

Single-sided deafness:  
Client Impact  
and Management options  
Phil Gomersall

Lecturer in Audiology



Anglia Ruskin  
University

# The plan...

- What is SSD?
- Evidence of handicap from literature

## Take home message:

- UHL can be very handicapping in some individuals
- What can we do to help?



# Evidence from literature

Table 1. Incidence of acquired unilateral SNHL

Condition	Incidence (per 100 000 adult population per year)	Authors	New cases per year in UK (2003 adult population 47.7 million)
Vestibular	2	Moffat <i>et al.</i> <sup>2</sup>	954
Schwannoma	1.04	Evans <i>et al.</i> <sup>3</sup>	458
Meniere's disease	4.3	Kotimaki <i>et al.</i> <sup>4</sup>	2051
Sudden unilateral sensorineural hearing loss	5–20	Byl <sup>5</sup>	2385–9540

- Approximately **7500** new cases per year (2003 UK population 48m)
- Equivalent to **9800** (Estimated 2012 population 63m)

[Clin Otolaryngol.](#) 2006 **The evidence base for the application of contralateral bone anchored hearing aids in acquired unilateral sensorineural hearing loss in adults.** 31(1):6-14. [Baguley DM](#), [Bird J](#), [Humphriss RL](#), [Prevost AT](#).

# Evidence from literature

## General SSDC population

- 73% (31/43 patients) with unilateral SNHL experienced significant audiological handicap (HHI-A)
- High variance in scores – wide range of handicaps
- Items related to **feeling frustrated, upset, and left out** had the three highest scores
- Range of thresholds

Newman et al. 1997 **Perceived hearing handicap of patients with unilateral or mild hearing loss.**  
Ann. Otol. Rhinol. Laryngol. 106, 210–214



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# Evidence from literature

## Sudden-onset hearing loss

- 86% (18/21) patients who had previously experienced sudden SNHL indicated severe audiological handicap.

Chiossoine-Kerdel J.A., Baguley D.M., Stoddart R.L. et al. (2000)

**An investigation of the audiological handicap associated with unilateral sudden sensorineural hearing loss.**

Am. J. Otol. 21, 645–651

## High co-incidence of troubling tinnitus

- 76% described tinnitus (42% ‘annoying’)
- Ti was significant predictor of greater anxiety and poorer QoL

Carlsson et al (2011) Quality of life, psychosocial consequences, and audiological rehabilitation after sudden sensorineural hearing loss.

IJA 50,(2) 139-144

# Evidence from literature

## Handicap in Meniere's:

- Significant hearing handicap in this population (but emotional handicap > physical)

### **Factors Influencing Quality of Life in Patients with Meniere's Disease, Identified by a Multidimensional Approach**

Söderman, Anne-Charlotte Hessén\*; Bagger-Sjöbäck, Dan\*; Bergenius, Johan†; Langius, Ann‡  
Otology & Neurotology: 23(6) pp941-948

## Middle ear surgery:

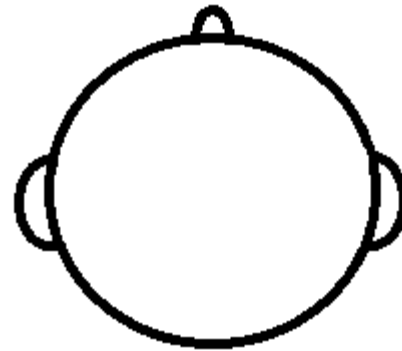
- Significant hearing handicap (along with vestibular handicap) in sample of two individuals

### **Patients' Lives following Stapedectomy Complications.**

Arnold W, Häusler R (eds): Otosclerosis and Stapes Surgery. Adv Otorhinolaryngol. Basel, Karger, 2007, vol 65, pp 348-352

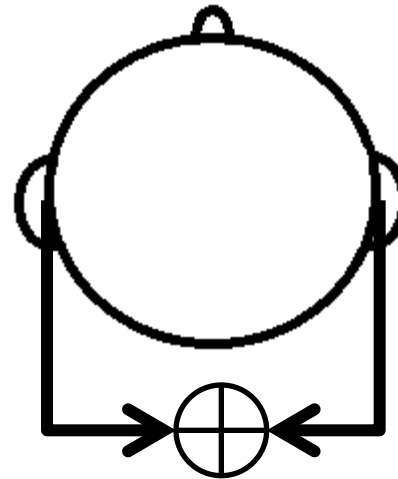


# Mechanism of auditory impairment



# Mechanism of auditory impairment

**Audibility / Loudness**





# Mechanism of auditory impairment

## Audibility / Loudness

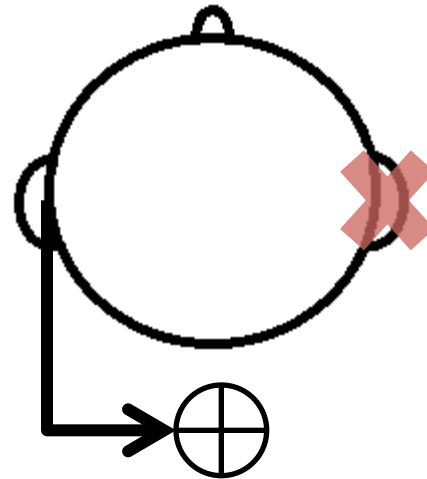
loss of binaural summation:

Loudness reduced by 3 dB at threshold,

6 dB at 30 dB > threshold

10 dB at 90 dB > threshold

(Hirsh, 1948; Licklider, 1948; Reynolds & Stevens, 1960).



# Mechanism of auditory impairment

## **Audibility / Loudness**

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Loudness reduced by 3 dB at threshold,

6 dB at 30 dB > threshold

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(Hirsh, 1948; Licklider, 1948; Reynolds & Stevens, 1960).

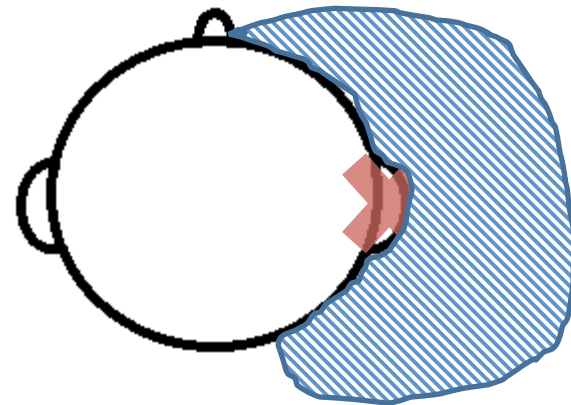
### Loss of 'directional audibility' : Head Shadow

Time-average speech attenuated by 6.4 dB

averaged across frequencies (Tillman et al, 1963).

