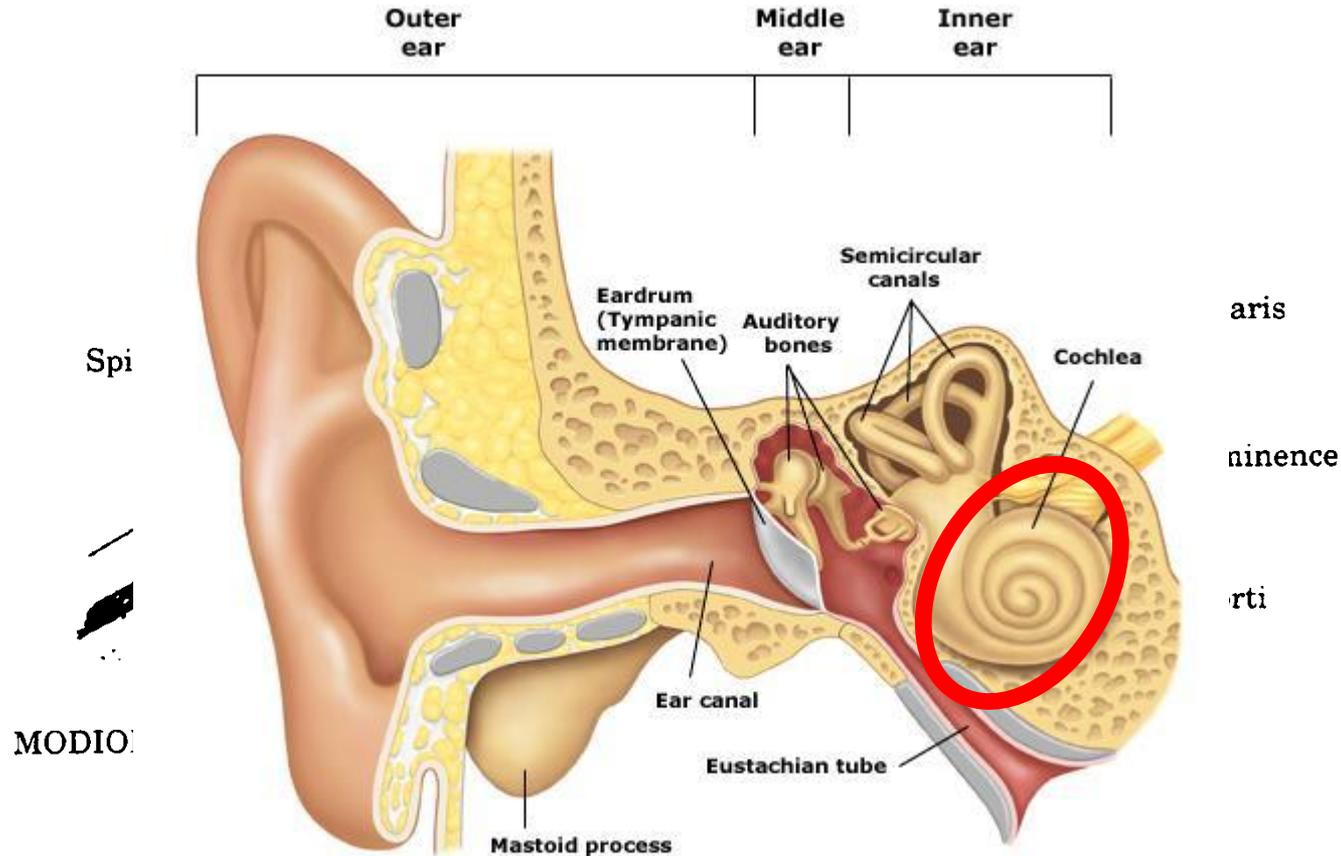


Speech understanding in noise

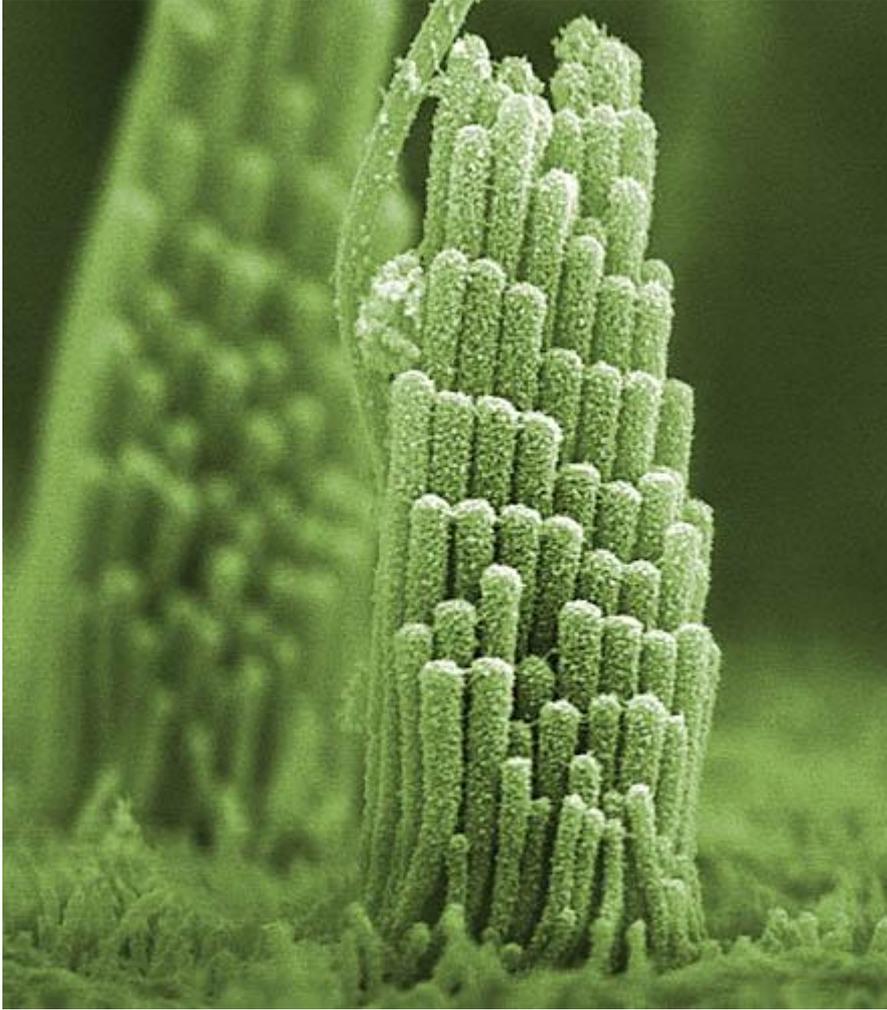
29-06-2013 Dr. Hans E. Mülder



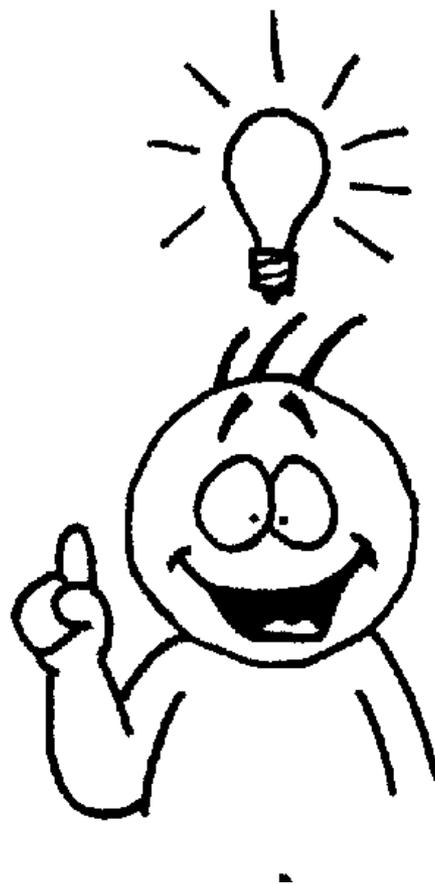
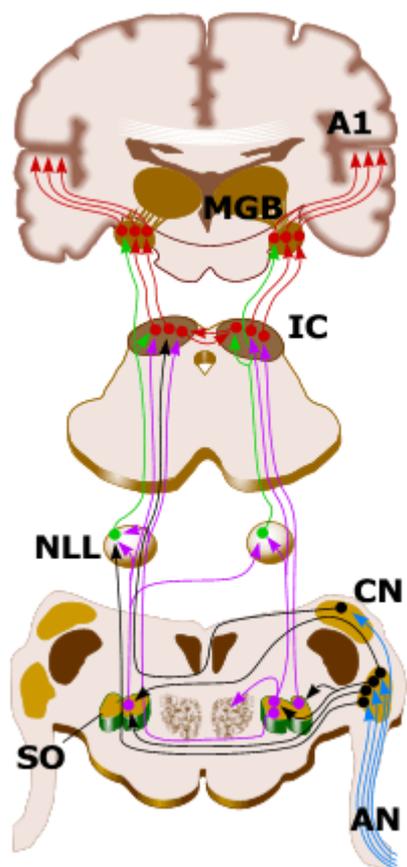
The organ of Corti in the inner ear is one of the most delicate structures in the human body



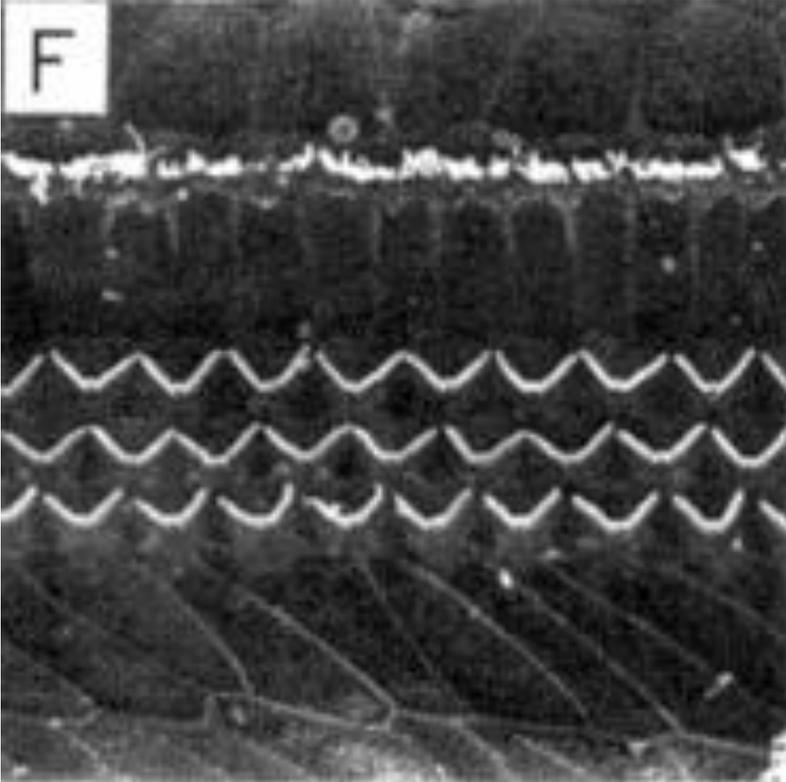
Thousands of hair cells transform mechanical energy into electrical nerve activity



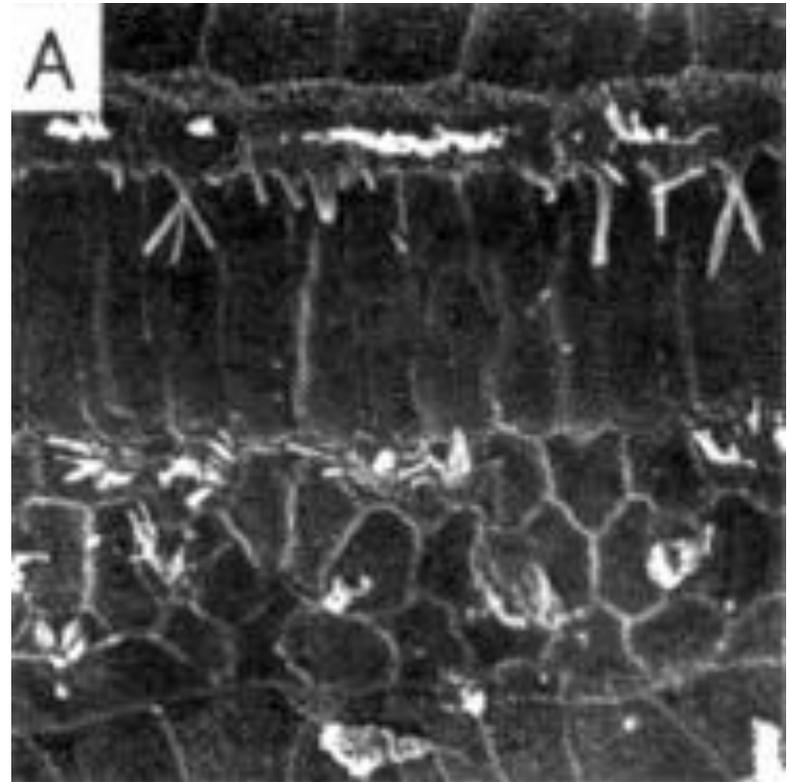
Signals are sent to the brainstem and the cortex for high-level processing



