# Rerouting signal in single side deafness

C. Vincent
Otology and Neurotology Department
University Hospital of Lille, France
Inserm U1008: Controlled drug delivery to the inner ear

## Stereophony

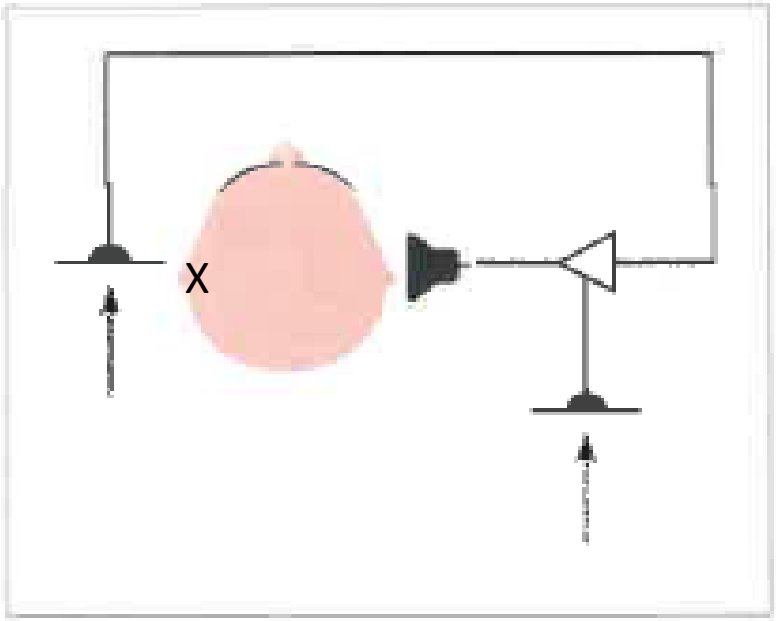
- augmentation of subjective threshold
- better sound localization
- better speech intelligibility in noise

## SSD

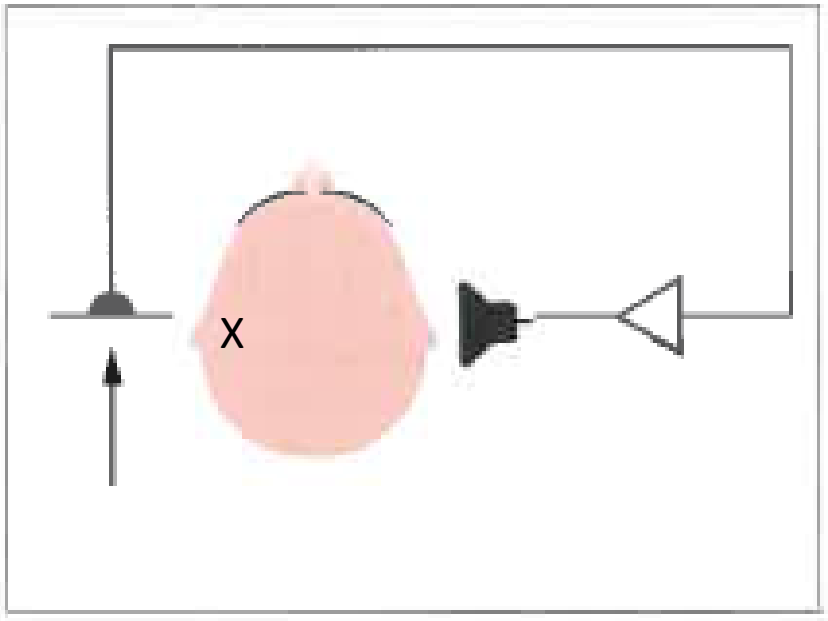
- problems with sound localization
- problem with speech intelligibility in noisy conditions
- difficulty to understand people located at the deaf side
- academic difficulties for children

# SSD rehabilitation: available devices

- Bone stimulation on the deaf side:
  - percutaneous: BAHA, PONTO
  - transcutaneous: BAHA Attract, Sophono, Bonebridge, Adhear, more to come…
- CROS, BICROS with conventional HA
- Cochlear implant (+ incapacitating tinnitus)




BICROS




CROS

# Rerouting SSD with BAHA

[Prosthetic rehabilitation of unilateral anakusis. Study with stereoaudiometry].

Vaneecloo FM, Hanson JN, Laroche C, Vincent C, Dehaussy J.

Ann Otolaryngol Chir Cervicofac. 2000 Dec;117(6):410-417

[The monaural pseudo-stereophonic hearing aid (BAHA) in unilateral total deafness: a study of 29 patients].

Vaneecloo FM, Ruzza I, Hanson JN, Gérard T, Dehaussy J, Cory M, Arrouet C, Vincent C.