Affects frequencies > 1KHz more severely –

reduces audibility of consonants

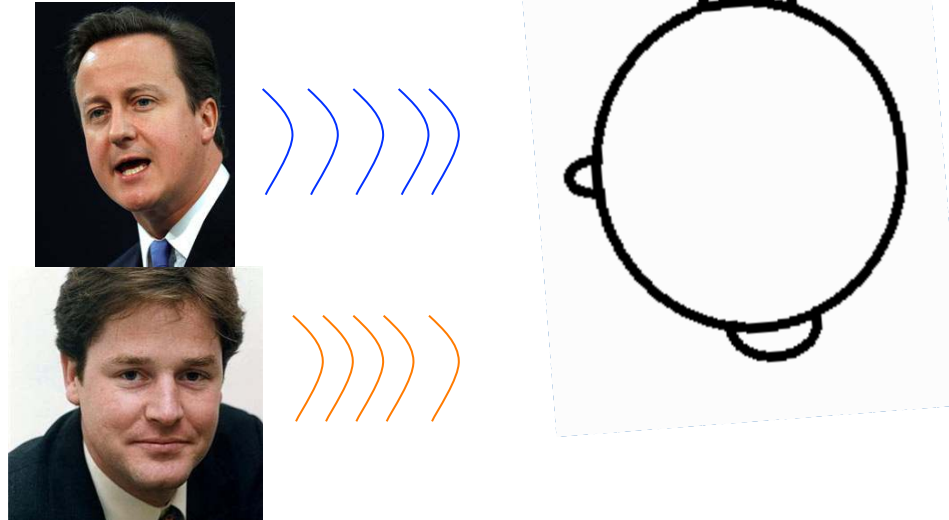


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# Mechanism of auditory impairment

## Cutting your binaural benefits

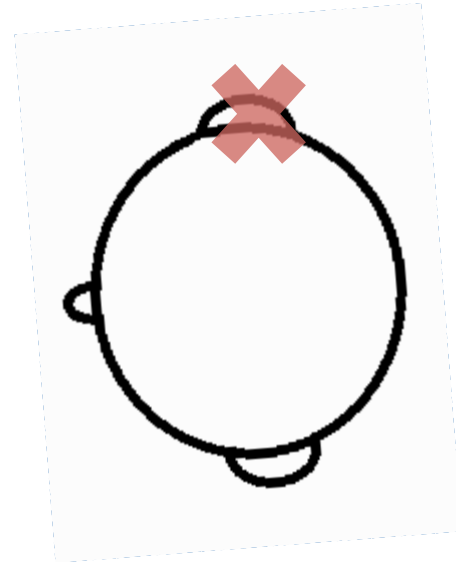
-Reduced source segregation



# Mechanism of auditory impairment

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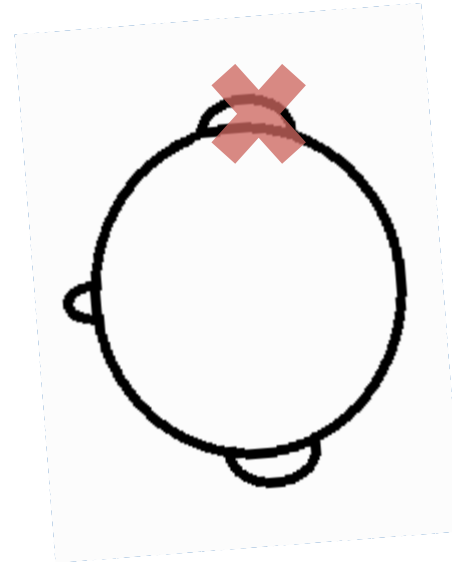
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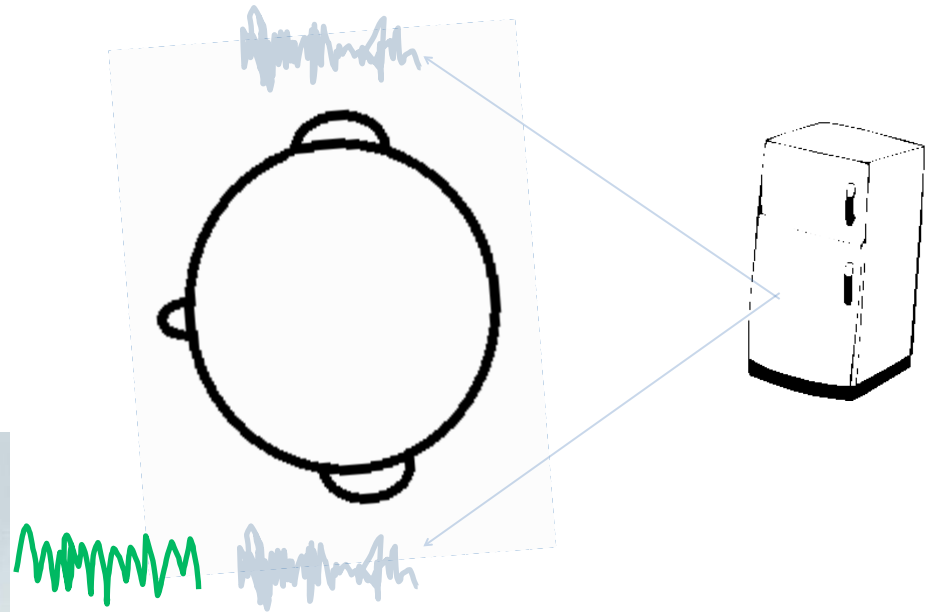
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# Mechanism of auditory impairment

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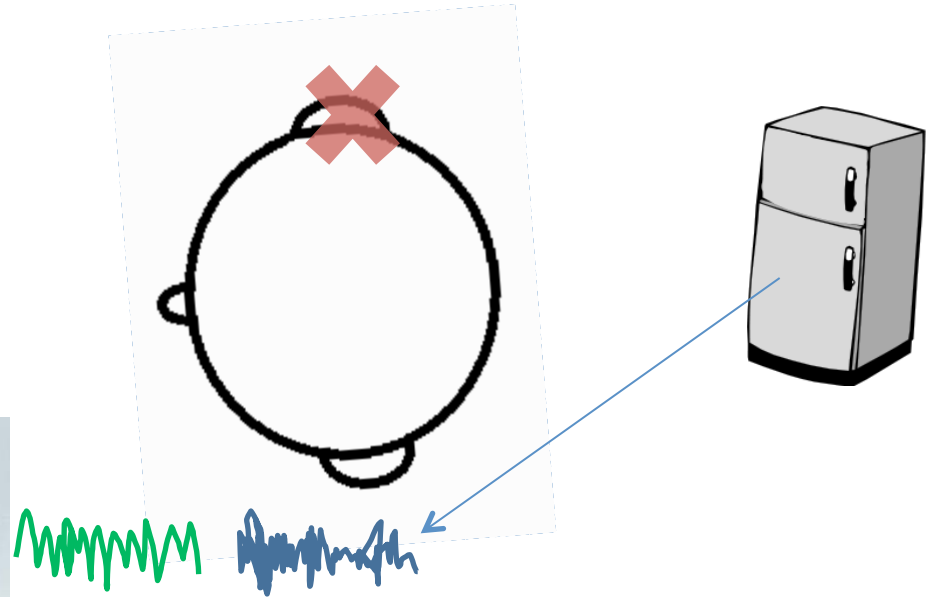
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- No binaural masking release (3db-13dB, Levitt and Rabiner 1967)