But in the case of a sensorineural hearing loss, things do not work as they should



healthy hair cells



damaged hair cells

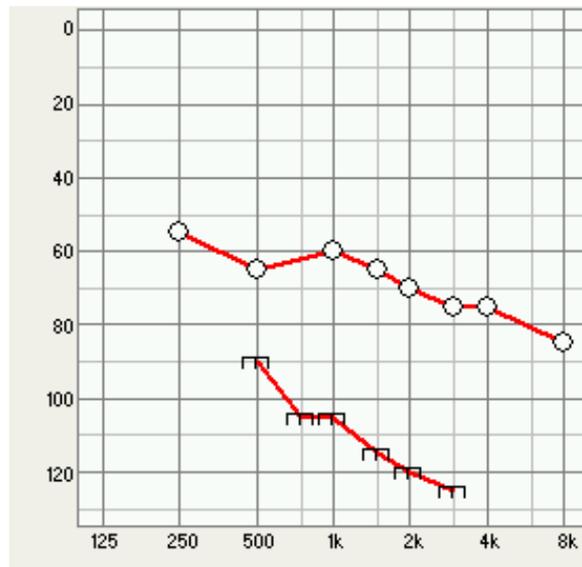
The phenomena of sensorineural hearing loss

- 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
- Part of standard diagnostics
- **Does not address the problems patients experience**

Right

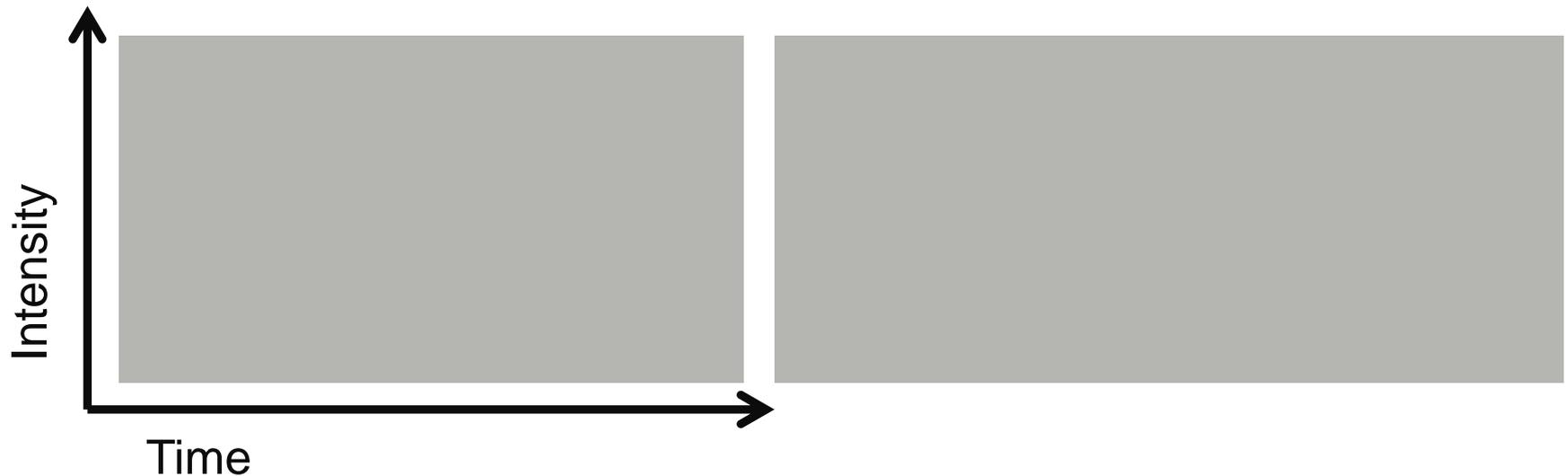


Left



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



Loss of time resolution in the presence of background noise

- It is getting very difficult



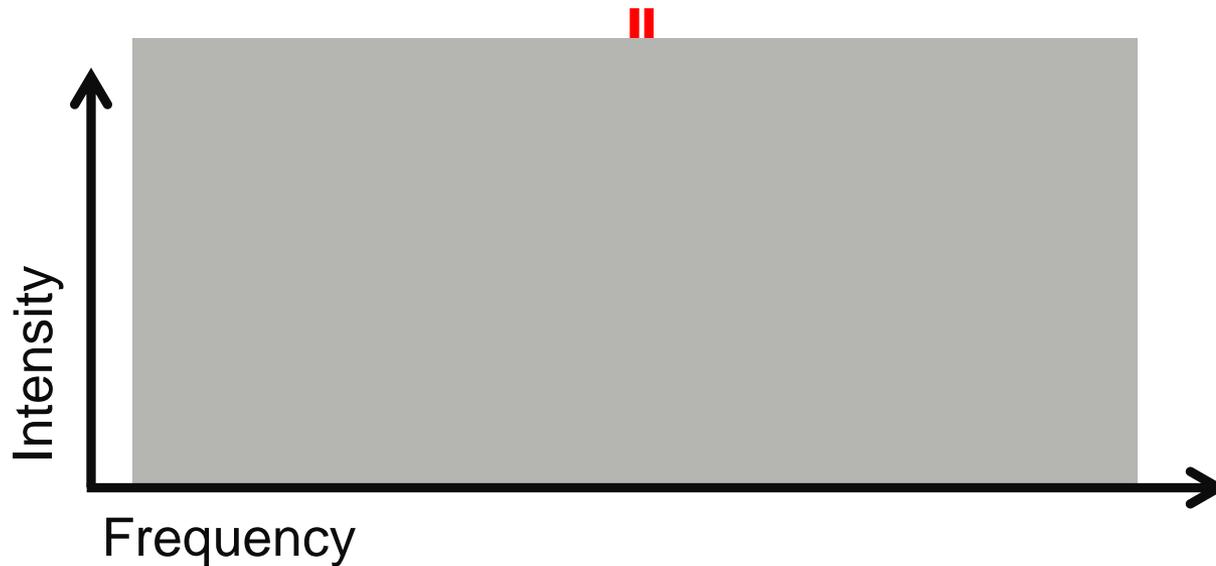
Loss of frequency resolution

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



Loss of frequency resolution in the presence of background noise

- It is getting very difficult



Loss of time and spectral resolution

- Not measured routinely - no standards exist
- Especially affects 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/
 - Speech scores in the presence of noise are worse for children than for adults
- ***No current hearing aid technology can solve this problem***
- ***'Cleaning the signal' before it reaches the ear is the only approach that works***

How can technology help overcome these problems?

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

- Loss of sensitivity → Amplification, frequency compression
- 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!

How to understand hearing in noise (1/3)

- **Signal-to-noise ratio** (SNR) is the relationship between the primary or desired auditory signal and all other unwanted background sounds.
- The more favorable the signal-to-noise ratio, the more intelligible the spoken message.

Example:

- speech = 65 dB noise = 65 dB → SNR = 0 dB
- speech = 65 dB noise = 60 dB → SNR = 5 dB
- speech = 70 dB noise = 80 dB → SNR = -10 dB

How to understand hearing in noise (2/3)

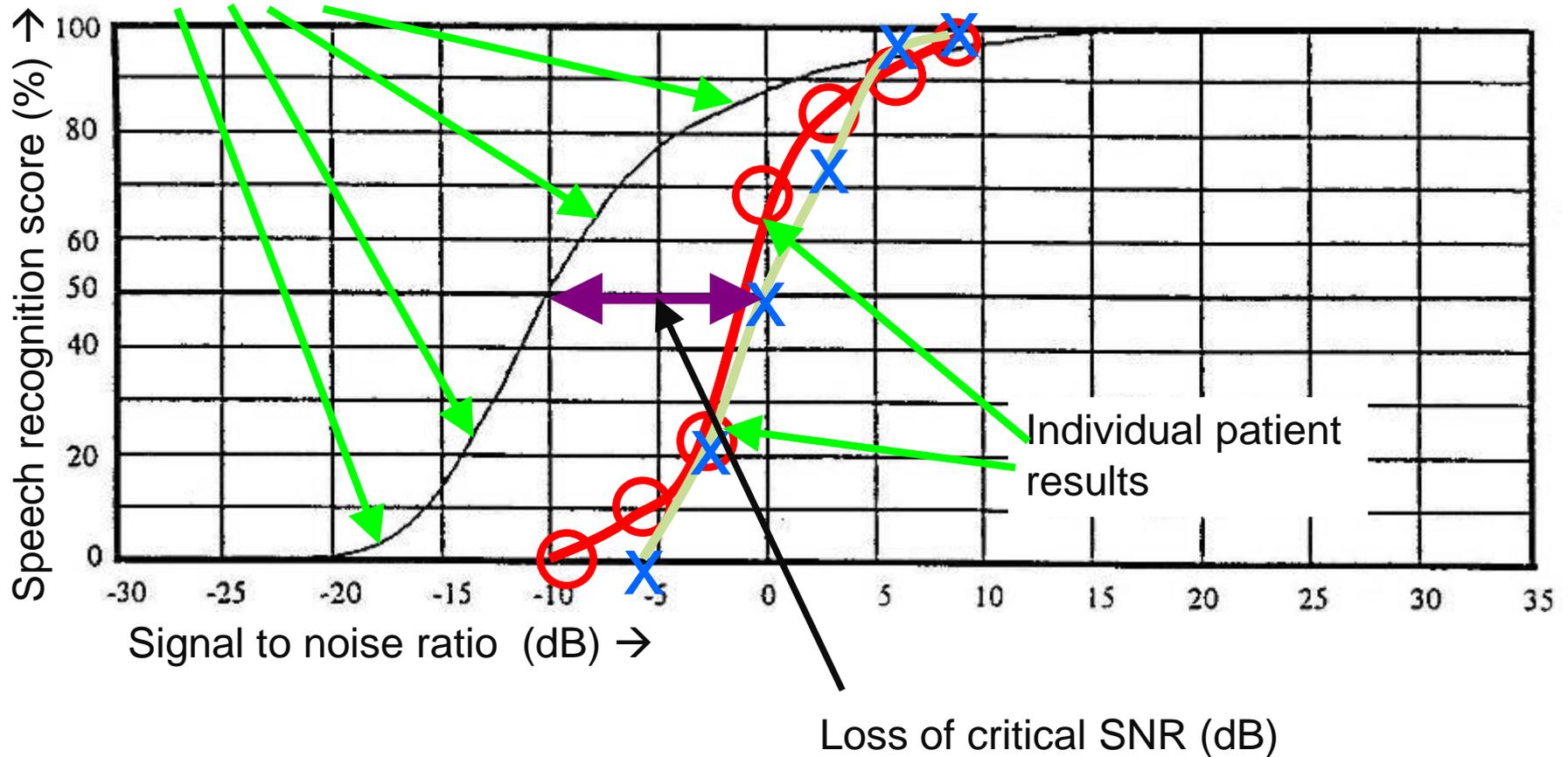
- “Critical SNR” = SNR at which 50% of speech is understood
- Critical SNR values depend on test set-up:
 - type of noise, speech material (including language)
 - scoring method
 - headphone or free field

How to understand hearing in noise (3/3)

- Critical SNR usually varies from
 - -6 dB (normal in adults)
 - to
 - 15 dB (profound)
- A loss of 1 dB in Critical SNR can result in a reduction in speech score of 15 to 20%
- A loss of only 3 dB in Critical SNR already has a severe impact on speech understanding in noise.

SNR-gram

Norm curve for normal hearing adults



Today's classification of hearing loss

- Mild - moderate - severe - profound
- Classification expresses how much a pure tone needs to be amplified to become audible

This classification is

- Globally standardized
- Not directly related to real life problems

Tomorrow's hearing loss classification

Proposal: one single number, expressing your loss in signal to noise ratio

- This number expresses your difficulties with understanding speech in noisy conditions, compared to normal hearing listeners of the same age
- This number tells you what type of technology you need

The new categories:

- Above -3 dB Normal
- -3 to -6 dB You need directional microphone technology
- Below -6 dB Severe loss, you need an FM system

Questions to the audience:

- Who was tested with speech in noise?
- Who knows his/her loss in signal-to-noise ratio?

