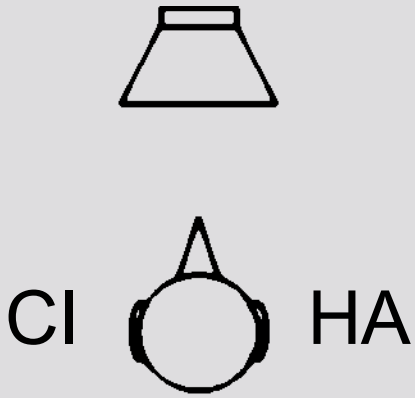
Advanced Bionics

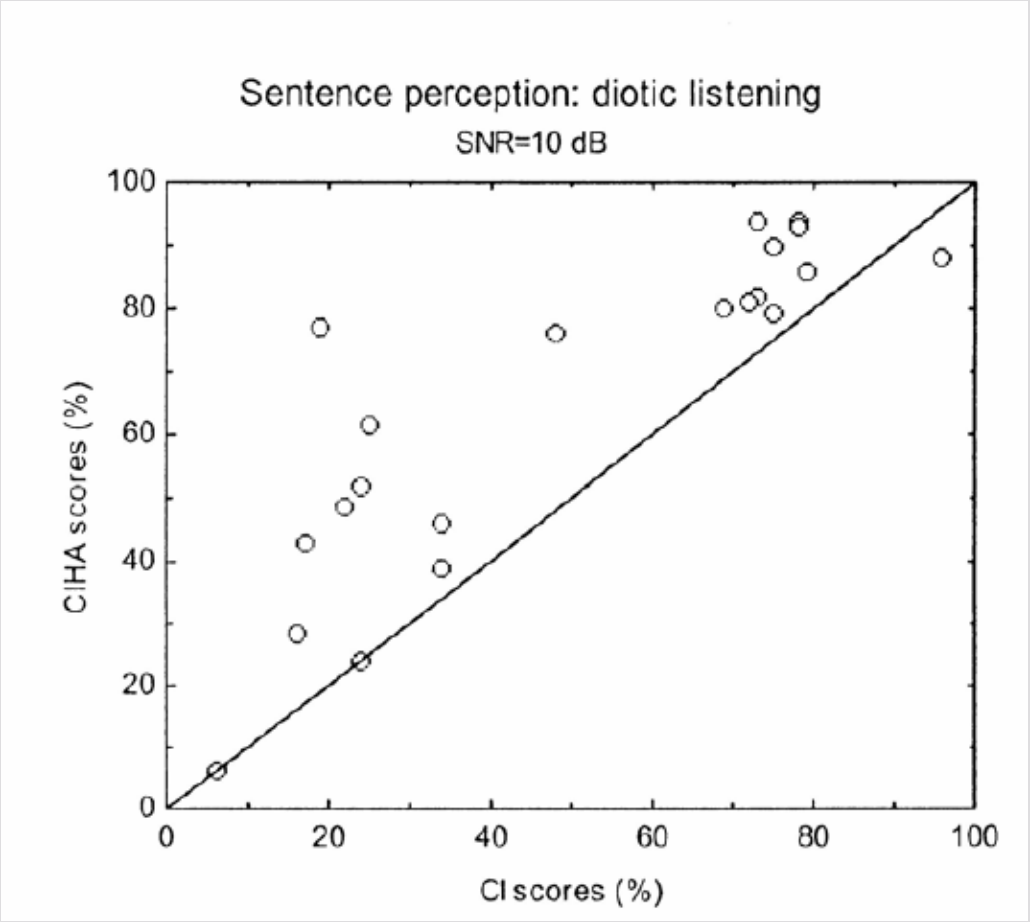
Cochlear

Idication range: electric-acoustic stimulation



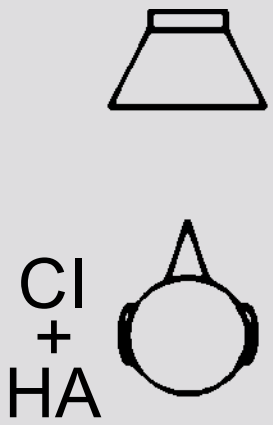
Advantages of Electric – Acoustic Hearing: Bimodal Condition

