

# New developments for better hearing in quiet and in noise

Drs. Hans E. Müller



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# Disclosure

- Presenter is employed by Phonak HQ in Switzerland

# Agenda



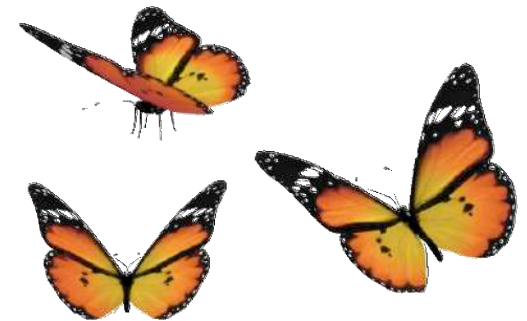
1. Some phenomena of severe hearing loss
2. New developments in hearing aids
3. New developments in wireless
4. New solutions for better hearing at work



## Some phenomena of severe hearing loss

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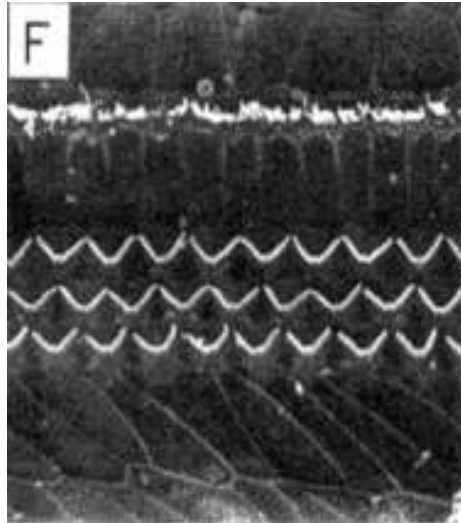
*A person with a severe to profound hearing loss  
is not a person  
with a mild hearing loss who needs more power*



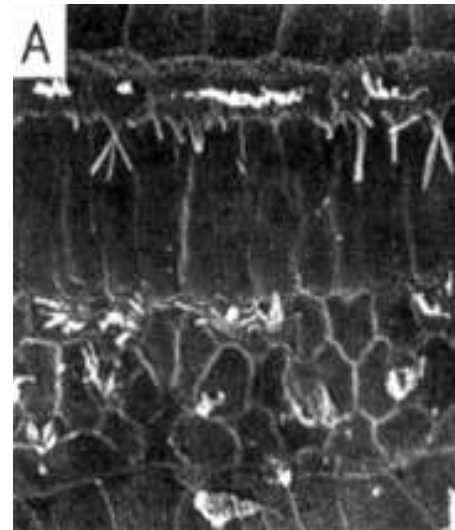
# Definition of severe hearing loss and profound hearing loss

Severe	61-80 dB HL (better ear)	Able to hear some words when shouted into better ear
Profound	81 dB HL or greater (better ear)	Unable to hear and understand even a shouted voice

The audiometric ISO values are averages of values at 500, 1,000, 2,000, 4,000 Hz

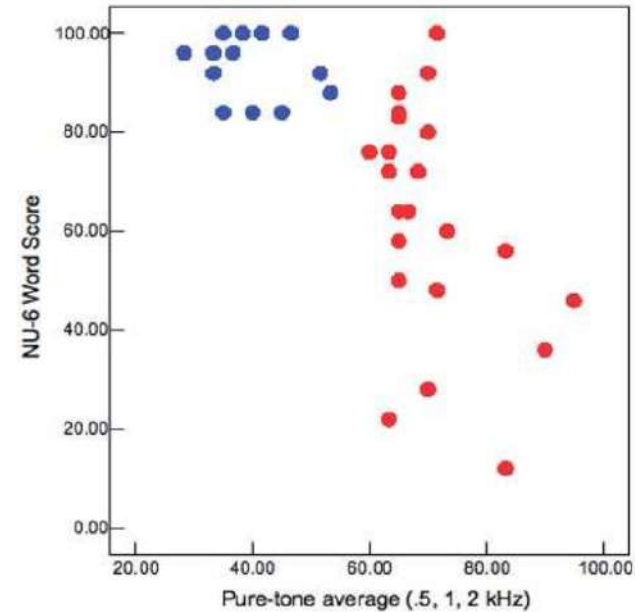
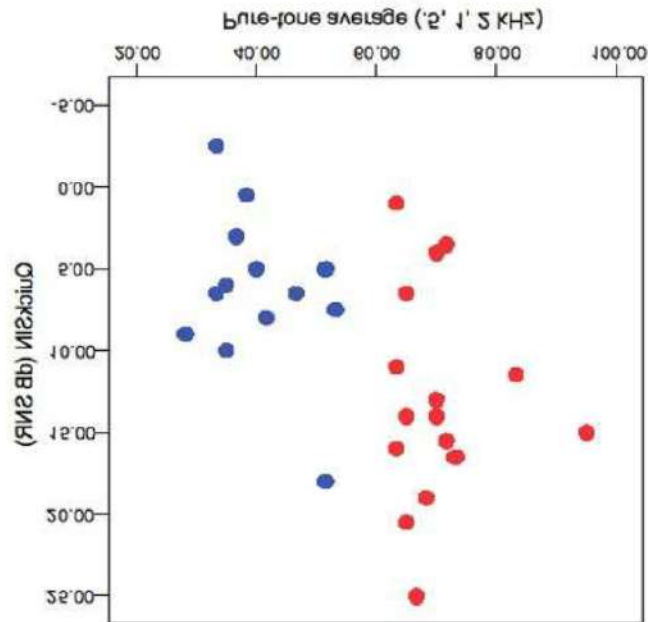


Healthy hair cells



Damaged hair cells

# Mild to moderate compared to severe hearing loss



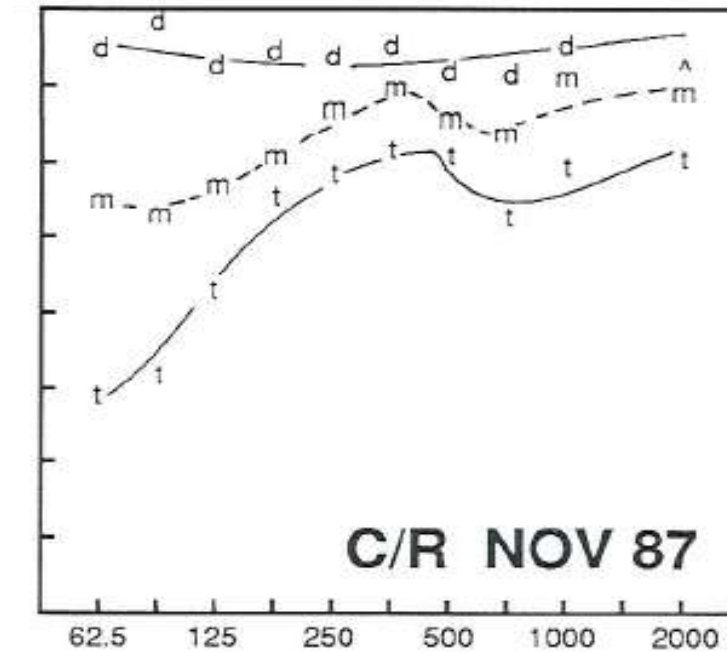
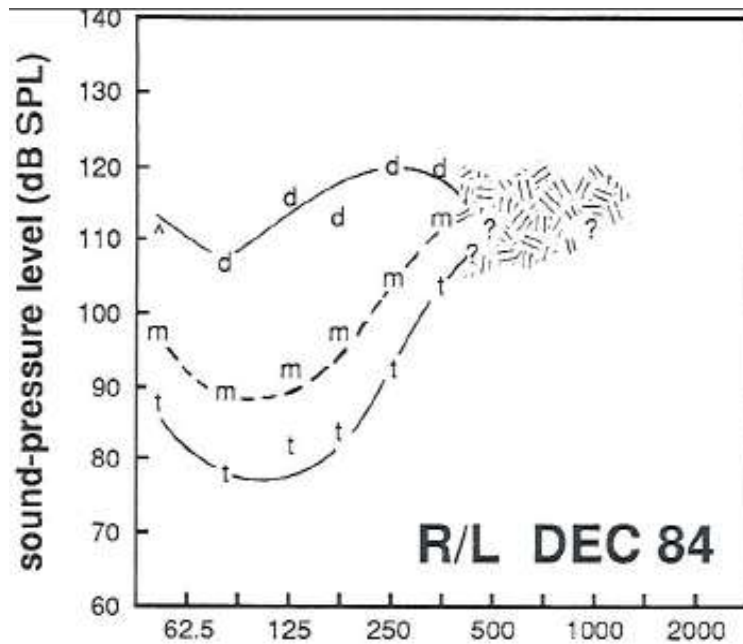
- Speech in noise vs pure tone average
  - Blue: mild to moderate hearing loss
  - Red: moderately severe to severe hearing loss

- Speech in quiet vs pure tone average

- Souza, P. (2009). Severe Hearing Loss Recommendations for Fitting Amplification. *Audiology Online*, January 19



## Two patients with different loudness perception.



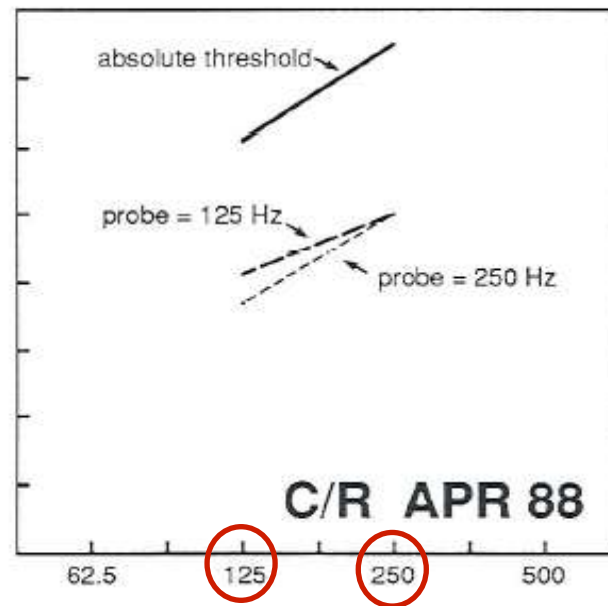
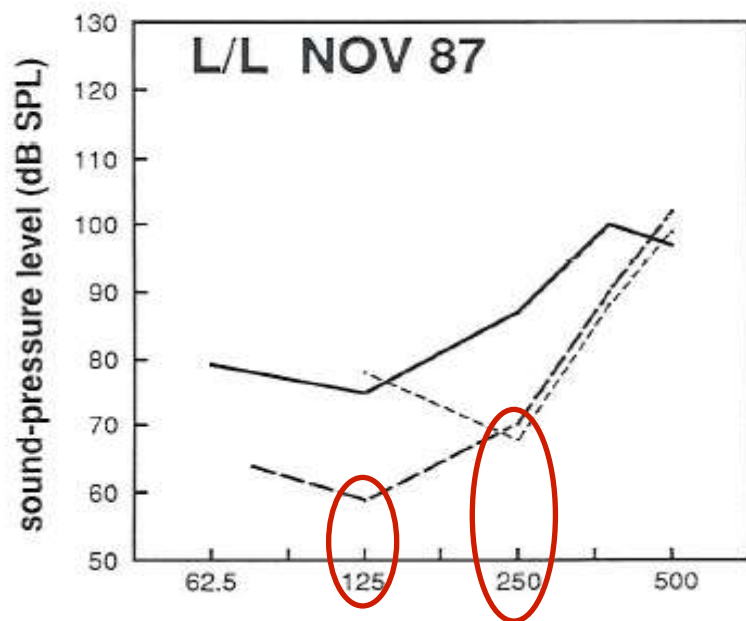
- Person 1 “R”
  - t: absolute thresholds
  - m: most comfortable levels
  - d: discomfort thresholds
  - #: “more sensation than a note,” “horrid squeaks”

Person 2 “C”

Stuart Rosen (1990). The Psychoacoustics of Profound Hearing Impairment. *Acta Otolaryngol (Stockh)*, Suppl. 469: 16 -22



# Same patients with different frequency resolution

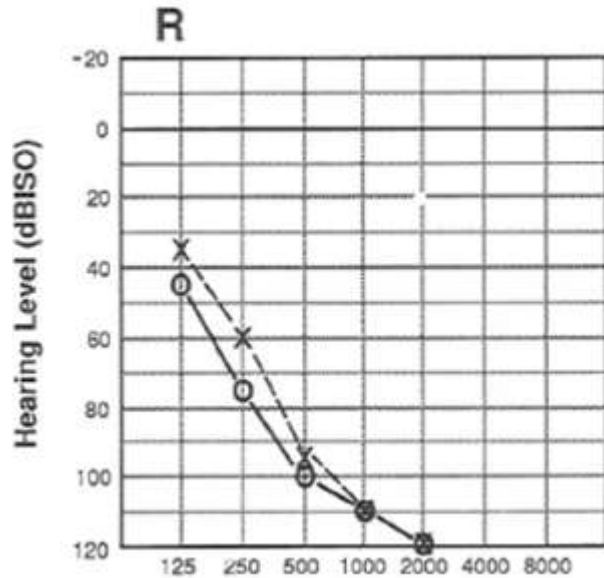


- Person 1 “R”
- Psychophysical tuning curves.
  - Solid line: absolute thresholds (pulsed tones)
  - Dashed lines: masker level required to just mask the probe tone at 10 dB SL.