From a Blog April 15, 2012
By Peter Stelmacovich, Canada

“People with hearing loss routinely complain of hearing in noise yet we rarely assess this.

We cannot just do a pure tone audiogram in quiet.

We need to assess the problem that is vexing our patients the most and then find equipment and strategies to deal with that.”

Test & Recommend...

- People with sensorineural hearing loss appear to have a Spatial Processing Disorder (SPD) which appears to be the major reason why hearing-impaired people have trouble listening in noise, despite wearing hearing aids
- These listeners do not benefit as much from moving distractors from the front to the side
- LiSN-S PGA was developed specifically to assess how clients use Spatial location cues & Pitch differences between voices to separate target speech from distracting speech that arrive simultaneously at the ears

What is LiSN-S PGA?

- LiSN-S PGA is a new diagnostic test that measures speech understanding in noise in patients with a hearing loss.
- LiSN-S PGA is administered under headphones.
- The patient's task is to repeat sentences.
- The professional enters the number of correct words.
- The test ends automatically within 5 minutes when the measurement result is precise enough

The Developers of LiSN-S PGA



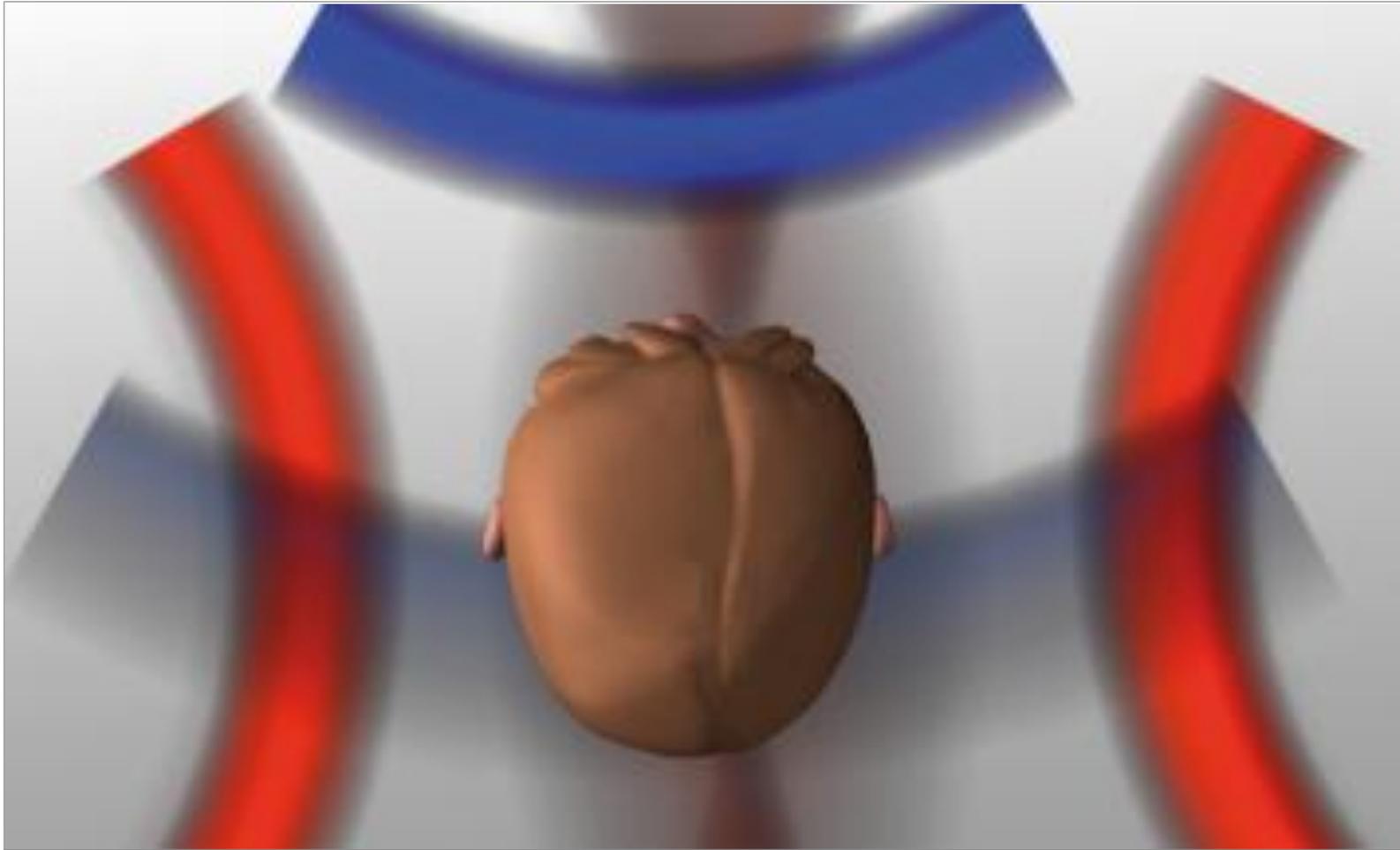
Sharon Cameron PhD

National Acoustic Laboratories
Australia



Harvey Dillon PhD

LiSN-S



PGA?

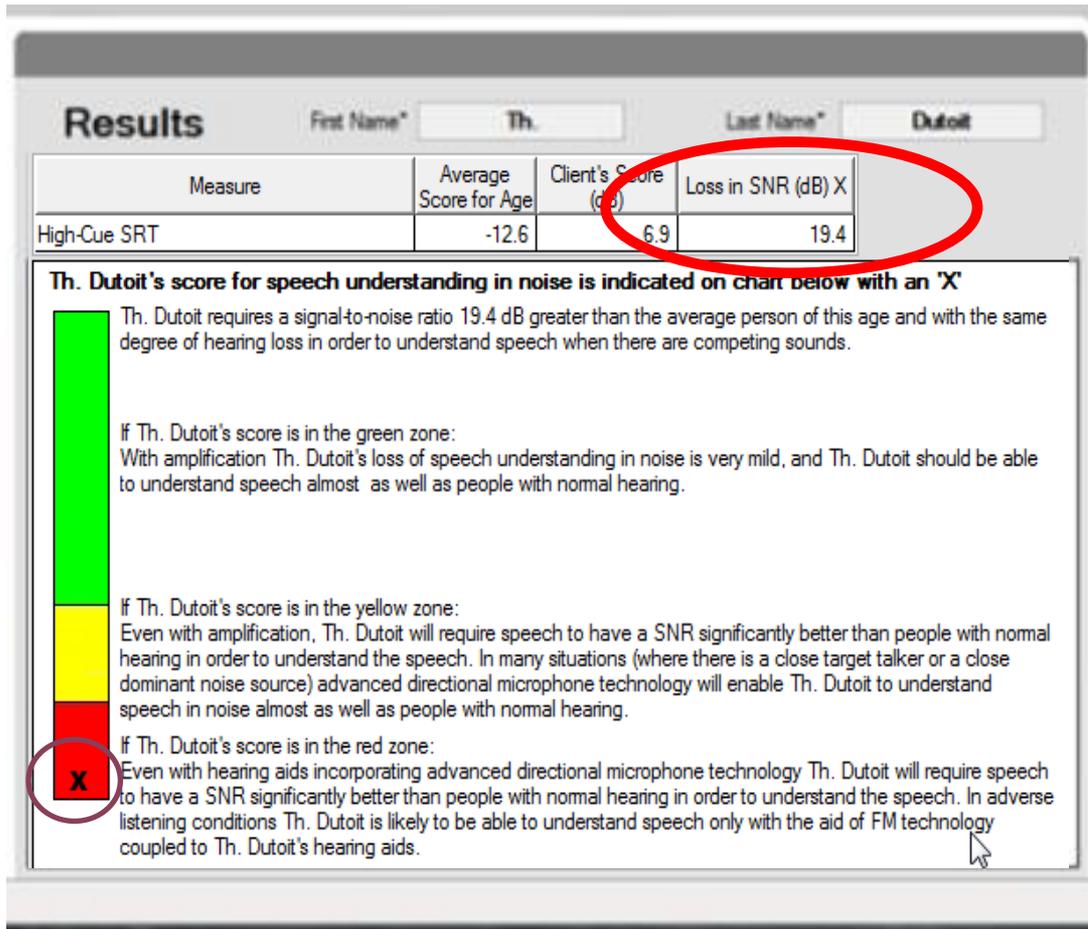
- PGA means Prescribed Gain Amplifier →
- The stimuli are amplified according to the hearing loss

So what does this mean?

- LiSN-S accurately measures a patient's ability to understand speech in noise as if they were wearing hearing instruments
- Compare a patient's performance with normal hearing persons of the same age
- The test predicts accurately the patient's performance in noisy situations
- If the predicted performance is not good, LiSN-S PGA gives clear, individual, technology recommendations how to improve speech understanding in noise.

Accurate diagnostics → evidence based recommendations

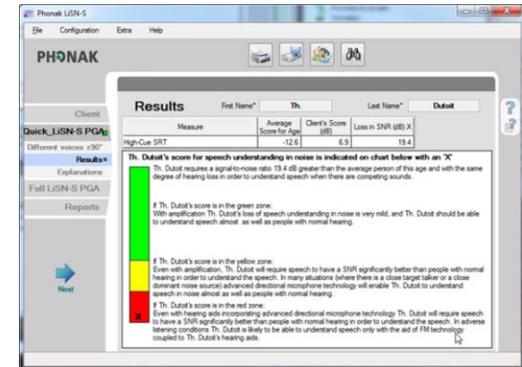
A single number for your hearing problems



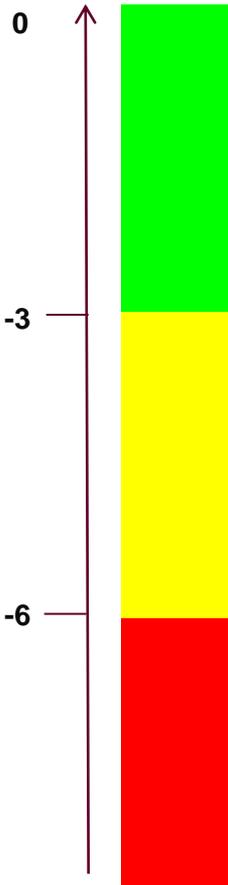
A cross (X) is displayed in the bar diagram indicating the individual score of the patient.

Next to the X the technology recommendations are listed, in clear wordings for both the professional and the patient

LiSN-S PGA recommendations



loss (SNR)



With amplification the patient's loss of speech understanding in noise is very mild, and the patient should be able to understand speech almost as well as people with normal hearing.

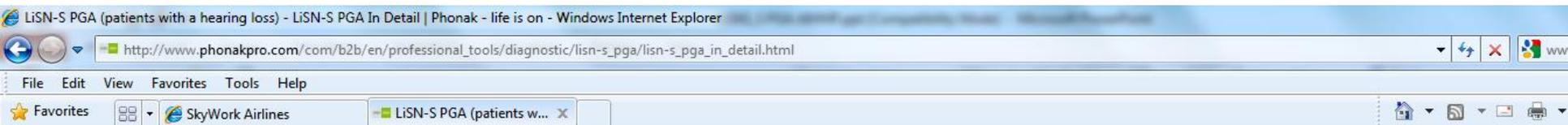
Even with amplification, the patient will require speech to have a SNR significantly better than people with normal hearing in order to understand the speech. In many situations (where there is a close target talker or a close dominant noise source) advanced directional microphone technology will enable the patient to understand speech in noise almost as well as people with normal hearing.

Even with hearing aids incorporating advanced directional microphone technology the patient will require speech to have a SNR significantly better than people with normal hearing in order to understand the speech. In adverse listening conditions the patient is likely to be able to understand speech only with the aid of FM technology coupled to the patient's hearing aids.

Benefits

1. Evidence based
2. Deeper insight
3. Takes just five minutes
4. Very clear recommendations
5. Supports the fitting of the right type of technology to patients who need it → Products with advanced directional microphones or wireless microphone systems
6. May help to get the right technology reimbursed
7. Attention: LiSN-S PGA is only available in English

More information on the web page LiSN-S on www.phonakpro.com



For Consumers Careers Contact | Phonak international (eng)

PHONAK life is on Products Professional Tools Pediatric eLearning Support Events Business

You are in: Home > Professional Tools > Diagnostic Software > LiSN-S PGA (patients with a hearing loss) > LiSN-S PGA In Detail

LiSN-S PGA

The new benchmark in speech-in-noise testing

LiSN-S PGA is the new benchmark speech-in-noise test for patients with an existing hearing loss. This unique diagnostic tool allows clinicians to accurately measure how well patients understand speech in noise, before recommending the hearing technology that best fits their needs.

