



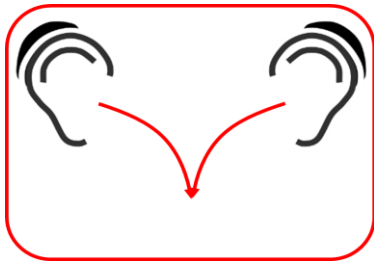
# “Binaural and bilateral considerations in hearing aid fitting”

*Mark Laureyns*

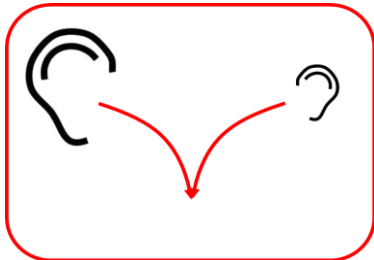
*Thomas More University College – Department of Audiology – Antwerp  
CRS - Amplifon Centre for Research & Studies – Milan – Italy  
European Association of Hearing Aid Professionals – Brussels - Belgium*



# What is the basis for selection?

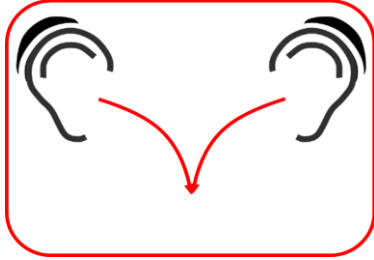


- **Symmetric Hearing Loss**
  - Good Localisation (Central Auditory Processing)
  - Poor Localisation (Central Auditory Processing)



- **Asymmetric Hearing Loss**
  - One Normal Ear – One Aidable Ear (Mono-Stereophony)
  - Asymmetric – Aidable Hearing Loss in both ears
  - Single Sided Deafness - One Un-Aidable Ear

# What is the basis for selection?

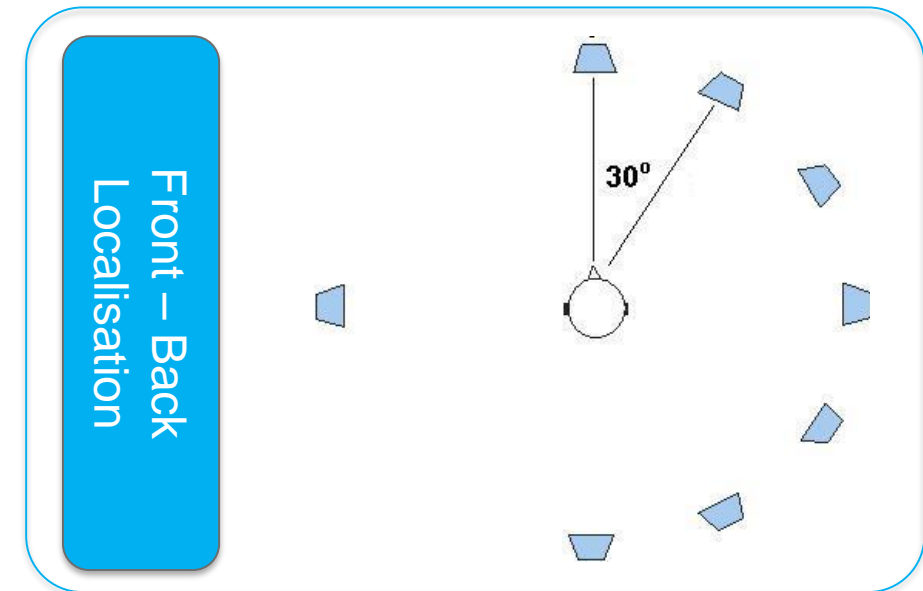
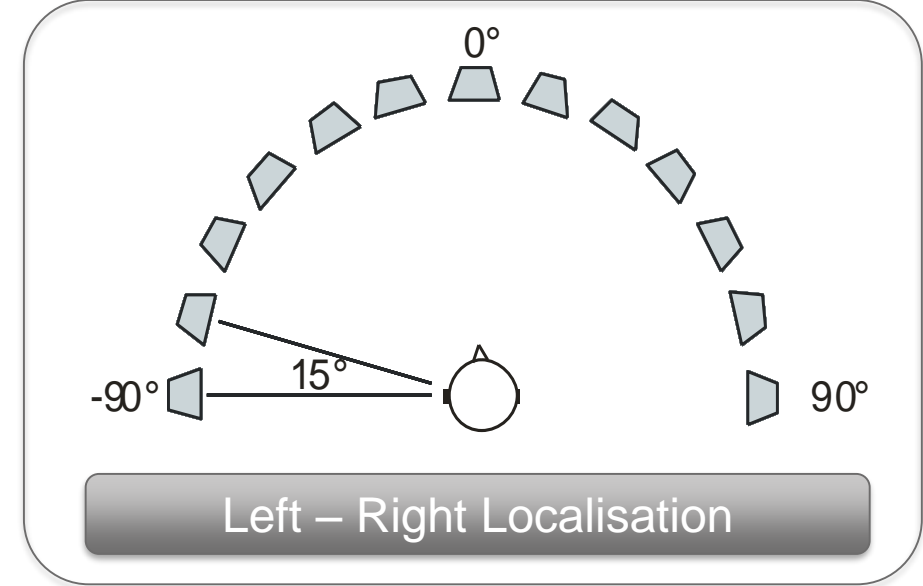
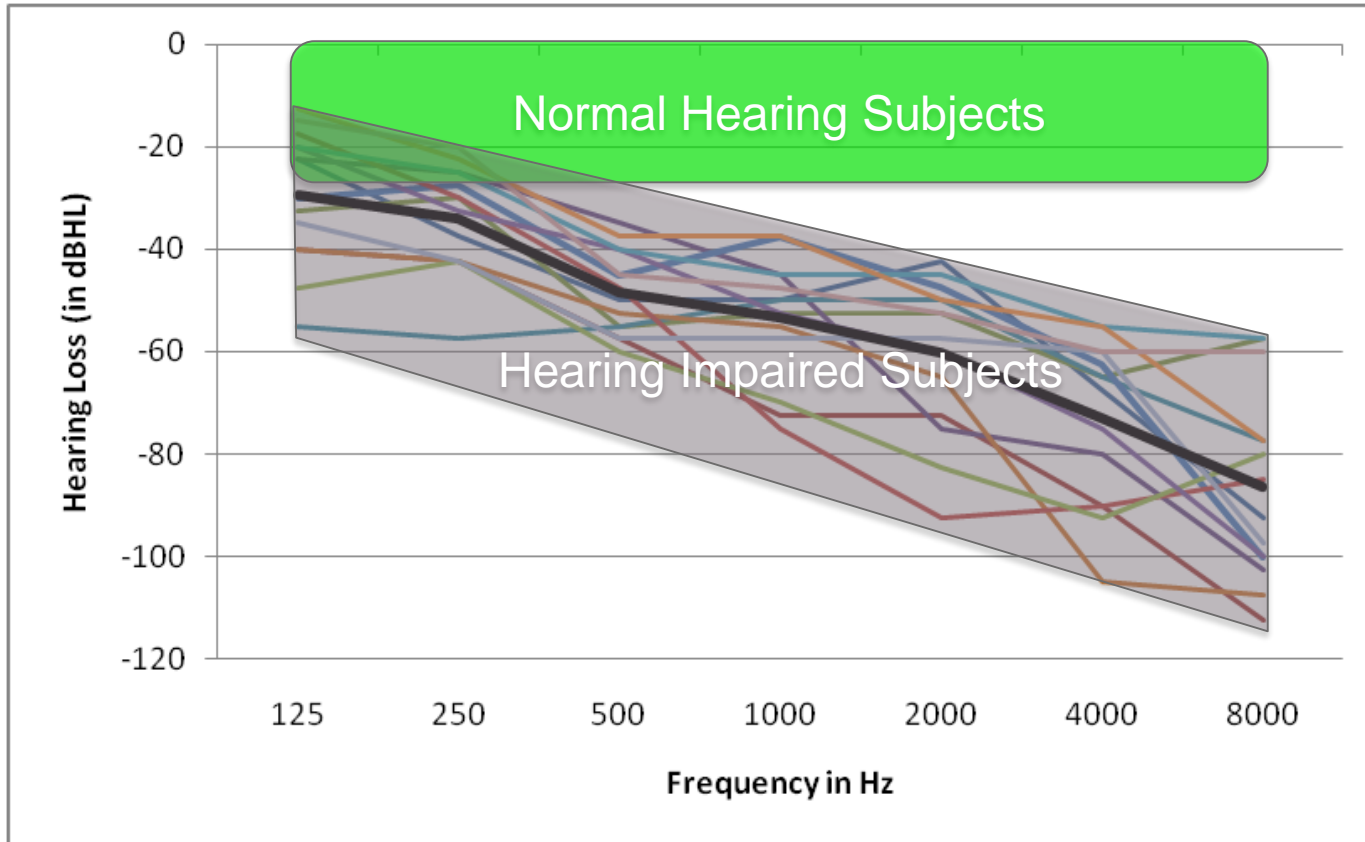