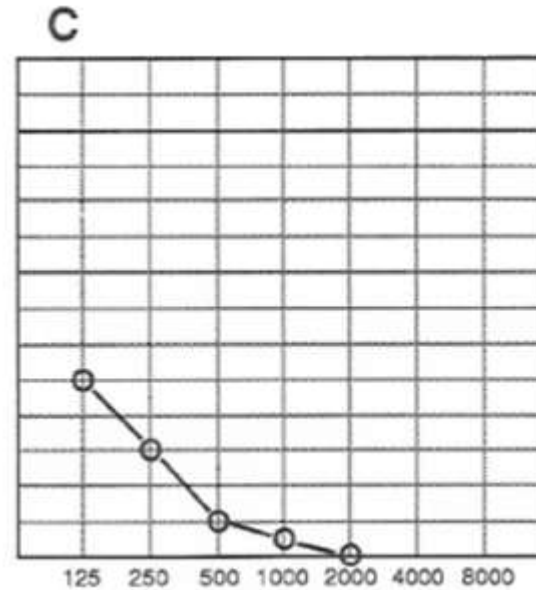
Person 2 “C”

Stuart Rosen (1990). The Psychoacoustics of Profound Hearing Impairment. *Acta Otolaryngol (Stockh)*, Suppl. 469: 16 -22

# The audiograms are however the same



- Person 1 “R”
- Loudness perception: much worse
- Frequency resolution: much better



- Person 2 “C”
- Loudness perception: much better
  - Frequency resolution: much worse

Stuart Rosen (1990). The Psychoacoustics of Profound Hearing Impairment. *Acta Otolaryngol (Stockh)*, Suppl. 469: 16- 22

## Take home messages

1. The pure tone audiogram does not tell the complete story
2. Same pure tone audiogram does not mean hearing loss is the same

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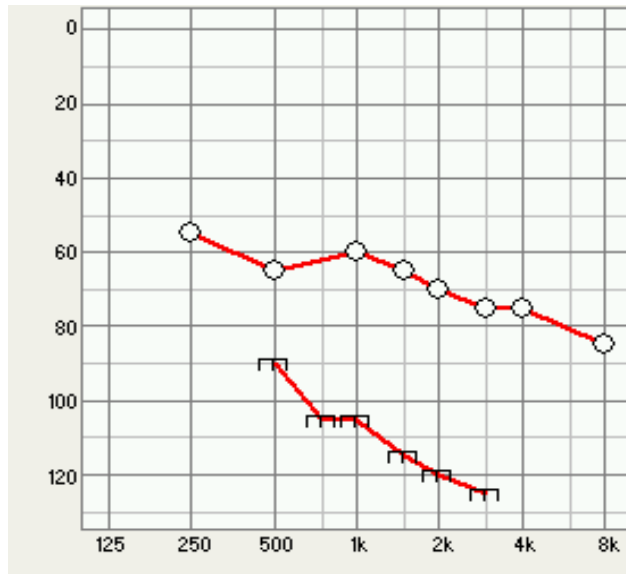
# The phenomena of sensorineural hearing loss

- Loss of sensitivity
- Loss of dynamic range
- Loss of time resolution (loss of inner hair cells)
- Loss of frequency resolution (loss of outer hair cells)
- Distortion, tinnitus

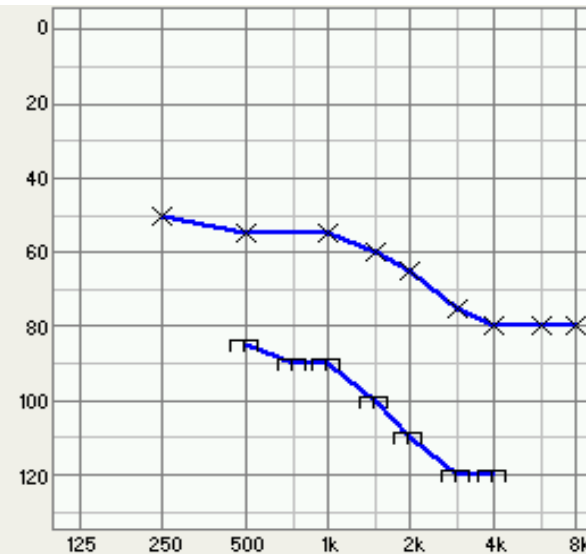
# Sensitivity loss and loss of dynamic range

- Measurement of the hearing threshold and uncomfortable threshold
- Depicted in the pure tone audiogram
- Standard diagnostics
- **Does not address the problems patients experience**

Right



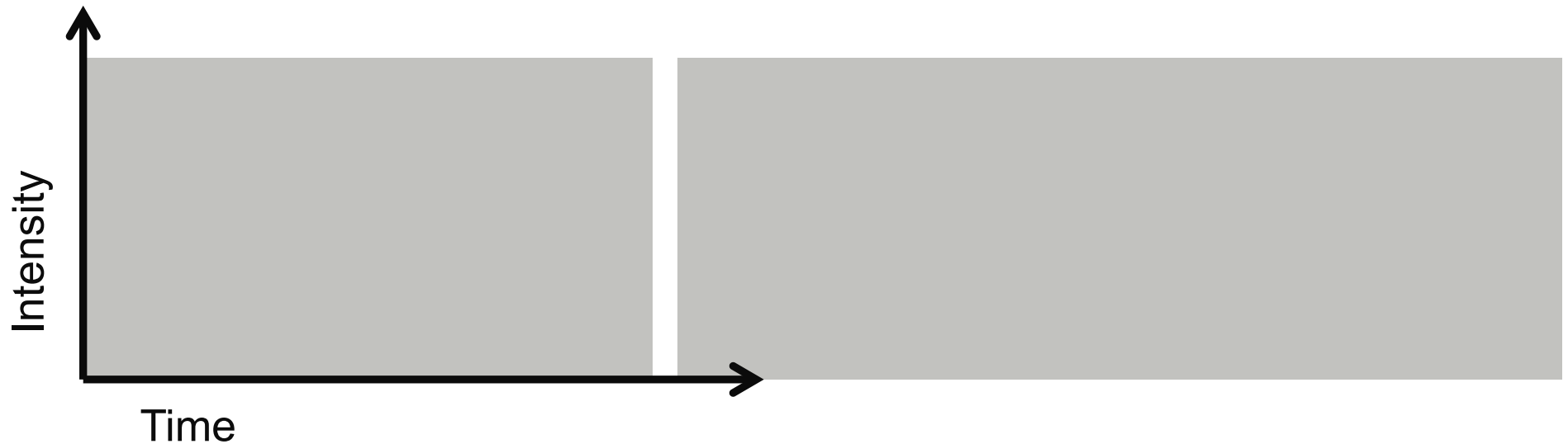
Left



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## Loss of time resolution

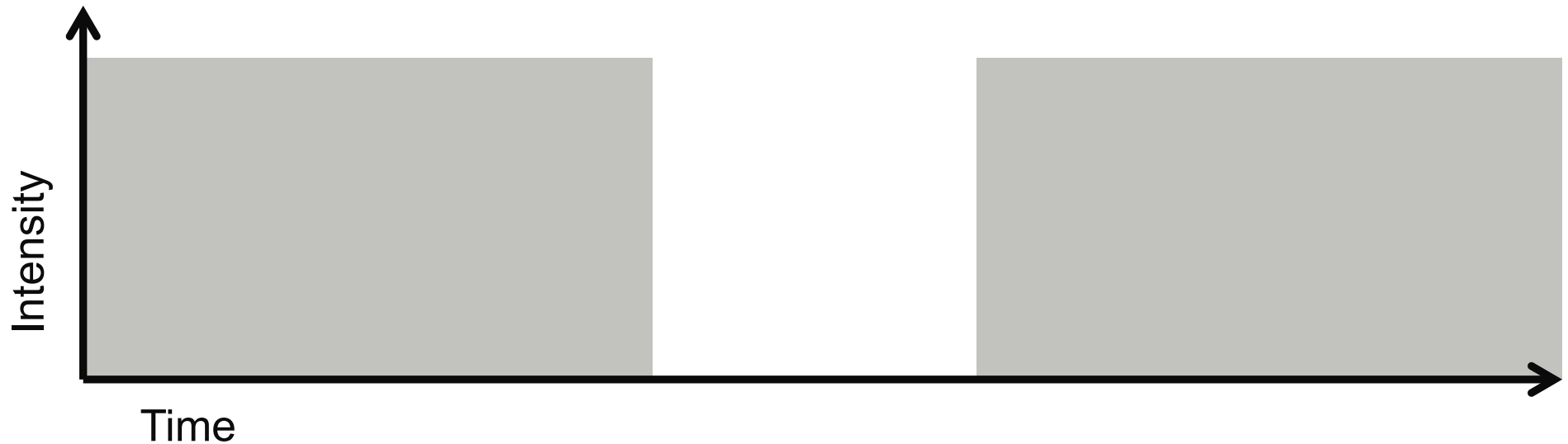
- The damaged ear is not capable of hearing correctly rapid changes in time in a sound signal
- The sound is smeared out over time
- For instance, a small pause in sound needs to be longer to be heard



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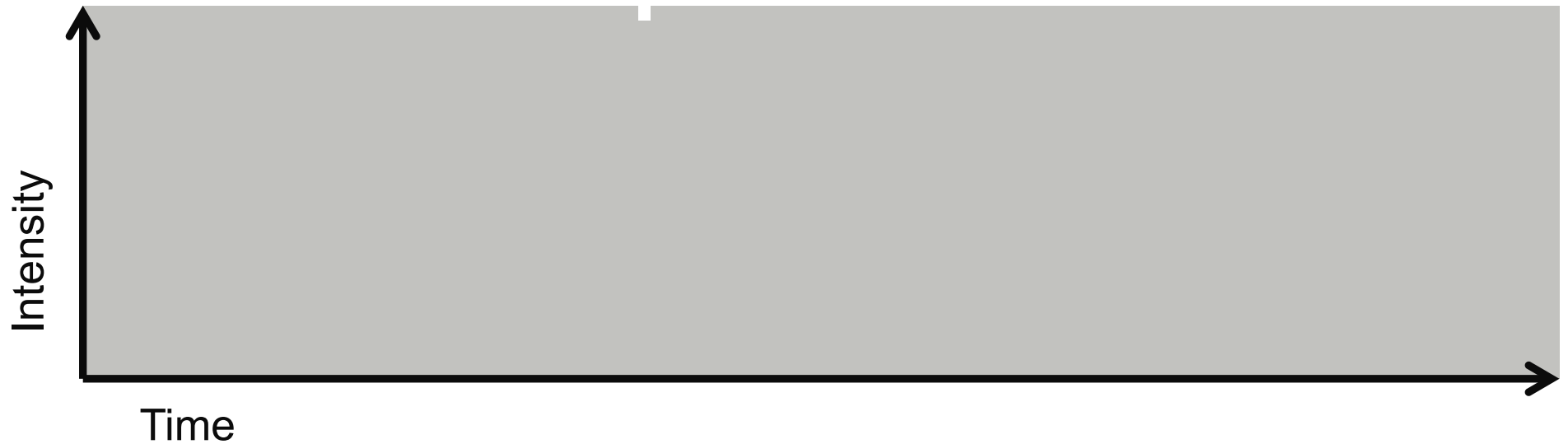