LiSN-S PGA is an adaptive test that is administered under specially configured headphones (supplied) where stimuli are spatially separated in a virtual 3D world that intelligently mimicks a free field test set-up.

The test is scientifically robust and takes just 5 minutes to run. After using LiSN-S PGA to assess the speech in noise performance of a patient with an existing hearing loss, the software provides tailored technology recommendations to help you educate your patient on form of hearing technology will best meet their needs.

LiSN-S PGA suits all English-speaking patients aged 6 and above. The tool was developed by Dr. Sharon Cameron and Dr. Harvey Dillon of National Acoustic Laboratories of Australia (NAL) and is distributed by Phonak.

LiSN-S PGA

- [LiSN-S PGA In Detail](#)
- [LiSN-S PGA Test Condition](#)
- [LiSN-S PGA FAQ](#)
- [LiSN-S PGA Software Versions](#)
- [LiSN-S PGA Request More Info](#)

Downloads

- [Leaflet \(PDF, 622kB\)](#)
- [Brochure \(PDF, 878kB\)](#)
- [User Manual \(PDF, 994kB\)](#)
- [LiSN-S Software V2.0 \(ZIP, 34MB\)](#)

MarkeTrak VI results (Sergei Kochkin)

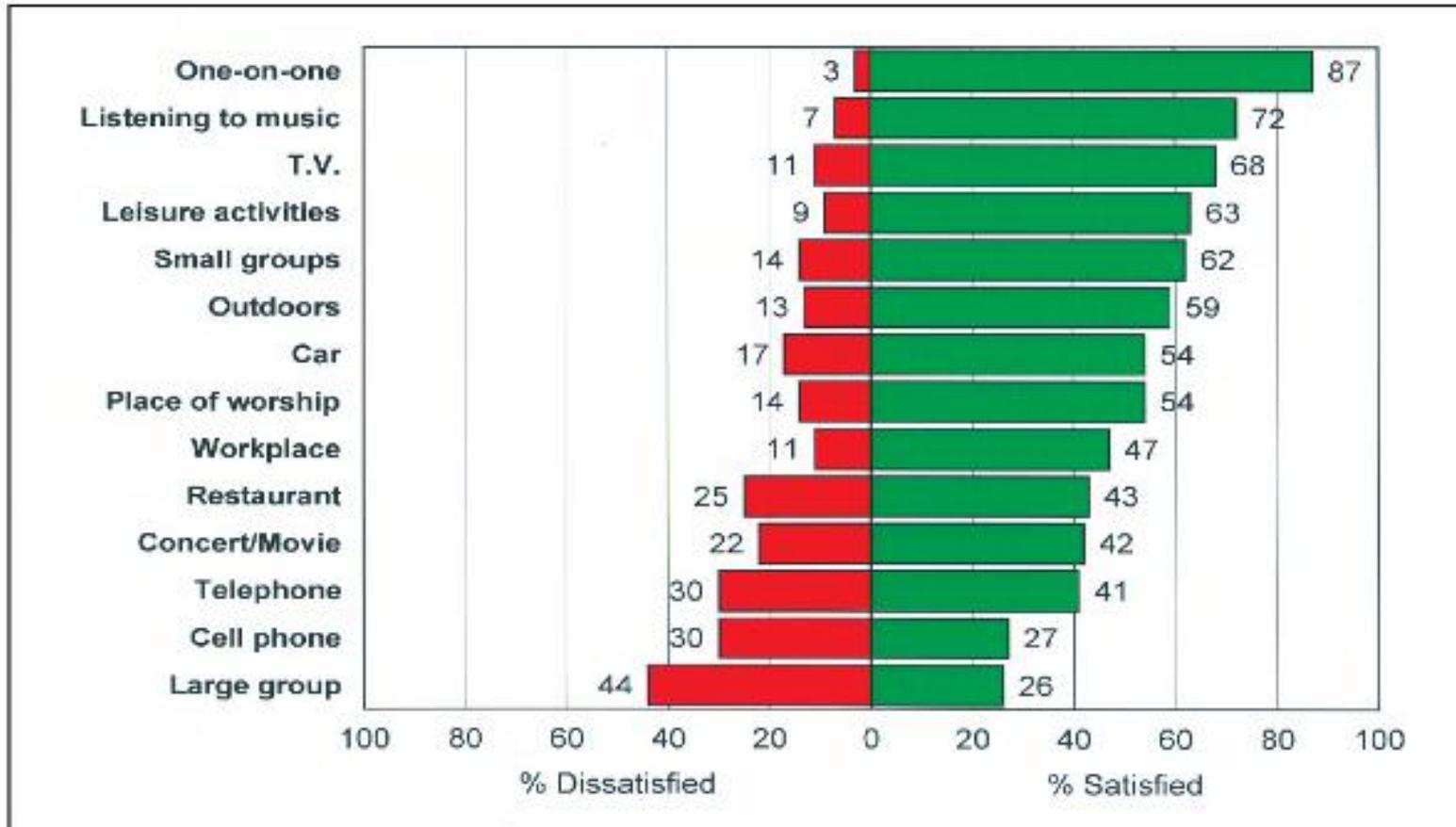


Figure 4a. *Customer satisfaction with hearing instruments in selected listening situations (hearing instruments less than 6 years old).*

MarkeTrak VI results (Sergei Kochkin)

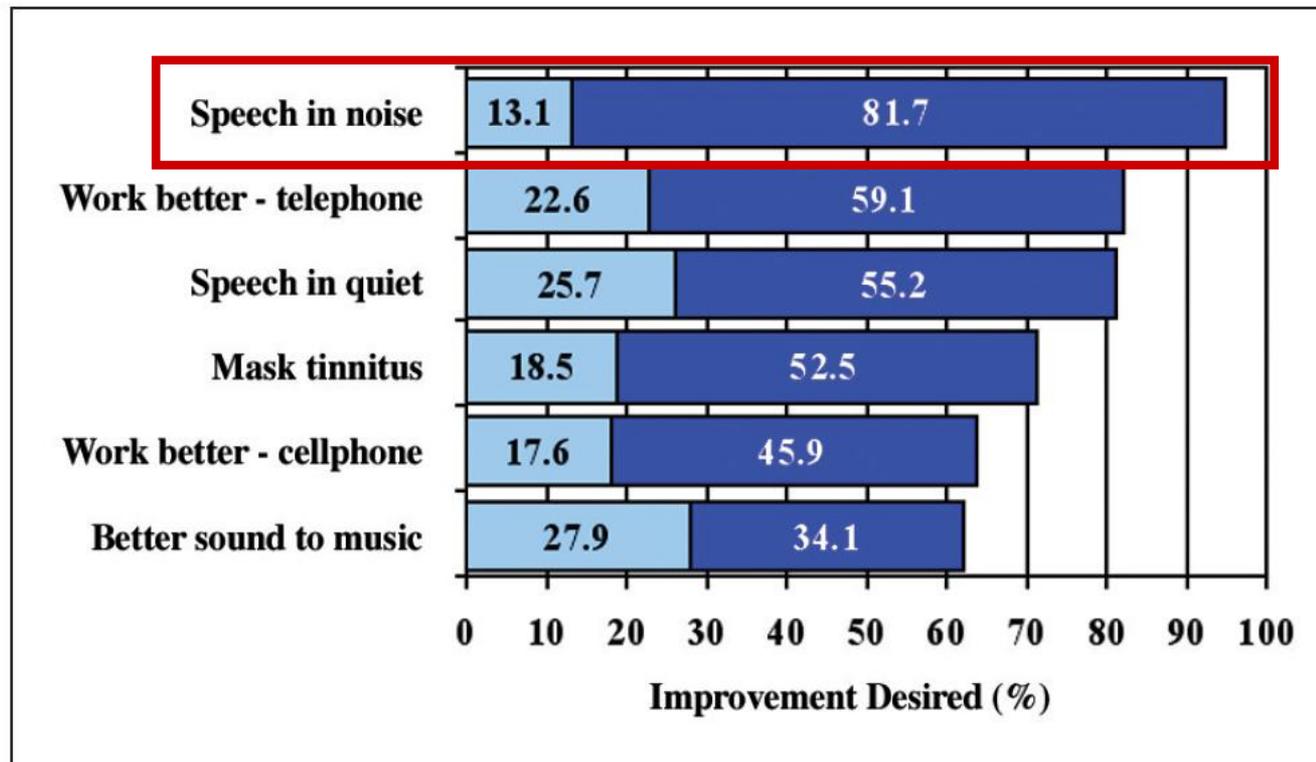
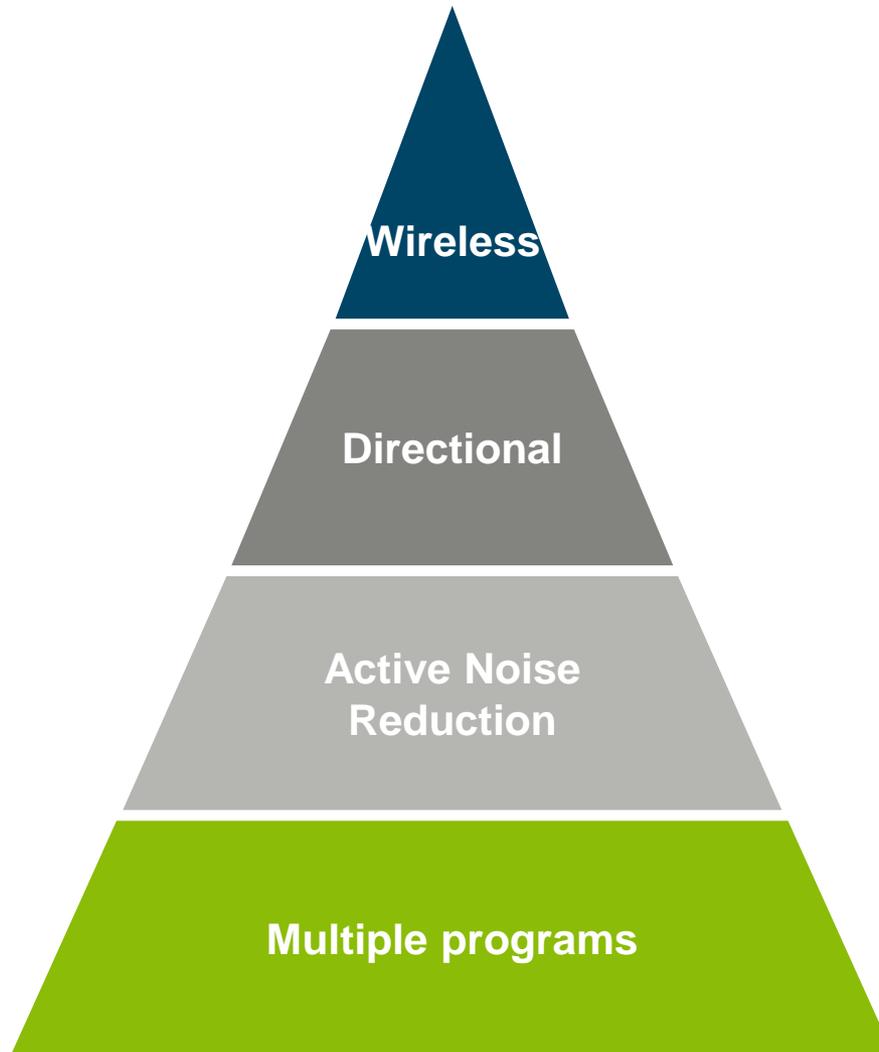
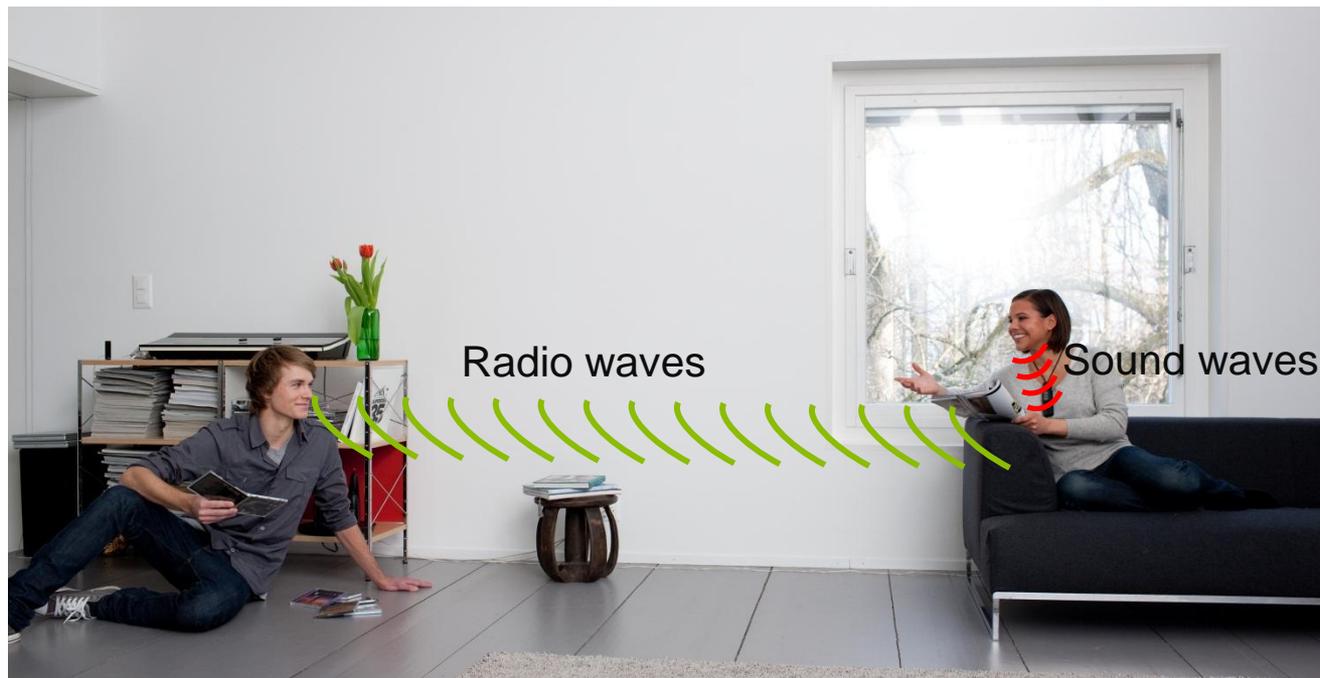