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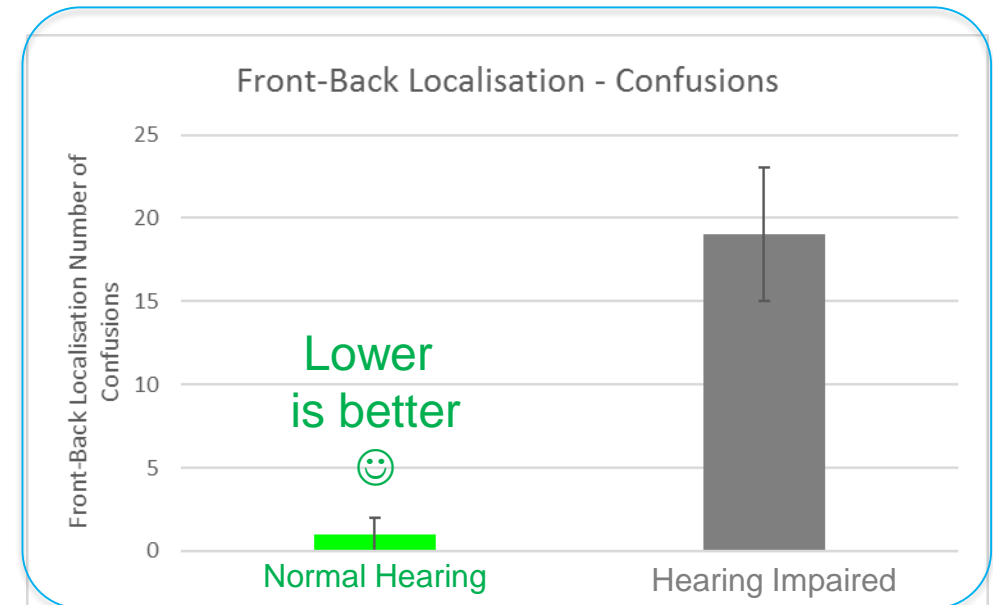
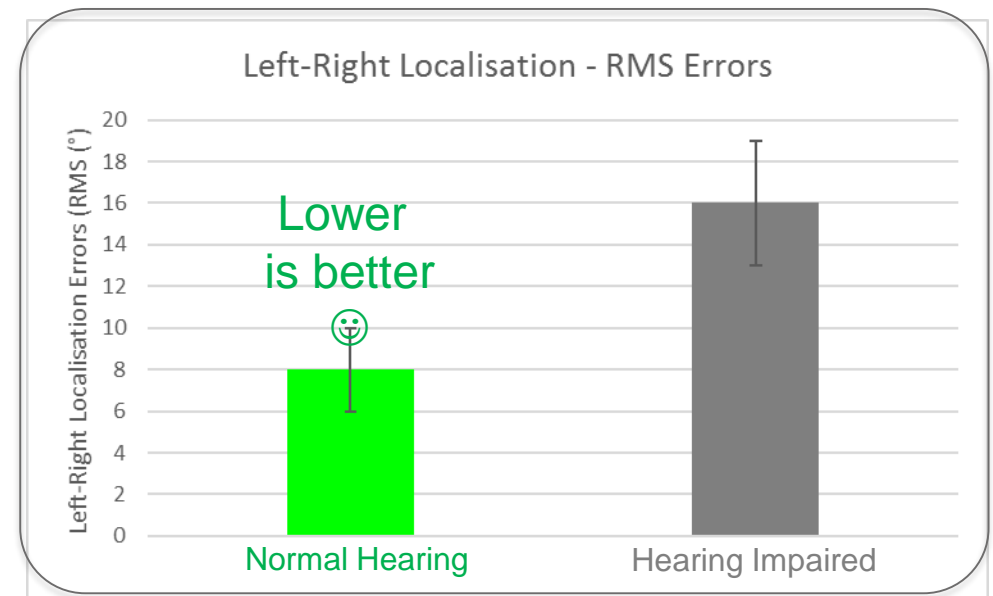
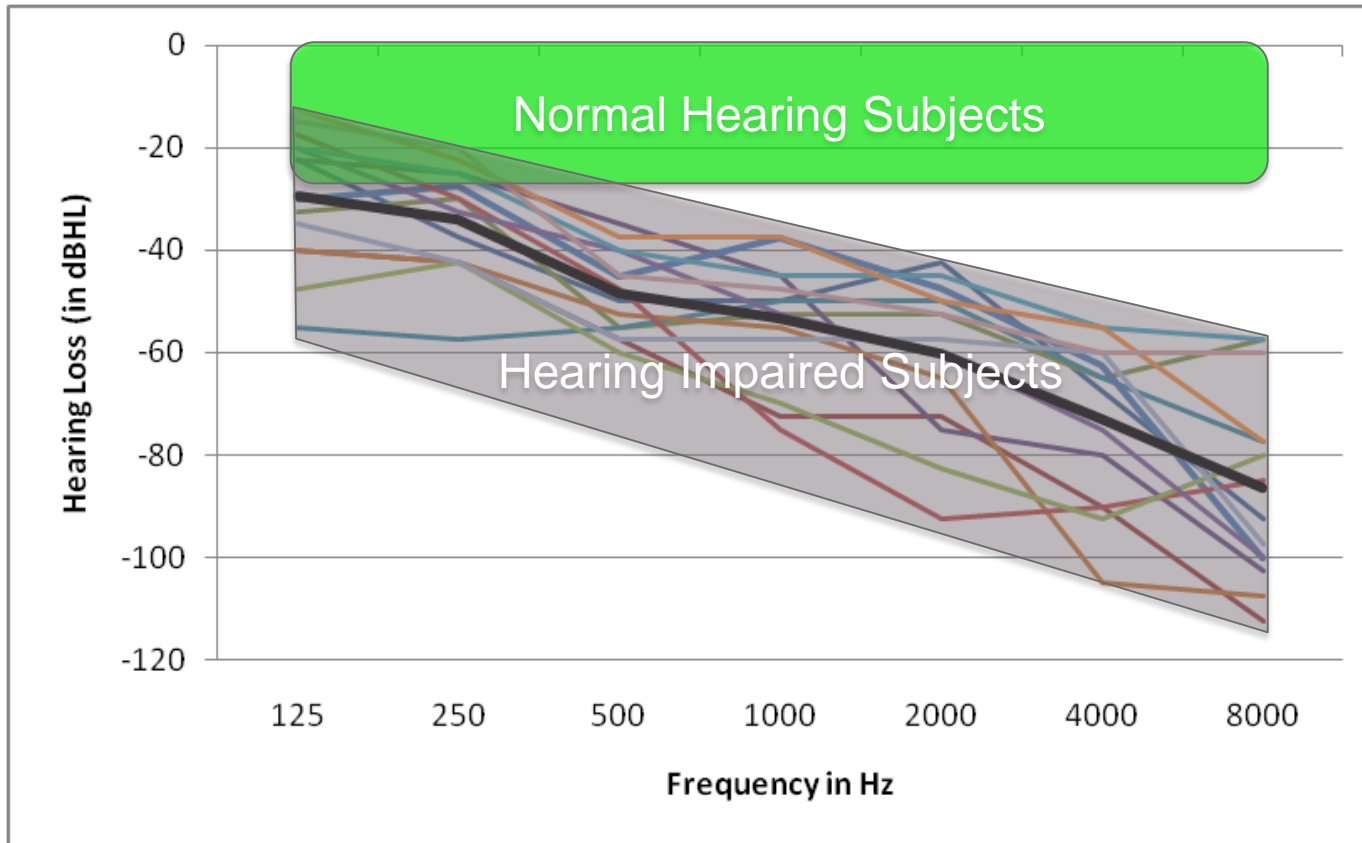


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  - One Normal Ear – One Aidable Ear (Mono-Stereophony)
  - Asymmetric – Aidable Hearing Loss in both ears
  - Single Sided Deafness - One Un-Aidable Ear

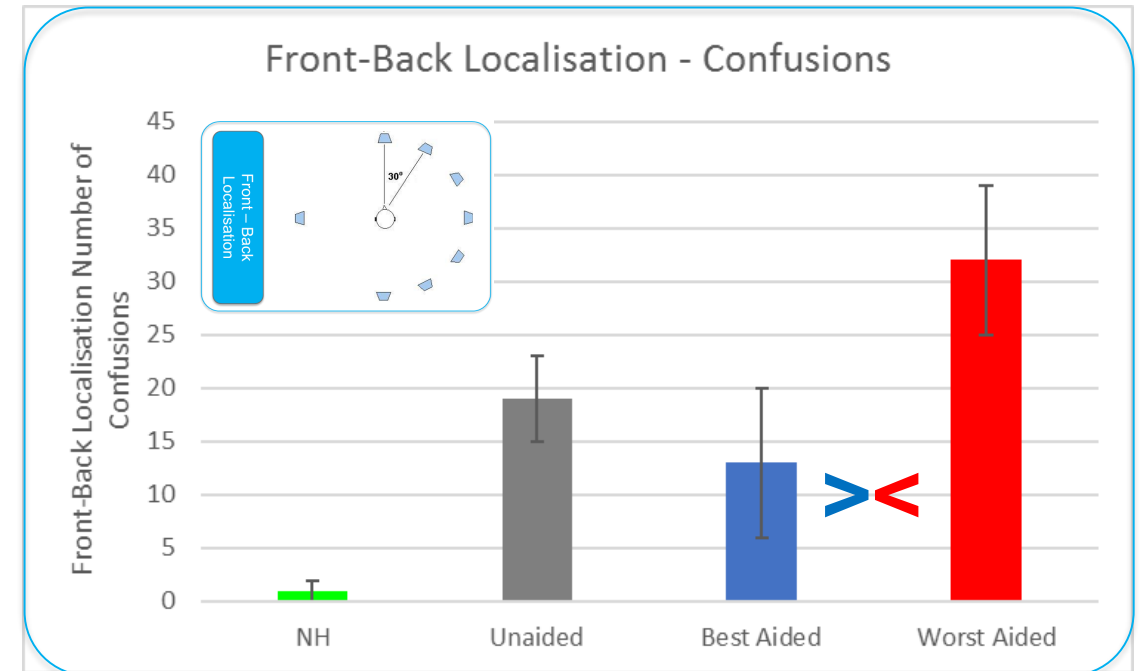
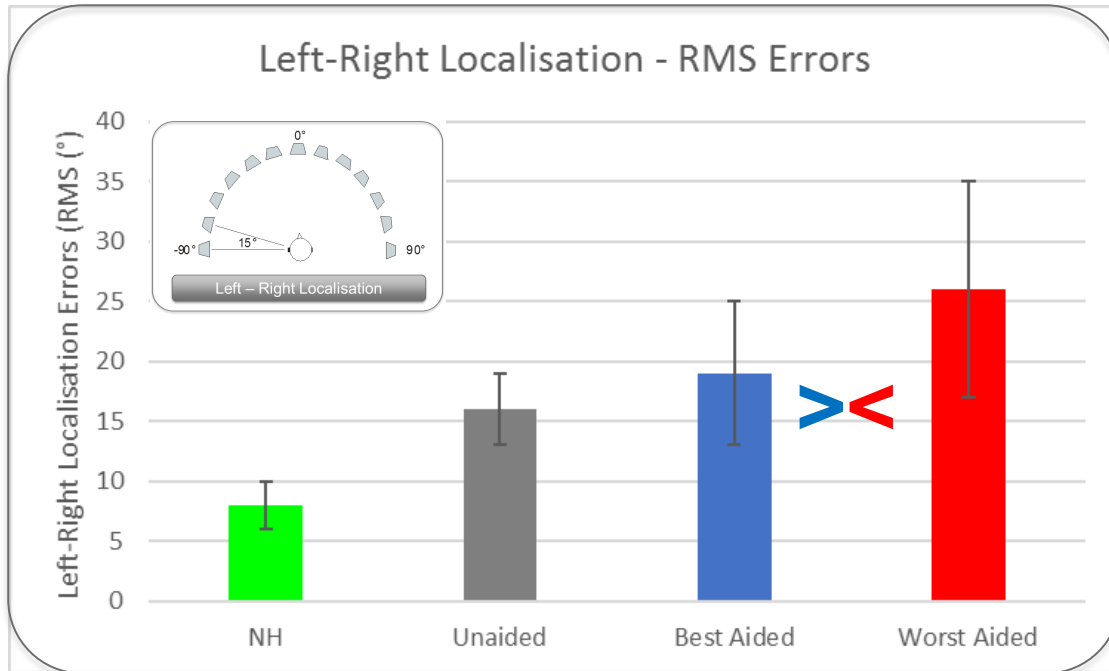
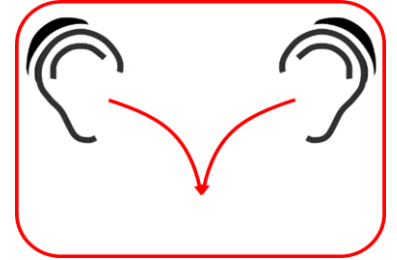
# Can symmetric hearing loss lead to localisation problems?