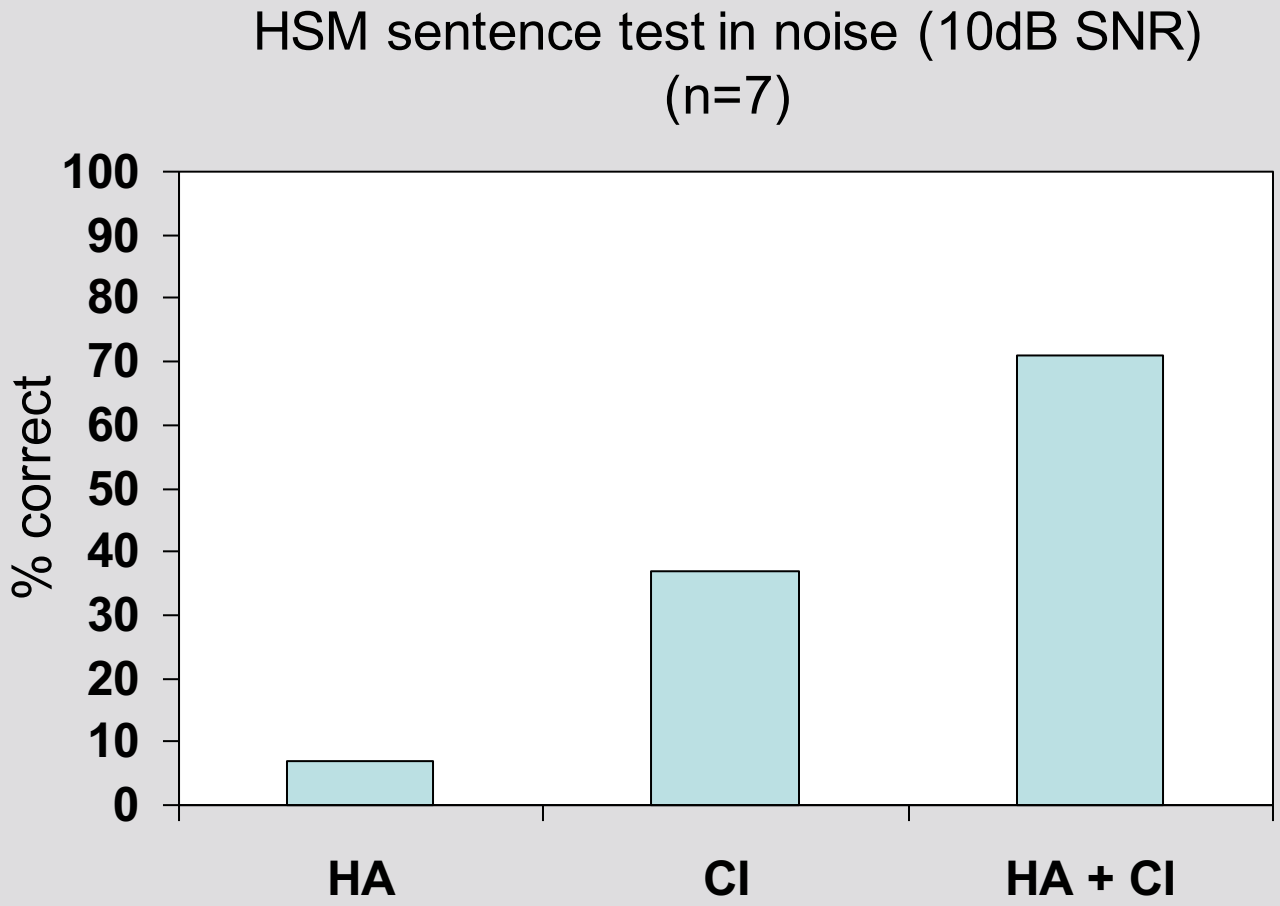




Ching, T. Y. C. , Incerti, P. , Hill, M.: Binaural benefits for adults who use hearing aids and cochlear implants in opposite ears. Ear and hearing 2004;25;1:9-21

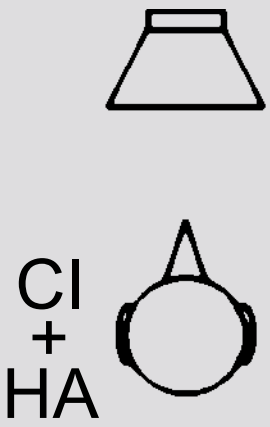
Advantages of Electric – Acoustic Hearing: Hybrid Systems