Figure 1. Benefit and listening improvements sought in hearing instruments by current owners. The dark blue bar represents consumers who rated the factor as “highly desirable” (a score of “5” on the survey), while the lighter blue bar represents those ratings of “desirable” (a score of “4” on the MarkeTrak VI survey).

Hierarchy of techniques to improve hearing in noise



How does a wireless microphone system work?



The talker speaks into the microphone

The speaker's voice is transmitted via radio waves

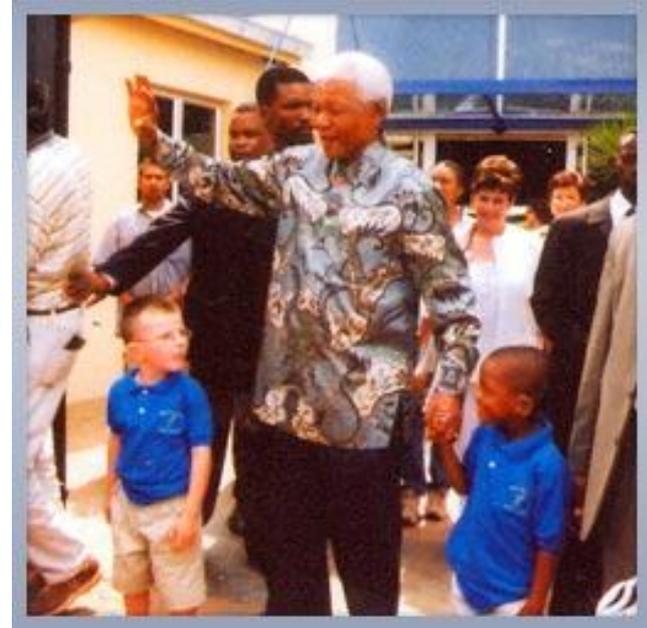
The radio receiver, which is connected to the hearing instrument, delivers the sound

Who can benefit from a wireless microphone system?



Children with hearing loss in special (deaf) schools

- Children with severe and profound hearing losses usually go to deaf schools
- Many of these children have multiple handicaps



Nelson Mandela at the opening of Eduplex in Pretoria, South Africa

Children with hearing loss in regular schools

- 80% of children with hearing loss attend regular schools
- There are rarely special adaptations and technologies available to optimize learning
- In regular schools, groups of children are larger than in deaf schools, and teachers are not used to educating the hard of hearing
- FM systems allow children to attend regular school
- FM is often fully reimbursed



Adults with hearing instruments

- Adults with hearing loss often suffer from poor critical signal to noise ratios
- More Hearing Care Professionals consider FM systems a crucial component of intervention for adults with hearing loss
- FM systems can be successfully fitted to elderly people, provided they receive quality counseling
- Partners play an important role and benefit too



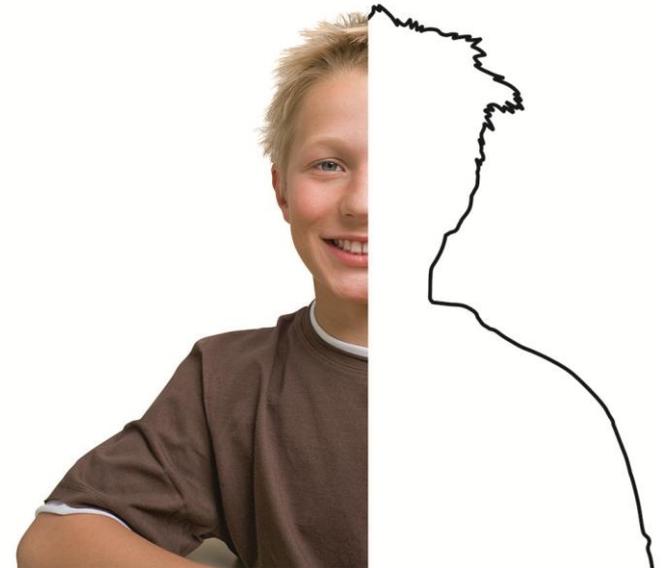
Children and adults with cochlear implants (CI's)

- Frequency resolution is limited
- Speech in noise scores are usually low with a CI alone
- Adult and child CI users benefit from FM
- 40% of the world's CI recipients use an FM system



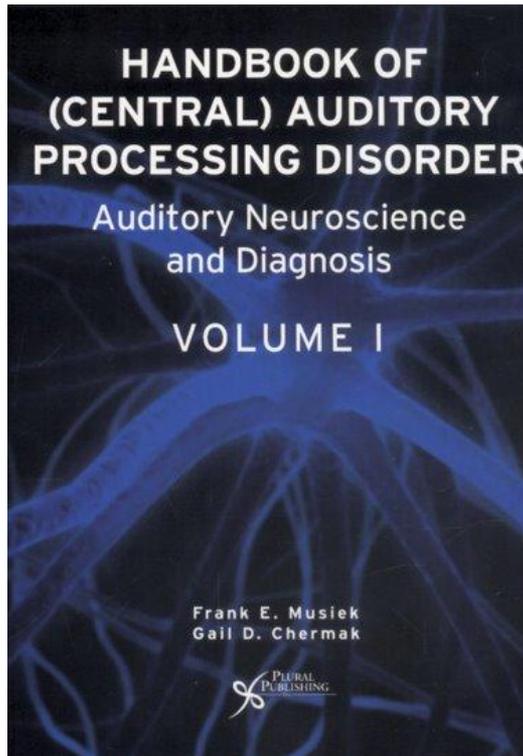
Children and adults with unilateral hearing loss

- Consequences of a unilateral hearing loss are underestimated
- Many children with unilateral hearing loss fail grades
- FM systems are best at improving speech understanding in the classroom
- FM systems provide upfront, direct access to the voice of the teacher



Children and adults with auditory processing disorder

- FM systems are systematically fitted to children with (C)APD since 2004
- Clinical experience and studies from around the world have proven the clear benefits these children enjoy with FM
- FM reimbursement for children with (C)APD is continually improving



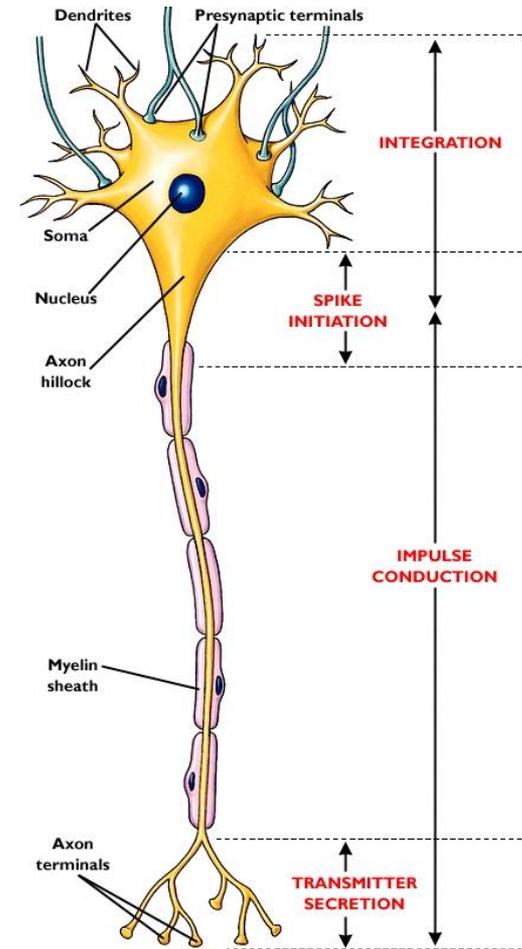
Nonnative learners

- Children or adults who learn in a different language at school/college can experience difficulty understanding speech in noise
- Lack of a full lexicon and fewer readily accessible syntactical and morphological rules hinders the top-down speech understanding process
- Immigrant families often use a different language at home than children hear at school
- Poor academic achievement is common with such children, despite normal hearing and cognition
- FM systems provide a clean signal from the teacher to the child's ears



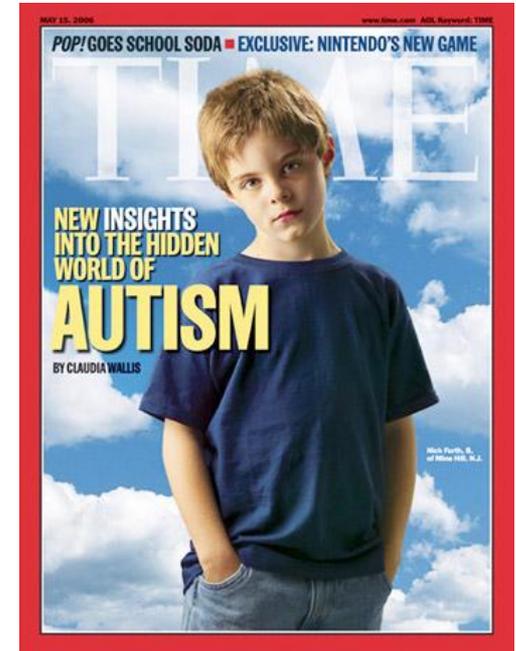
Adults with multiple sclerosis

- Multiple sclerosis is an inflammatory disease of the central nervous system
- 1 in 700 adults are affected
- Despite normal peripheral hearing thresholds, 40-60% of MS patients have difficulty hearing in noise
- FM systems help with such conversations, which will then be less tiring for these patients (Lewis 2006)



Children with Autism Spectrum Disorder

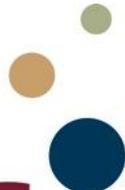
- Studies in Denmark indicate that children with Autism Spectrum Disorder can benefit from an FM system
- FM usage has been documented to improve:
 1. Spontaneous communication: 7/17
 2. Visual attention: 10/17
 3. Eye contact: 10/17
 4. Dialogue (more able to follow): 13/17
 5. Self stimulation: down in 10/17
 6. Anxiety decrease: 10/17





Bridging the understanding gap

Roger is the new digital standard that bridges the understanding gap, in noise and over distance, by wirelessly transmitting the speaker's voice directly to the listener.