Rev Laryngol Otol Rhinol (Bord). 2001;122(5):343-50

- Hearing in noise benefit
- Localization benefit

- Proper selection of candidates

# Tests for binaural hearing

- Discrepancies between questionnaires and audiological tests

→ problem of adequate audiological tests

- clinical test ≠ test performed for a clinical study
- Need to test 2 conditions:
  - Localization of sound
  - Hearing in noise
- Testing at home for 1 month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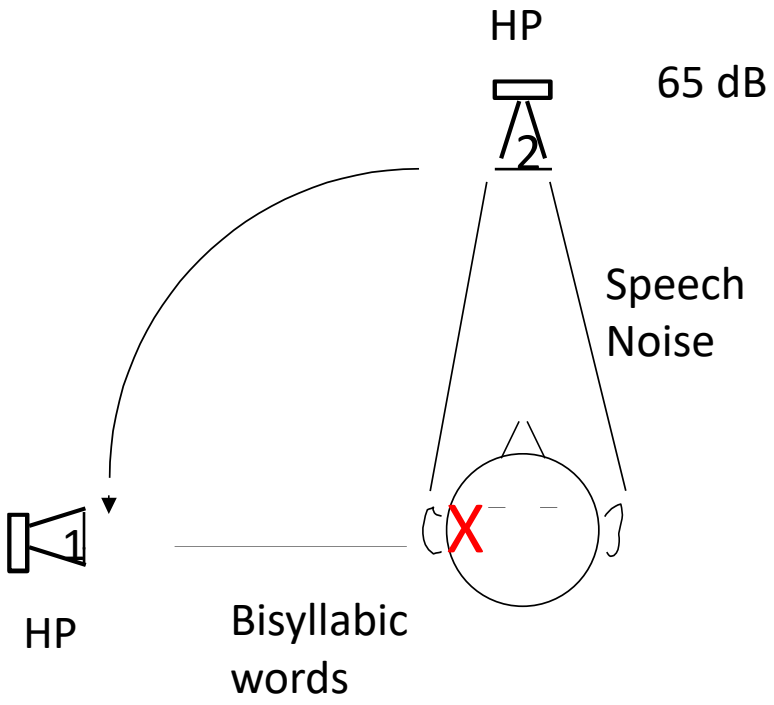
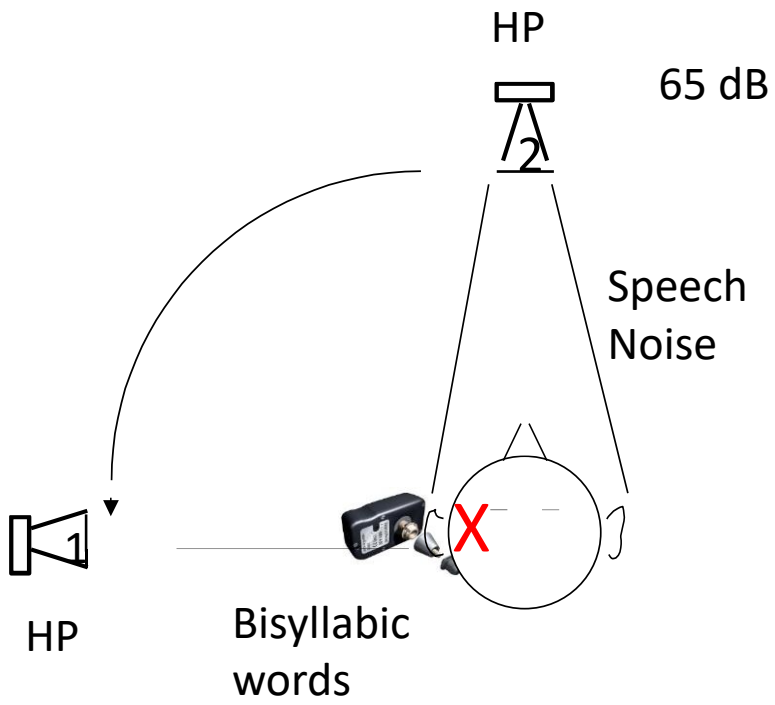
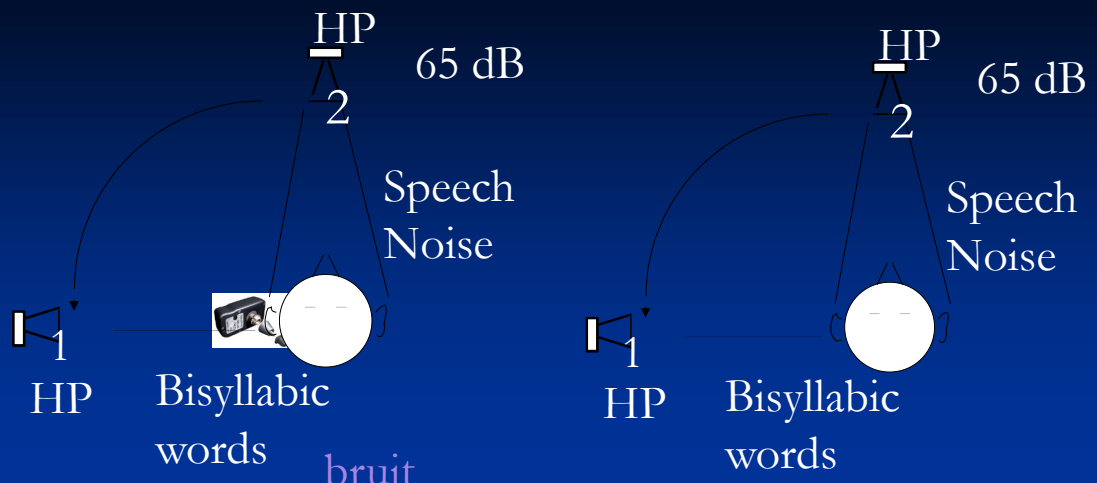
# Hirsh's test: Head Shadow Effect