# Can symmetric hearing loss lead to localisation problems?

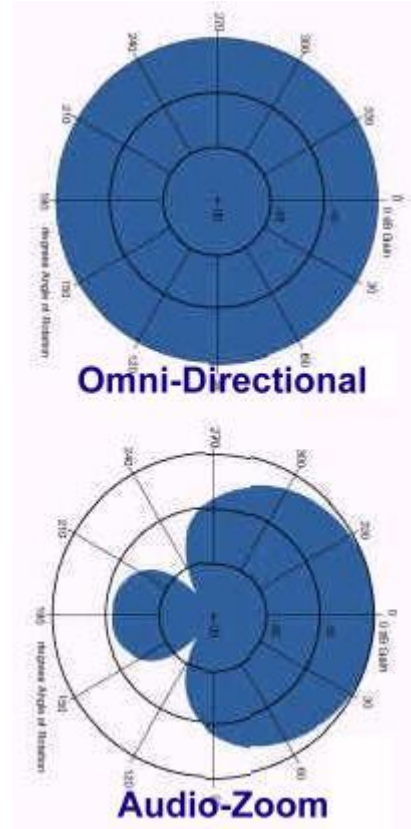
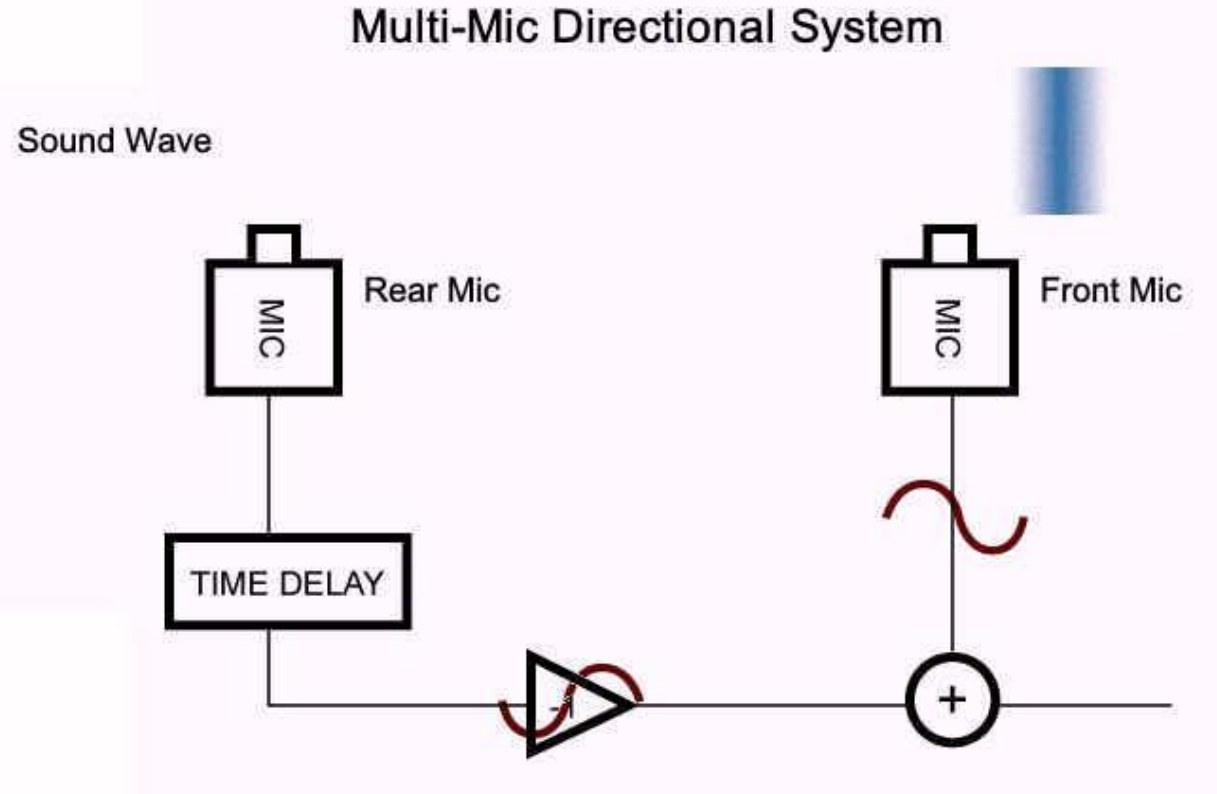


# Do Hearing Aids impact localisation in symmetric hearing loss?



# Traditional Fixed Directionality

- + Improves SNR by 3 dB
- Low Frequency Roll Off
- Wind Noise Problems
- Noise (when using bass boost)

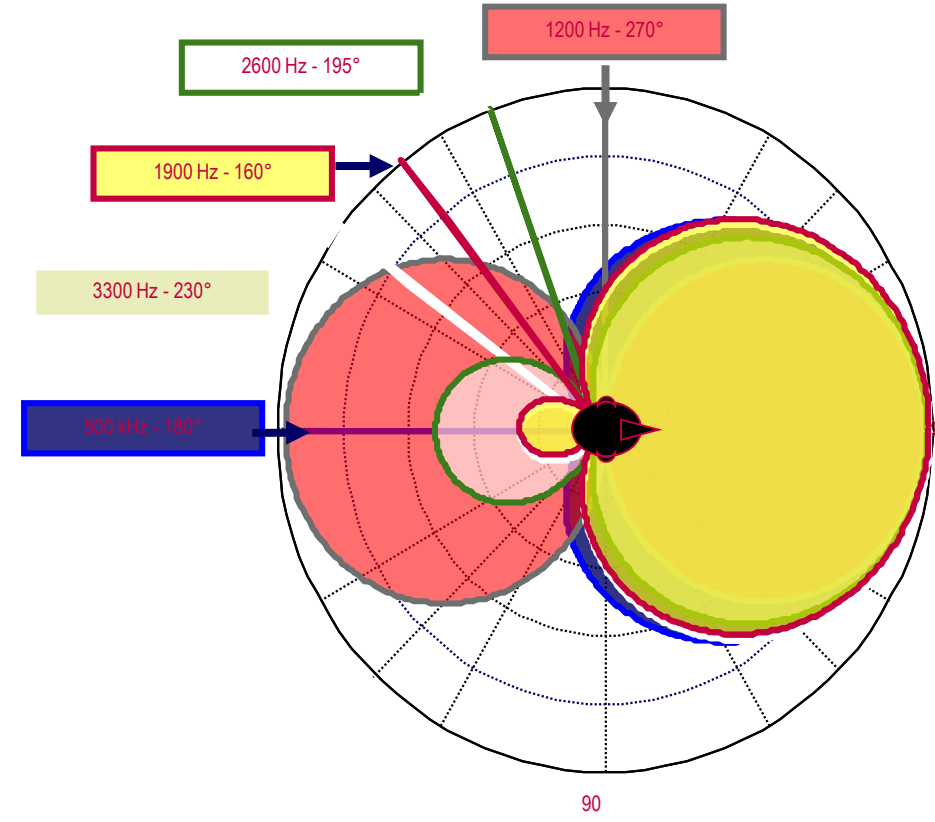
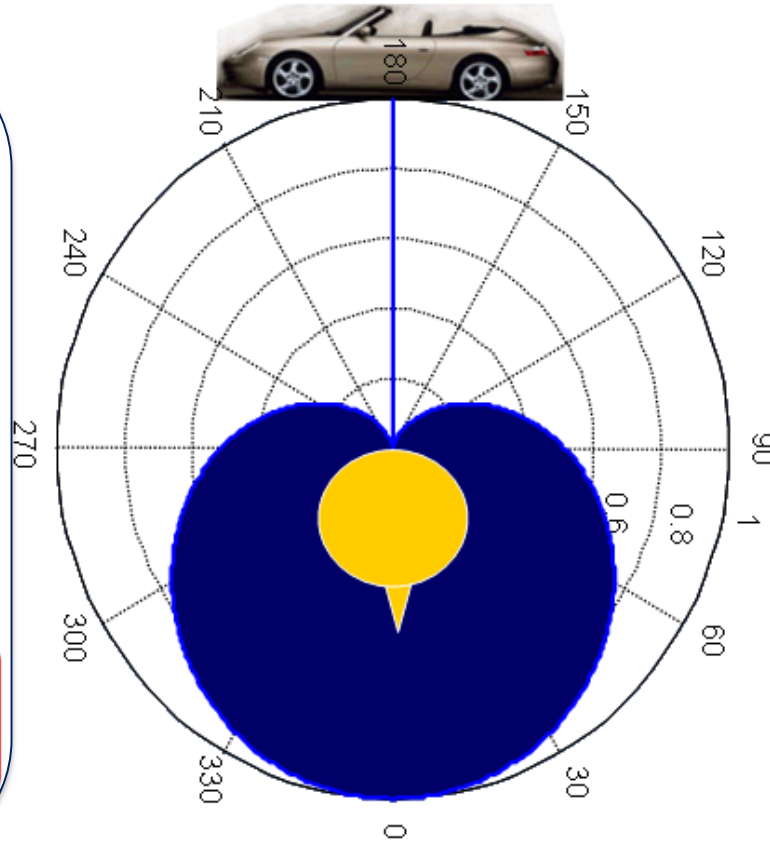


