Can we compare

Sound Quality of Noise Reduction

between commercial hearing aids?

A method to level the ground between devices

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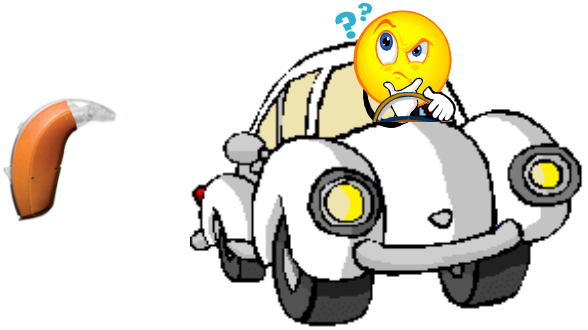
Introduction

Speech in quiet

NO PROBLEM

Speech in noise



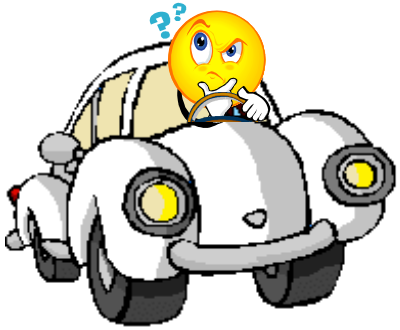
PROBLEM

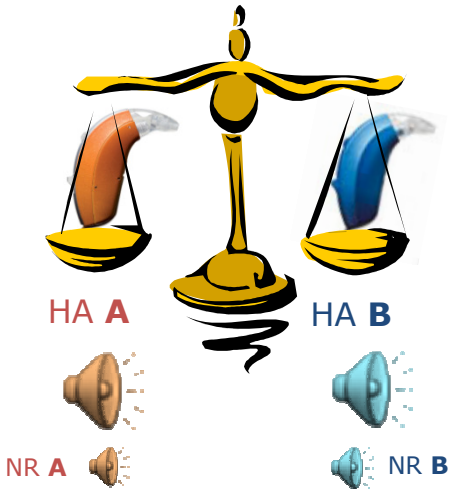
Noise Reduction in Hearing Aids

- Chosen principles unknown to clinician: “black box”
  - Selection of best NR for individual
  - Selection of best NR for situation
  - Selection of best NR for Hearing loss
  - Trial and error
- Technical properties differ between hearing aids
- Perceptual effects are unknown
- Direct comparison between NRs required

Noise Reduction in Hearing Aids

Can noise reduction features of different hearing aids directly be compared?





NO

HA first fit
Flat sensorineural 50 dB HL

- Direct comparison between NRs required
  - Problem: effect of hearing aid >> effect of noise reduction
  - Wanted: effect of hearing aid << effect of noise reduction

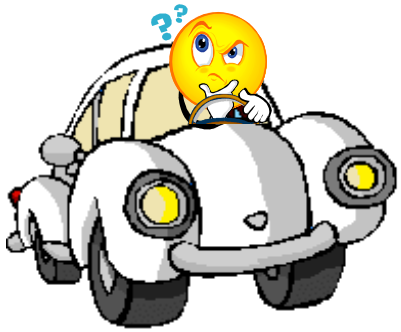
Method – Hearing aids

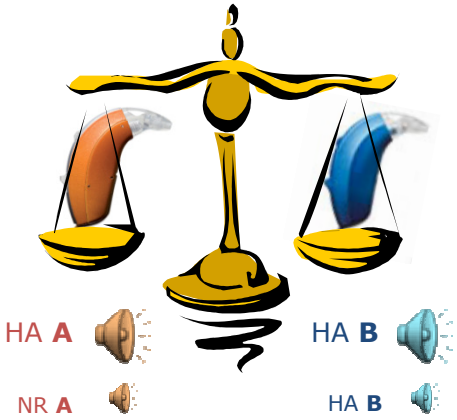
- Hearing aids (BTE)
  -  Oticon Vigo Pro
  -  Phonak Exélia M
  -  ReSound Azure AZ80-DVI
  -  Widex Mind 440
  -  Starkey Destiny 1200

- Programming
  - Fine-tuning of first fit
    - Equal insertion gain (difference between aided and unaided response)
    - Compression ratio 1.0 (= no compression)
  - Microphone omnidirectional
  - All features OFF

Method – Hearing aids

Is the fine-tuned fit (with insertion gain) good enough?