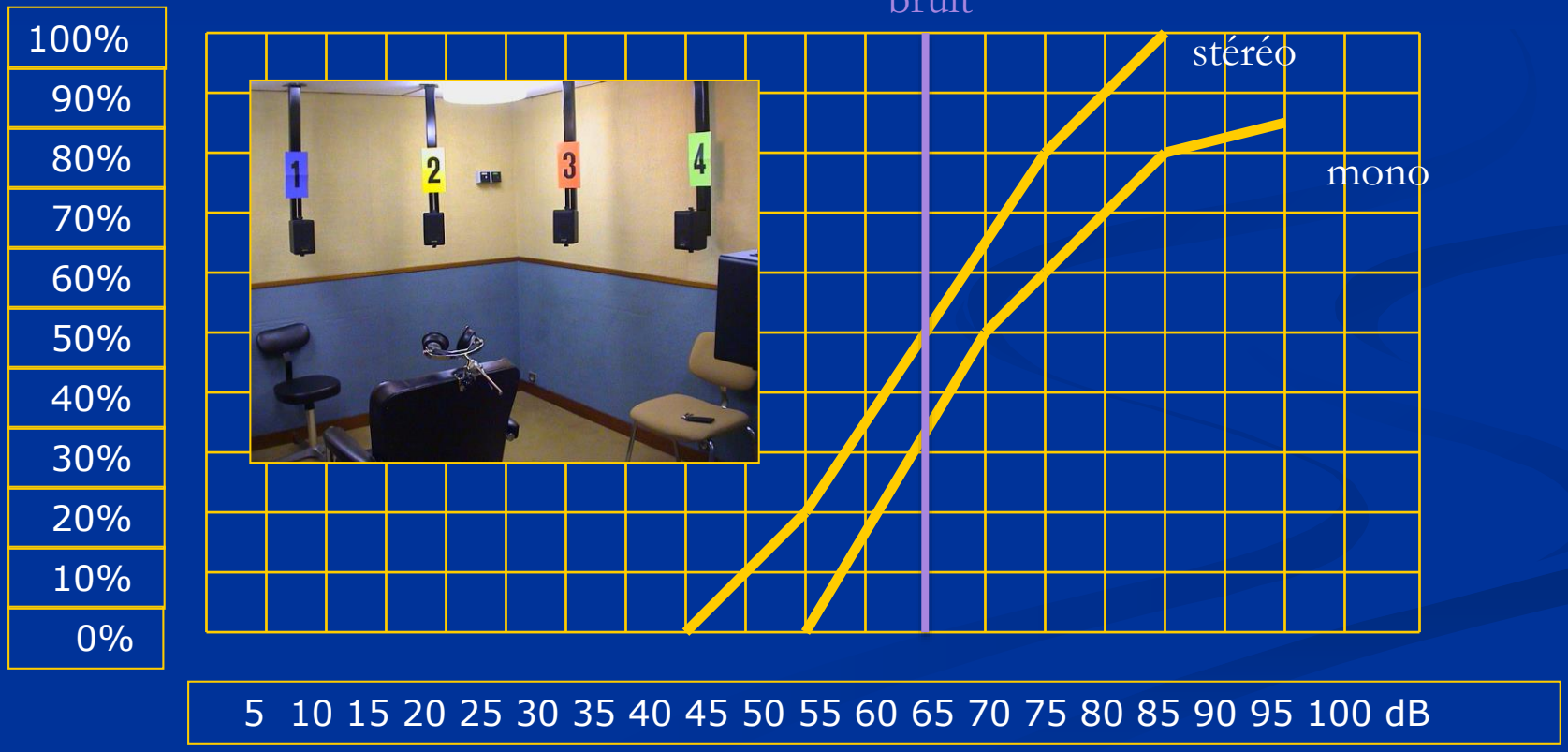



Monaural




Monaural+BAHA


HP
2
65 dB
Speech
Noise
1
HP
Bisyllabic
words
HP
2
65 dB
Speech
Noise
1
HP
Bisyllabic
words


100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
bruit
stéréo
mono
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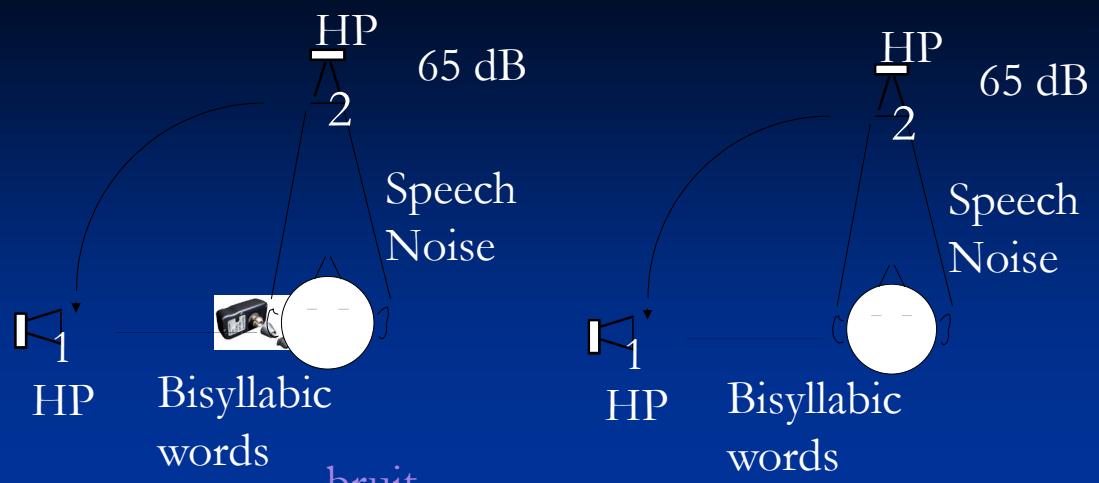
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 dB