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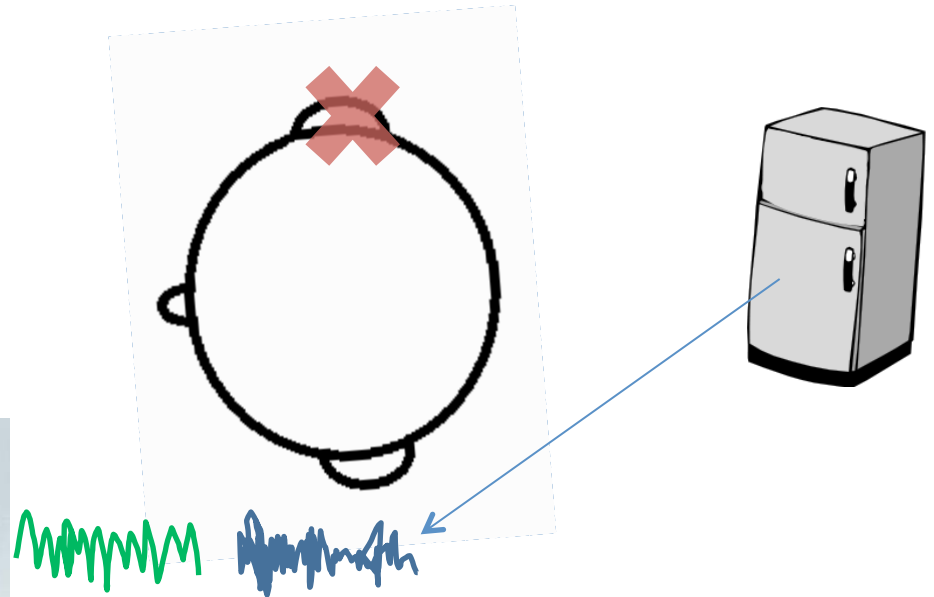
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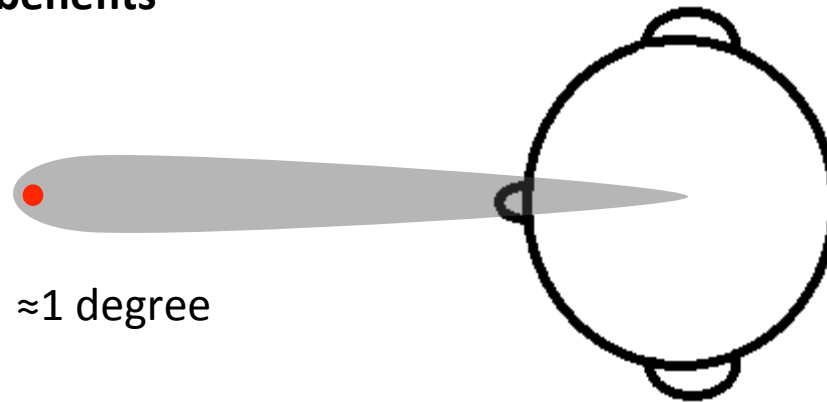
The result of losing these benefits is that a significantly higher signal-to-noise ratio is required in order for speech discrimination to occur



# Mechanism of auditory impairment

## Cutting your binaural benefits

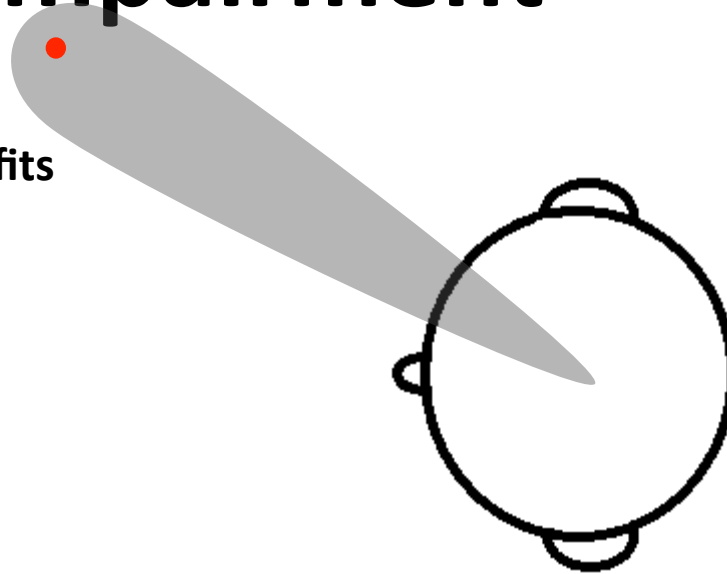
- Reduced source segregation
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- Reduced localisation (Van Wanrooij and Van Opstal 2006)



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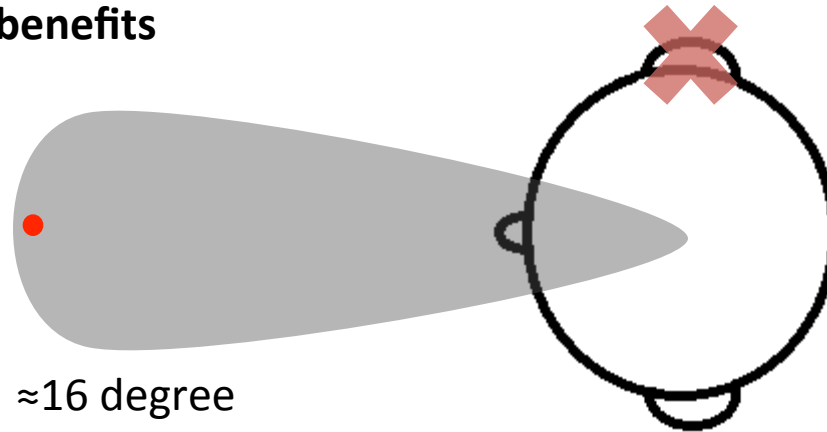
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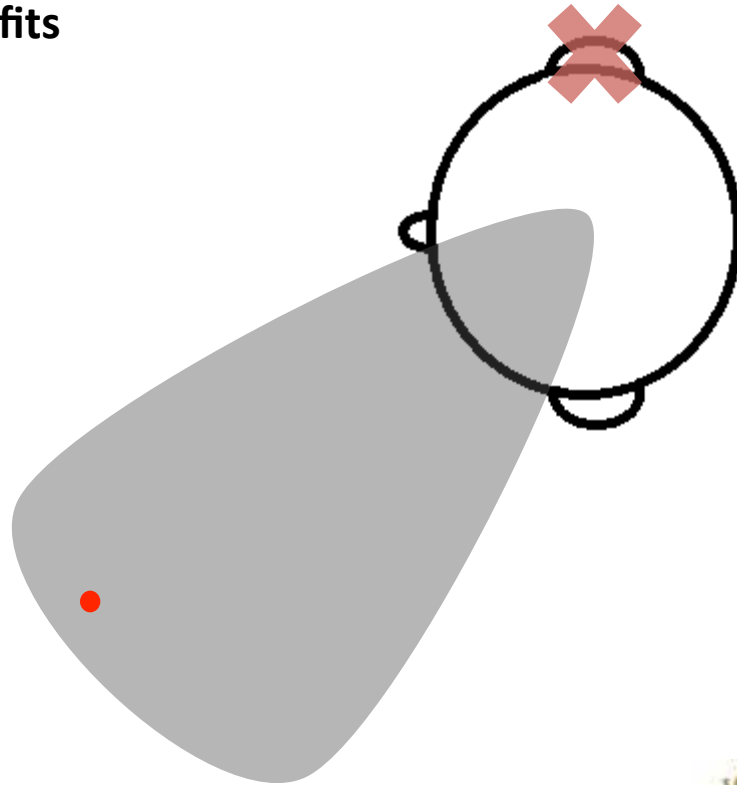
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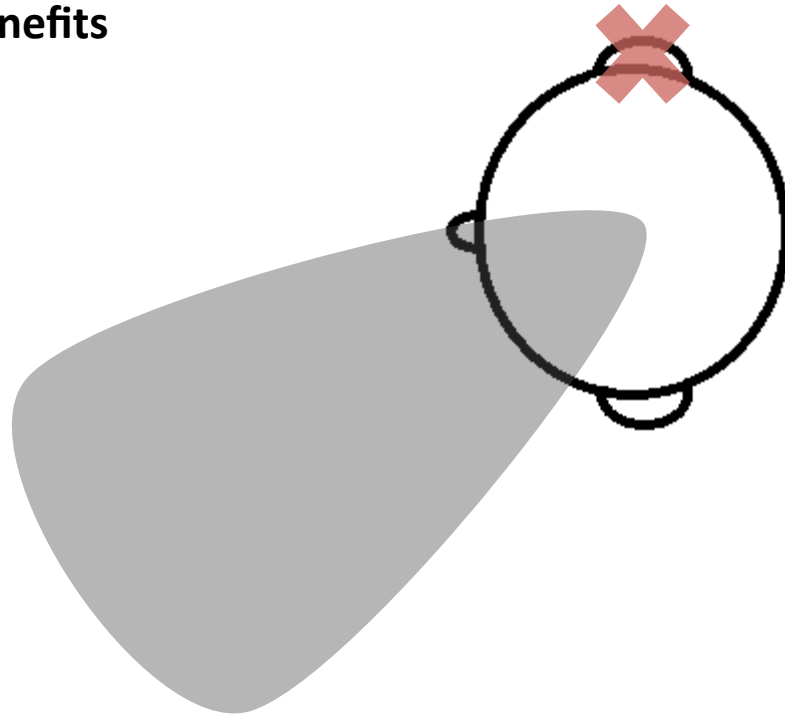