# Adaptive Directionality



+ Impressive effect at first experience (realistic 3 dB SNR Improvement)

- Low Frequency Roll Off  
Wind Noise Problems  
Noise (when using bass boost)  
Left-Right Localisation Problems  
Aggressive Processing







# Horizontal localization with bilateral hearing aids

THE JOURNAL OF THE  
ACOUSTICAL SOCIETY  
OF AMERICA

# JASA

## Horizontal localization with bilateral hearing aids: Without is better than with

J. Acoust. Soc. Am. **119** (1), January 2006

Tim Van den Bogaert<sup>a)</sup>

*Lab exp. ORL, K. U. Leuven, Kapucijnenvoer 33, B-3000 Leuven, Belgium*

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Lieselot Van Deun

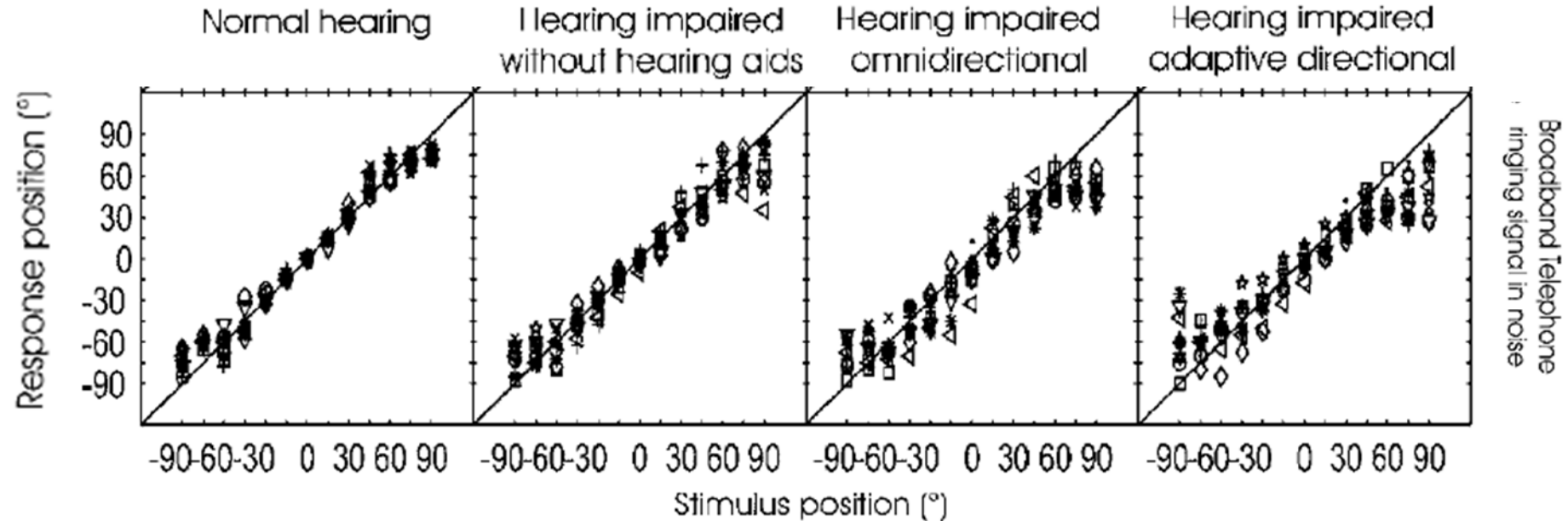
*Lab exp. ORL, K. U. Leuven, Kapucijnenvoer 33, B-3000 Leuven, Belgium*

Jan Wouters

*Lab exp. ORL, K. U. Leuven, Kapucijnenvoer 33, B-3000 Leuven, Belgium*

Adaptive Directionality in  
Hearing Aids Leads to  
Localisation Problems

Omni is better  
Unaided is better

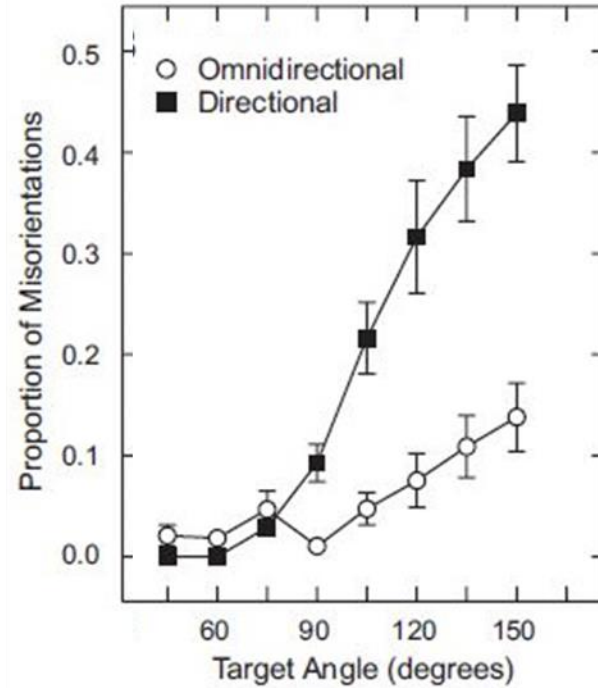
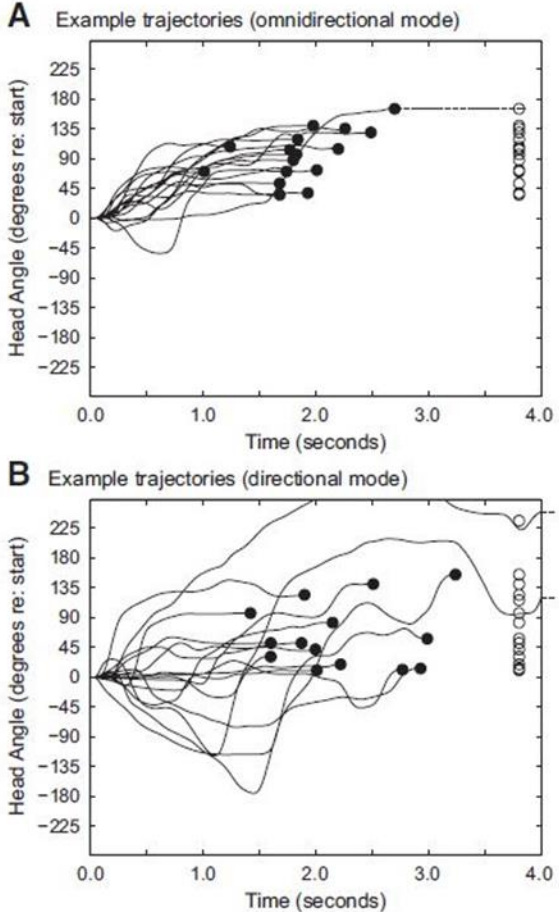


THOMAS  
MORE

Adaptive Directionality results in Localisation Problems



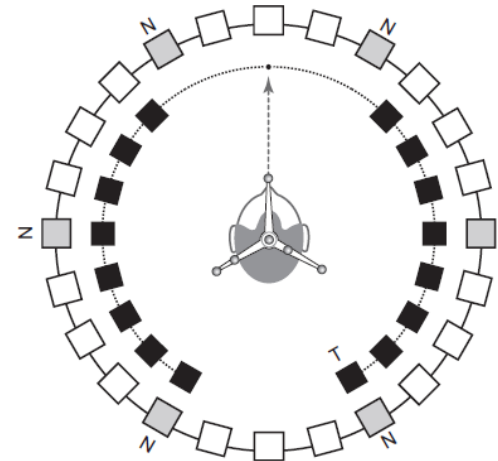
# Directional Microphone Configurations and Orientation



## The Effect of Hearing Aid Microphone Mode on Performance in an Auditory Orienting Task

W. Owen Brimijoin, William M. Whitmer, David McShefferty, and Michael A. Akeroyd

EAR & HEARING, VOL. 35, NO. 5, e204–e212



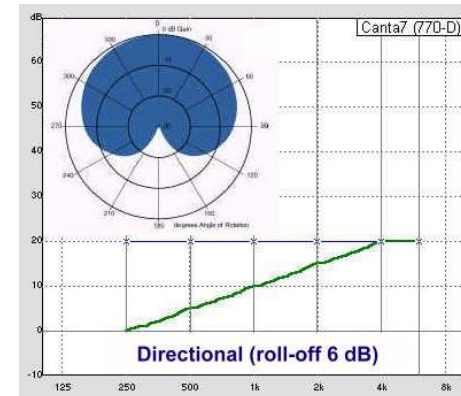
Adaptive Directionality in Hearing Aids Leads to Orientation Problems

Omni is better

Adaptive Directionality results in Orientation Problems



In a double blind study, forced-choice design, 23 participants (hearing aid users) were asked to choose the program they judged as having the best sound quality (for Music-Speech-Environmental sounds). Groth, Laureyns, 2010