HP
2
65 dB
Speech
Noise
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HP
Bisyllabic
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HP
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Speech
Noise
1
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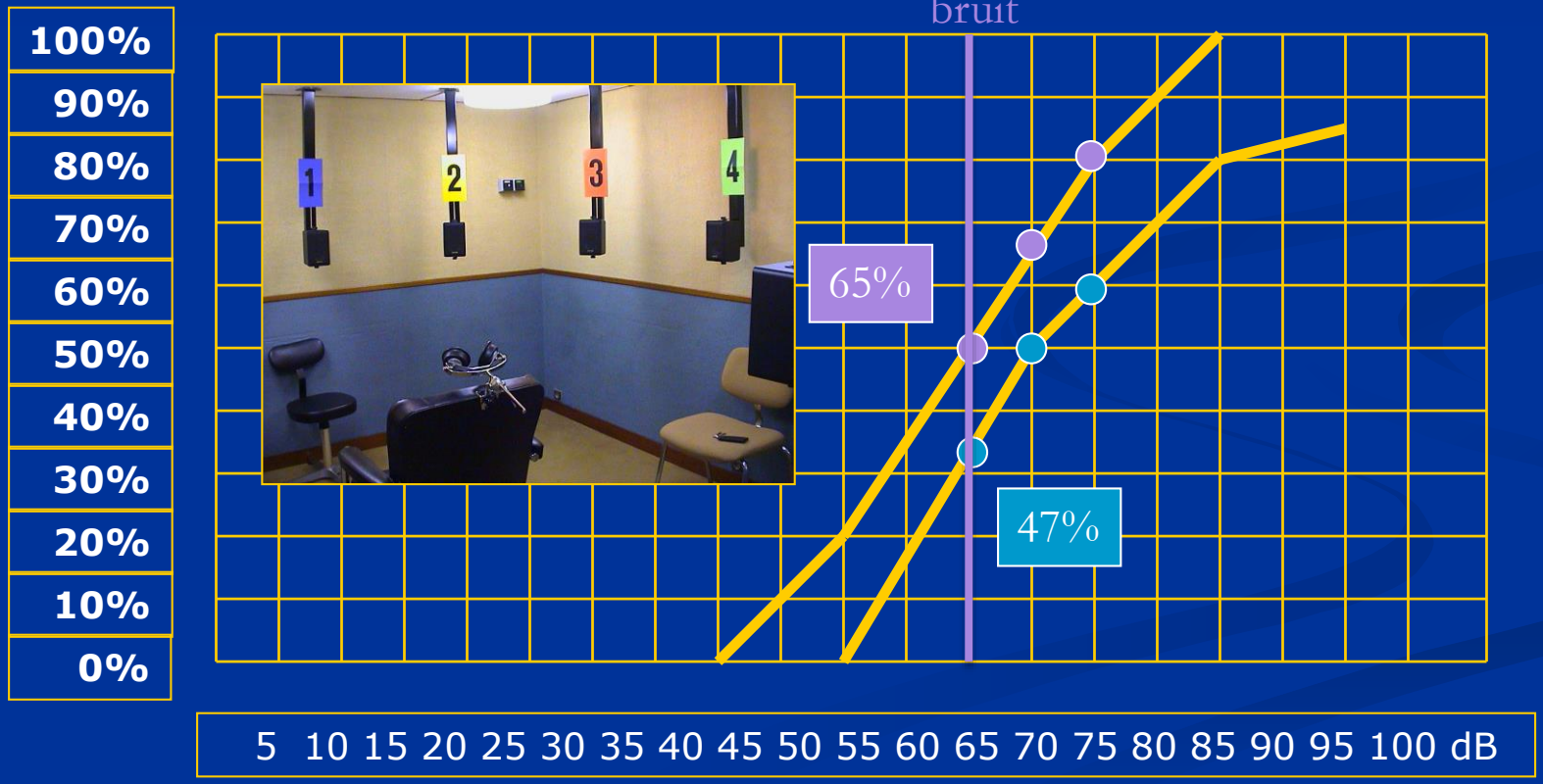
Bisyllabic
words