# Mechanism of auditory impairment



## Cutting your binaural benefits

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# Summary of impairments of 'normal' binaural auditory function

- Reduced source segregation
- Reduced release from binaural masking
- Reduced localisation

# Take care of the SSD patient

- Aetiologies of unilateral hearing loss include sudden hearing loss
- This may provide different challenges to the dispenser
- Shock/grief/anger
- Important factors in rehabilitation process
- Consider the “patient journey model” before considering devices



# LOST AND SOUND



[The Film](#) [The Filmmakers](#) [Trailer](#) [Screenings](#) [Press](#) [Your Panic List](#) [Links](#) [Contact](#)

## The Film



Lost and Sound is a moving creative documentary, made by a partially deaf filmmaker.

It weaves its way through a startling world of sound and silence, via the ears and brains of these extraordinary people as they try to re-discover music after deafness: a dancer deaf since birth, a young pianist who lost her hearing as a baby, and a music critic facing sudden partial hearing loss.

Music is one of the greatest of all human experiences; millions of us fall under its spell every day, and it engages more parts of the brain than any other human activity.

But 1 in 7 of us will experience deafness in our lifetime. What if you lost the ability to hear music?

Could you find it again... and could music find you?

Featuring: Dr David Eagleman, Philip Ball, Professor Nigel Osborne, Dr Katie Overy, Professor David Huron, Dr Robert Zatorre

© Little by Little Films & Animal Monday

<http://lostandsound.org/>




# Approaches to Management: “Sudden onset” population

- Counselling and support
- Listening tactics
- Assistive listening devices (safety)
- Tinnitus management
- Clinical anxiety and/or depression
- Diagnostics: ULLs and speech testing

# Amplification options: Contralateral Routing of Signal

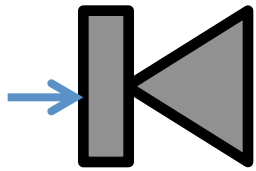
- CROS aids
- BiCROS aid Transcranial CROS
- Candidacy
- Evidence base for effectiveness
- Technology
- Fitting and verification
- Future developments



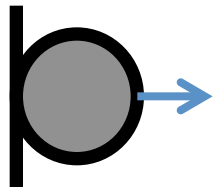
Discussed  
in context  
of  
maximising  
Outcomes

# CROS

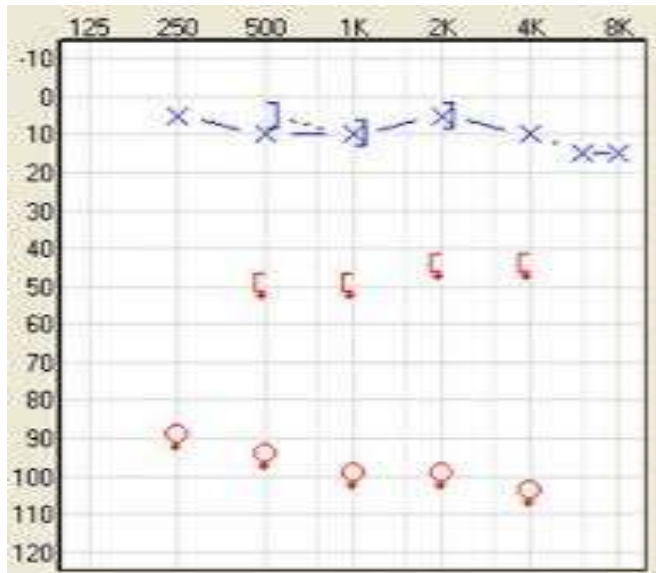
Contralateral Routing Of Signal



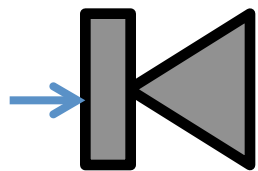
Receiver



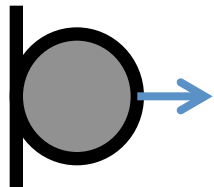
Microphone



# CROS



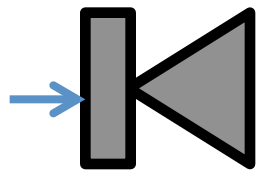
Receiver



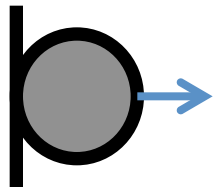
Microphone



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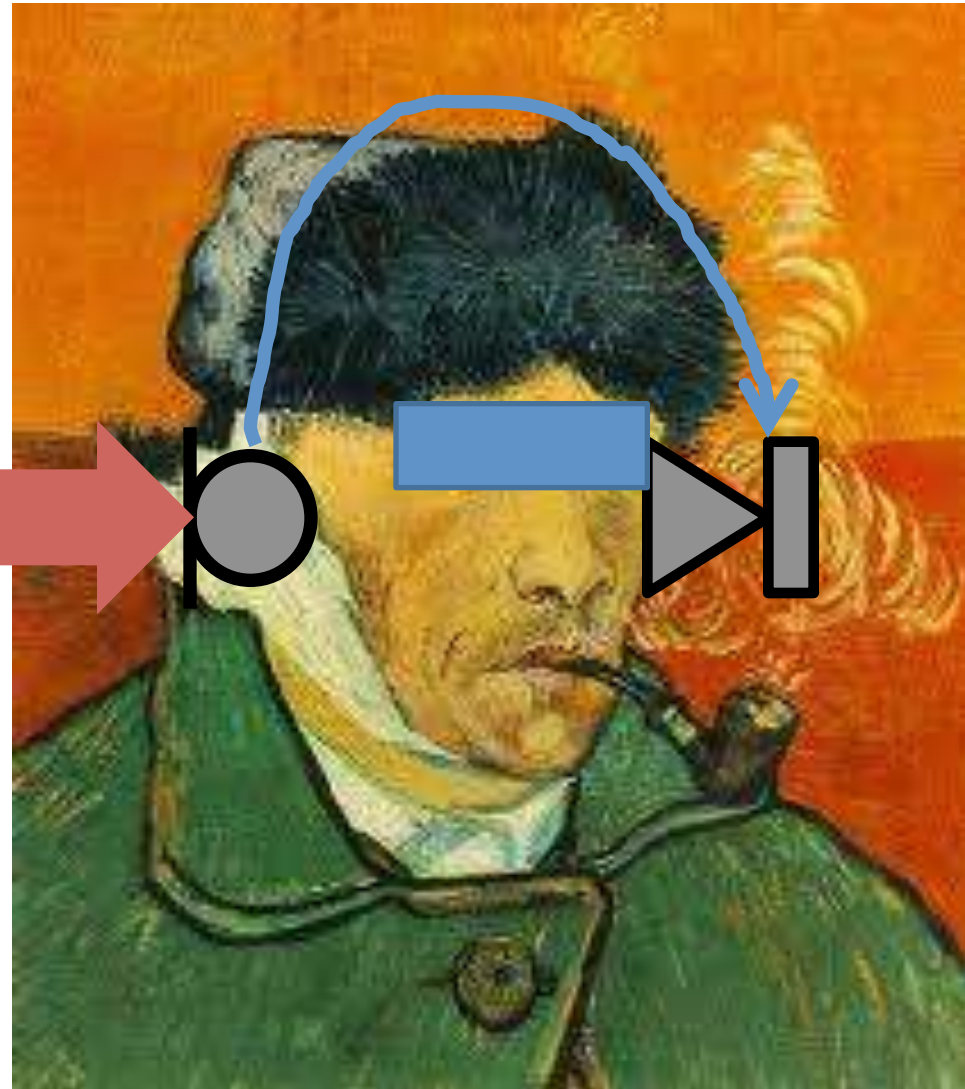