# Traditional Fixed and Adaptive Directionality

## The Roll-Off consequences

**P1: Omni**

+ Good Audibility  
+ Low Noise

Omni

**P2: No BassBoost**

+ Low Noise  
- Reduced Audibility  
*lost low frequencies*

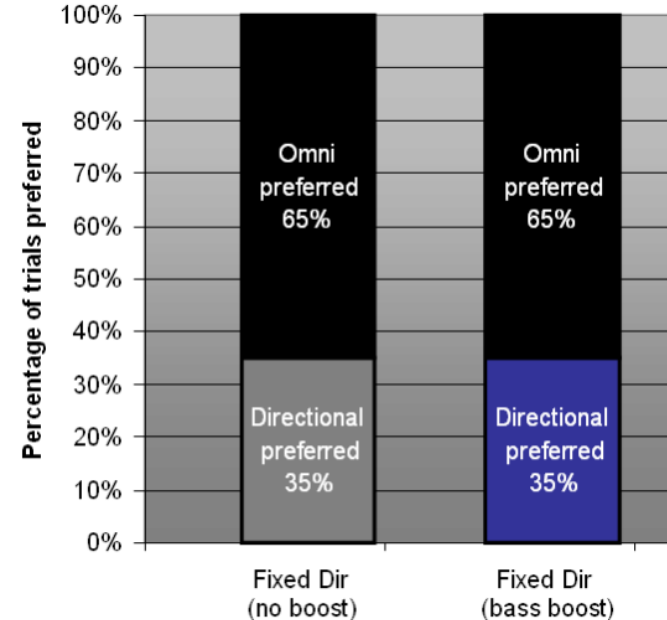
No Bass boost

**P3: BassBoost**

+ Good Audibility  
- High Noise  
*bass noise-floor*

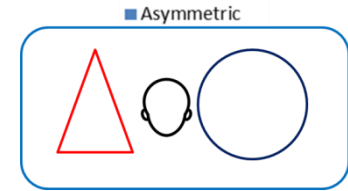
Bass Boost

Sound quality preference for directional processing scheme compared to omnidirectional

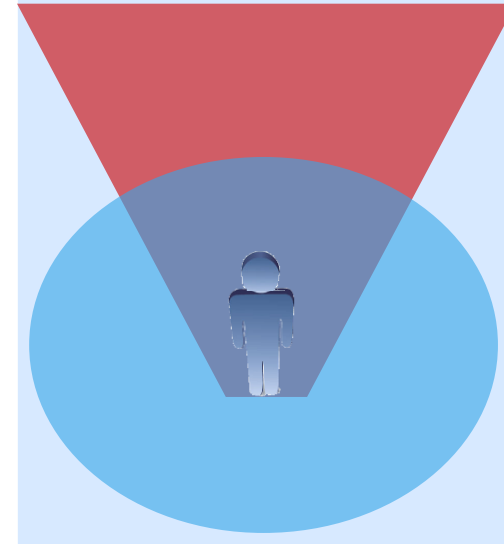


Traditional Directionality results in Poor Sound Quality

# Asymmetric Directionality



- + Better Sound Quality  
Keep low frequencies at omni side  
No need to switch  
3dB SNR Improvement
- Left-Right Localisation Problems



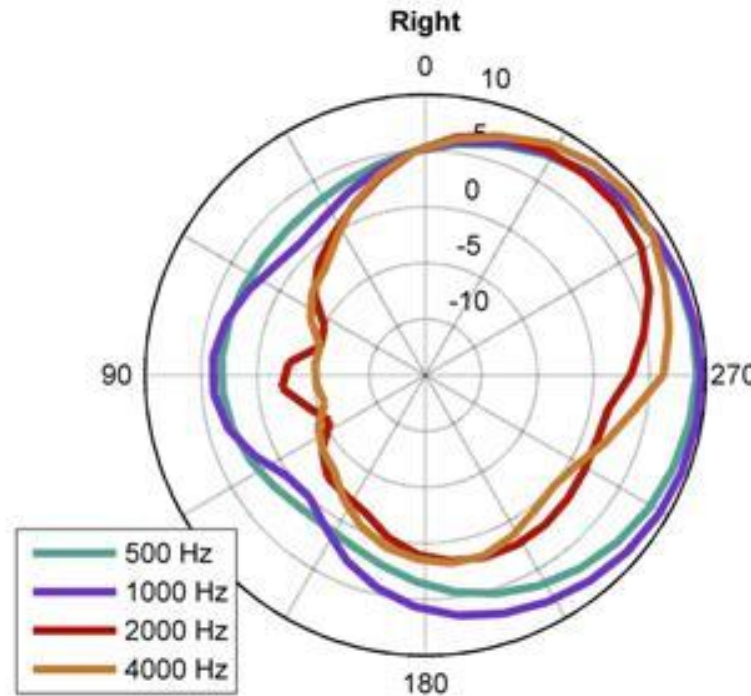
# Pinna Directionality



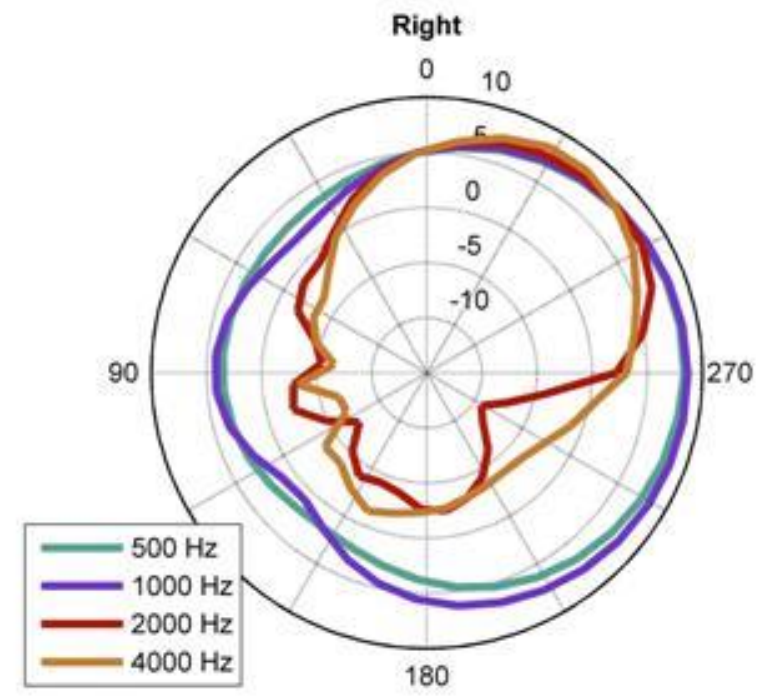
- + Better Sound Quality
- Very natural experience
- Keep low frequencies
- No need to switch
- Good localisation both Left-Right and Front-Back
- 3 dB SNR Improvement



- Less impressive at first demo



Open human ear



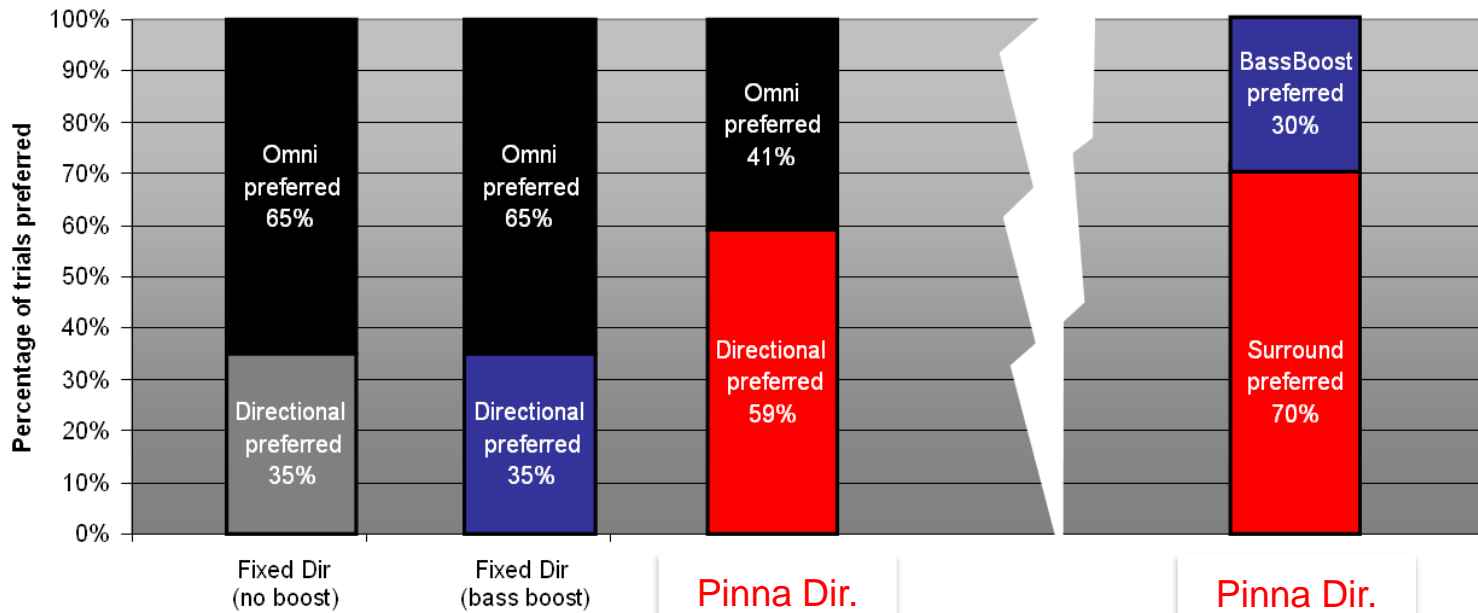
Pinna Directionality

In a double blind study, forced-choice design, 23 participants (hearing aid users) were asked to choose the program they judged as having the best sound quality (for Music-Speech-Environmental sounds). Groth, Laureyns, 2010

# Sound Quality – Double Blind Study

Sound quality preference for directional processing scheme

compared to omnidirectional



Bass Boost <=> Pinna Dir.