100%
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60%
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40%
30%
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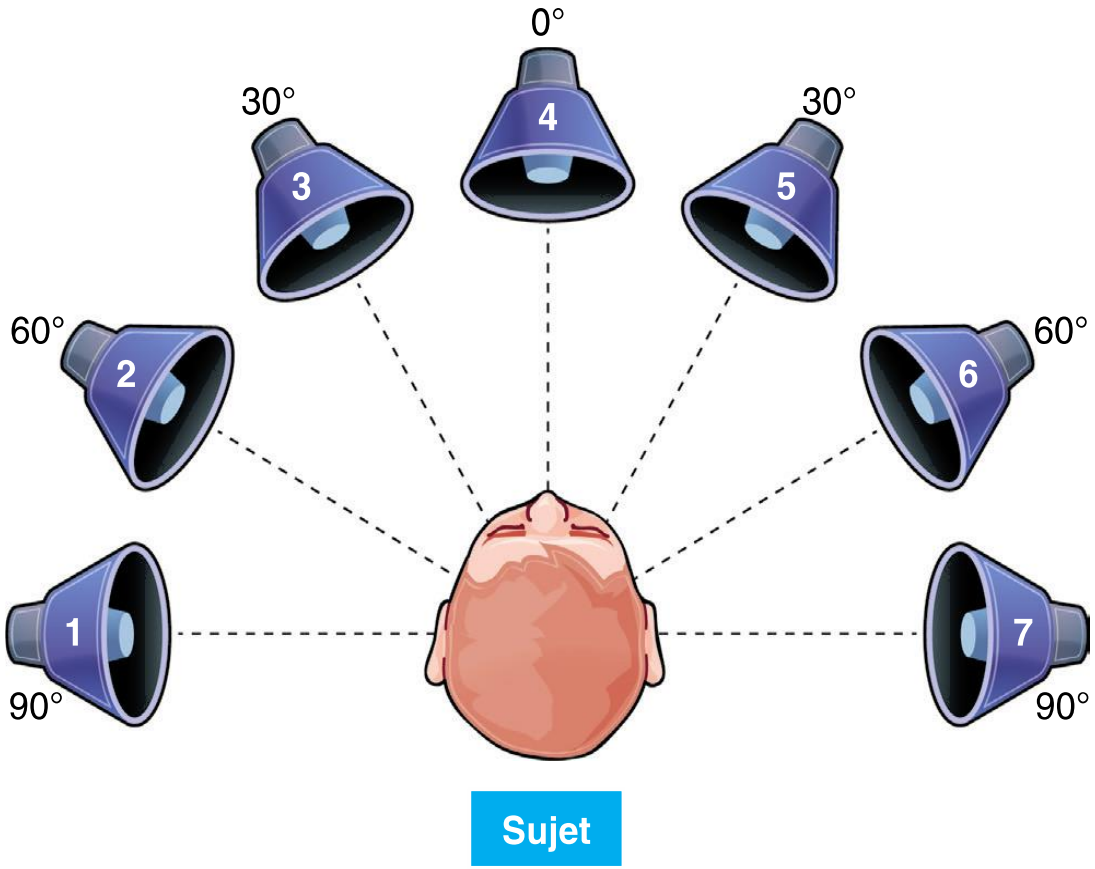
10%
0%
bruit
65%
47%
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 dB

# Hearing in noise benefit with BAHA & SSD

- Summation effect ≈ 6 dB
- Better speech intelligibility in noise ≈ 25 %
- Better hearing from the deaf side




Subject seated at 1.5 m from the loudspeakers

Testing protocol (Risoud et al, Eur Ann Otorhinolaryngol Head Neck Dis. 2018 Aug;135(4):259-264).

Table 1. Accuracy of azimuthal sound source localization by interaural time difference (ITD) and interaural level difference (ILD) according to frequency.

| Binaural localization cue | Localization accuracy | | |
|---|---|---|---|
| | < 1000 Hz | 1000–3000 Hz | > 3000 Hz |
| ITD | Good | Mediocre | Impossible |
| ILD | Impossible | Mediocre | Good |

Table 2. Accuracy of sound source localization in the vertical plane by head-related transfer function (HRTF) according to frequency.

| Monaural localization cue | Localization accuracy | |
|---|---|---|
| | < 7000 Hz | > 7000 Hz |
| HRTF | Moderate | Good |

Risoud et al, Eur Ann Otorhinolaryngol Head Neck Dis. 2018 Aug;135(4):259-264

# Clinical aspects of patient selection

- No indication based on the tonal audiometry,
- Clinical test (rod test) and stereaudiometry battery tests,
- Testing the device @ home for 1 month
- Patient motivation

-> Major point: duration of sound deprivation.

# First results of our series

- 60 SSD patients with BAHA
- mean age: 53 yo
- mean follow-up: 40 months

- questionnaires
- hearing in noise test
- localization test

# GLASGOW HEARING AID BENEFIT PROFILE

- 18.7 % very satisfied,
- 50.7 % satisfied,
- 20 % rather satisfied,
- 5.3 % rather unsatisfied,
- 5.3 % unsatisfied.

# Hearing in noise

- Speech intelligibility: disyllabic word @ 70 dB

in a speech noise background @ 65 dB

+22.8 % (lower SRT: – 6 dB)

# Localization

- Better localization:  25 %
- Localization right/left: 18.3 %
- No benefit in localization: 56.7 %

# Localization with BAHA & SSD

- ~~Interaural time differences (ITD)~~
- ~~Interaural level differences (ILD)~~
- Head-related transfer function (HRTF)