Receiver

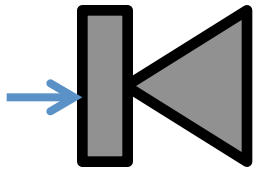


Microphone

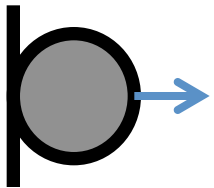
**SOUND**



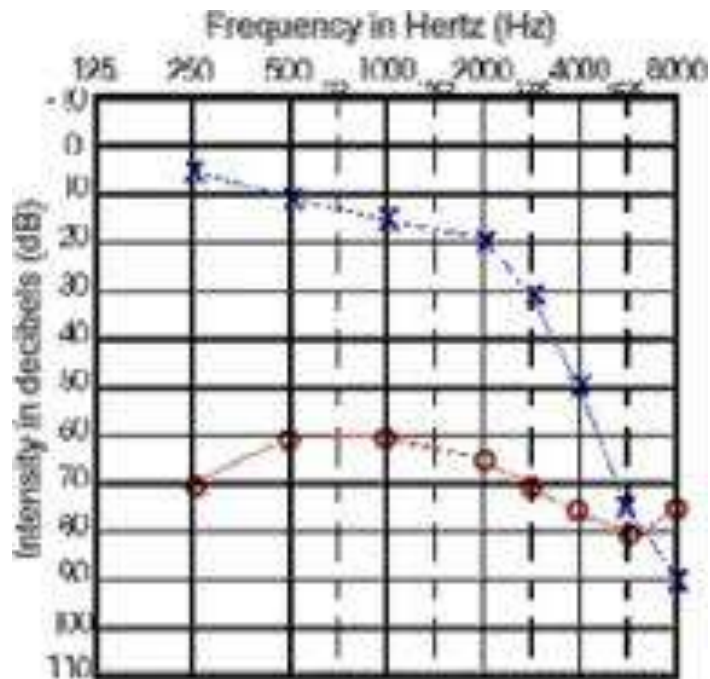
# BiCROS



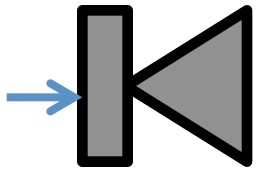
Receiver



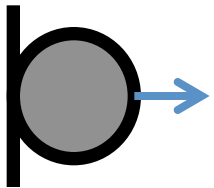
Microphone



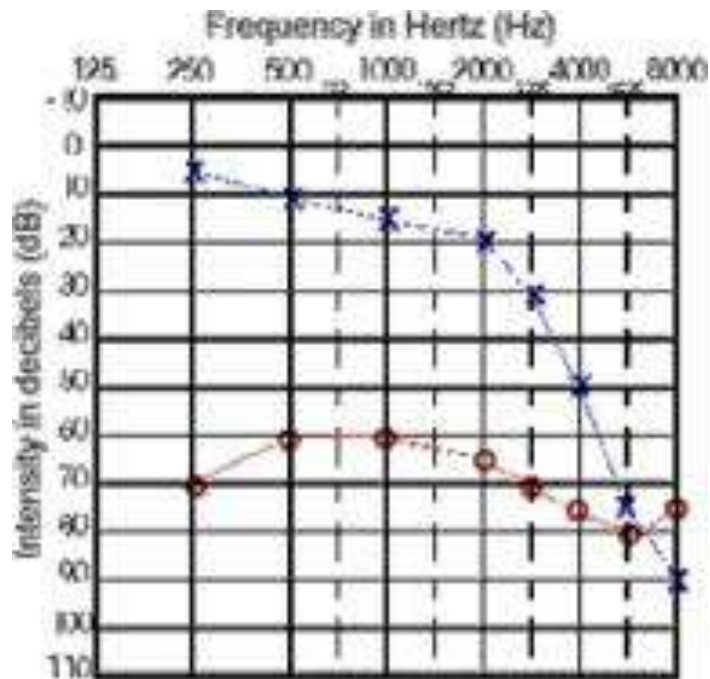
# BiCROS



Receiver



Microphone





# CROS vs BiCROS

- CROS

1x microphone (poor ear)

+

1x speaker (better ear)

- BiCROS

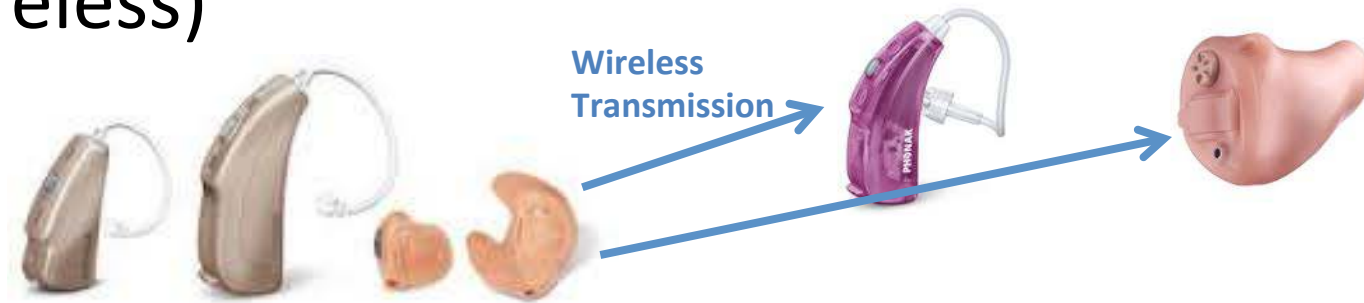
2x microphones (poor ear + better ear)

+

1x speaker (better ear)

# (Bi)CROS aids

- Different types (BTE vs ITE. wired vs Specs vs wireless)

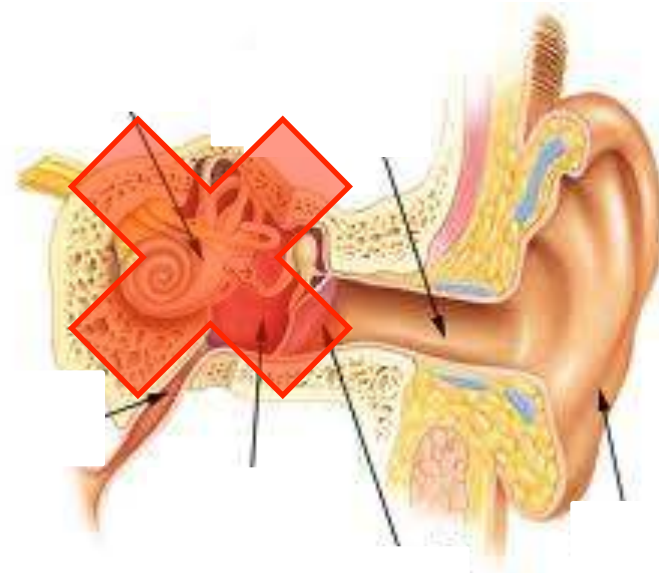
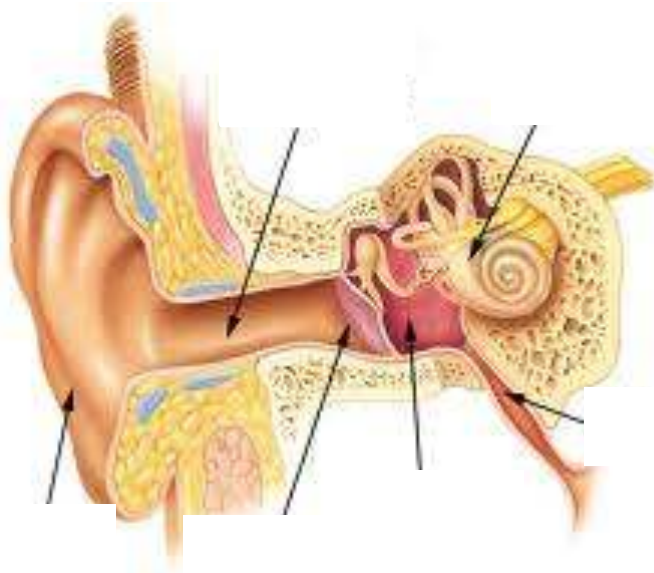