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# Loss of time resolution in the presence of background noise

- It is getting very difficult



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# Loss of time resolution in the presence of background noise

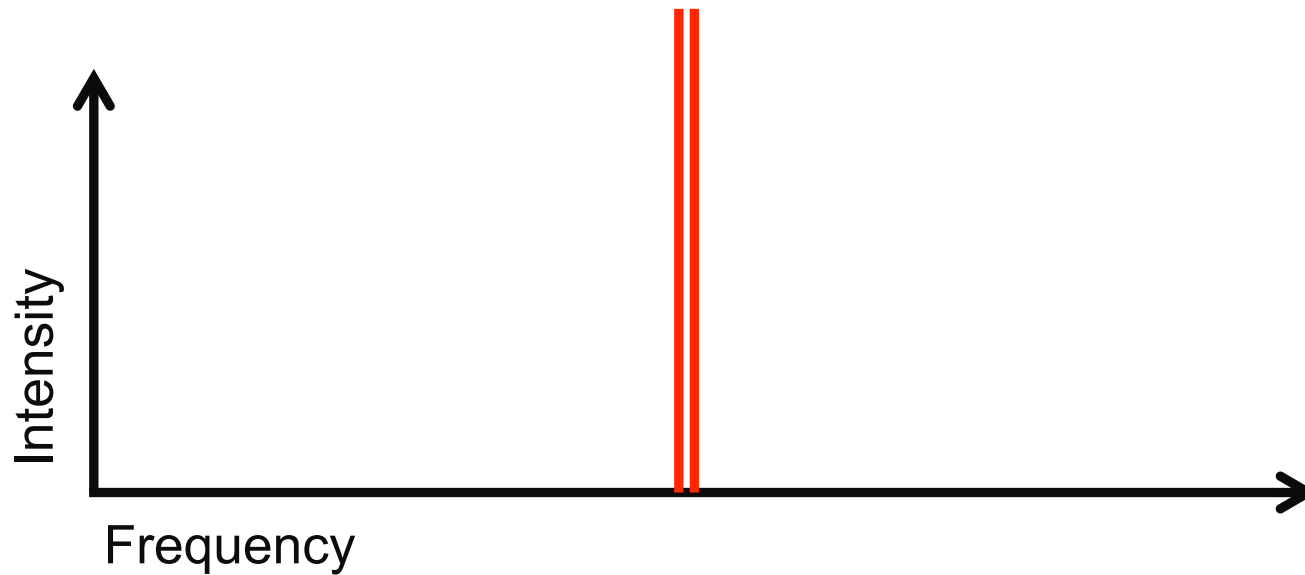
- It is getting very difficult



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# Loss of frequency resolution

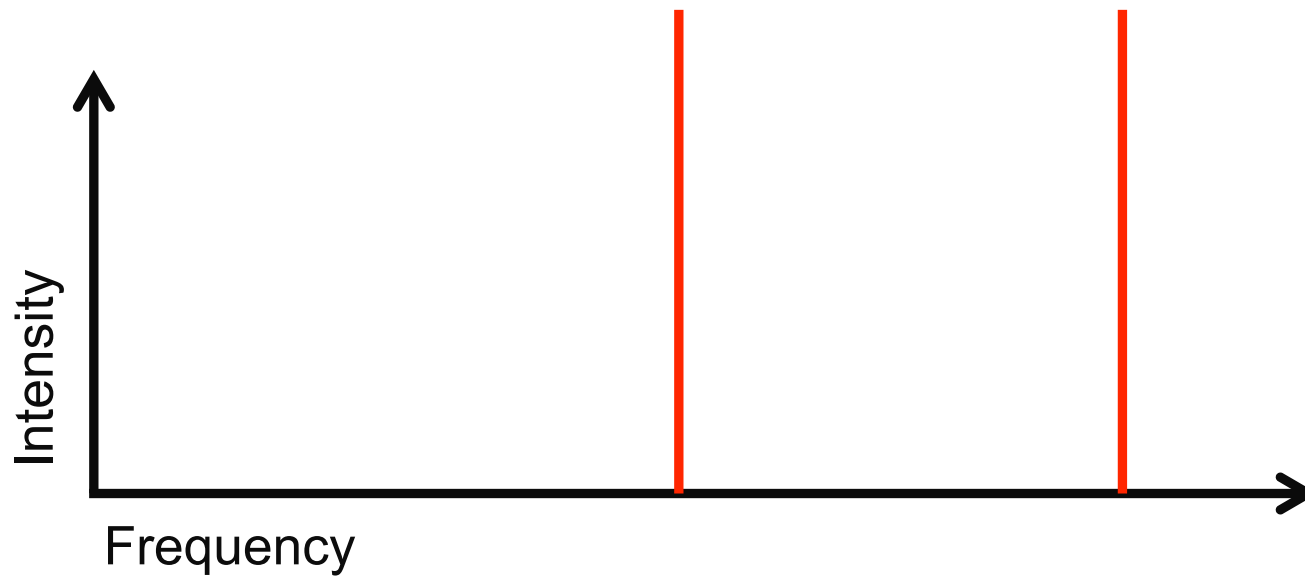
- Differences in frequency (pitch) need be larger before they are noticed



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# Loss of frequency resolution

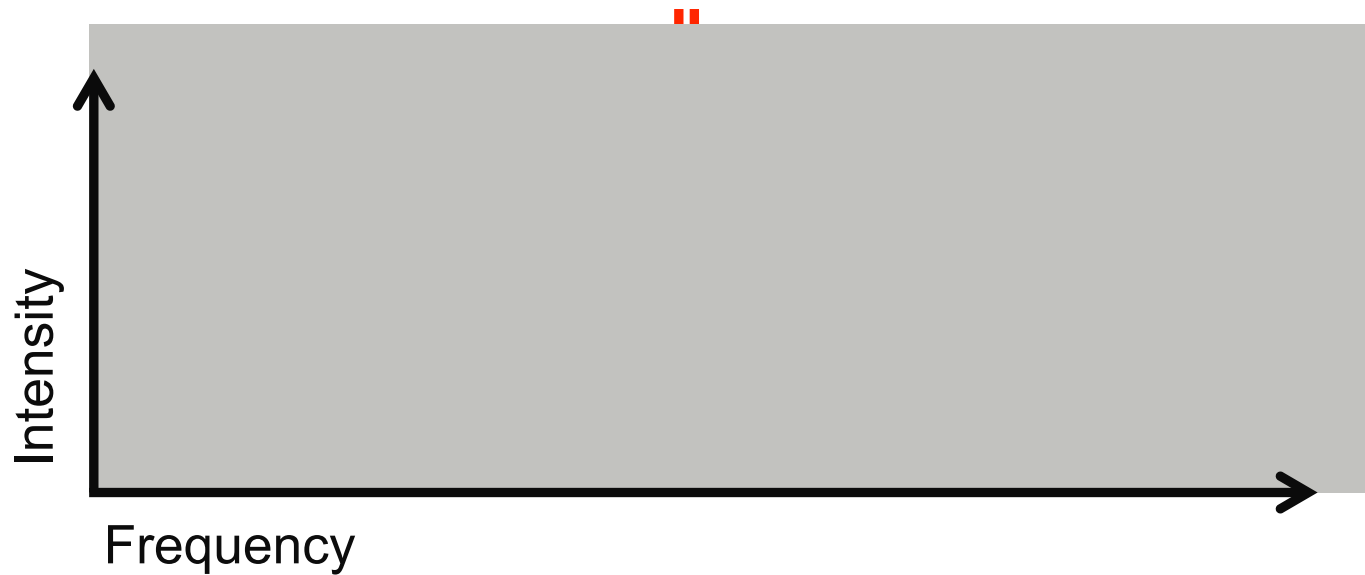
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# Loss of frequency resolution in the presence of background noise

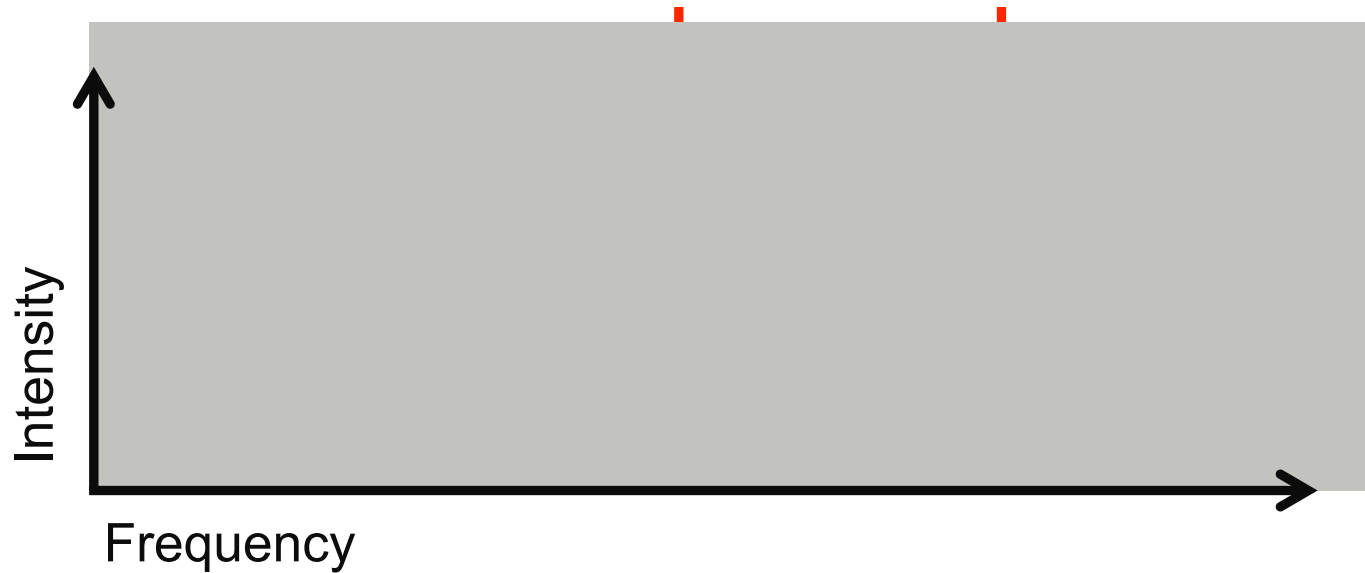
- It is getting very difficult



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# Loss of frequency resolution in the presence of background noise

- It is getting very difficult



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# Loss of time and spectral resolution

- Not measured routinely - no standards exist
- Affects especially hearing in noise
- Subtle speech cues get lost and as a result consonants (carriers of most speech information) get confused

- Clusters that sound similar are

/p/,/t/,/k/

/f/,/s/,/ʃ/

/m/,/n/,/ŋ/

- ***No current hearing aid technology can solve this problem***
- ***‘Cleaning the signal’ before it reaches the ear is the only approach that works***

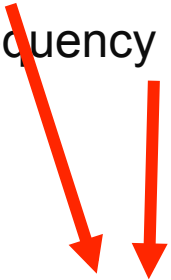


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# How can technology help overcome these problems?