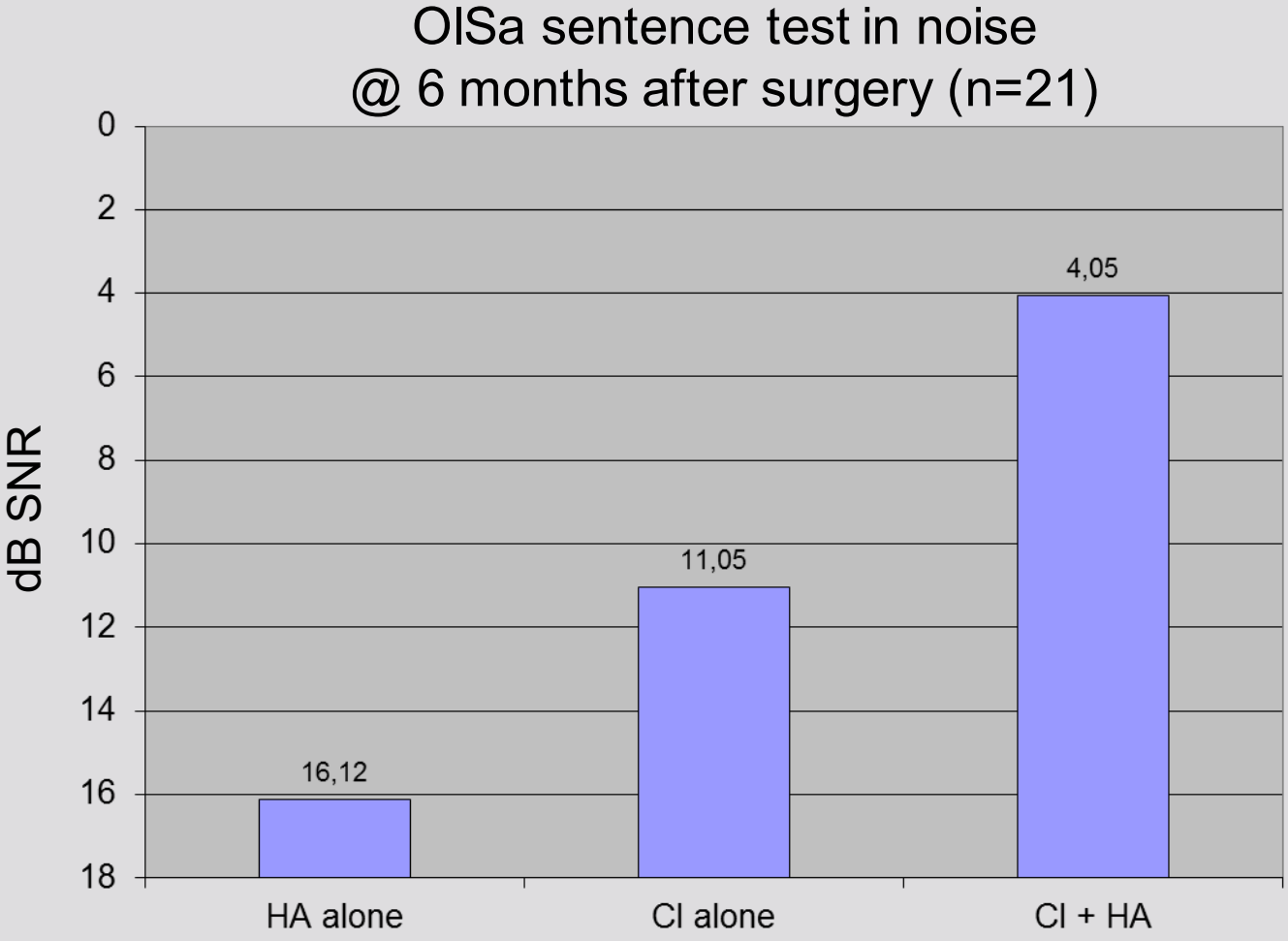




Gstöttner WK, Adunka OF, Kiefer J, Pok S (2004): Electric acoustic stimulation of the auditory system – clinical issues and results. Presentation at the 7th European Symposium on Paediatric Cochlear Implantation, 2-5 May 2004, Geneva, Switzerland.