[spectaclehearingaids.wordpress.com](http://spectaclehearingaids.wordpress.com)



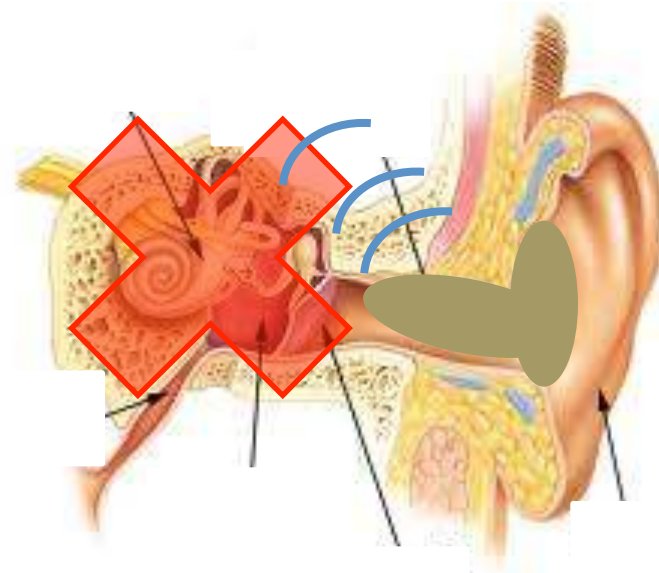
# Transcranial CROS

- High-powered amplifier
- Deep, occluding earmould (reaching bony portion of auditory meatus)



# Transcranial CROS

- High-powered amplifier
- Deep, occluding earmould (reaching bony portion of auditory meatus)
- Sound energy transmitted via bone conduction to contralateral cochlea
- Feedback?
- Comfort? Deep mould + vibrotactile sensation
- Not suitable for 'problem ears'



# Evidence-base for CROS use

## “Success rate” < 50%

Harford E, Barry J A rehabilitative approach to the problem of unilateral hearing impairment: the contralateral routing of signals (CROS) J Speech Hear Disord 196; 30:121-138

Harford E, Dodds E. The clinical application of CROS. A hearing aid for unilateral deafness Arch Otolaryngol 1966; 83(5):455-464

Valente et al, Fitting Options for Adult Patients with Single Sided Deafness (SSD), Audiology online (2006)

## Higher success rate in cases with a mild high-frequency hearing loss on better hearing ear

Taylor R, Contralateral Routing of the Signal Amplification Strategies Semin Hear 2010; 31(4): 378-392

## Better outcomes linked to high levels of motivation

Punch J, CROS revisited ASHA 1988; 30 (2) 35-37

## Issues with the above:

Candidacy – use correct tool for correct purpose

Improvements in technology (verification, validation and d

# Candidacy: (Bi)CROS

- Suitable hearing losses = one 'unaidable' ear
  - Dead / Severe-Profound
  - Poor speech discrimination
  - Hasn't tolerated unilateral aiding (hyperacusis)
  - Infection risk
- Candidate identifies difficulties of 'offside listening'

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# Candidacy: (Bi)CROS

- Assessment of needs

Use of relevant validated questionnaires:

- Client Orientated Scale Improvement (COSI)
- Speech Spatial Qualities (SSQ)
- Counselling (expectation monitoring)

Honest appraisal of benefits.

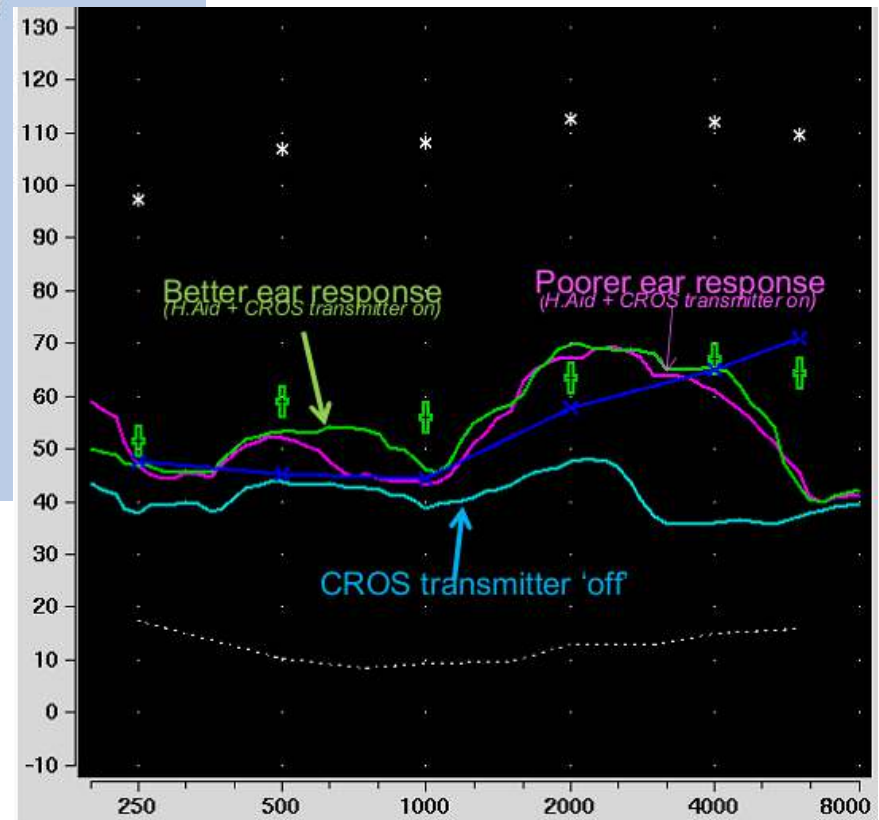
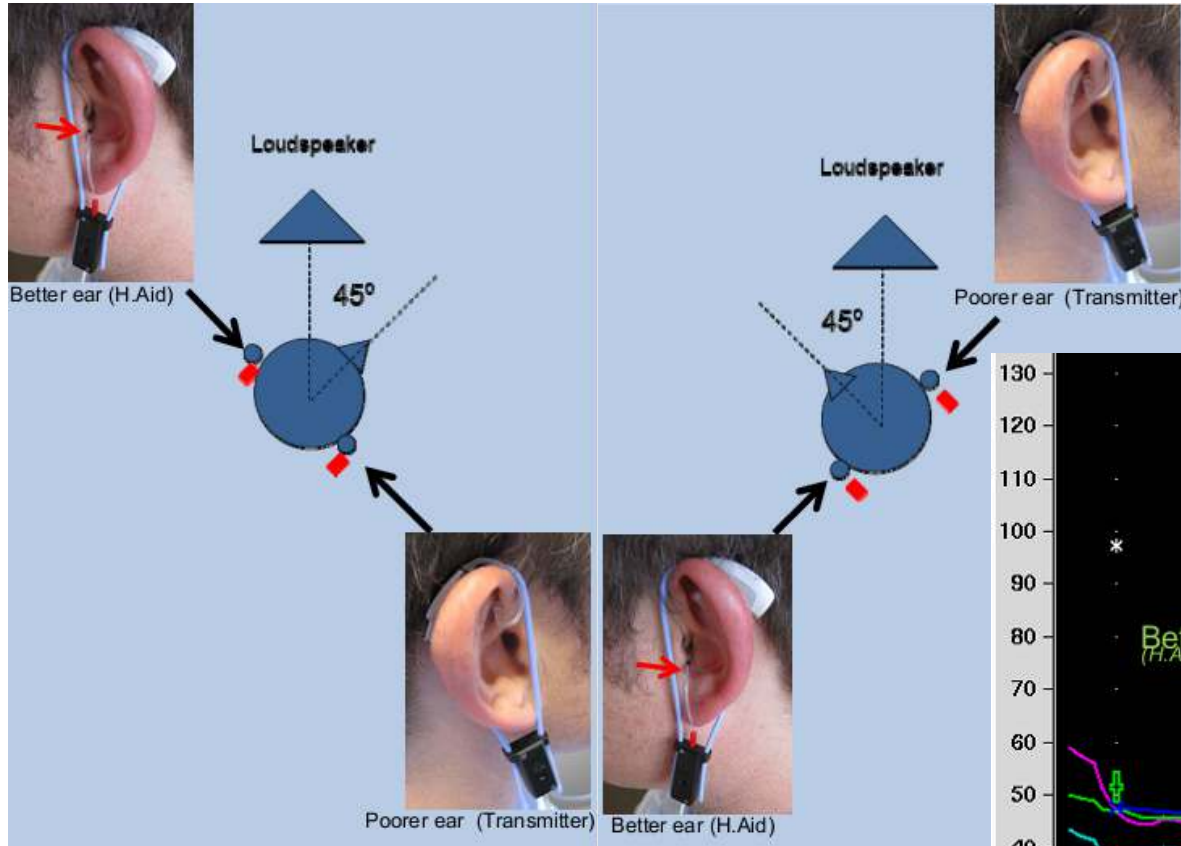
How much to wear?