A sensorineural hearing loss usually has at least the following effects:

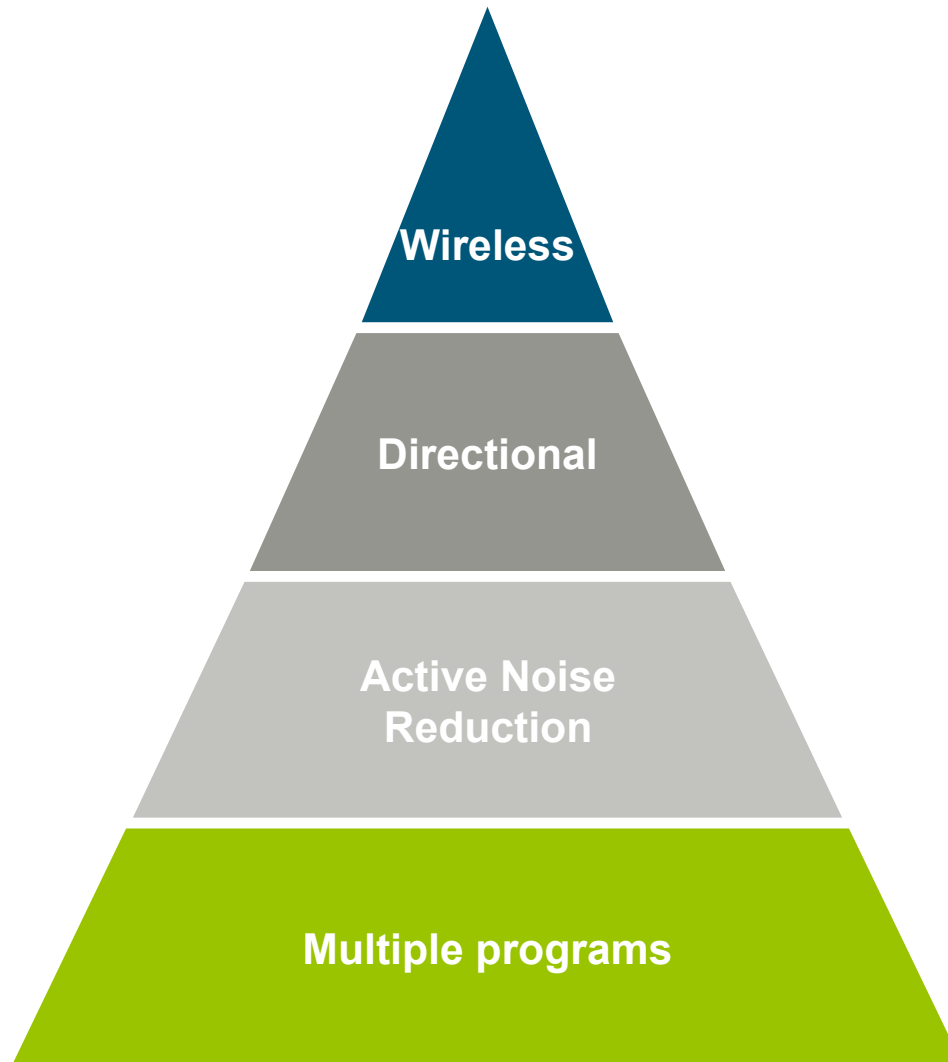
- Loss of sensitivity → Amplification, **frequency lowering**
- Loss of dynamic range → Amplitude compression
- Loss of time resolution → ???
- Loss of frequency resolution → ???



Poor speech discrimination, especially in noise.  
This is still a major problem for hearing aid and CI users!

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# Hierarchy of techniques to improve hearing in noise

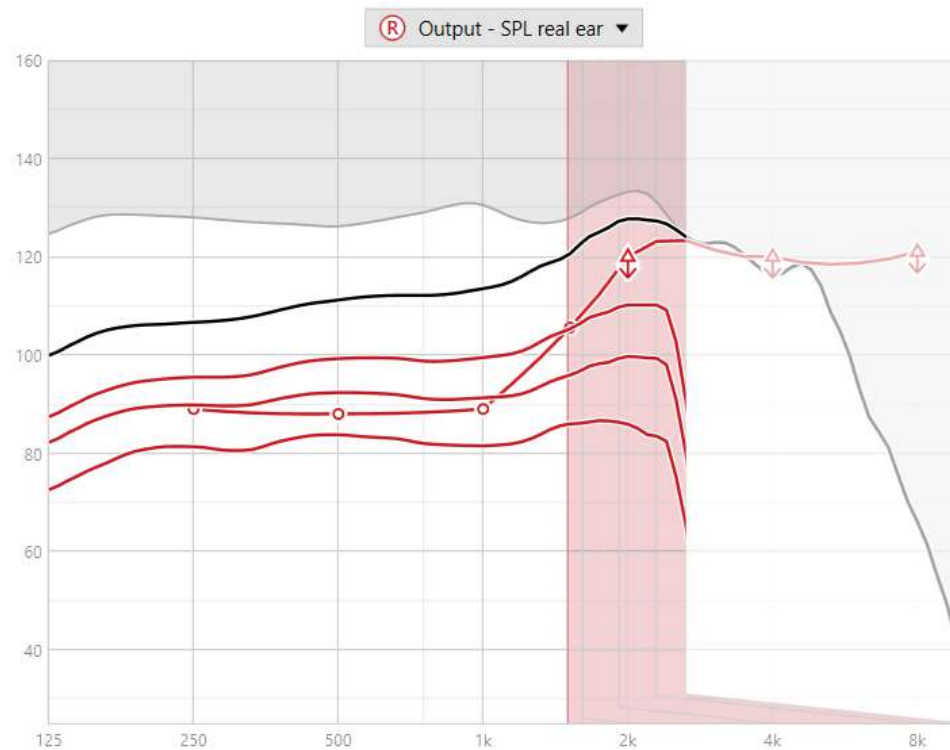




## New developments in hearing aid technology

# What to do if high frequencies cannot be heard?

- We bring them down to a lower frequency range where they become audible
- In 2007 Phonak brought SoundRecover
- Today in more than 10 million hearing aids world wide



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# SoundRecover evidence

## Peer reviewed

Glista D, Scollie S, Sulkers J (2012) Perceptual Acclimatization Post Nonlinear Frequency Compression Hearing Aid Fitting in Older Children. *J Speech Lang Hear Res.* May 21. [Epub ahead of print]

Wolfe J, John A, Schafer E, Nyffeler M, Boretzki M, Caraway T, Hudson M. (2011) Long-term effects of non-linear frequency compression for children with moderate hearing loss. *Int J Audiol.* Jun;50(6):396-404

Wolfe J, John A, Schafer E, Nyffeler M, Boretzki M, Caraway T. (2010) Evaluation of nonlinear frequency compression for school-age children with moderate to moderately severe hearing loss. *J Am Acad Audiol.* Nov-Dec;21(10):618-28

Bohnert A, Nyffeler M, Keilmann A.(2010) Advantages of a non-linear frequency compression algorithm in noise. *Eur Arch Otorhinolaryngol.* Jul;267(7):1045-53

Glista D, Scollie S, Bagatto M, Seewald R, Parsa V, Johnson A.(2009) Evaluation of nonlinear frequency compression: clinical outcomes. *Int J Audiol.* 48(9):632-44

Simpson A.(2009) Frequency-lowering devices for managing high-frequency hearing loss: a review. *Trends Amplif.* 13:87-106.

Stelmachowicz, P., Pittman, A., Hoover, B., Lewis, D. (2002). Aided perception of the /s/ and /z/ by hearing-impaired children. *Ear and Hearing*, 23 (4), 316-324

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# SoundRecover evidence

## Non-peer reviewed

McDermott HJ. (2011) A technical comparison of digital frequency-lowering algorithms available in two current hearing aids. *PLoS One.*;6(7):e22358

Timmer B. (2010): Neue Ansätze bei direktionalen multi-mikrofonssystemen. *Hörakustik* 11/2010:12-16

Nyffeler M. (2010): Geschaffen für erstklassigen Hörgenuss, tatsächlich binaural. *AudioInfos* 10:78-82

Wolfe, J., Caraway, T., John, A., Schafer, E. C., & Nyffeler, M. (2009). Study suggests that non-linear frequency compression helps children with moderate loss. *The Hearing Journal*, 62 (9), 32-37.

Alexander JM. (2009) Candidacy, selection, and verification of SoundRecover options. Paper presented at: *The 3rd Phonak Virtual Audiology Conference*; May

Glista D, Scollie S, Polonenko M, Sulkers J. (2009) A comparison of performance in children with nonlinear frequency compression systems. *Hearing Review*. 16(12):20-24.

Nyffeler, M. (2008) Study finds that non-linear frequency compression boosts speech intelligibility, *The Hearing Journal*, 61 (12)

Scollie, S., Glista, D., Bagatto, M., & Seewald, R. (2007). Multichannel nonlinear frequency compression: A new technology for children with hearing loss. Paper presented at the *A Sound Foundation Through Early Amplification*, Chicago, IL. December.

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## So what is there to improve?

- For profound hearing losses we did not bring high frequencies down to low enough frequencies to make them audible
- For if we would do that to make /s/ or /sh/ audible, vowels would sound heavily distorted



# **SoundRecover2**

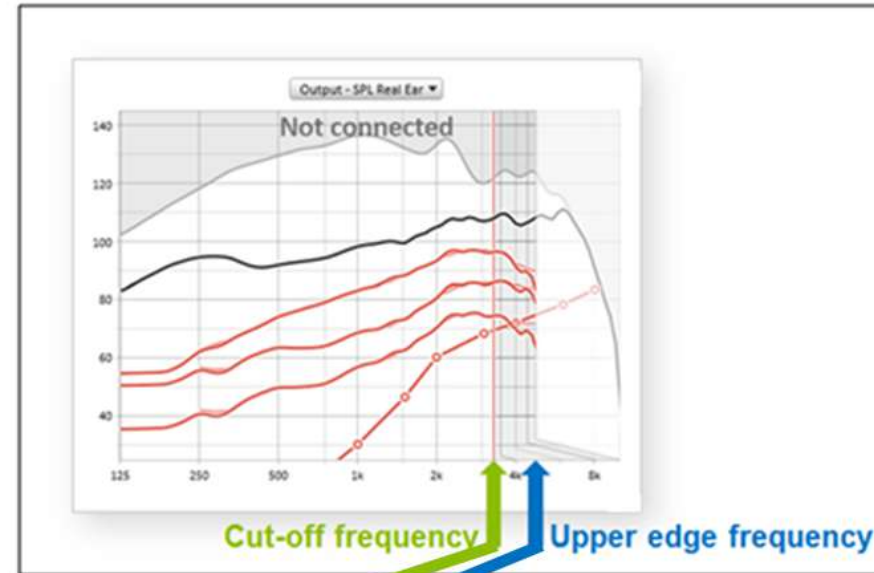
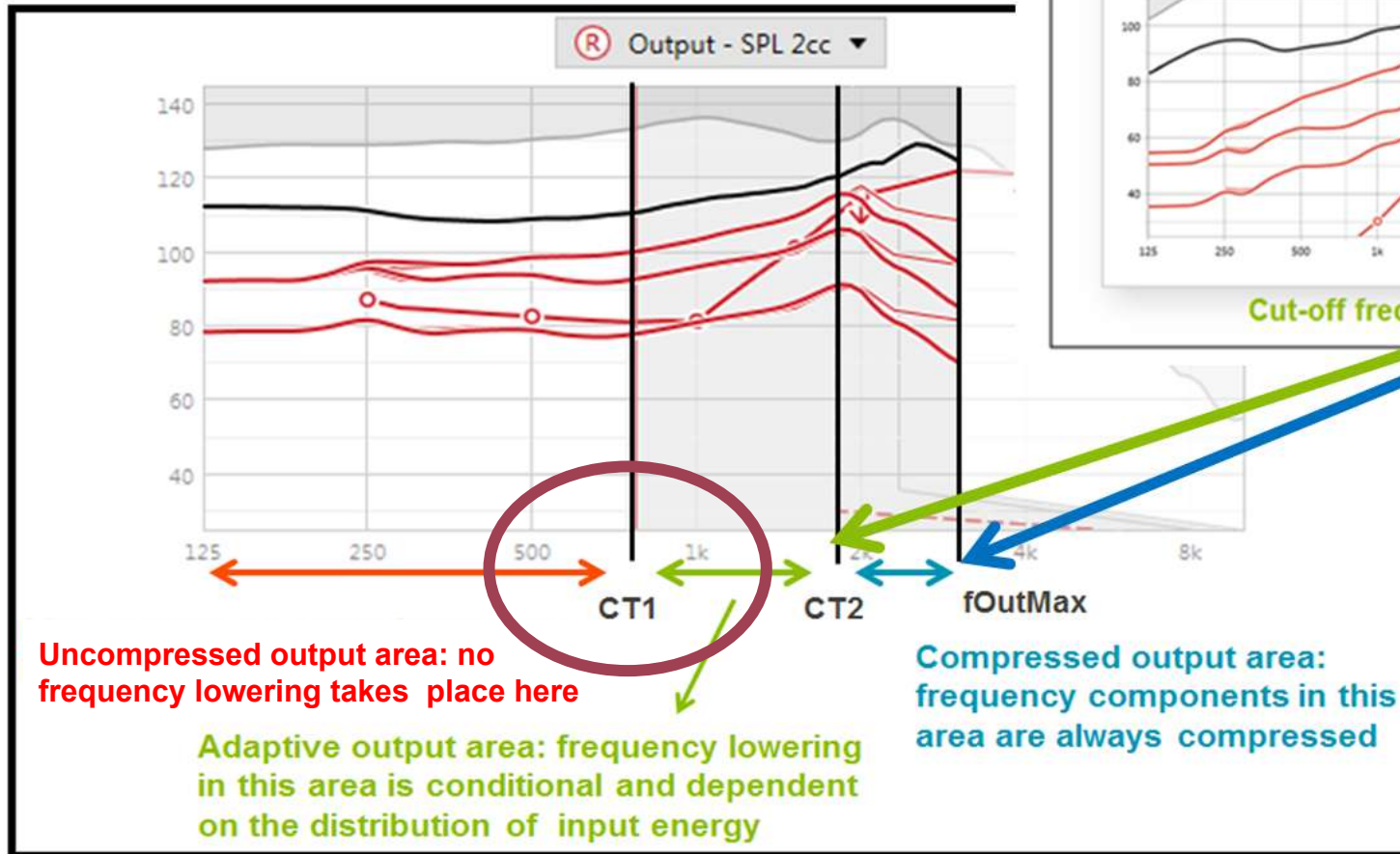
**The world's first adaptive  
frequency compression  
algorithm**