# Aim of the study

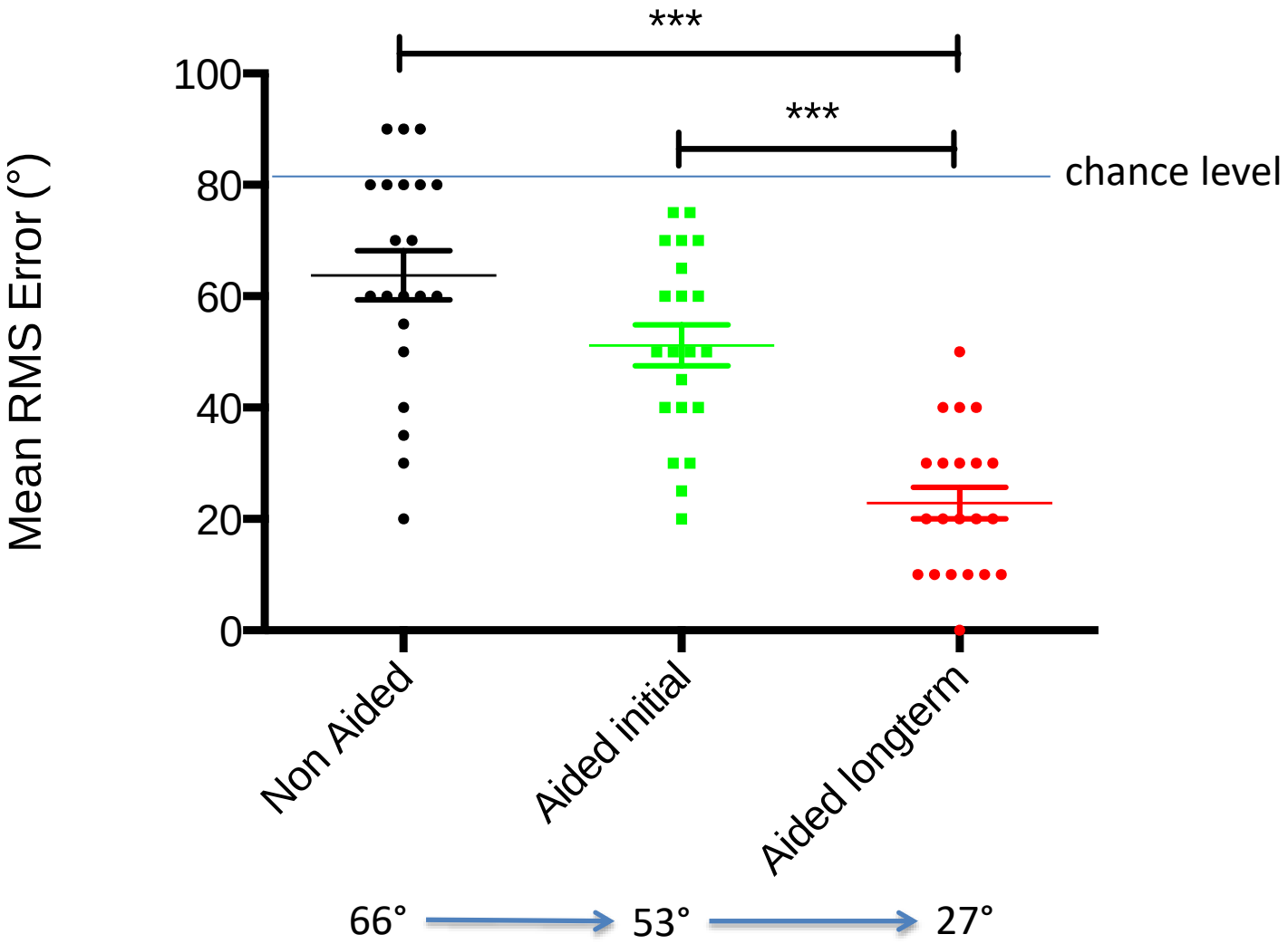
- Analyze the evolution of localization skills in the horizontal plane of SSD patients with BAHA and a long term follow-up

- Comparison of 3 situations:
  - non aided,
  - aided initially,
  - aided at last follow-up