**Lessius**  
HOGESCHOOL

**Double blind sound quality study**  
(comparison of directionality modes)  
23 HI Users

Leen Heymans\*, Leen Van der Vliet\*, Nele Van De Winkel\*,  
Laure Huyghe\*\*, Leen Crets\*\*, Paul Van Doren\*\*,  
Mark Laureyns\*/\*\*

\* = Lessius University College – Audiology Department – Antwerp Belgium  
\*\* = Dialogue Hearing Centers Belgium

**Lessius** HOGESCHOOL

Goal of the study

- This study has the aim to evaluate sound quality of hearing aids with a double blind protocol – (nor the subjects or the researchers evaluating sound quality are informed on the signal processing active in the hearing aids and all hearing aids have an identical design)

Double blind sound quality study - 2009

**Lessius** HOGESCHOOL

Sound files used for the study

Music:  
Celine Dion – All by myself  
Celine Dion – Because you loved me  
Andrea Bocelli – Ultimo re

Running Speech:  
Dutch speech sample  
French speech sample  
English speech sample

Environmental Sounds: Rain  
Footsteps in water  
Wind chimes

Pinna Directionality results in the best sound quality

# Directional Microphone Configurations & Localisation

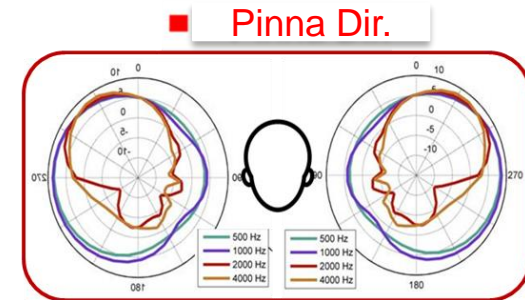
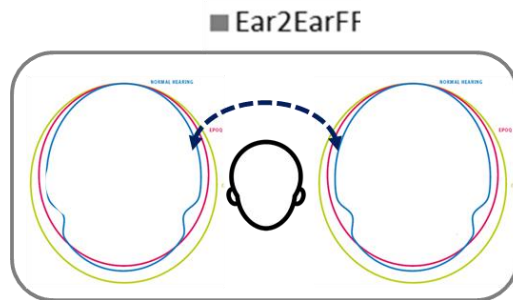
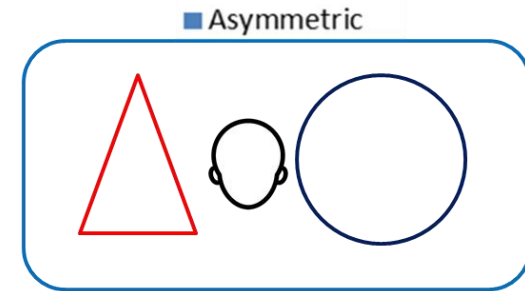
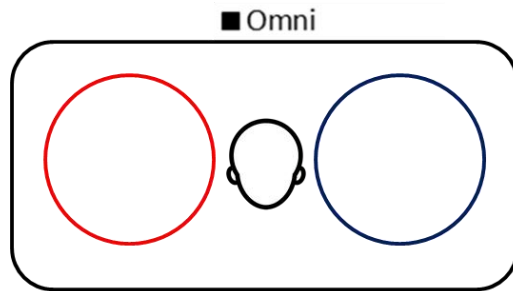


Left-Right and Front-Back Spatial Hearing with Multiple Directional Microphone Configurations in Modern Hearing Aids

J Am Acad Audiol 25:791–803 (2014)

Evelyne Carette\*†  
 Tim Van den Bogaert\*  
 Mark Laureyns‡  
 Jan Wouters\*

- Unaided
- Asymmetric
- Omni
- Pinna Dir.
- Ear2EarFF



# Directional Microphone Configurations & Localisation

Left-Right and Front-Back Spatial Hearing with  
Multiple Directional Microphone Configurations in  
Modern Hearing Aids

J Am Acad Audiol 25:791–803 (2014)

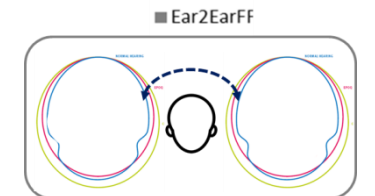
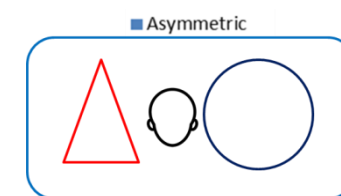
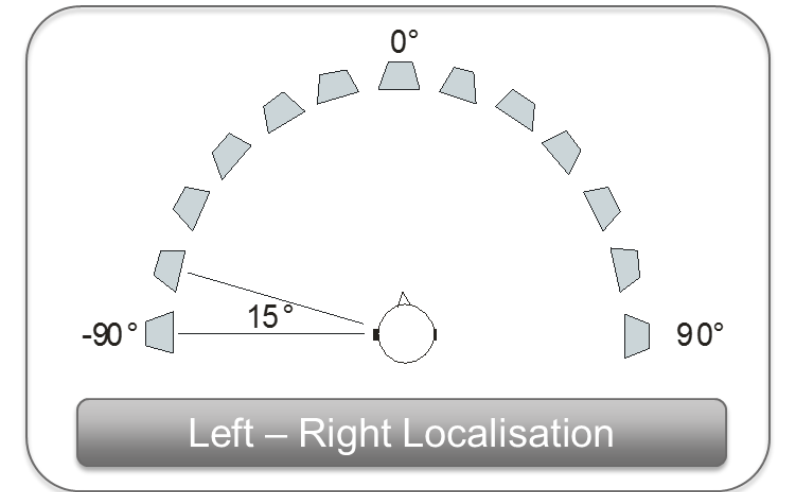
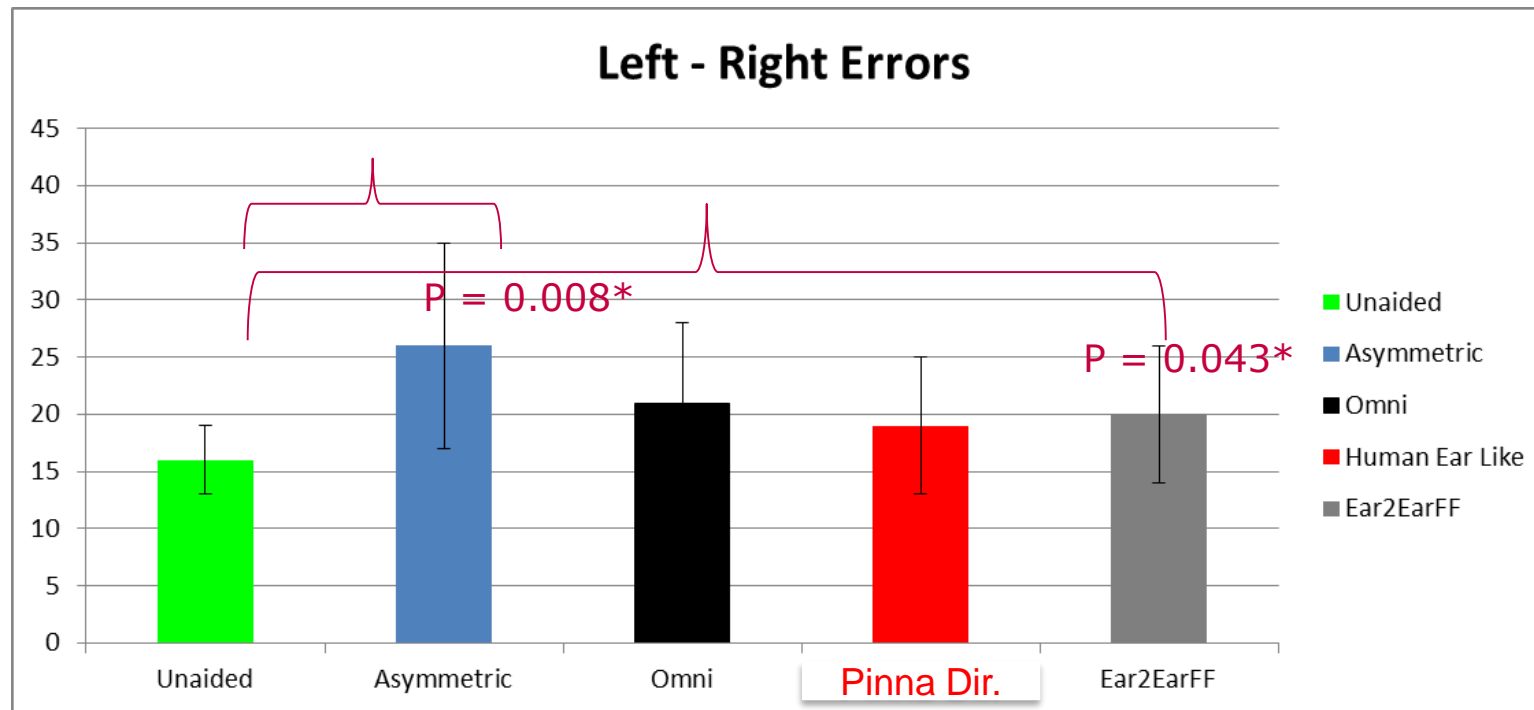
Evelyne Carette\*†  
Tim Van den Bogaert\*  
Mark Laureyns‡  
Jan Wouters\*