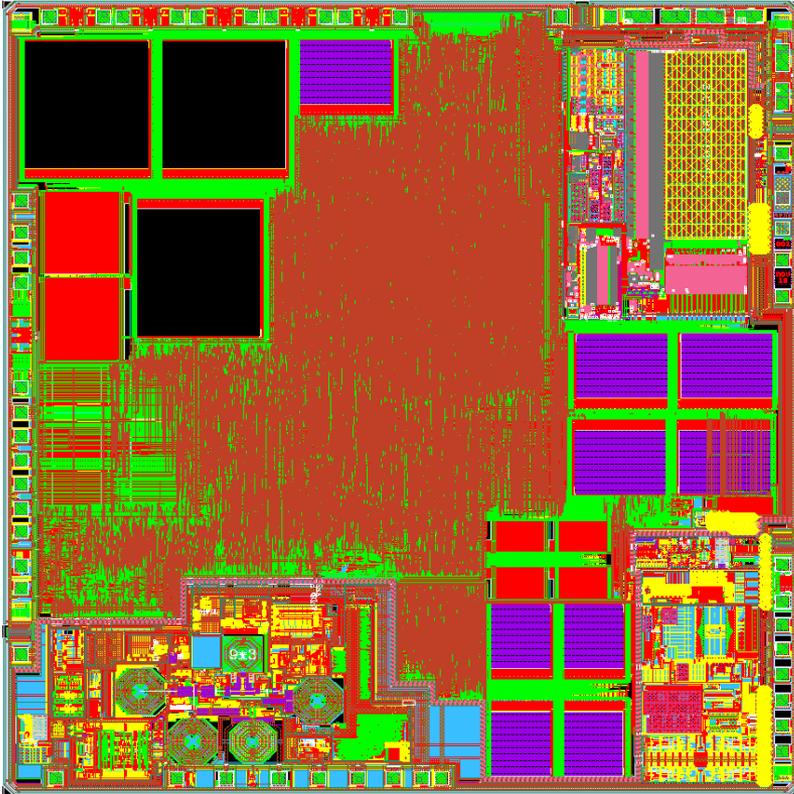
röger

What is Roger?

- Roger is a new digital wireless technology standard
- Allows for low delay and reliable long-range broadcast towards miniature, low-power receivers
- Operates on 2.4 GHz band (ISM), with intelligent adaptive protocols
- Audio bandwidth up to 7300 Hz
- Privacy is guaranteed

The technology

Roger is based on a new Microchip with 6.8 million transistors



Roger systems

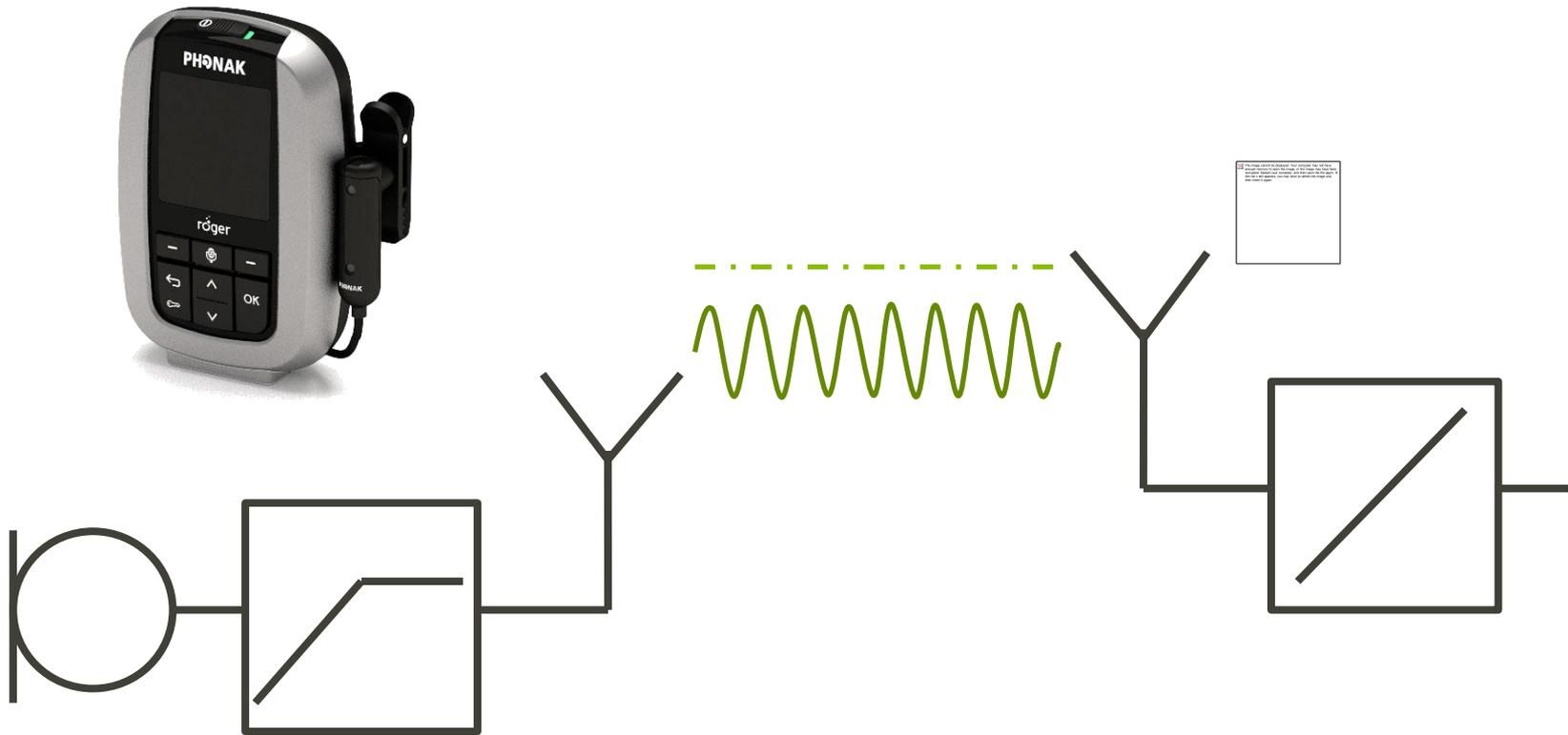
- Roger systems consist of **wireless microphones** and **wireless receivers** – still the best way to improve speech understanding in noise

Roger components:

- Design-integrated receivers for certain hearing instruments and select CI speech processors
- Universal receivers for all HI brands
- A choice of wireless microphones

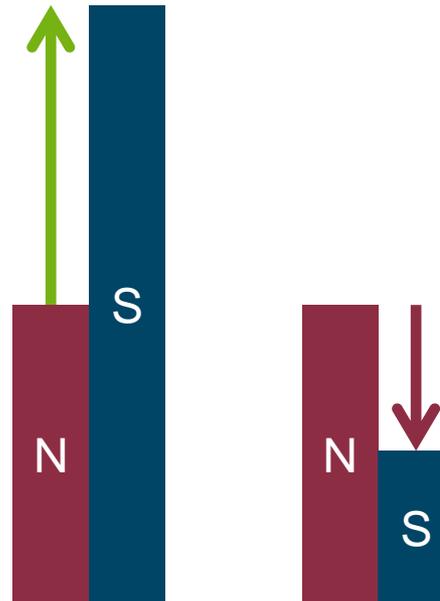


How does a Roger system function?