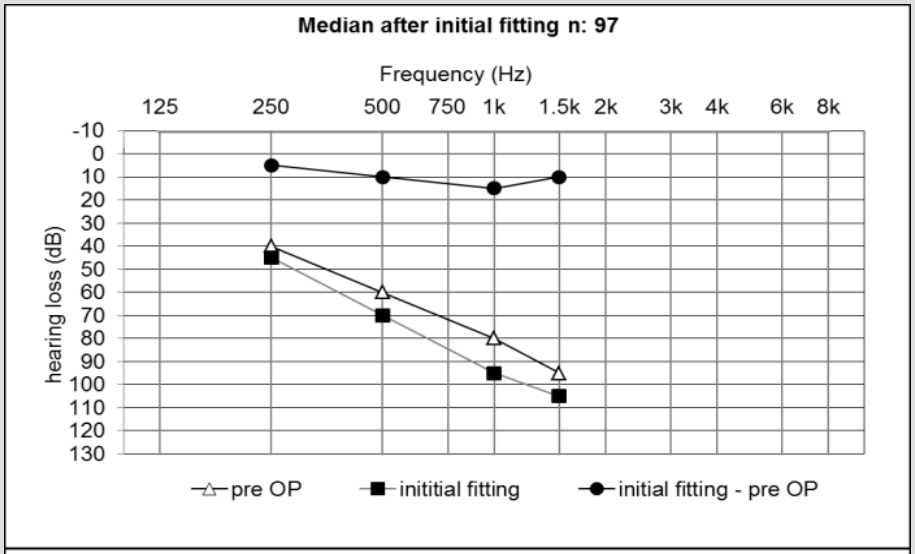
“Historic” MHH Hybrid-L results

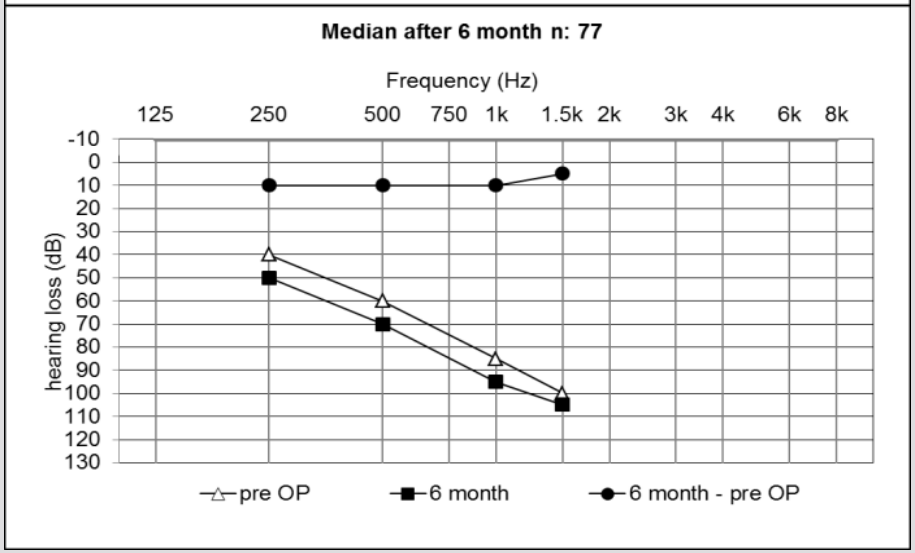


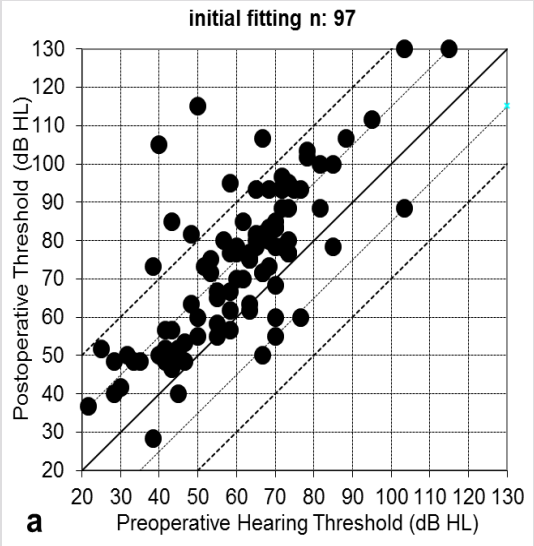


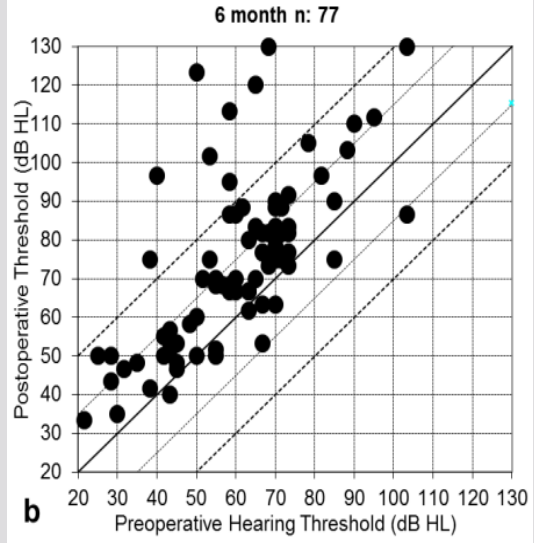
Lenarz et al. : Hybrid-L results from the first clinical trial at MHH and the multicentre European trial
2nd International Electro-Acoustic Workshop 14. / 15. December 2007, Hannover

Audiometric thresholds pre and post surgery: Cochlear Hybrid-L electrode





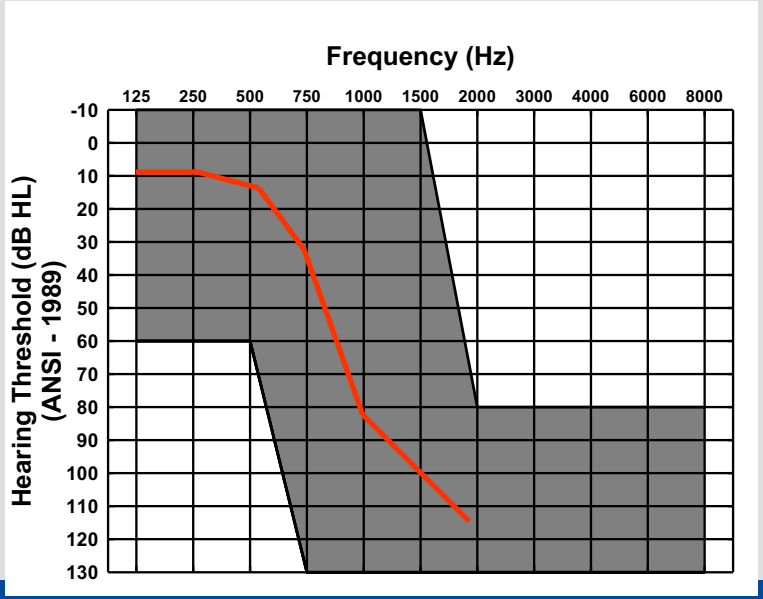




Simulation of an EAS hearing perception

CI-System with a frequency response of 300 Hz to 8000 Hz:

Residual Hearing only (ski slope hearing loss):



Bimodal CI+HA:

Original:

Intermediate Summary EAS

Residual acoustic hearing, even if limited to below 500 Hz, can significantly enhance hearing in noise

Music perception, usually poor with electric stimulation only, is vastly improved when using some residual low frequency hearing

As more and more cochlear implant candidates show residual hearing on both ears, the use of new atraumatic electrodes becomes increasingly essential for cochlear implant provision in general