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## SoundRecover2: the hearing aid listens and responds adaptively

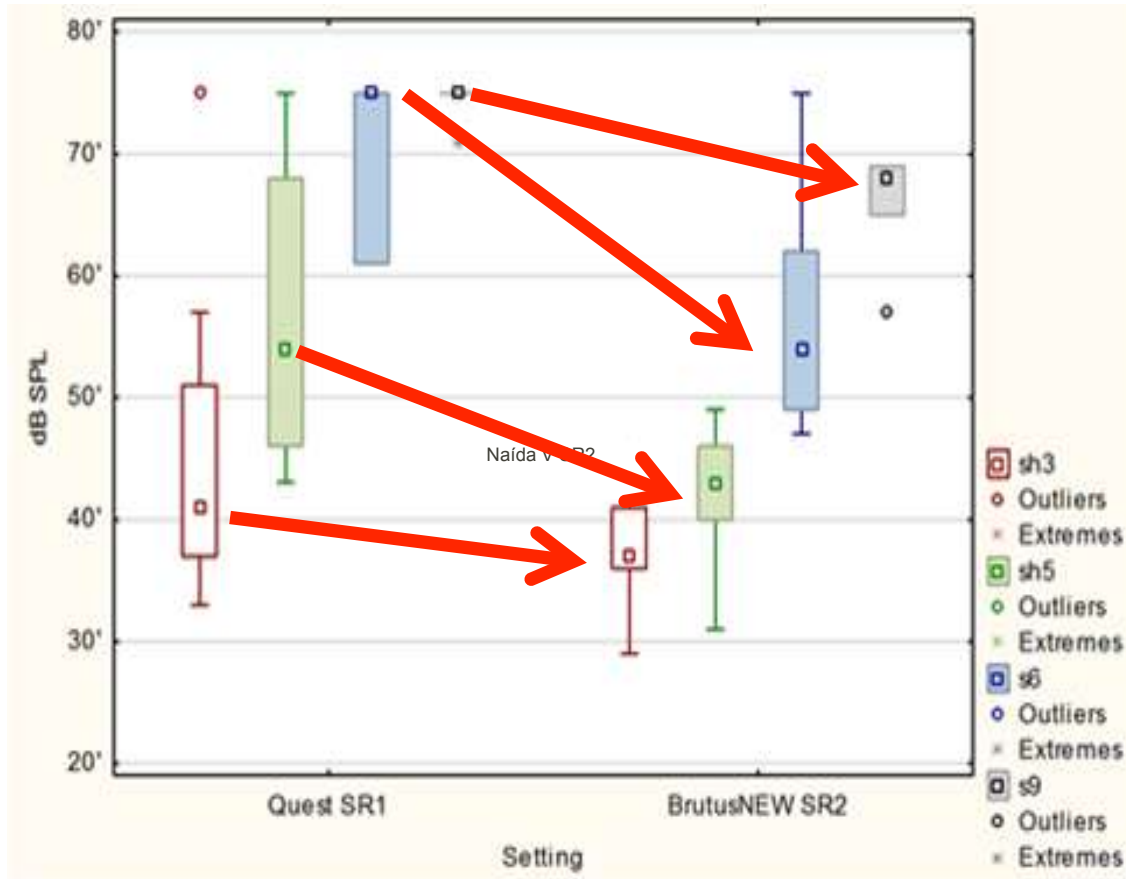
- SoundRecover 2 is adaptive
- It lowers sound to much lower frequencies to make high frequency sounds like /s/ and /sh/ audible, even for profound hearing losses
- BUT, it only does that when a high frequency sounds are detected by the hearing aid
- If there is low frequency energy in the sound signal, the signal is not lowered in frequency
- This preserves the sound quality of vowels

# From SoundRecover to SoundRecover2



# Improved detection thresholds for high frequency sounds

- Profound hearing loss



## Take home messages

**3. For profound hearing loss you need more than amplification alone to make sounds audible**

**4. New adaptive frequency compression algorithm (SoundRecover2) shows significant improvement**



## Roger update

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# Roger: the standard in wireless technology

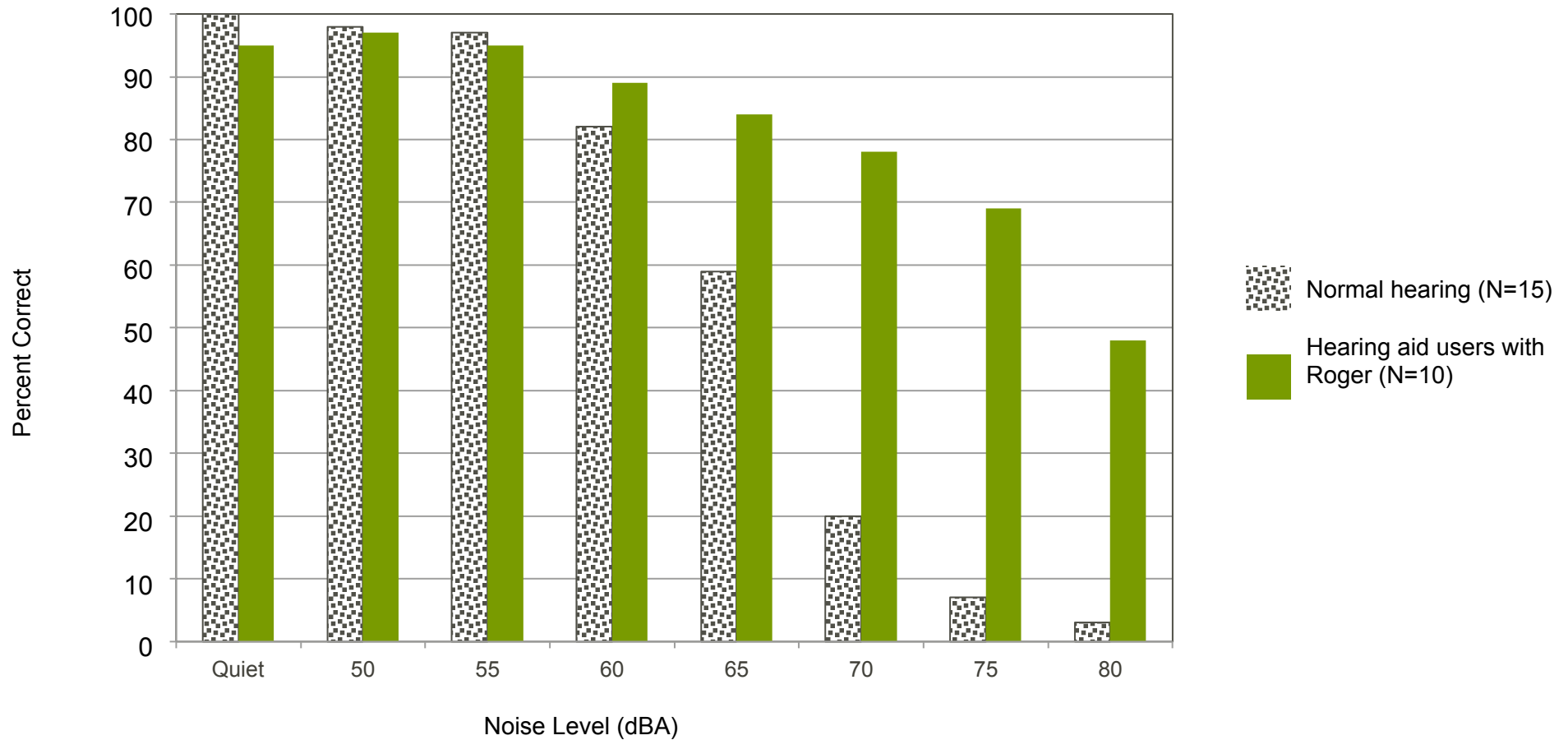
- Specifically developed for people with hearing loss (unlike Bluetooth)
- Compatible with all brands of hearing aids and cochlear implants
- Well documented performance