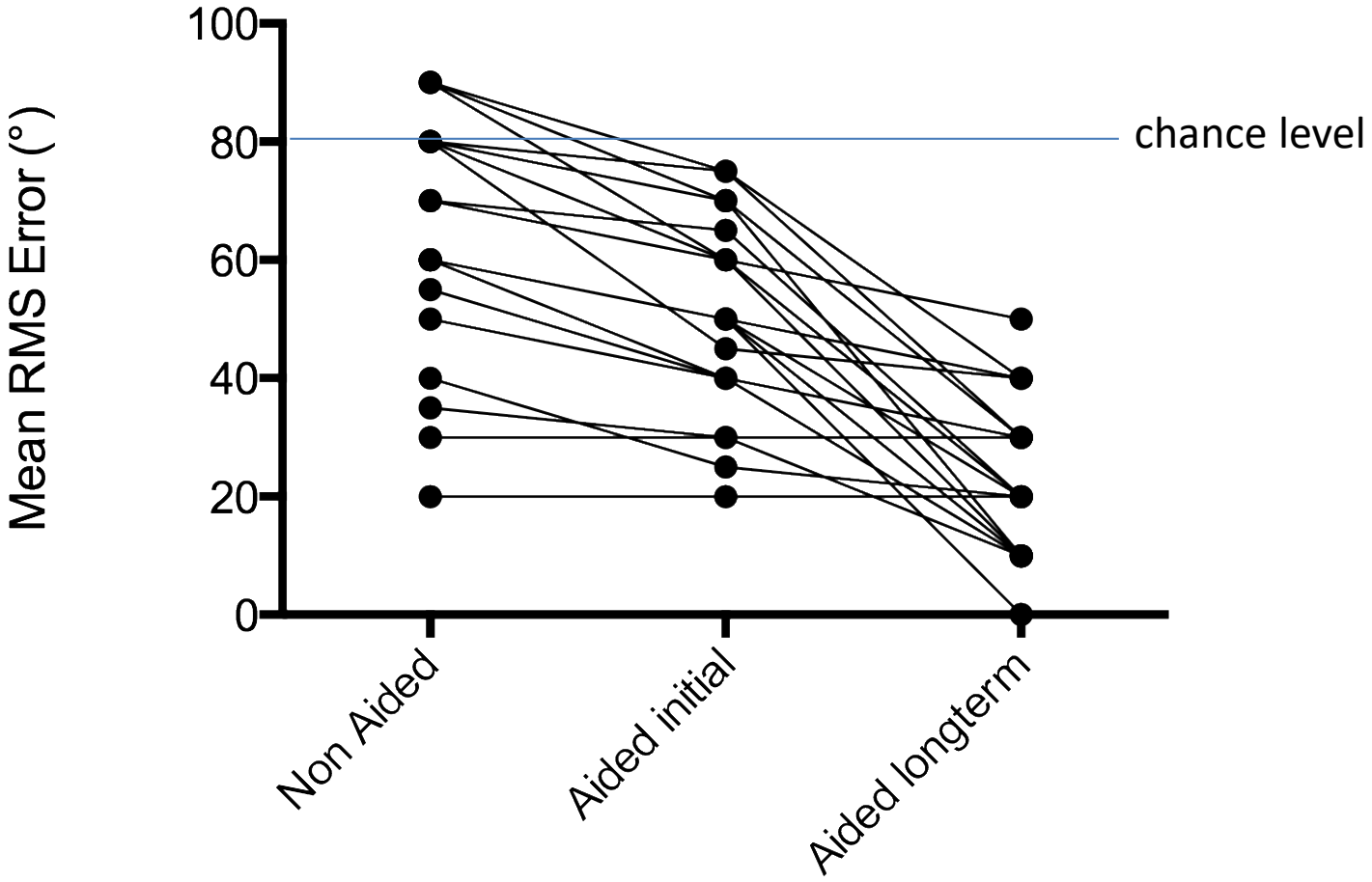
# Our series

- 122 SSD patients rehabilitated with the BAHA device between 2003 and 2012
- 48 patients had normal hearing on the contro-lateral side (PTA < 20 dB, SDS > 90 %)
- 21 patients (mean: 44 yo, median: 50 yo) accepted to come for evaluation
- Mean follow-up time: 6.4 years (median: 8 years)

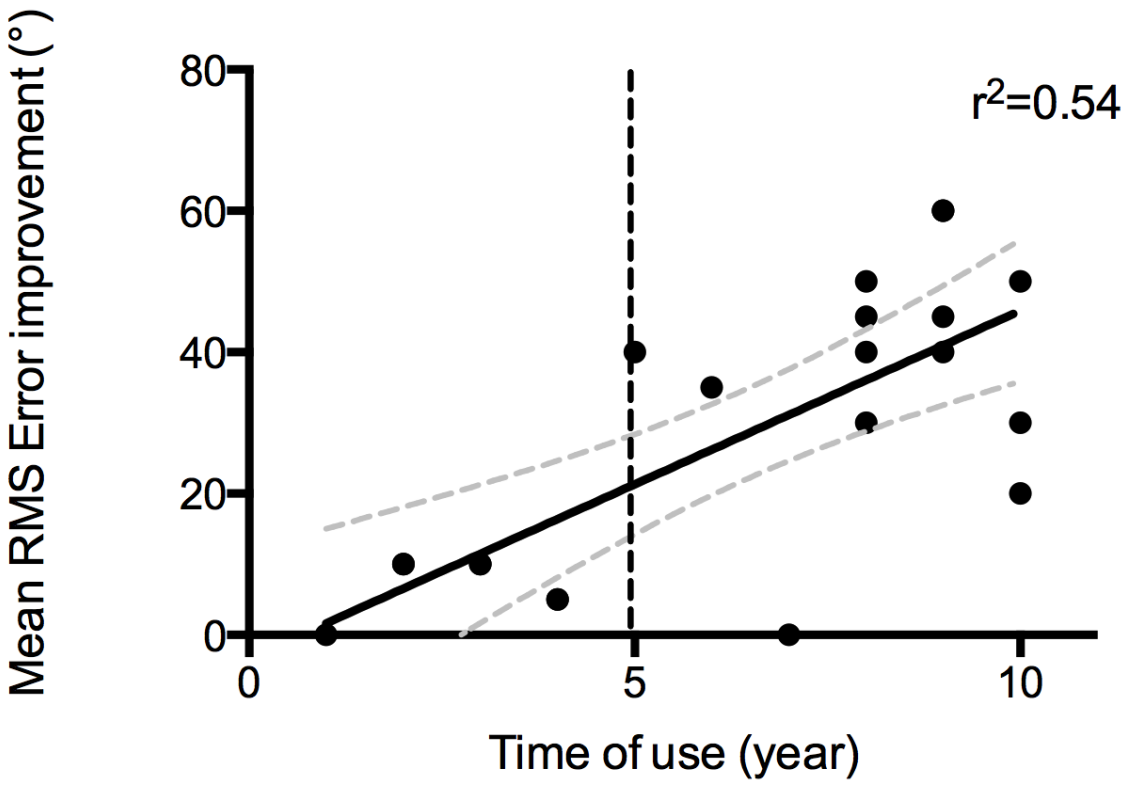
# Evolution of localization performances