# Technological improvements

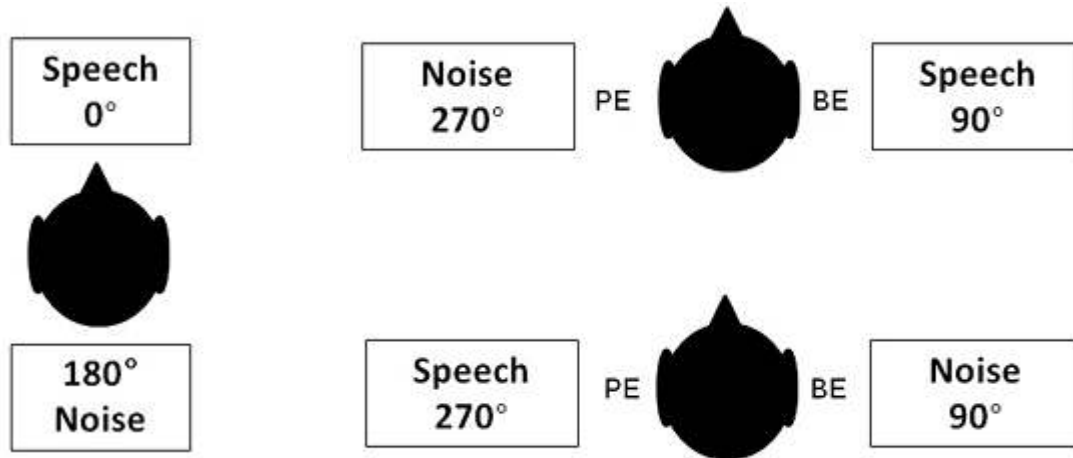
- Verification
- Validation
- Devices
- Directionality and beamforming
- Assistive listening devices / Bluetooth compatibility

# Fitting, Verification and Validation



# Validation

- (spatially separated) Speech in noise testing



## Words-in-Noise

(WIN; Wilson, 2003) test. The WIN test involved the presentation of monosyllabic words in multi-talker babble at seven signal-to-noise ratios (SNRs) from 24 to 0 dB in 4dB decrements.

# Technology: Devices

- Wireless vs wired devices

## Advantages: wireless

- obvious **cosmetic** and **practical** advantage

## Advantages: wired

- Signal quality (interference and loss of signal)
- Battery drain



- Digital wireless (small packets of digital data uses FM) vs analogue wireless (AM)

## Advantages: digital

- Interference resistant (frequency hopping spread spectrum)
- Output not linked to separation between devices (up to limits of range)
- Can be encrypted (can't listen-in to other people's CROS aids)

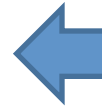
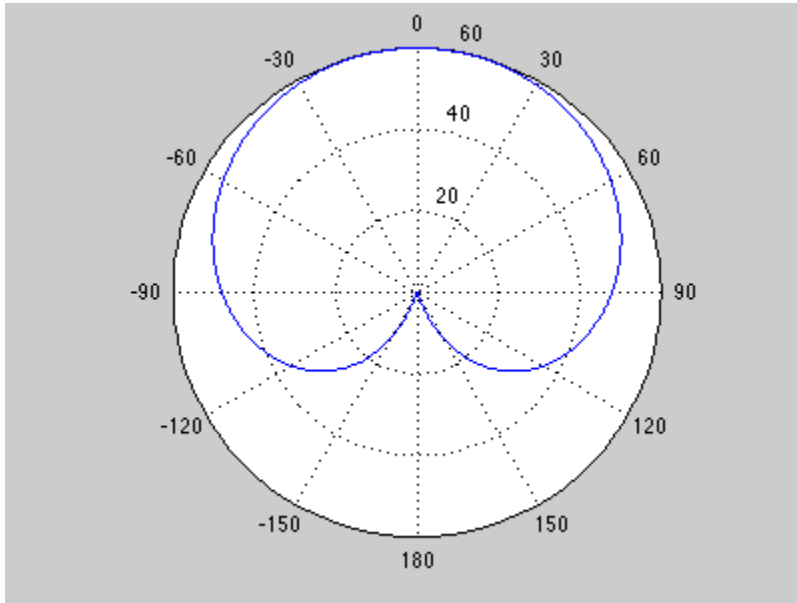
## Disadvantages: digital

- AD conversion takes time- introduces a lag
- Can reduce by reducing information sent (reduces quality)
- Can reduce by improving chipset (increases cost)
- Full Audiosignal transfer at 300kb/s
- Battery drain



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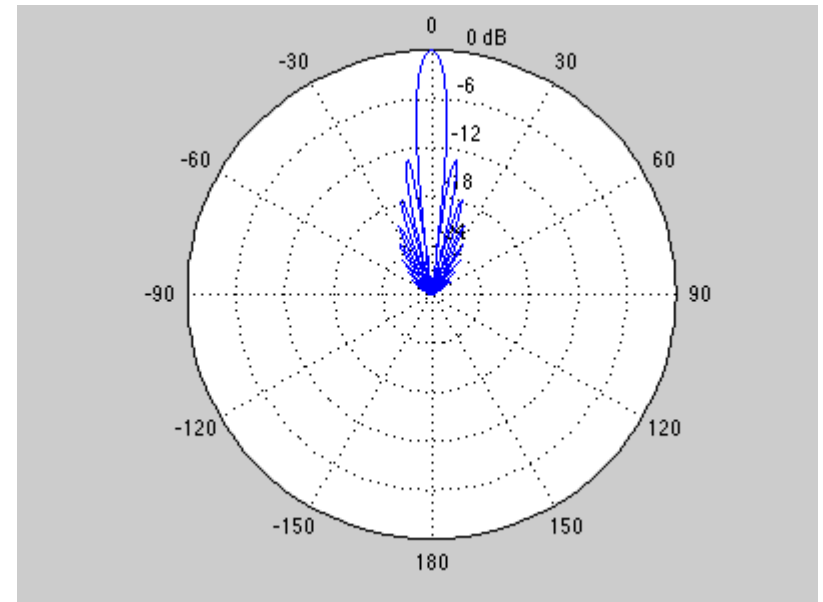
# Directionality and beamforming