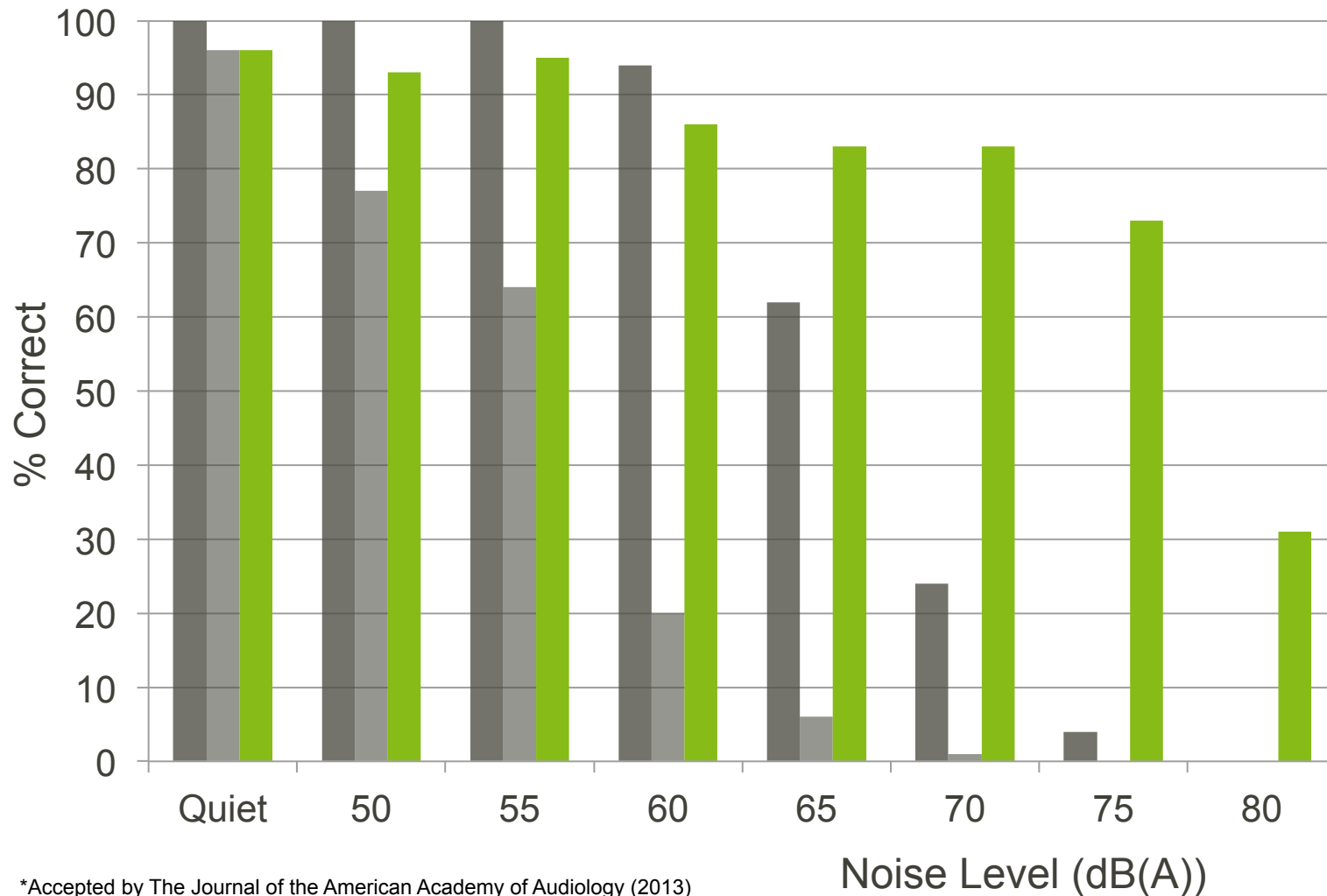
roger



# Speech understanding in noise, hearing instrument users plus Roger versus normal hearing listeners



# Speech understanding in various noise levels; AB Harmony



N=13

\*Accepted by The Journal of the American Academy of Audiology (2013)



Next step: speech understanding in noise with multiple talkers

The ultimate challenge !!

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# Study: multiple microphone network performance in noise

## Acknowledgements:

Geert De Ceulaer, Paul J. Govaerts,  
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Felix Goldbeck

Phonak Communications, Murten, Switzerland

Sebastien Pierre Janssens de Varebeke

ENT Department, Jessa Hospital, Hasselt, Belgium

## Real life situation



# Roger and Naída CI

Roger Clip-On Mic



Roger Pen



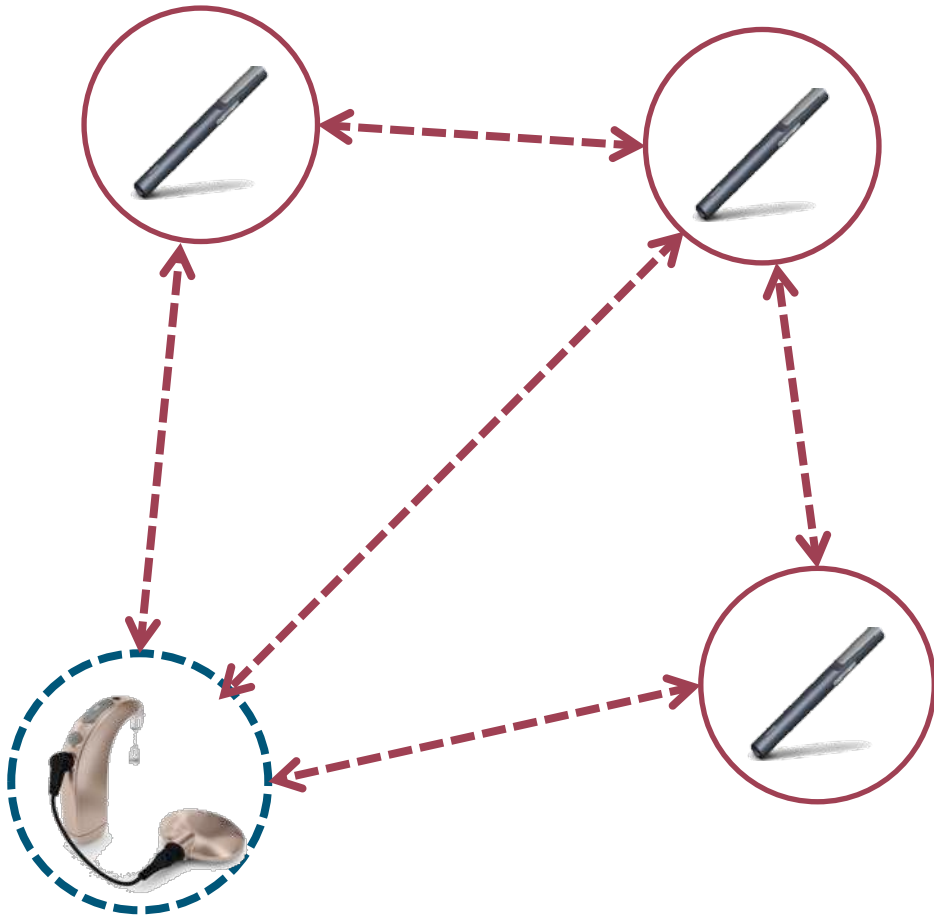
**PHONAK**



Design integrated receiver: Roger 17



# Multi-talker network



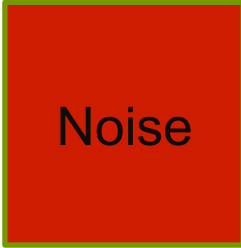
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## Study design

- Measure speech understanding with and without 3 Roger Pens
- Adults Naída CI users
- 12 subjects
- Randomized order of conditions



Test set-up



Speech  
Loudspeaker

Speech normal  
conversation level

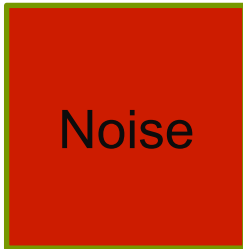
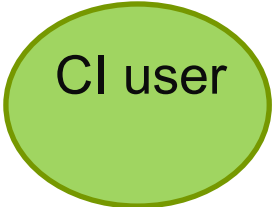
Surrounding babble noise at  
varying levels: from 55 dB  
SPL to 80 dB SPL