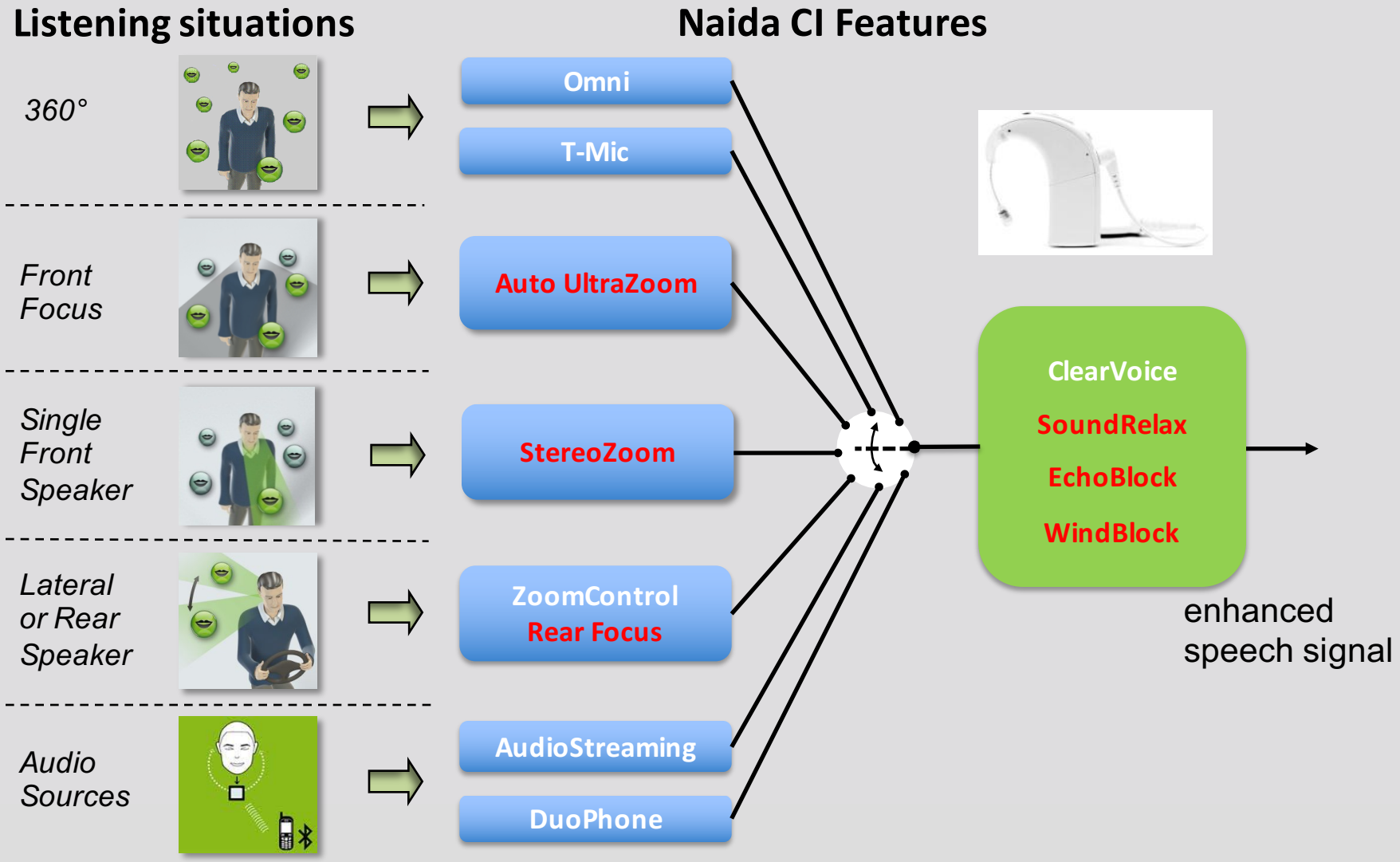
What else can we do?

Technically enhance the acoustic signal

- adaptive AGC systems
- scene dependent signal processing
- noise reduction algorithms
- adaptive directional microphones

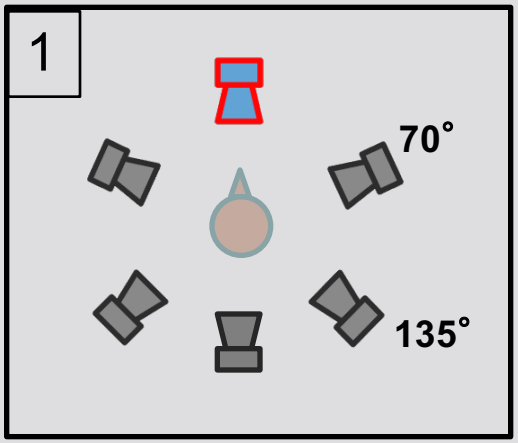
→ These features have been available in hearing aids for many years

Noise Management with the Naida CI Q90



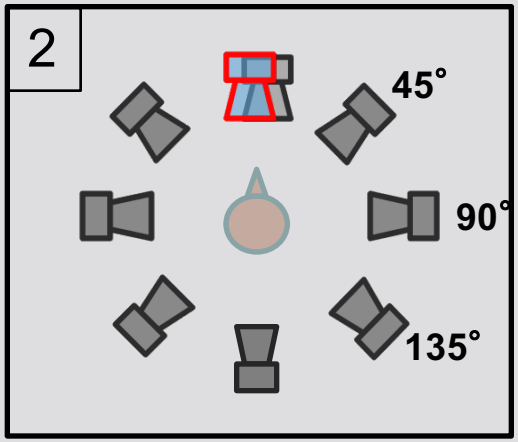
Loudspeaker Configurations

6 Loudspeakers



- Speech from 0°
- 5-LS Olnoise, 65dB

8 Loudspeakers



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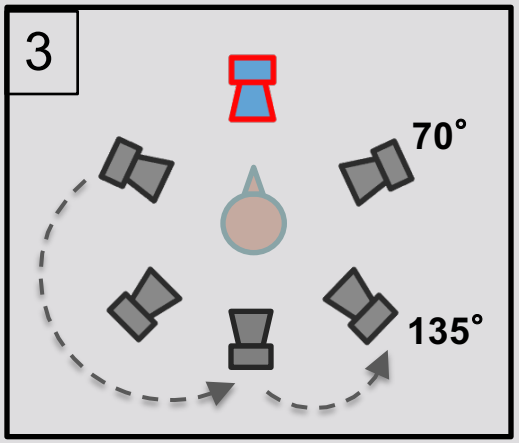
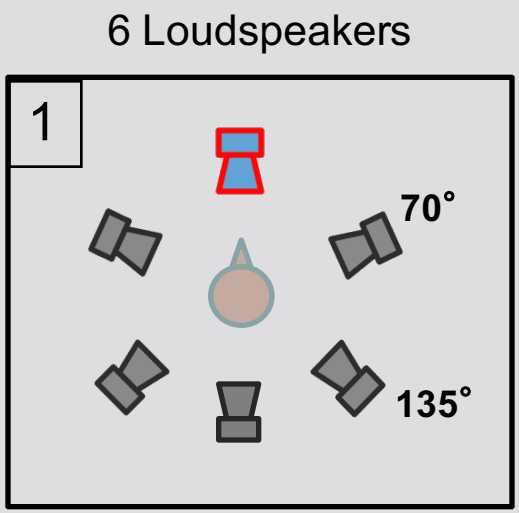