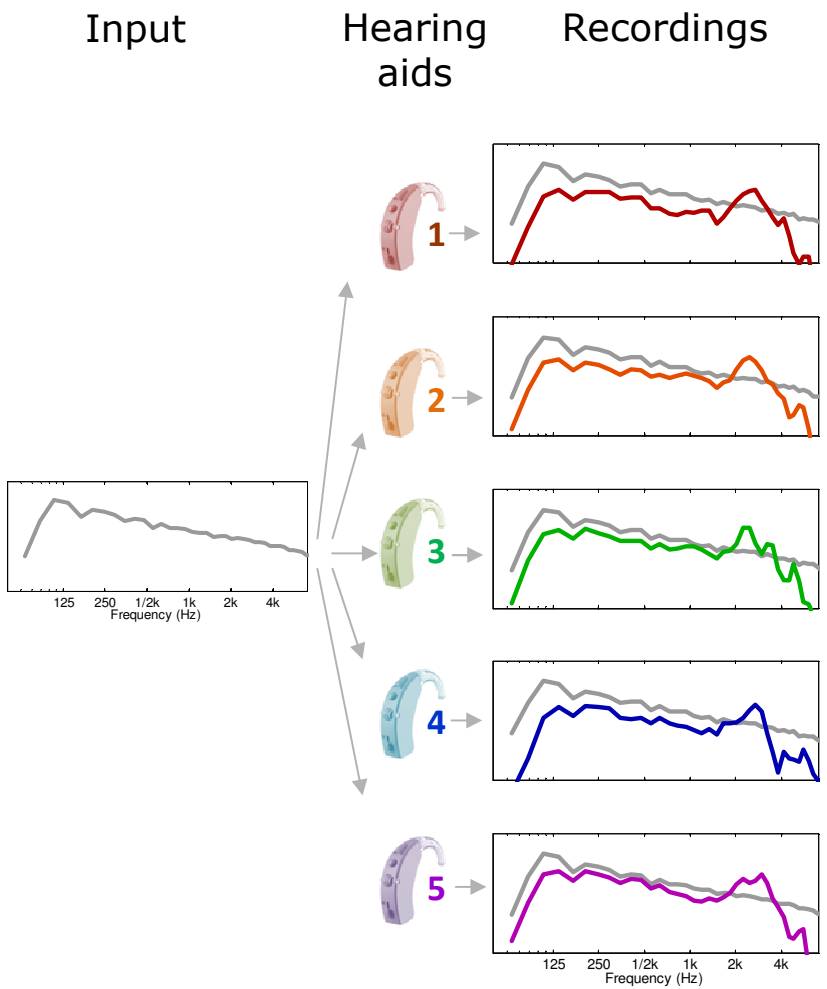




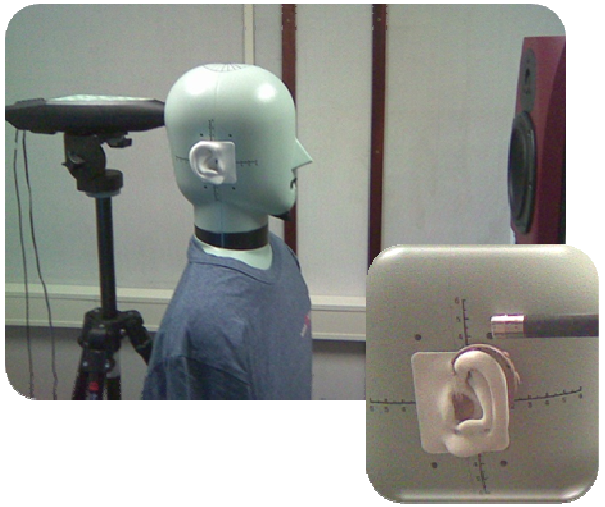
NO

Linear fit
Based on insertion gain