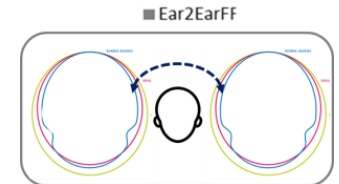
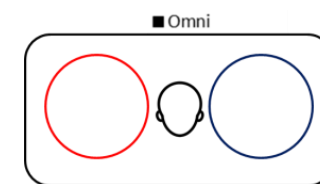
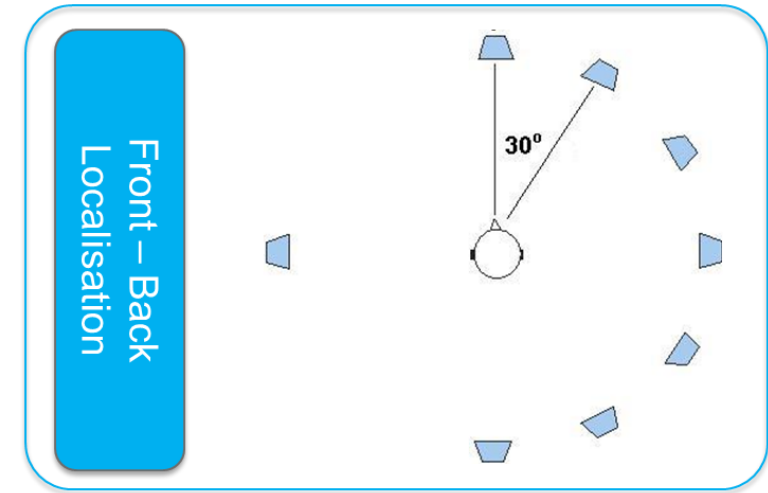
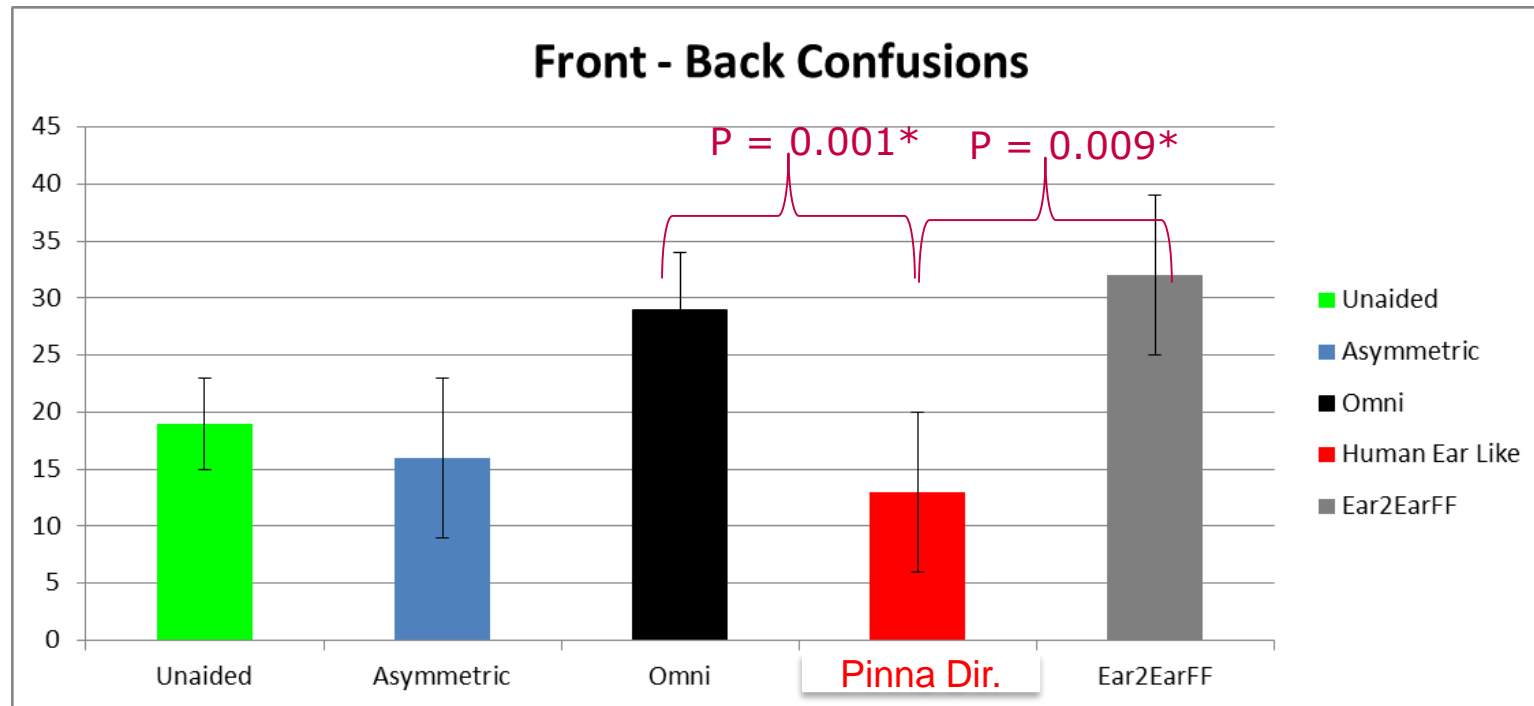
# Directional Microphone Configurations & Left-Right Localisation

Left-Right and Front-Back Spatial Hearing with Multiple Directional Microphone Configurations in Modern Hearing Aids



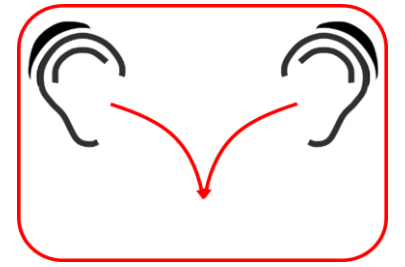
# Directional Microphone Configurations & Front-Back Localisation

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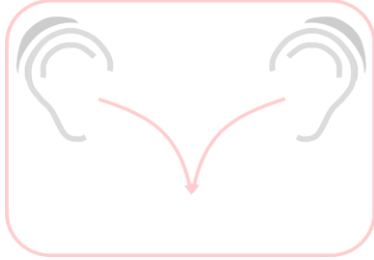
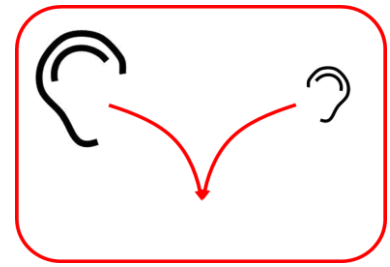


# What is the basis for selection?

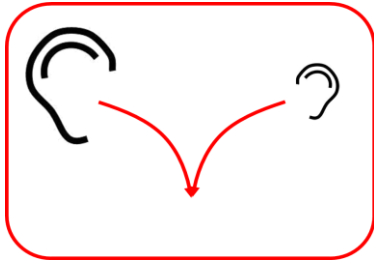
- **Symmetric Hearing Loss**
- Evaluate Localisation Performance – Test or Questionnaire (SSQ)
  - Good Localisation (Central Auditory Processing)
    - Select directionality that preserves localisation cues (Pinna Directionality is now available in all major hearing aid brands – but is rarely default)
    - Ensure good balance between both ears
    - Evaluated aided localisation performance (and compare to unaided)
  - Poor Localisation (Central Auditory Processing)
    - Evaluate if poor localisation could be caused by earlier hearing aid selection or fitting.
    - Here you can use more aggressive directionality
    - Consider accessories – remote microphone – FM systems (up to 20 dB SNR Improvement)



# What is the basis for selection?



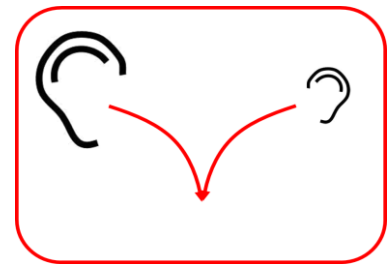
- **Symmetric Hearing Loss**
  - Good Localisation (Central Auditory Processing)
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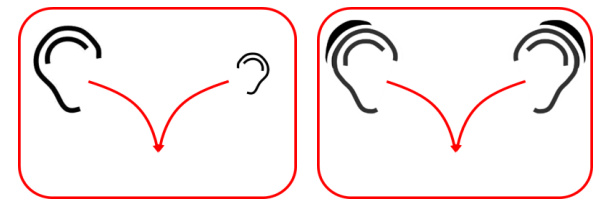


- **Asymmetric Hearing Loss**
  - One Normal Ear – One Aidable Ear (Mono-Stereophony)
  - Asymmetric – Aidable Hearing Loss in both ears
  - Single Sided Deafness - One Un-Aidable Ear

# What is the basis for selection?

- **Asymmetric Hearing Loss**
  - One Normal Ear – One Aidable Ear (Mono-Stereophony)
    - The goal is to restore natural binaural hearing & localisation
    - Ensure good aided balance between both ears – don't use the fitting formula but use localisation or balance test
    - Select directionality that is comparable to the real ear performance (Pinna Directionality is now available in all major hearing aid brands – but is rarely default)
    - Use little or no noise reduction ... this leads to unbalance between the ears
    - Evaluated aided localisation performance (and compare to unaided)





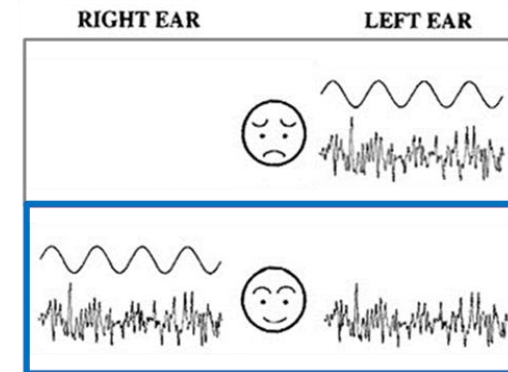
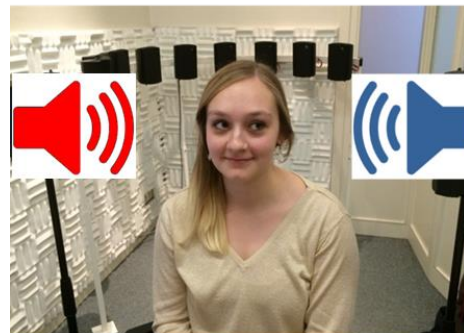
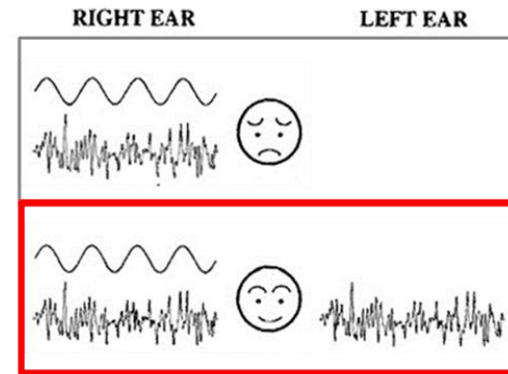
# What is the basis for selection?