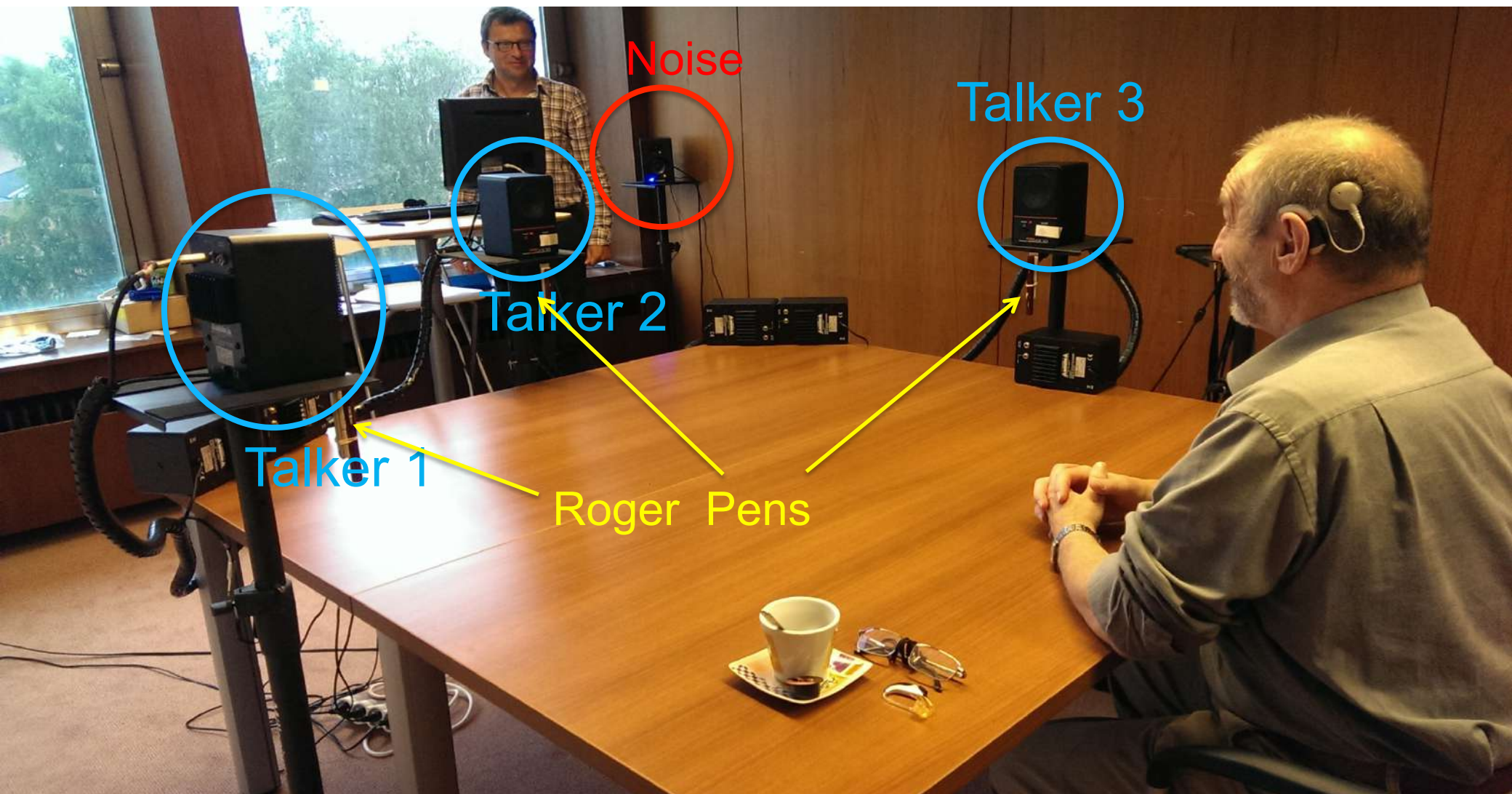
Speech  
Loudspeaker



Speech  
Loudspeaker



Each sentence comes  
randomly from 1 of the 3  
speakers



Noise

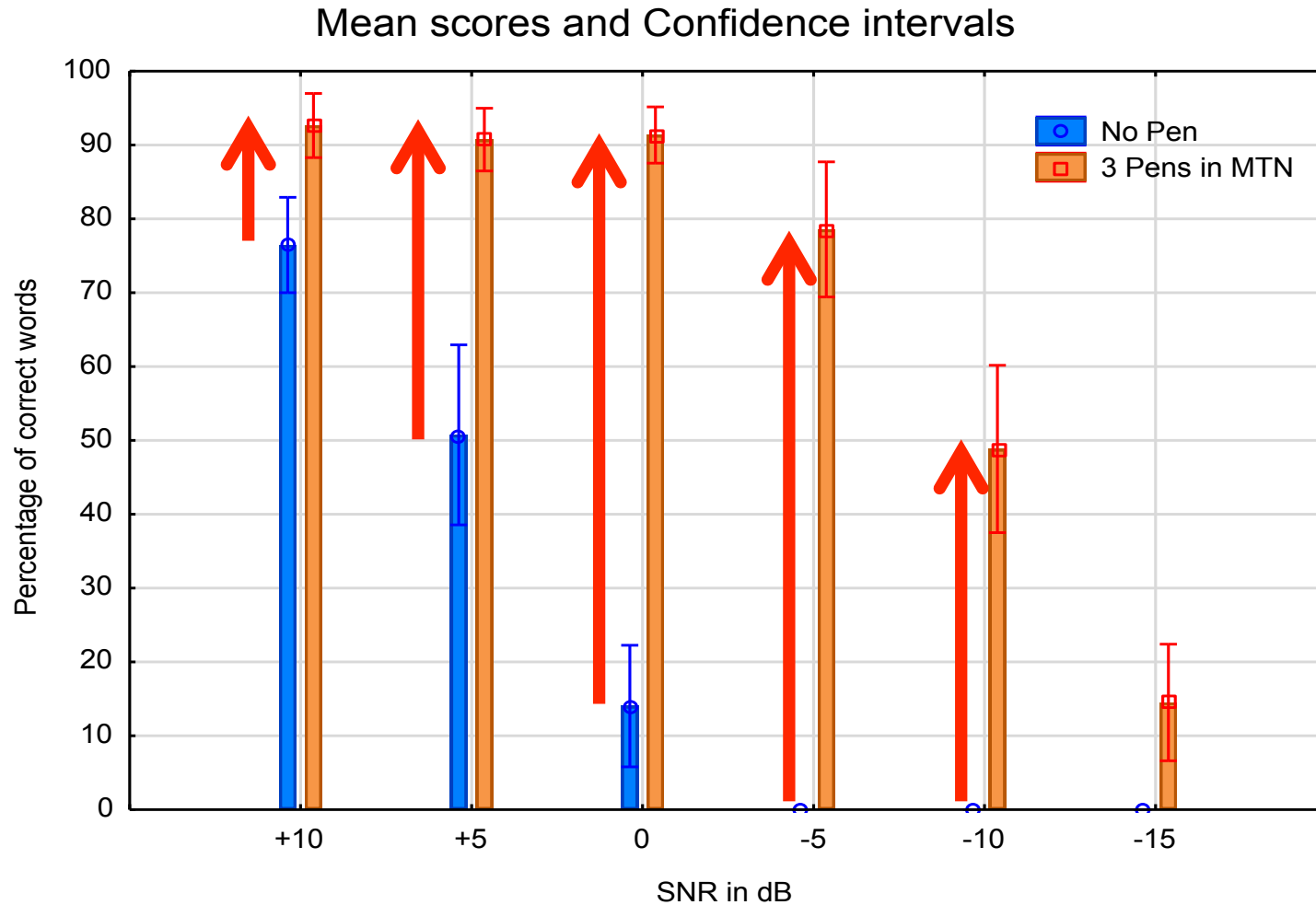
Talker 3

Talker 2

Talker 1

Roger Pens

# Results: significant improvement in speech understanding in noise



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# Conclusions

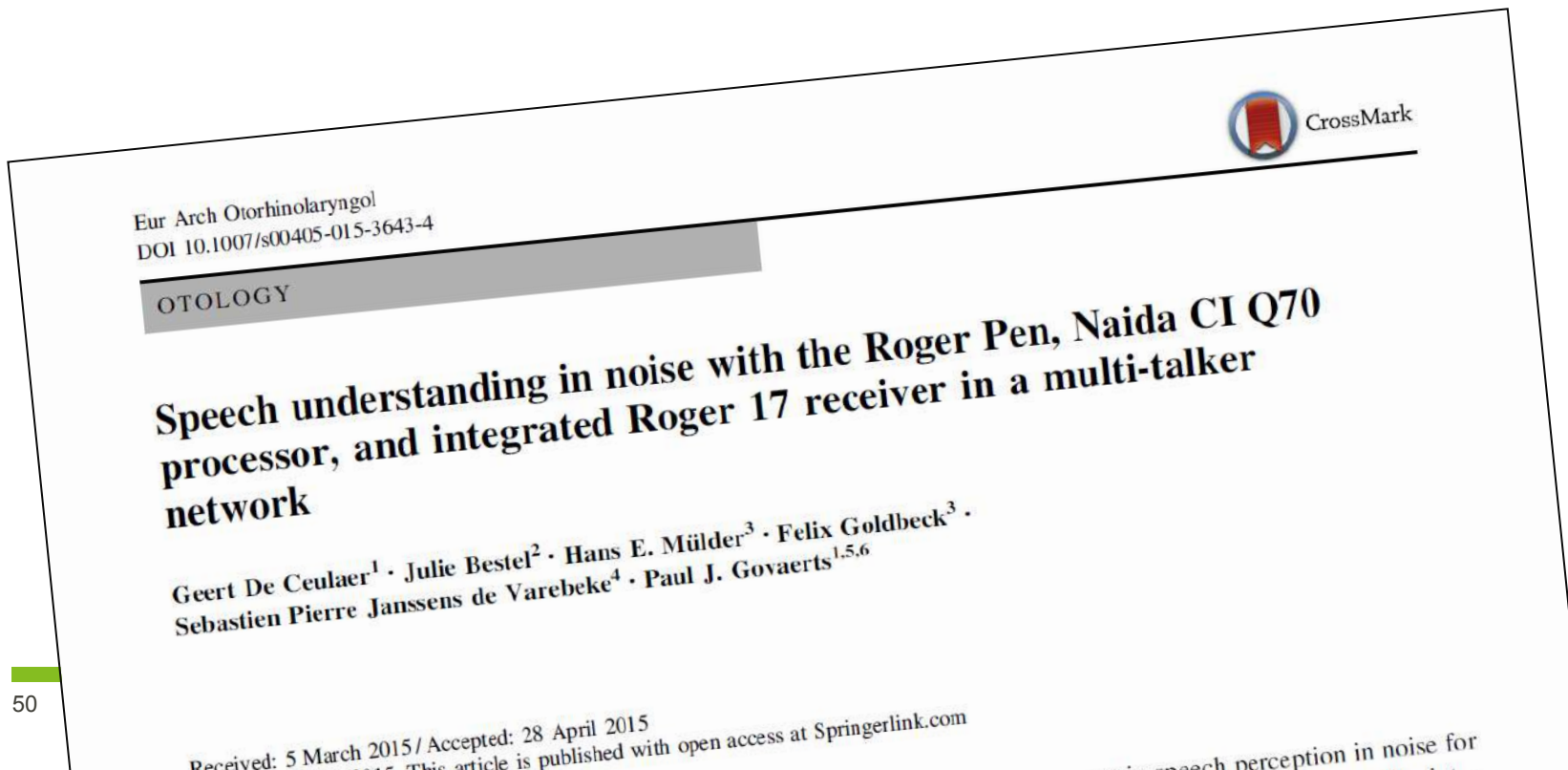
- Everyday life very challenging situation:
  - High noise levels, no lip reading, multiple talkers
- Roger network works extremely well: switches fast between talkers
- In noise, improvement in speech understanding of up to 79%

Study is published

European Archives of Oto-Rhino-Laryngology and Head & Neck

Want a pdf?

Email: [hans.mulder@phonak.com](mailto:hans.mulder@phonak.com)



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## Take home messages

**5. When talking with more than one person in noise, multiple Roger microphones help really well**





## Hearing at work



# Persons affected by hearing loss encounter difficulties at work on a daily basis



*'It's a bit problematic when they come and say something and I cannot hear, because sometimes we cannot talk loudly in my profession. For example, when we're sitting in the reception area and have to speak quietly to each other, I think I miss every second word, so I have to guess what they are saying.'*



*'Yes, it's a bit tough, I think. I cannot hear exactly what they say, so I have to ask them to repeat several times until I catch what they have said. It becomes annoying for them too.'*



*'At a conference I try to sit close to the speaker where I can both see and hear him/her clearly. In that way I can follow the speech better. If I sit at the back of the hall and other people talk, it's more difficult'*

Some of the statements in a phenomenographic study; "Conceptions of working life among employees with mild-moderate aided hearing impairment". By Håkan Hua, Agneta Anderzén-Carlsson, Stephen Widén, Claes Möller & Björn Lyxell International Journal of Audiology 2015

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## Hearing at work

- Complicated content
  - Less familiar voices than at home
  - Multiple languages
  - Hierarchical relationships
  - Speed is essential
  - Less understanding or patience from colleagues
  - People with severe to profound hearing loss have less career opportunities
- 
- **Noise, distance and bad room acoustics**

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Let's embark on a common mission

*Thanks to our joint efforts  
hearing at the workplace  
will be  
no issue anymore*

Phonak developed a complete solution to stay at work



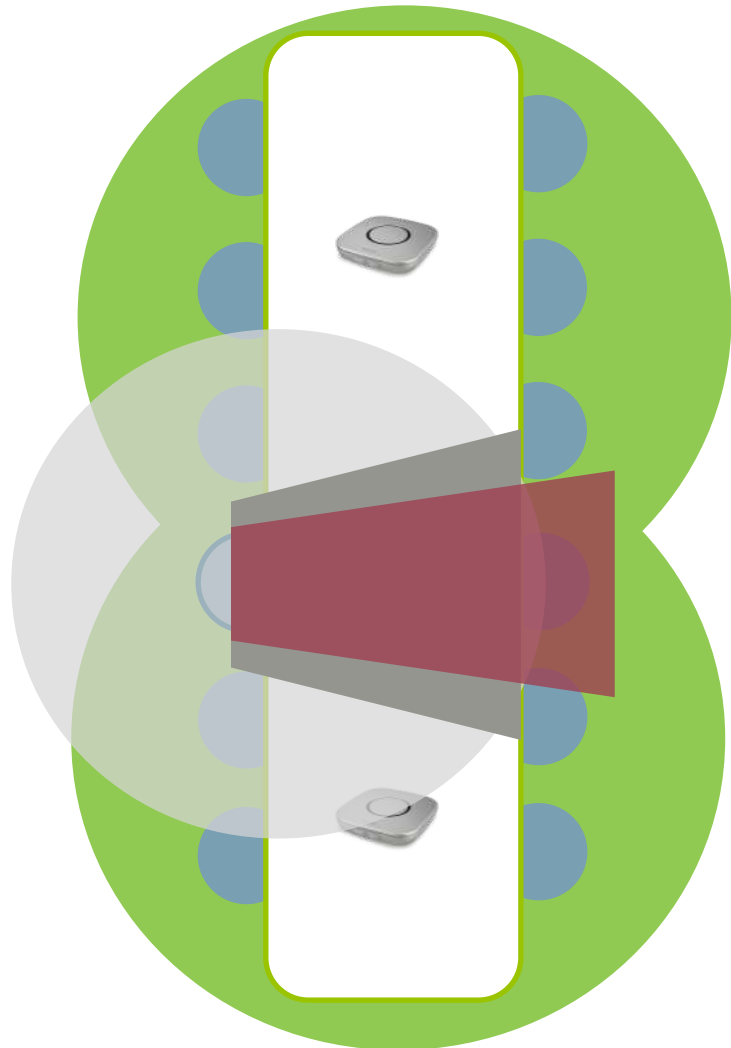
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## New: Roger Table Mic



- Designed especially for meetings
- Possibility to expand to larger and very large meetings
- Battery capacity > 20 hours of operating time
- Range > 20 meters
- Remote Control