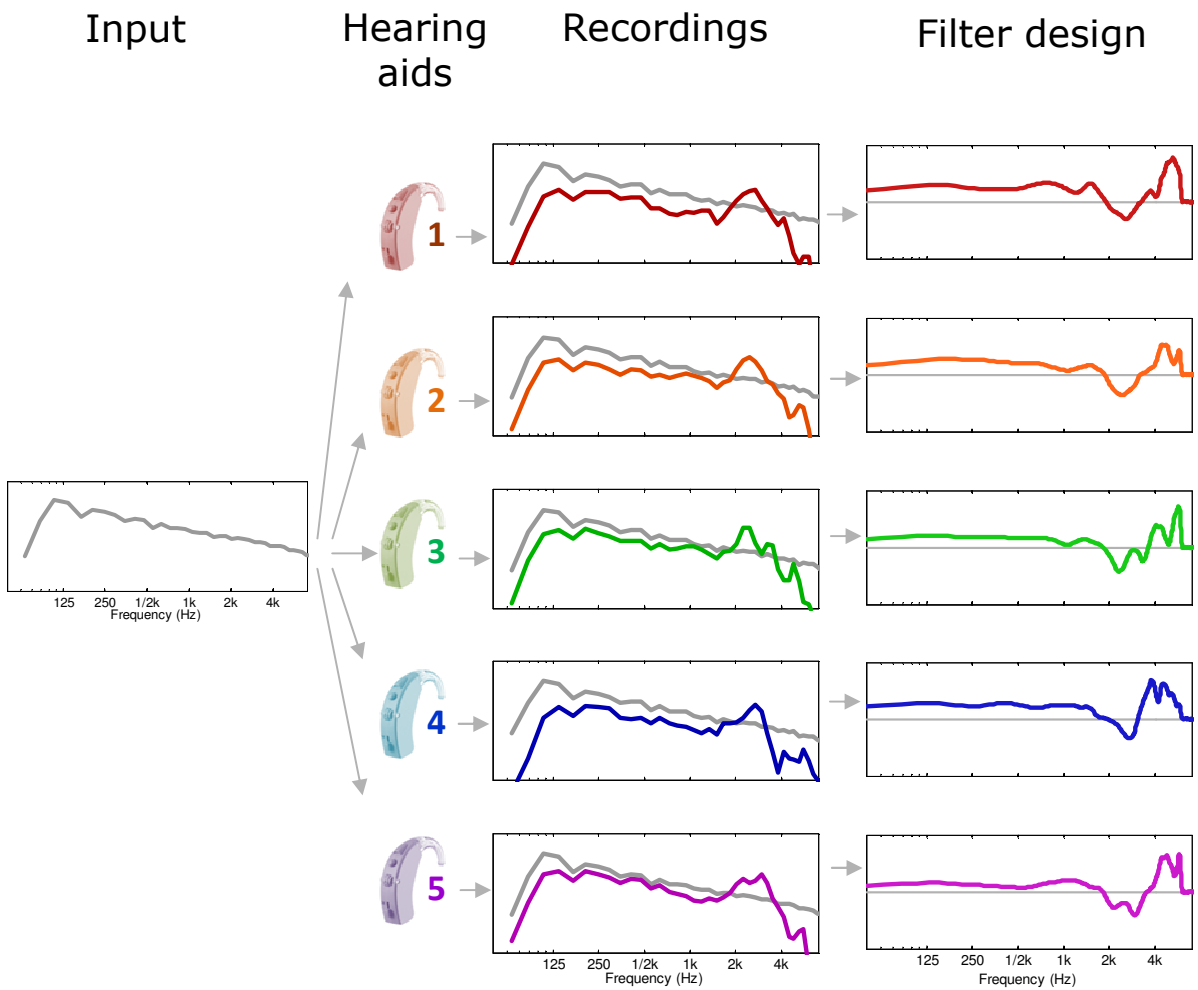
Method - Recordings



- Recording
  - Input: pink noise at 70 dB SPL
  - Hearing aid on Head and Torso Simulator