- Asymmetric Hearing Loss – restore binaural masking release

HP	/	FF	
3,0		2,5	NH
2,3		2,0	Control
1,3		1,0	HI users

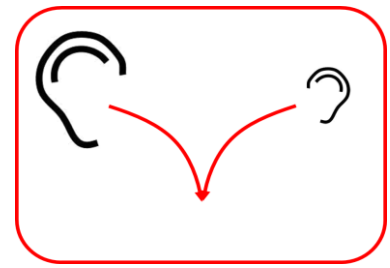
Laureyns et al, 2017

- 30 Young Normal Hearing Subjects
  - Avg Age 22y – 70% female
- 20 Control Subjects (Gender/Age)
  - Avg Age 73y – 67% female
- 20 Hearing Instrument Users
  - Avg Age 73y – 67% female



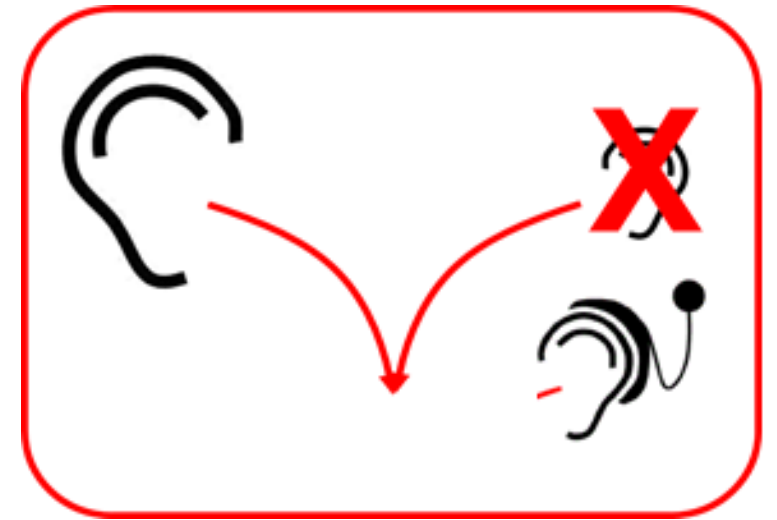
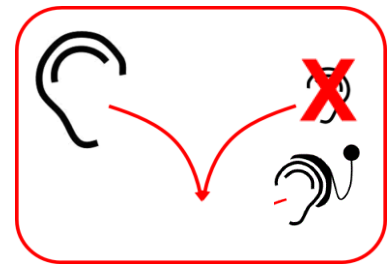
# What is the basis for selection?

- **Asymmetric Hearing Loss**
  - Asymmetric – Aidable Hearing Loss in both ears
    - The goal is to restore natural binaural hearing & localisation
    - Ensure good aided balance between both ears – only use the fitting formula at the start for the worst ear - use localisation or balance test to fine-tune.
    - When the worst ear was not aided for a long time, allow time for habituation and repeat balance test systematically.
    - If speech intelligibility on the worst ear is poor, you may fit this ear as a noise reference ear (to support binaural masking release)



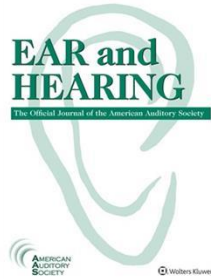
# What is the basis for selection?

- **Asymmetric Hearing Loss**
  - Single Sided Deafness - One Un-Aidable Ear
    - CROS – Transcranial Cros – Hearing Aids – Bone Anchored
    - CI – Cochlear Implant on the unaidable ear





# Single Sided Deafness and CROS



## Hearing Instruments for Unilateral Severe-to-Profound Sensorineural Hearing Loss in Adults: A Systematic Review and Meta-Analysis

Pádraig Thomas Kitterick,<sup>1,2</sup> Sandra Nelson Smith,<sup>1,2</sup> and Laura Lucas<sup>1,2</sup>

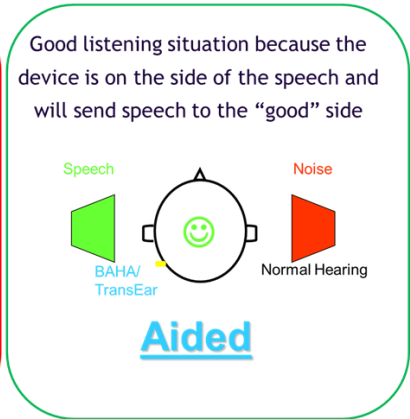
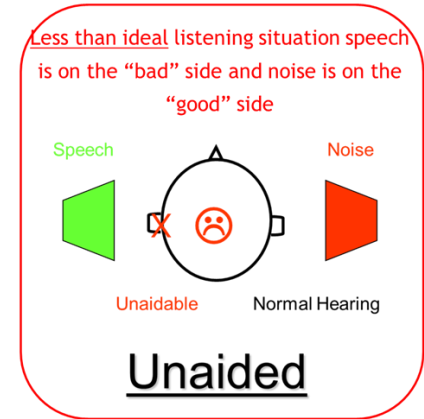
EAR & HEARING, VOL. 37, NO. 5, 495–507 (2016)

### Conclusions:

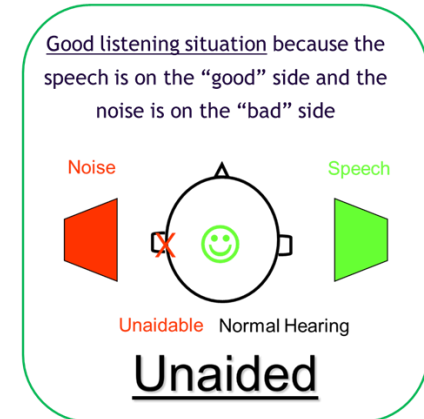
Devices that reroute sounds from an ear with a severe to profound hearing loss to an ear with minimal hearing loss may improve speech perception in noise when signals of interest are located toward the impaired ear.

However, the same device may also degrade speech perception as all signals are rerouted indiscriminately, including noise.

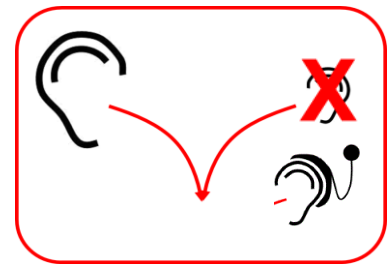
CROS works if the noise is on the hearing side



CROS does not work if the noise is on the "deaf" side



# Single Sided Deafness and Cochlear Implants



Cochlear Implants International  
An Interdisciplinary Journal

ISSN: 1467-0100 (Print) 1754-7628 (Online) Journal homepage: <http://www.tandfonline.com/loi/ycii20>



*Otology & Neurotology*  
37:e154–e160 © 2016, Otology & Neurotology, Inc.

Predicting speech perception outcomes following cochlear implantation in adults with unilateral deafness or highly asymmetric hearing loss

Pádraig T. Kitterick & Laura Lucas

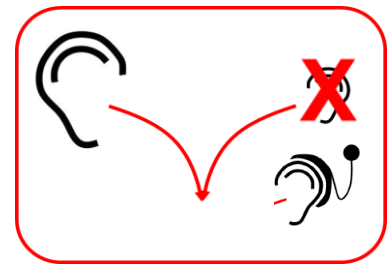
Patients with a shorter duration of deafness were more likely to improve in listening conditions that created a less favourable SNR at the implanted ear than the non-implanted ear. Those with more residual hearing in the better ear were more likely to improve in the listening condition that created a less favourable SNR at that ear.

Single-sided Deafness Cochlear Implantation: Candidacy, Evaluation, and Outcomes in Children and Adults

David R. Friedmann, Omar H. Ahmed, Sean O. McMenemy, William H. Shapiro, Susan B. Waltzman, and J. Thomas Roland Jr.

Conclusions: The data reveal significant improvement in speech perception performance in quiet and in noise in patients with single-sided deafness after implantation.

# Single Sided Deafness and Cochlear Implants



REVIEW

Current Opinion in  
Otolaryngology & Head and Neck Surgery

Although cochlear implant is not a Food and Drug Administration-approved treatment for SSD, several recent studies show improvements in speech understanding, sound localization, and tinnitus.

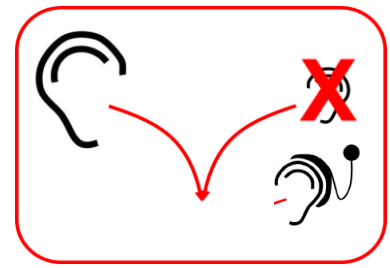


## Cochlear implantation and single-sided deafness

*Joshua Tokita<sup>a</sup>, Camille Dunn<sup>a</sup>, and Marlan R. Hansen<sup>a,b</sup>*

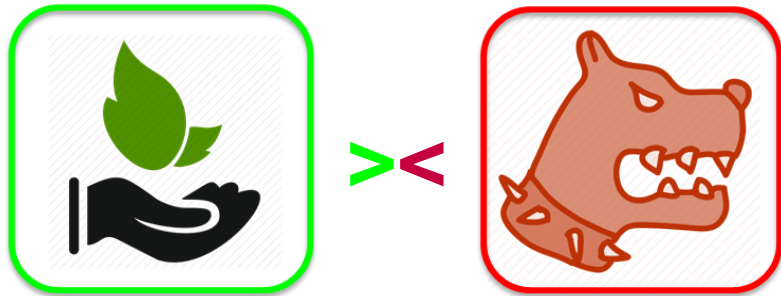
Tokita et al. *Curr Opin Otolaryngol Head Neck Surg* 2014, 22:353–358

# What is the basis for selection?



- **Asymmetric Hearing Loss**
  - Single Sided Deafness - One Un-Aidable Ear
  - CROS – Transcranial Cros – Hearing Aids – Bone Anchored
    - The goal is to reduce the head shadow effect
    - CROS improves the situation if speech is on the “deaf” side and noise on the “good” side.
    - CROS makes things worse, if speech is on the “good” side and noise on the “deaf” side.
    - Classification or Noise Reduction may reduce the negative effects
    - YOU CAN NOT IMPROVE LOCALISATION!
  - CI – Cochlear Implant on the unaidable ear
    - This can improve localisation (next to communication and tinnitus)
    - But mostly not seen as a cost-effective intervention (for now ...)

# Conclusion



**Natural >< Aggressive**

- **In binaural fitting – localisation is essential**
  - **Evaluate Localisation** both unaided and aided
  - When localisation is possible, **select natural features that preserve localisation cues.**
    - Watch out for aggressive signal processing
    - Pinna Directionality preserves localisation cues and sound quality.
- **For mono-stereophony**
  - Avoid Noise Reduction
  - Only Human Ear Like Directionality
  - Fitting needs to be based on balance not on the default gain formula
- **Don't go for quick fit ... or default ... go for personalised quality hearing care.**



# “Binaural and bilateral considerations in hearing aid fitting”

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