- Speech from 0°
- 5-LS Olnoise, 60dB
- IFFM “Competing Talker”, 63.4dB, moving every 1.5s

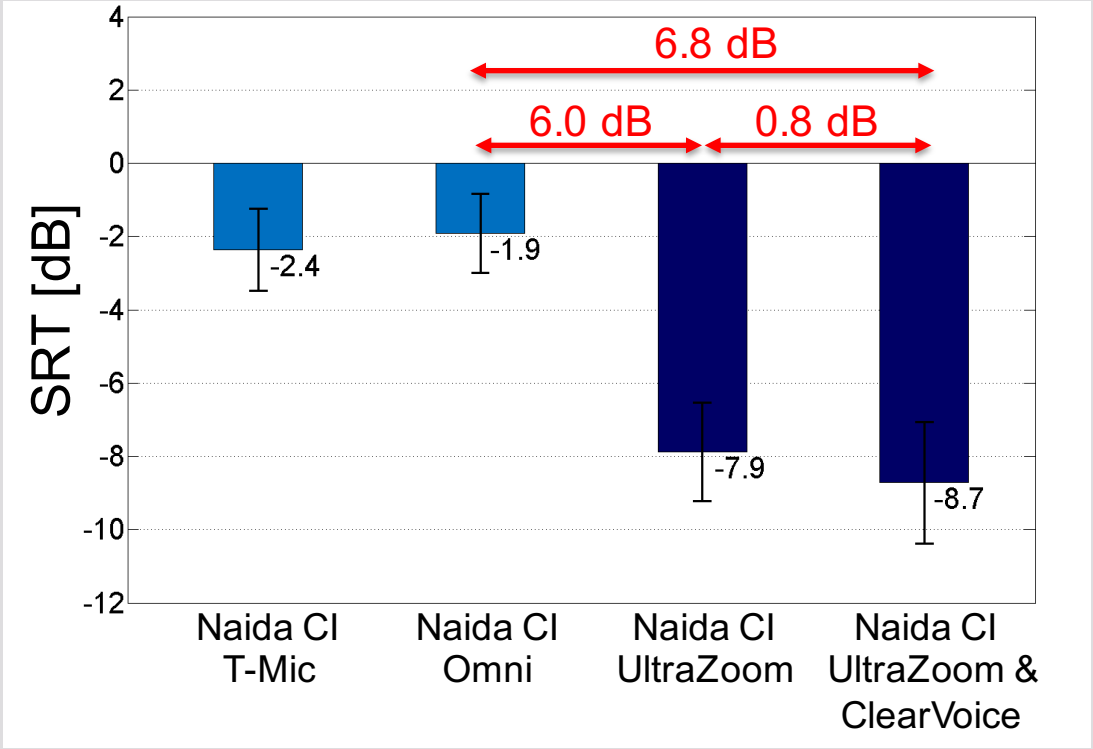
Speech signal

Noise signal

Configuration 1: UltraZoom & ClearVoice



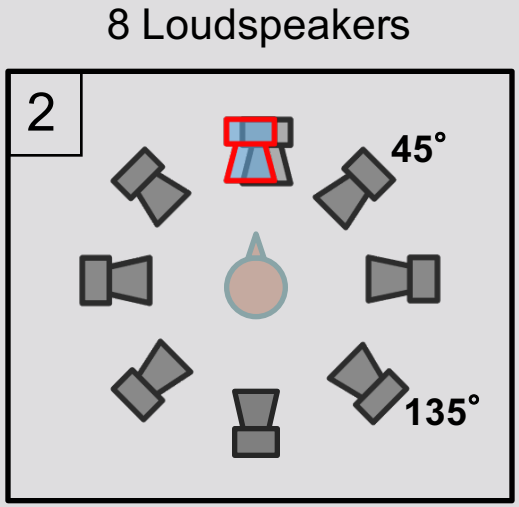
- Speech from 0°
- 5-LS Olnoise, 65dB



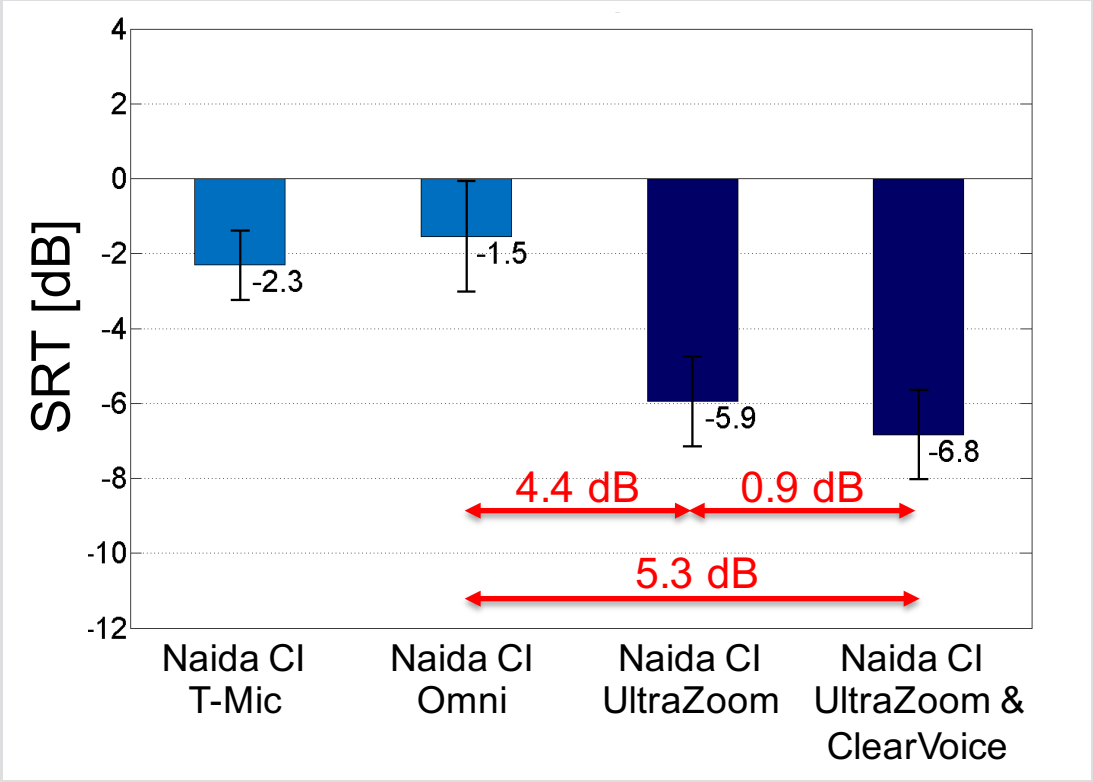
- Improvement in SRTs of 6.0 dB with UltraZoom (n=10)