Signal-to-noise ratio can be improved through directional microphones – modest improvements in speech understanding in noise

Dual microphones (+hence directionality) are now available on CROS transmitters

Binaurally-linked signal processing (between two devices) allows quite significant 'beamforming' of gain profile



# Assistive listening devices and bluetooth compatibility

- Use of remote microphones or inputs from devices TV/media players can significantly improve signal to noise ratio
- Might help alleviate loss of binaural benefits

Contemporary wireless CROS aids have capability of high levels of connectivity via a **'streamer'**



# Bone anchored hearing aid vs CROS

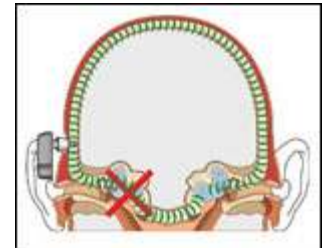
Insertion of permanent fixture into skull bones

Attachment of device that drives sound waves efficiently into skull

Transfers efficiently via bone conduction to hearing ear

Overcomes head shadow, but no different to CROS aid, except

- Poorer frequency response
- Surgical intervention (greater costs, maintenance and risk)
- Abutment not easily removed
- Limited power output
- Harder to verify fitting



# Future developments: Cochlear Implant for SSD



## Now CE-Marked!

Individuals with Single-Sided Deafness (SSD) can now benefit from Binaural hearing.

MED-EL offers the only CI system that is CE-Marked for SSD in both children and adults.

A true 'binaural' solution

Some implants have been inserted primarily for relief of chronic tinnitus

Research ongoing to determine what settings might return the greatest degree of binaural benefit



# Maximising CROS Outcomes

- My opinion:

Some individuals will **definitely** benefit from use of CROS aid.

With current technology this is significantly more than previously reported.

Some will definitely not benefit. Try and use suitable assessment and counselling to triage

- Motivation is the key to success. The wearer must recognize some situation or situations where his/her unaidable ear is degrading an aspect of his/her performance
- Don't oversell the aid – honesty about the limitations (as well as demonstrations of potential benefits)
- To use full time or not? Users will pick and choose their situations
- The most successful user will be a well-informed BiCROS user – multiple programs to maximise spatial benefit, perhaps verified, demonstrated and practiced in suitable soundfield set-up.
- Remember that we are not fitting a cochlear hearing loss in the case of a CROS fitting – think carefully about prescription formula and compression settings. As little gain as possible, low MPOs

# Thanks Again!



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University


# Slide 14: Evidence-base: CROS vs BiCROS


# Slide 23: Future research


# Slide 21: Summary of Williams 2012 article

# Disability

Welsh LW et al 2004 Functional impairments due to unilateral deafness Ann Otol Rhinol Laryngol. (12):987-93.

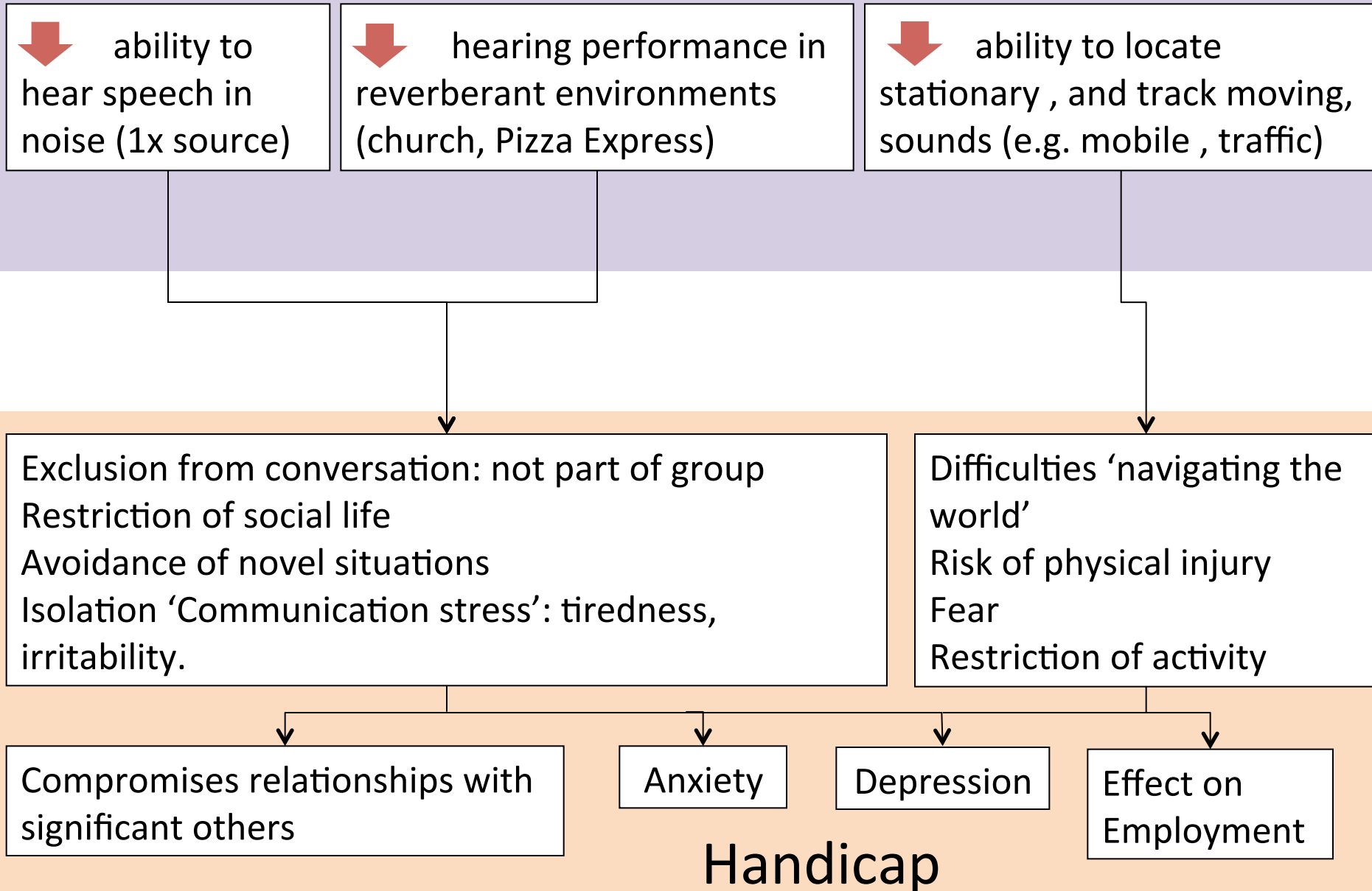
 ability to hear speech in noise (1x source)

 hearing performance in reverberant environments (church, Pizza Express)

 ability to locate stationary , and track moving, sounds (e.g. mobile , traffic)

# Disability

Welsh LW et al 2004 Functional impairments due to unilateral deafness *Ann Otol Rhinol Laryngol.* (12):987-93.



# Disability

Not feeling part of the auditory world

Loss/change of identity

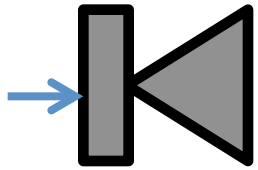
Loss of enjoyment of rich  
stereo sounds, in  
particular music

Anxiety

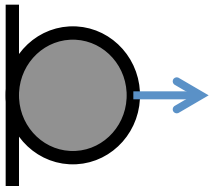
Depression

# Handicap





Speaker (receiver)



Microphone