Legend for the following slides

- Noise = Ruby bars
- Speech = Petrol bars
- Arrows = Signal-to-noise ratio



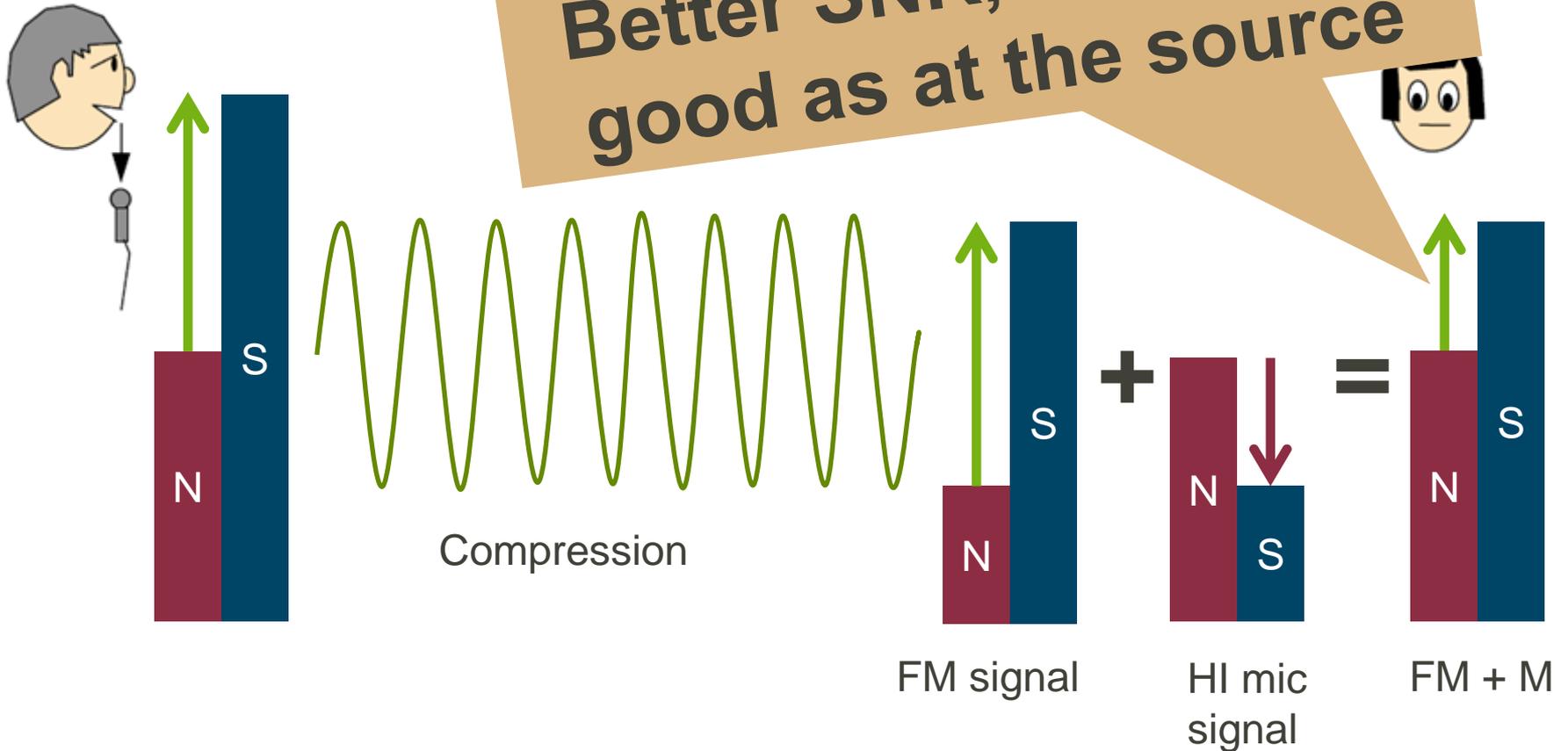
SNR without a wireless microphone



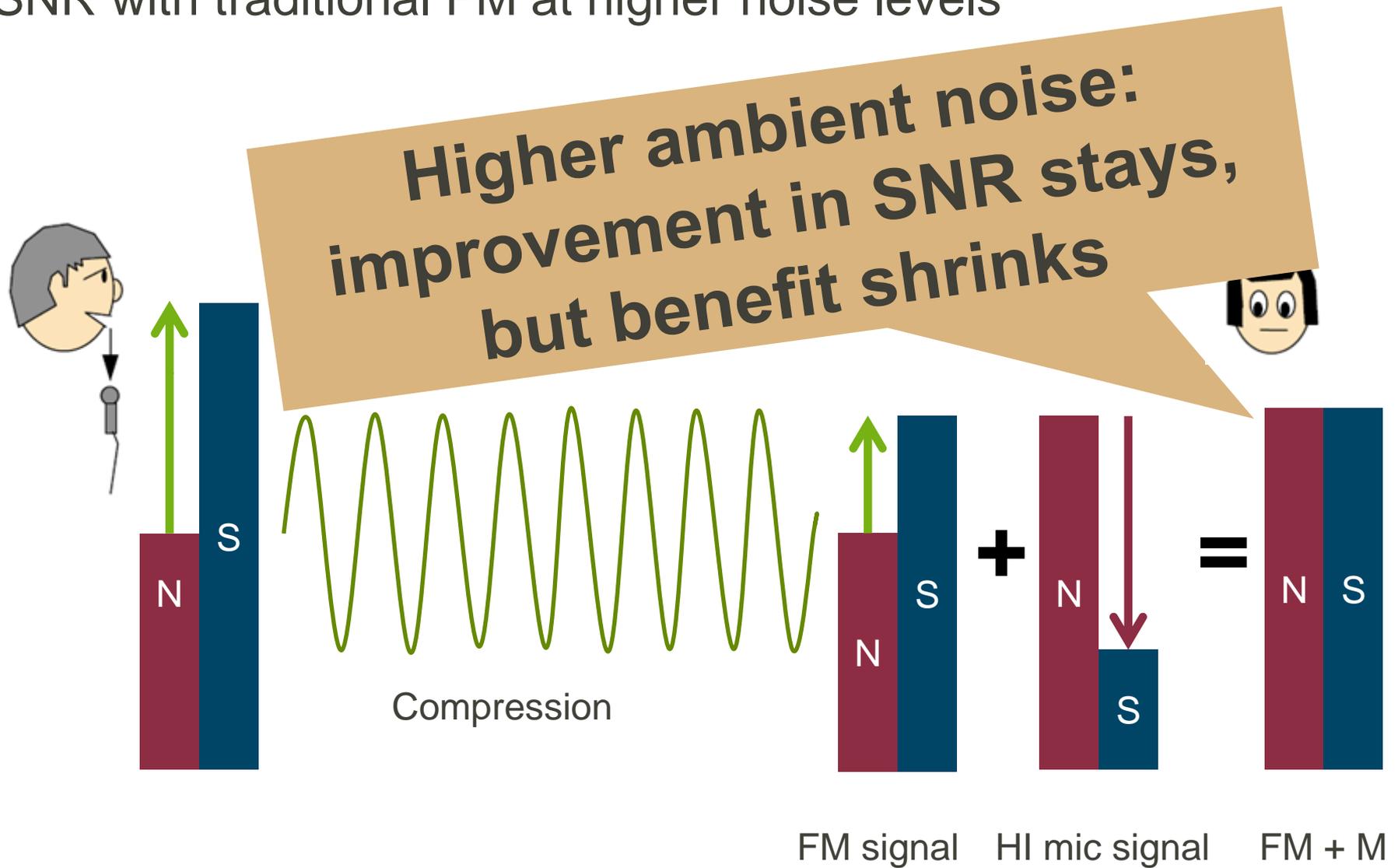
- Noise is often equally distributed throughout a room
- Speech level drops over distance

SNR with traditional FM

**With traditional FM:
Better SNR, but not as
good as at the source**

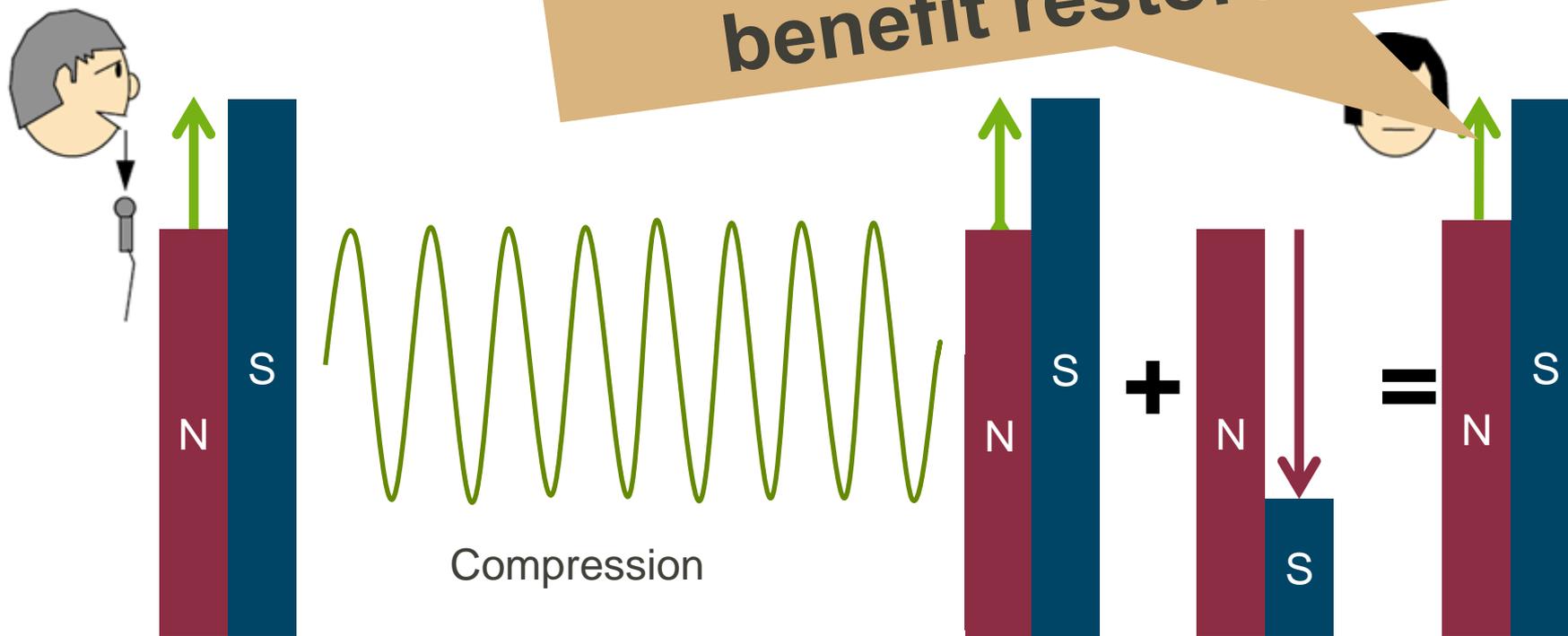


SNR with traditional FM at higher noise levels



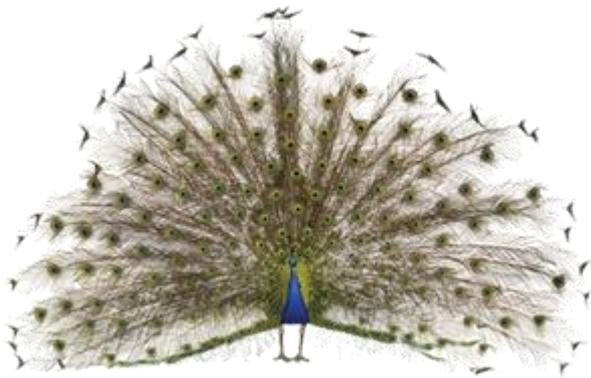
With a Roger receiver...

**Roger adaptive gain:
benefit restored**



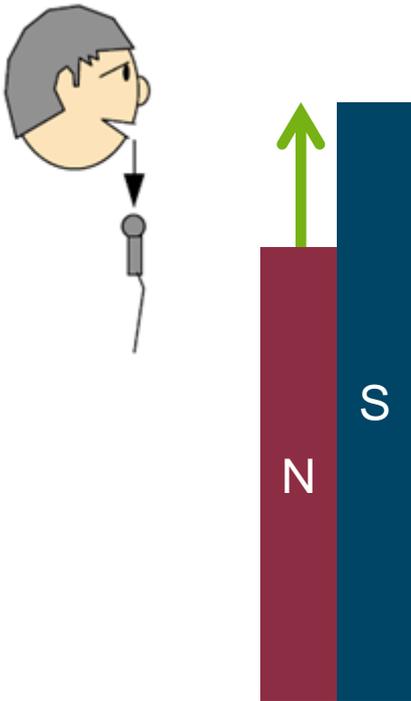
Adaptive mixing of Roger and M

- *Increasing the gain of the Roger receiver at higher noise levels preserves the positive signal-to-noise ratio as captured by the Roger microphone*



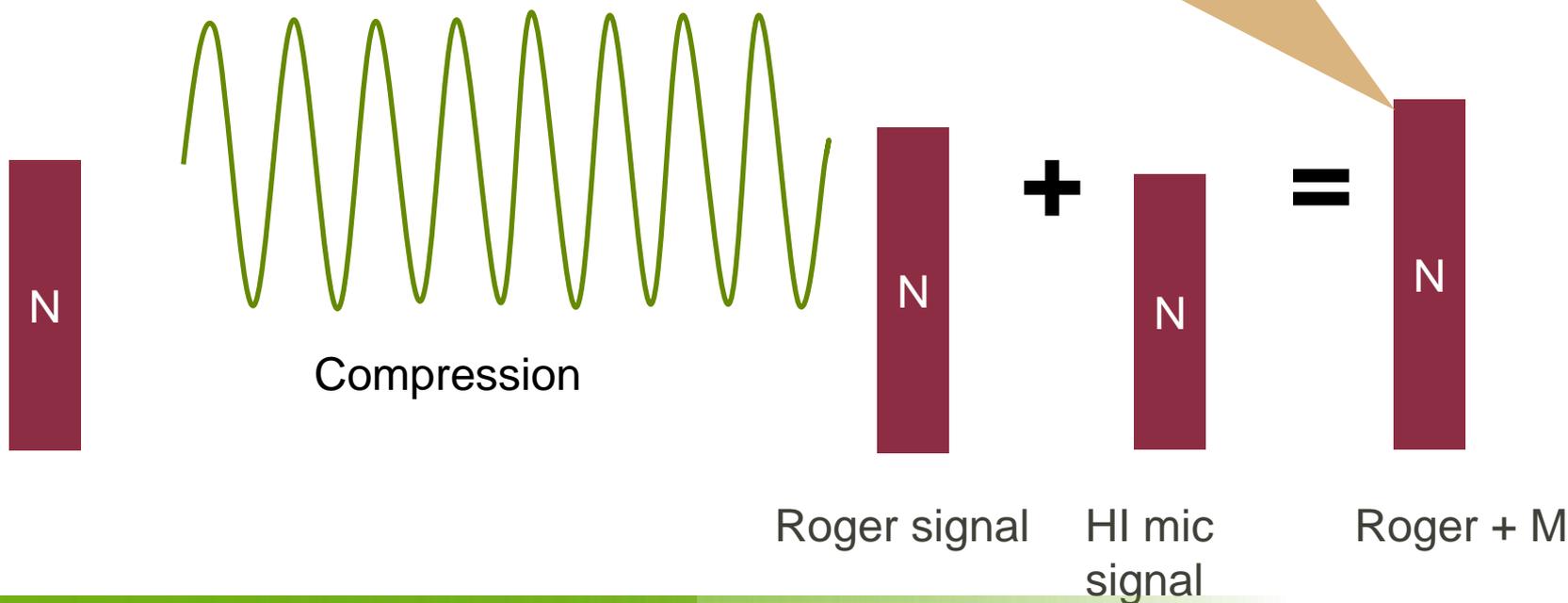
Directional microphones

- A directional microphone close to the mouth of the speaker helps much more than a simple omnidirectional microphone



What about when the talker is silent?