# What to expect from Roger Table Mics in meetings

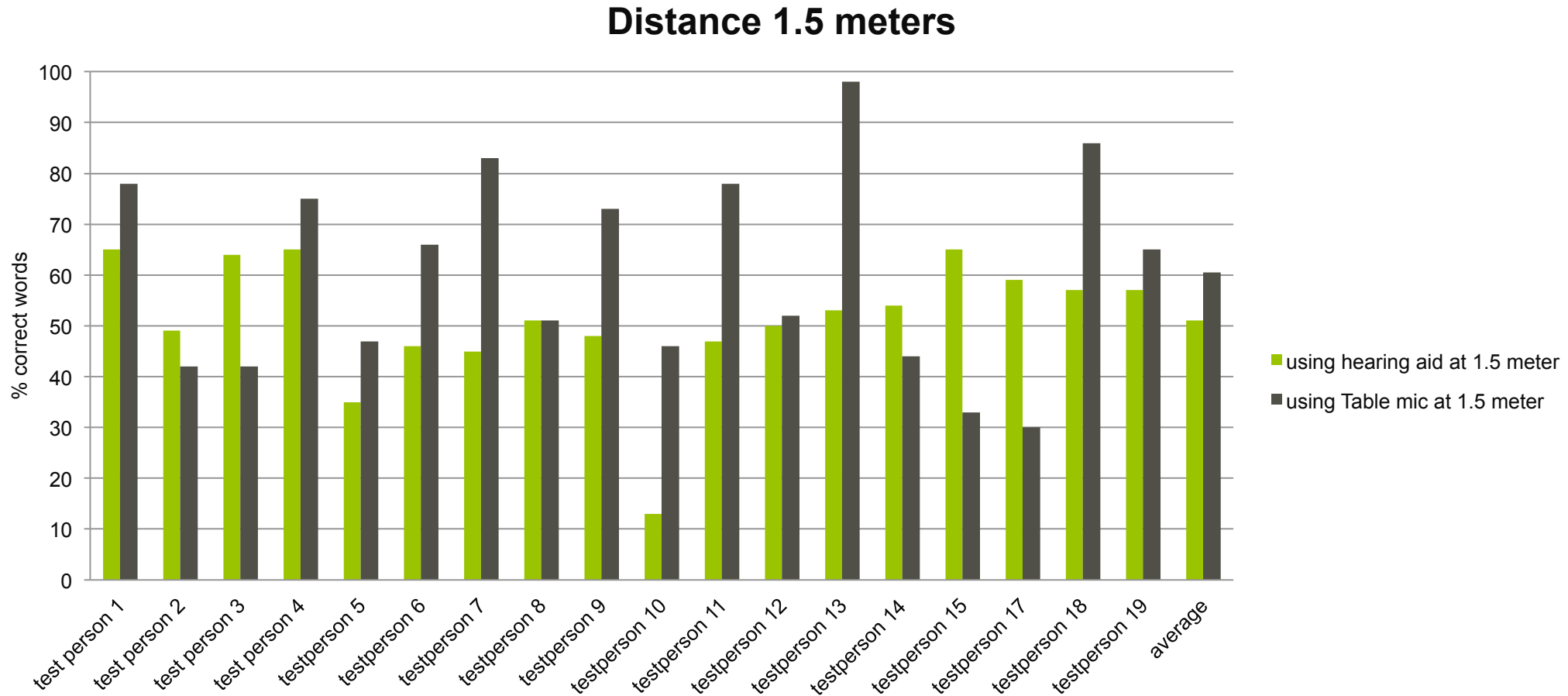


- Omnidirectional hearing aids
- Directional hearing aids
- StereoZoom
- Roger Table Mic

# Roger Table Mic – easy to use

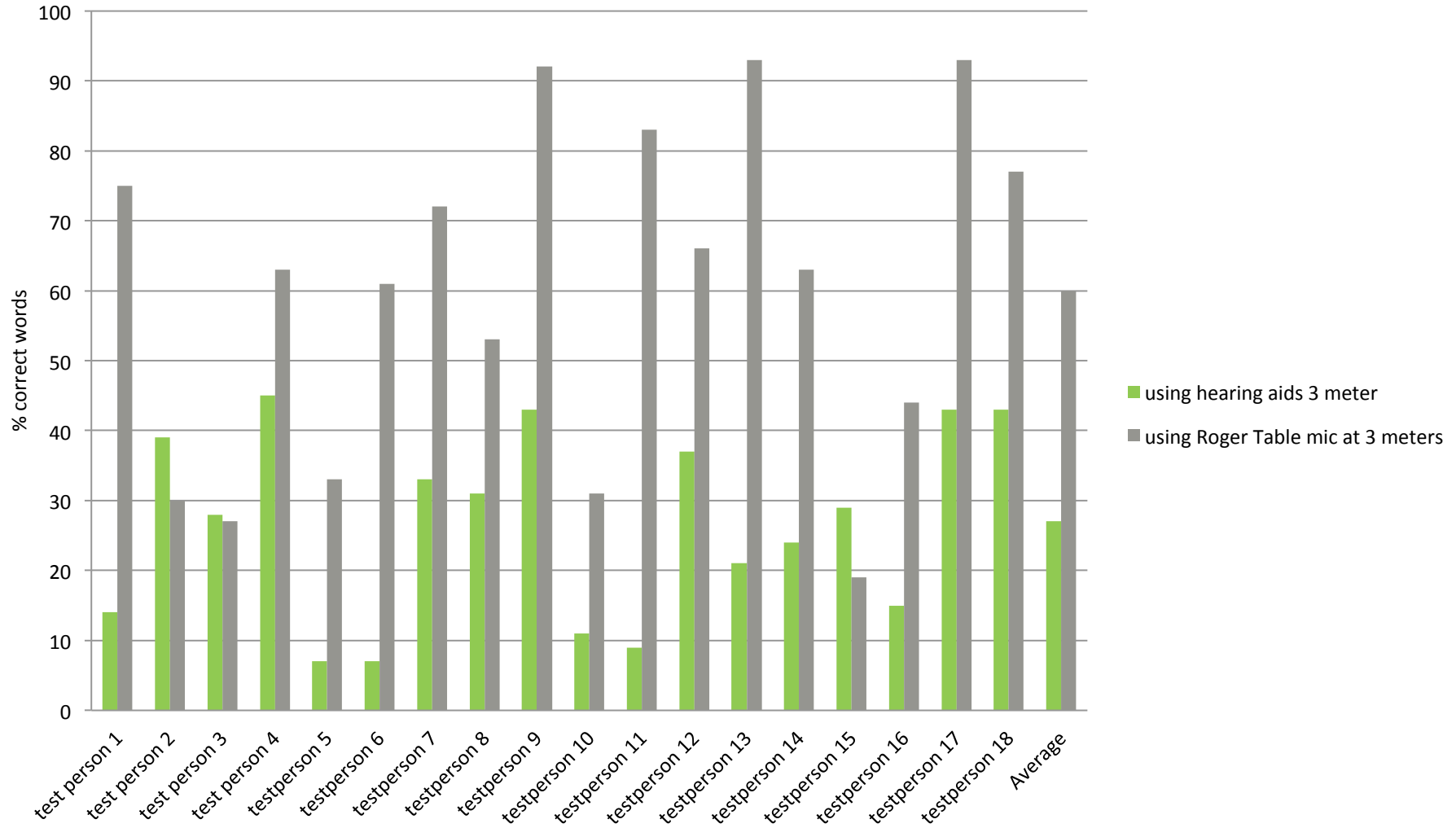


# Speech understanding scores at 1.5 meter to talker

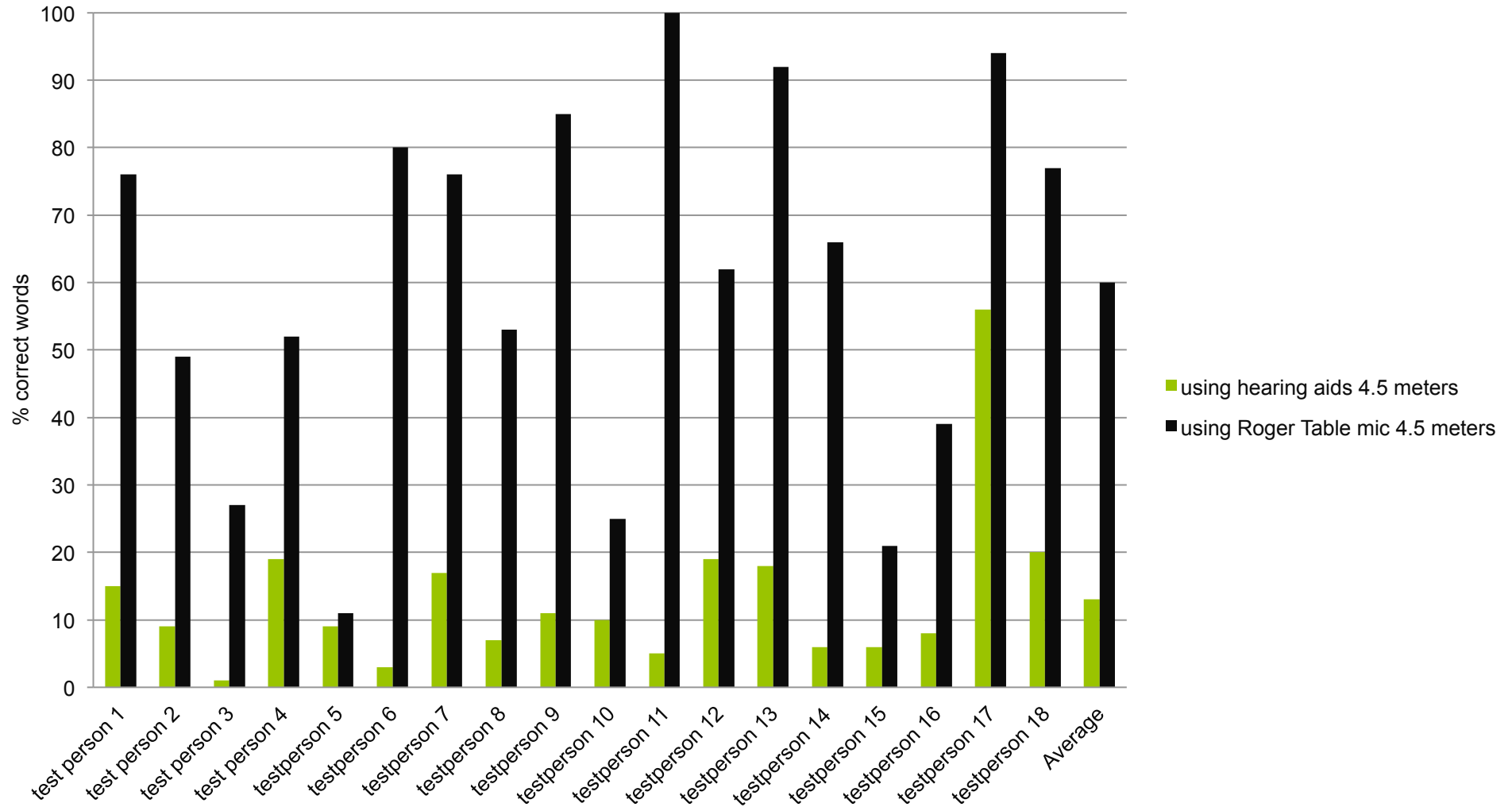




# Speech understanding scores at 3 meters to talker



# Speech understanding scores at 4.5 meters to talker



# Reimbursement is available in many countries

	Reimbursement for Worklife	Social life Adults	Almost unlimited amount for reimbursement	Independent on degree of hearing loss	Comments
Norway	Yes	Yes	Yes	Yes	
Sweden	Yes	No	12 000 CHF	Yes	
Denmark	Yes	Yes	Yes	Yes	One person got a system for 20 500 Euro in January
Holland	Yes	Yes	Yes	Yes	
Belgium	Yes	Yes	2 820 CHF	Yes	Fixed prices for reimbursements
France	Yes	No	Yes	Yes	Often reimbursement by the company
Germany	Yes	Yes	Yes	Yes	
UK	Yes	Yes	Yes	Yes	
Switzerland	Yes	Yes	Yes	Yes	Fully reimbured by IV (Invaliden Versicherung)

## Recent example from Germany



- Patient ca 50 years old
- Bilateral CI user
- Manager
- Often meetings with 7-10 persons
- German office for integration funded the money for 2 Roger Pens and 10 Roger Clip-on Mics
- Patient very happy at the workplace, meeting s no issue any more

## Take home messages

- **6. Hearing at work is not easy**
- **7. Roger Table Mic will help at meetings**
- **8. Reimbursement is often available**



Thank you