# Evolution of localization performances

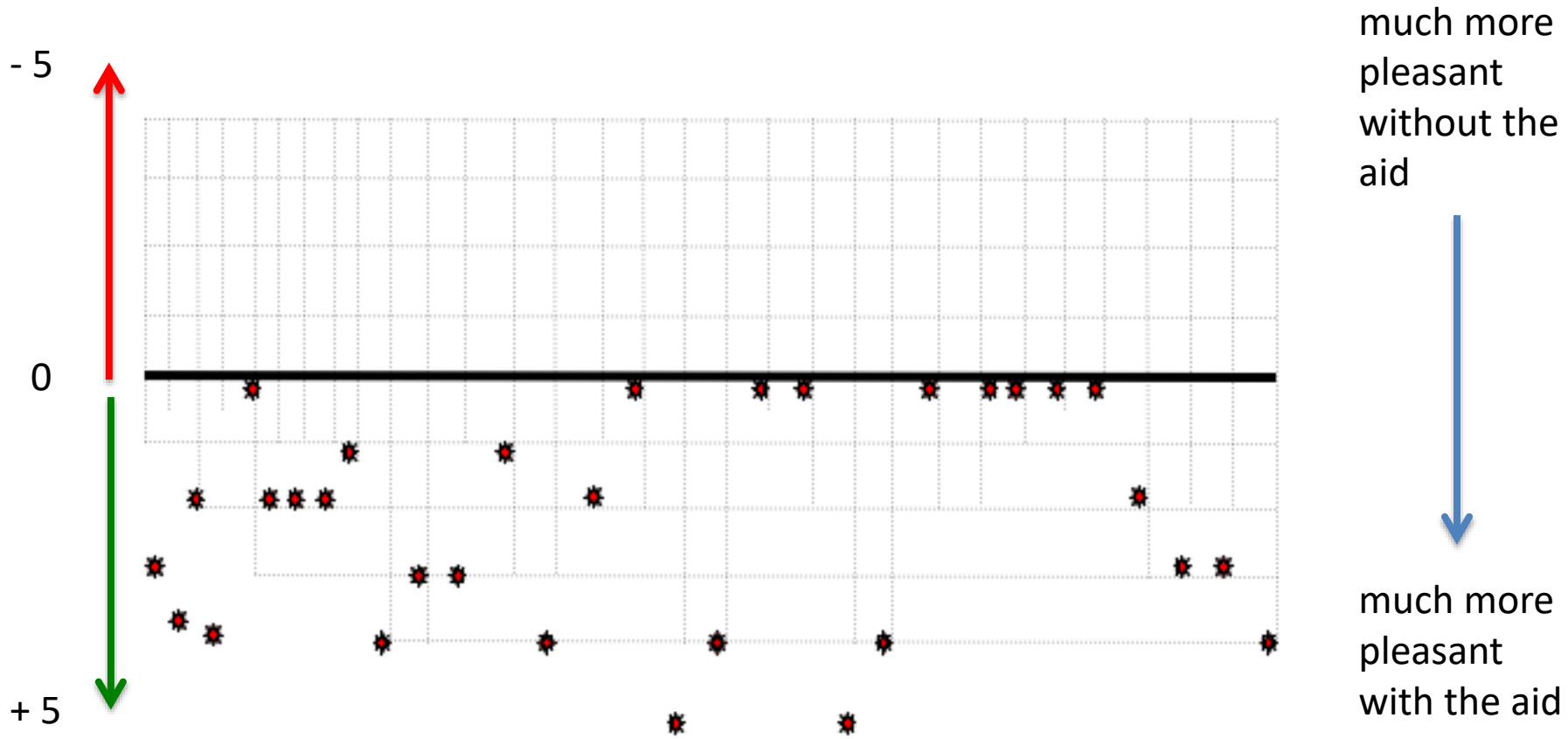


# Evolution of localization performances




Mean Improvement over time 4,11°(0-6.6) per year

# Bern Benefit in Single-Sided Deafness Questionnaire (BBSS)



# Conclusion for localization study

- Evolution of localization for 21 SSD patients with normal hearing and BAHA on deaf side
- Median follow-up was 8 years
- Evolution of RMS localization error:
  - 66° non aided,
  - 53° aided initially,
  - 27° with BAHA at last evaluation.
- Our main hypothesis: the auditory systems relearns to localize via adaptive plasticity with additional azimuth-dependent spectral cues from the BAHA on the deaf side.

# Binaural device with stereophony benefit (Decroix, Dehaussy, 1962)

- 4 criteria:
  - Auditory thresholds as symetrical as possible especially for the speech frequencies,
  - Respect of the functional independance of both ears,
  - Pick the sound at the ear level,
  - Allow variations of phase, intensity and delay with free head movements.

# SSD rehabilitation

- Bone stimulation on the deaf side:
  - percutaneous: BAHA, PONTO
  - transcutaneous: BAHA Attract, Sophono, Bonebridge, Adhear
- CROS, BICROS with conventional HA
- Cochlear implant (+ incapacitating tinnitus)