Listening comfort and conservation of HI SNR

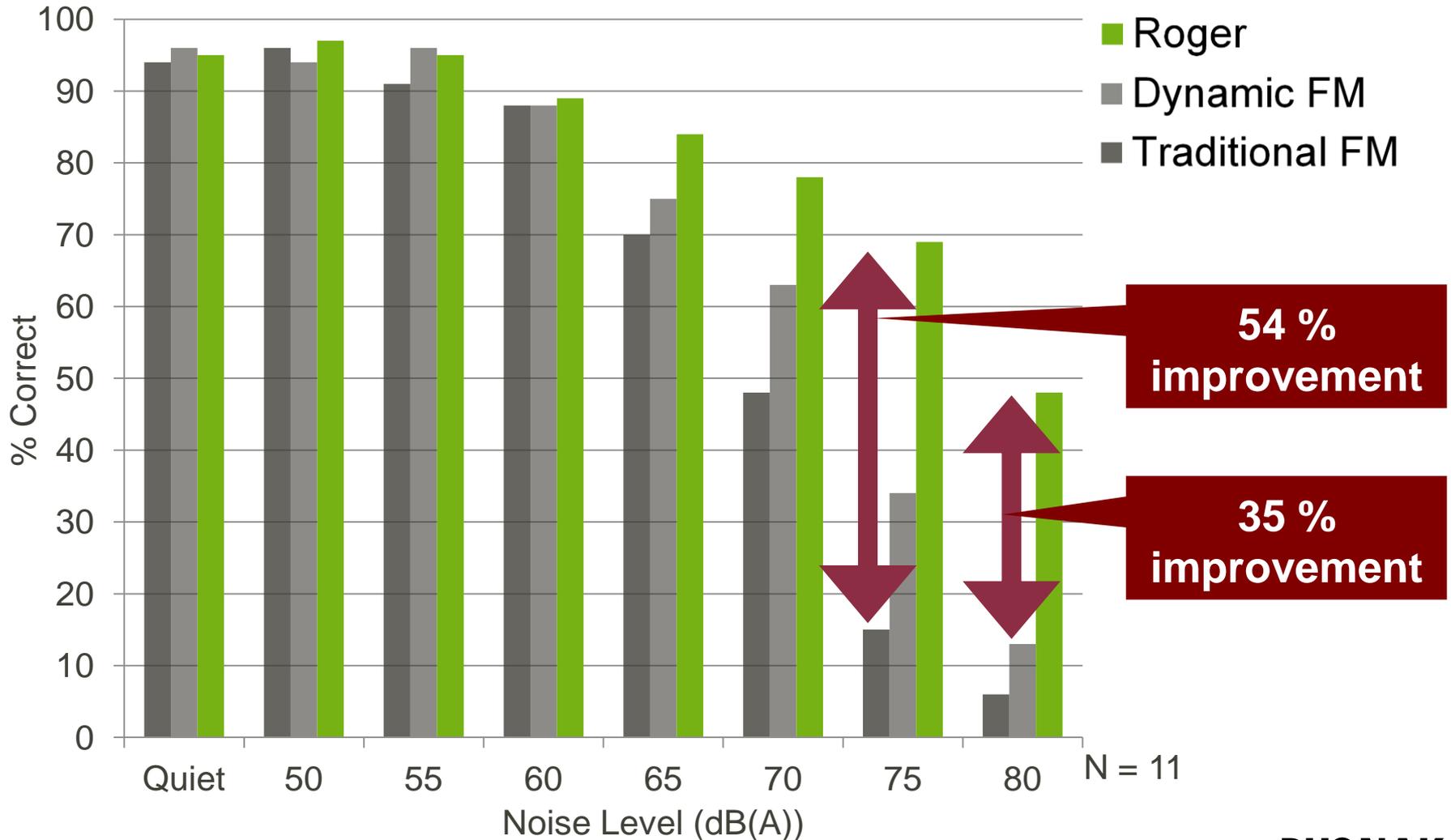


The right strategy

1. Bring the microphone **to the source**, cutting out the distance
2. Optimize SNR at the source with **beam former**
3. Mix **adaptively** the wireless microphone signal with the ear-level microphone of the hearing instrument, by increasing the gain of the Roger receiver in higher ambient noise levels
4. **Reduce** the gain when no voice is present

Make no mistake: not all wireless microphones perform equally, there are significant differences

Speech understanding at 18 ft in various noise levels



Linda Thibodeau on Roger

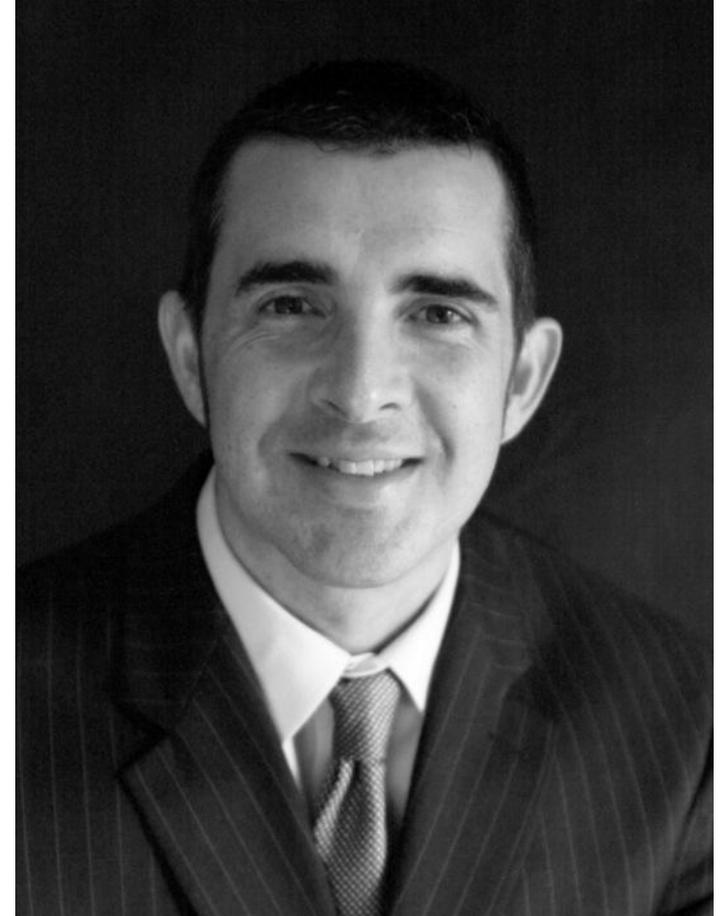


“I was amazed by the performance of students who used Roger. They were able to hear and understand the speaker in noise levels that would not have been possible using previous FM system technology.”

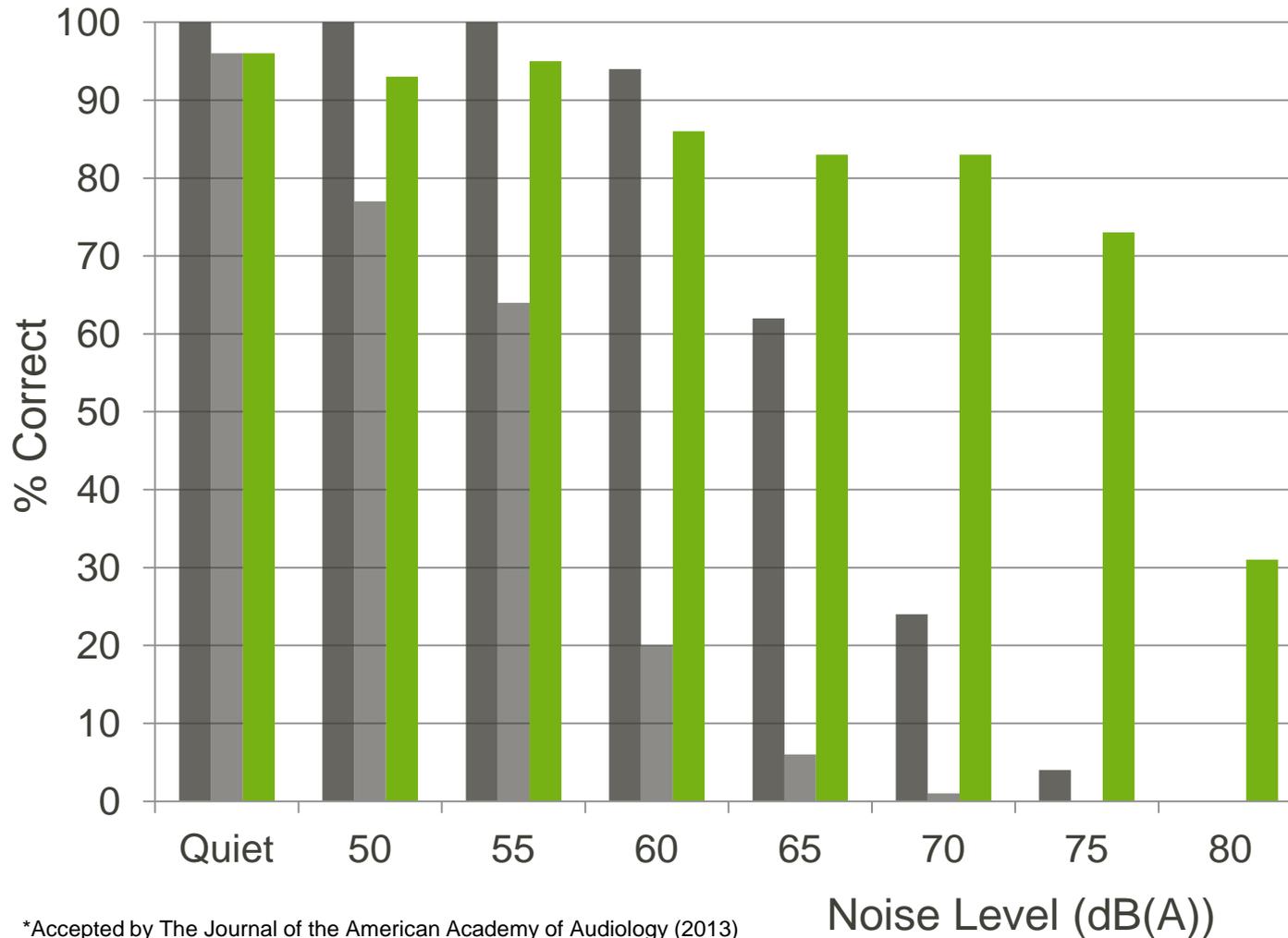
Professor Linda Thibodeau, PhD

More evidence

- Dr. Jace Wolfe
- Hearts for Hearing Foundation, Oklahoma
- University of Oklahoma Health Sciences Center
- Identical test set-up to Linda Thibodeau's, but with Cochlear Implant recipients



Speech understanding in various noise levels; AB Harmony



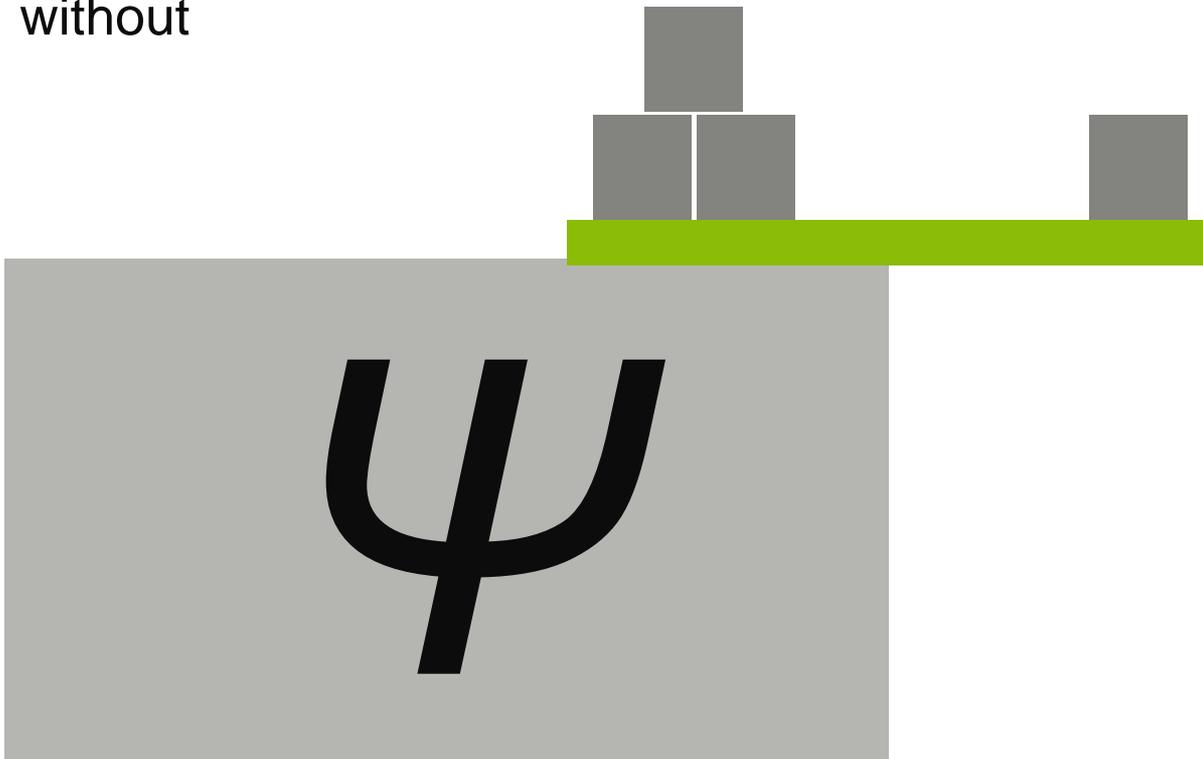
N=13

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

Three words on psychology

Data have shown that listeners with a hearing loss feel less embarrassed with their wireless microphone than without

It takes some courage to use a wireless microphone



Take home messages

1. Speech understanding in noise should be measured in each patient
2. Degree of hearing loss should be expressed as loss in signal to noise ratio
3. Many different types of patients and their partners can benefit from wireless microphone technology, but there are huge differences in performance level between various wireless microphone technologies





THANK YOU