- Additional 0.8 dB improvement with ClearVoice

➢ 6.8 dB improvement in combination

Configuration 2: UltraZoom & ClearVoice



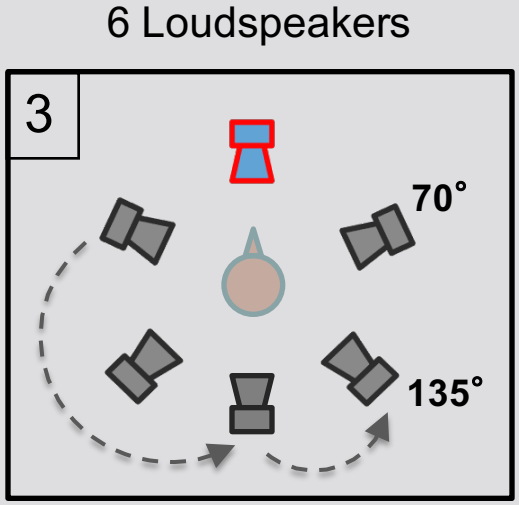
- Speech from 0°
- 8-LS Olnoise, 65dB



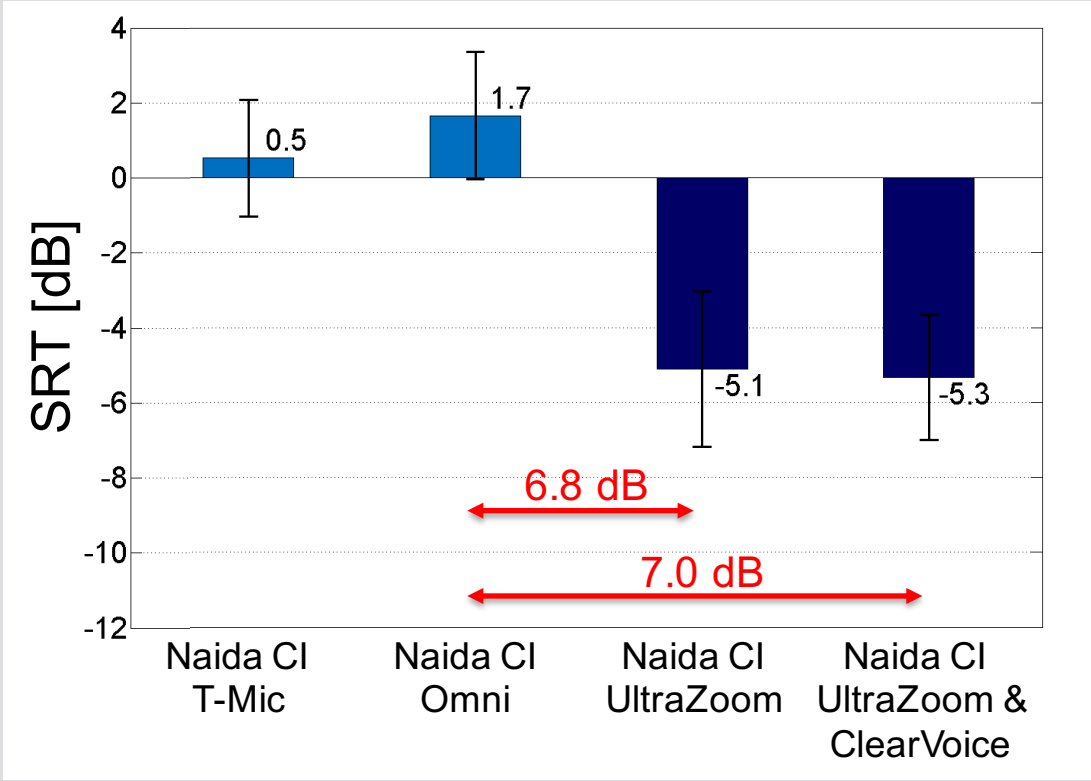
- Improvement in SRTs of 4.4 dB with UltraZoom in quasi diffuse noise
- Additional 0.9 dB improvement with ClearVoice

