"Binaural and bilateral considerations in hearing aid fitting"

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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
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Can symmetric hearing loss lead to localisation problems?

Symmetric Hearing Loss can result in Poorer Localisation

Left-Right and Front-Back Spatial Hearing with Multiple Directional Microphone Configurations in Modern Hearing Aids – Carette et al. 2014
Can symmetric hearing loss lead to localisation problems?

Symmetric Hearing Loss can result in Poorer Localisation
Do Hearing Aids impact localisation in symmetric hearing loss?

Directional Systems can result in Good or Poor Localisation
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: Without is better than with


Adaptive Directionality in Hearing Aids Leads to Localisation Problems

Omni is better
Unaided is better

Adaptive Directionality results in Localisation Problems
Directional Microphone Configurations and Orientation

Adaptive Directionality in Hearing Aids Leads to Orientation Problems

Omn is better
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

P2: No BassBoost

+ Low Noise
- Reduced Audibility
  lost low frequencies

P3: BassBoost

+ Good Audibility
- High Noise
  bass noise-floor

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

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

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

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

Unaided
Asymmetric
Omni
Pinna Dir.
Ear2EarFF
Pinna Dir.

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Directional Microphone Configurations & Left-Right Localisation

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

**Left - Right Errors**

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

![Graph showing error rates for different configurations](image)

- P = 0.008*
- P = 0.043*

* The competitive system was using Ear 2 Ear to improve Left-Right localization

**Pinna Directionality and Omni result in the best left/right localisation**
Directional Microphone Configurations & Front-Back Localisation

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

Pinna Directionality results in the best front/back localisation

Front - Back Confusions

- P = 0.001*
- P = 0.009*

Unaided, Asymmetric, Omni, Pinna Dir., Ear2EarFF
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?

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  - Good Localisation (Central Auditory Processing)
  - Poor Localisation (Central Auditory Processing)

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  - 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

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,1,2 Sandra Nelson Smith,1,2 and Laura Lucas1,2

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.
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.

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

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

• 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.
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