➢ 5.3 dB improvement in combination

Configuration 3: UltraZoom & ClearVoice



- Speech from 0°
- 5-LS Olnoise, 60 dB
- IFFM “Competing Talker”, 63.4 dB, moving every 1.5s



- Improvement in SRTs of 6.8 dB with UltraZoom in complex, dynamic situation

➢ 7.0 dB improvement in combination with ClearVoice

Final Conclusions

Cochlear Implant devices have been significantly improved over the last two decades

Indication criteria have been more and more relaxed, and users of hearing aids with significant residual hearing consider implantation encouraged by the impressive outcomes

Residual hearing can significantly improve hearing with a cochlear implant and should be preserved to the largest possible degree. Therefore, atraumatic electrodes and soft surgery techniques have been developed and are constantly being improved.

The frontend-processing know-how of the HA industry has finally found its way into cochlear implant processors improving speech perception in difficult listening scenarios.

Listening Strategies at “Cocktail-Parties”

The human auditory system is able to decompose the acoustic world into discrete objects of perception. Today it is believed that the auditory system uses the fundamental frequencies of different talkers to segregate talkers from each other.*

Only if the fundamental frequencies of the voices are too much alike, directional information of the sound source comes into play to differentiate between talkers.

→ Cochlear Implant subjects have not yet access to temporal fine structure in the low frequencies.

→ A reconstruction of the missing fundamental from harmonics is not possible in CI subjects due to insufficient frequency resulution of current implant systems.

*Auditory Cortical Contrast Enhancing by Global Winner-Take-All Inhibitory Interactions
Kurt S, Deutscher A, Crook JM, Ohl FW, Budinger E, et al. (2008). PLoS ONE 3(3): e1735. doi:10.1371

Phenomenon of the missing fundamental

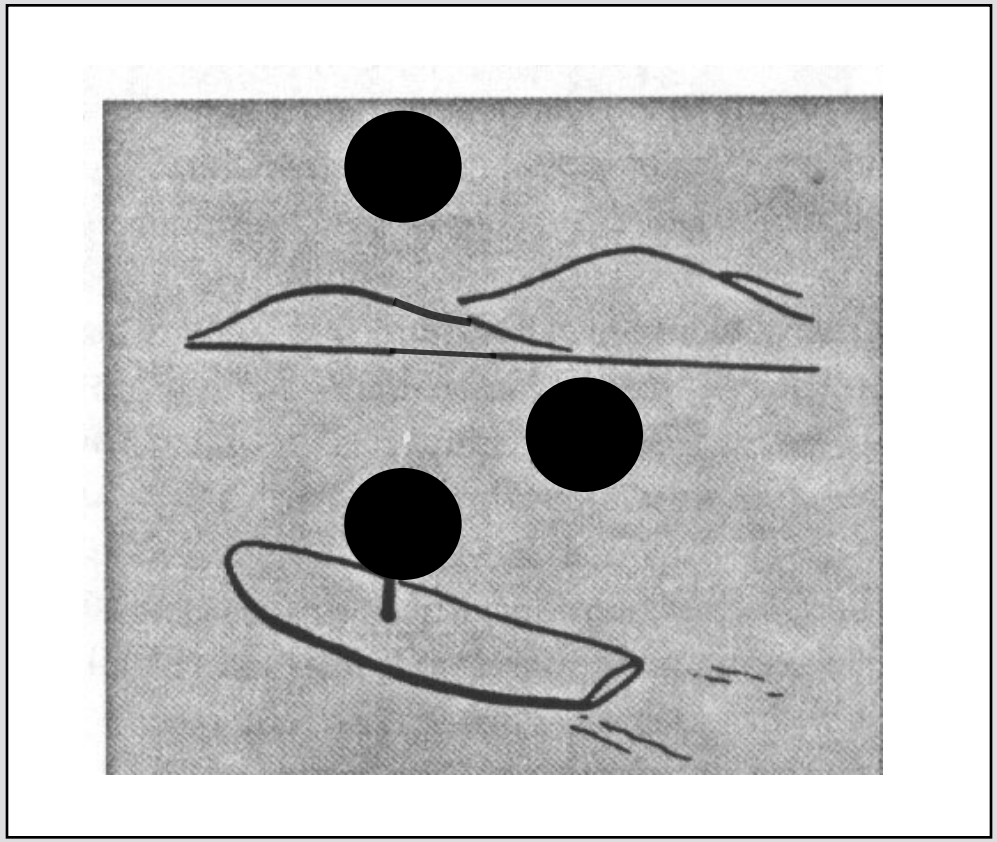
The auditory system can reconstruct a missing f0 from the information present in the overtones. The precise way in which it does so is still a matter of debate, but the processing seems to be based on an autocorrelation involving the timing of neural impulses in the auditory nerve.

Sample 1:
Two competing talkers:
full frequency spectrum

Sample 2:
Two competing talkers:
300 Hz highpass filter applied

→ The example containing f0 sounds richer, but the pitch of the talkers‘ voices can be perceived and identified in both samples

Reconstructing missing details in the visual system



“Surfbrett auf dem See.”
Biologie in unserer Zeit,
Heft5, 1995.