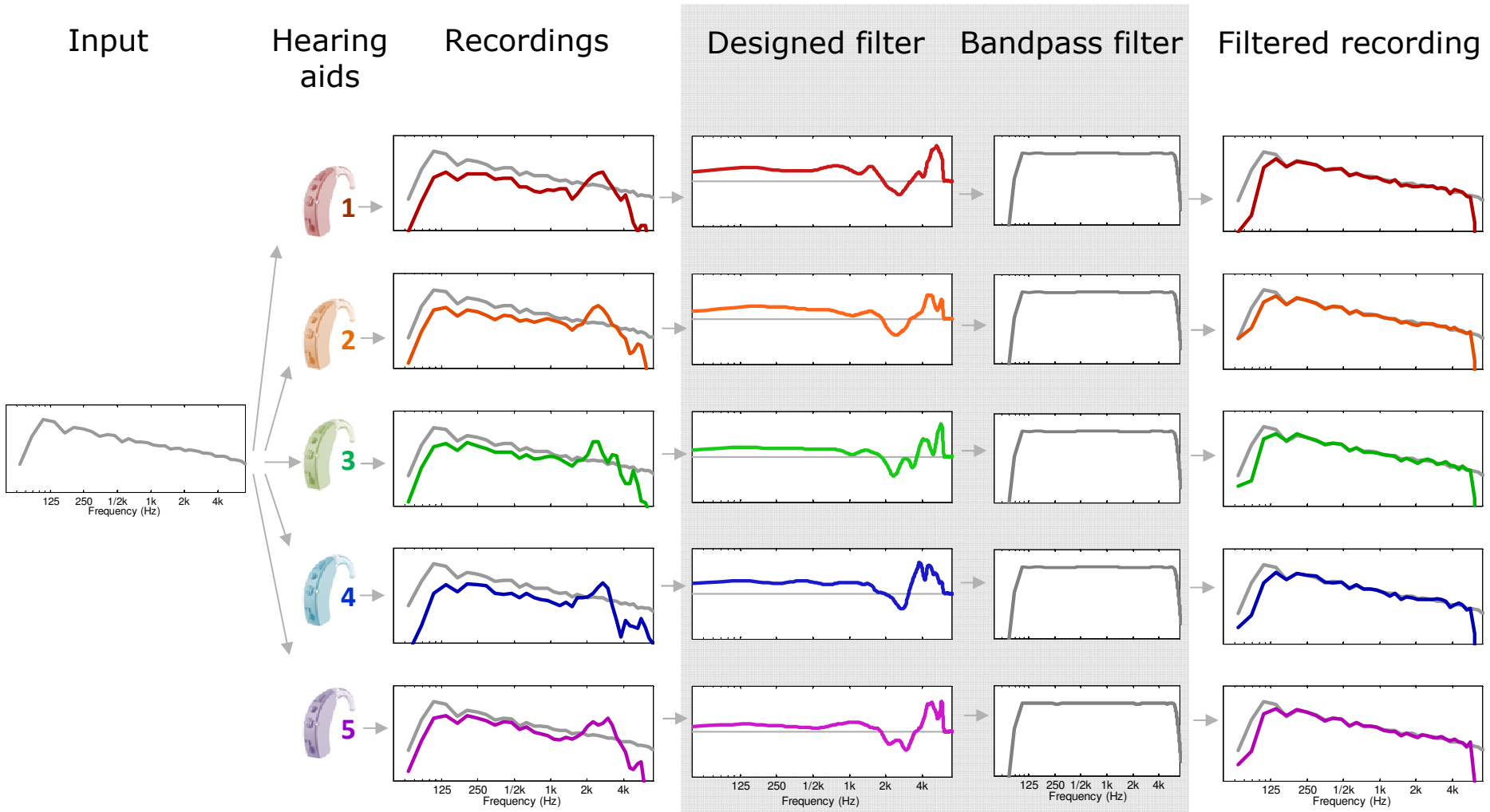


Method – Filter design



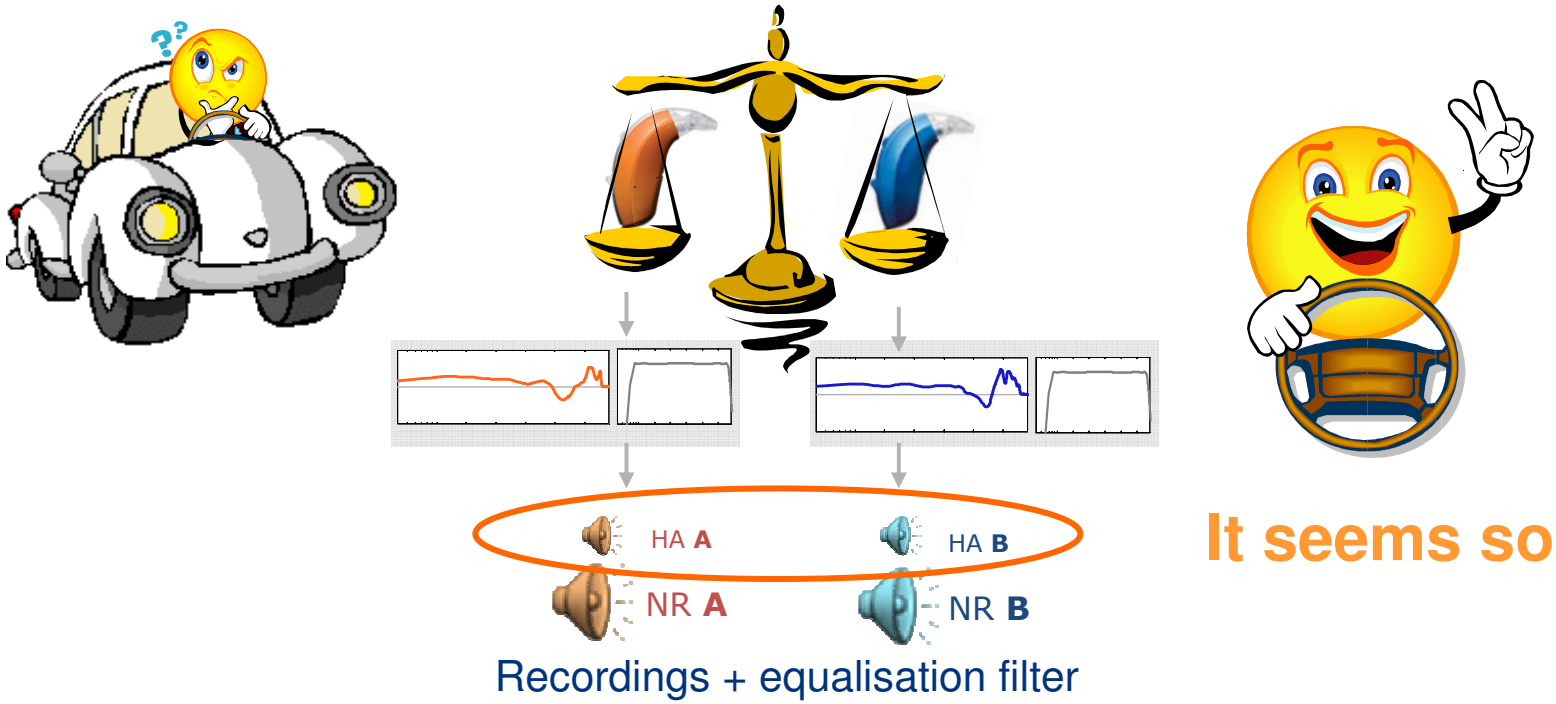
- Filter design
  - Linear system analysis
  - Dividing output spectrum by input spectrum
  - FIR filter with 500 taps

Method - Filtering



Results

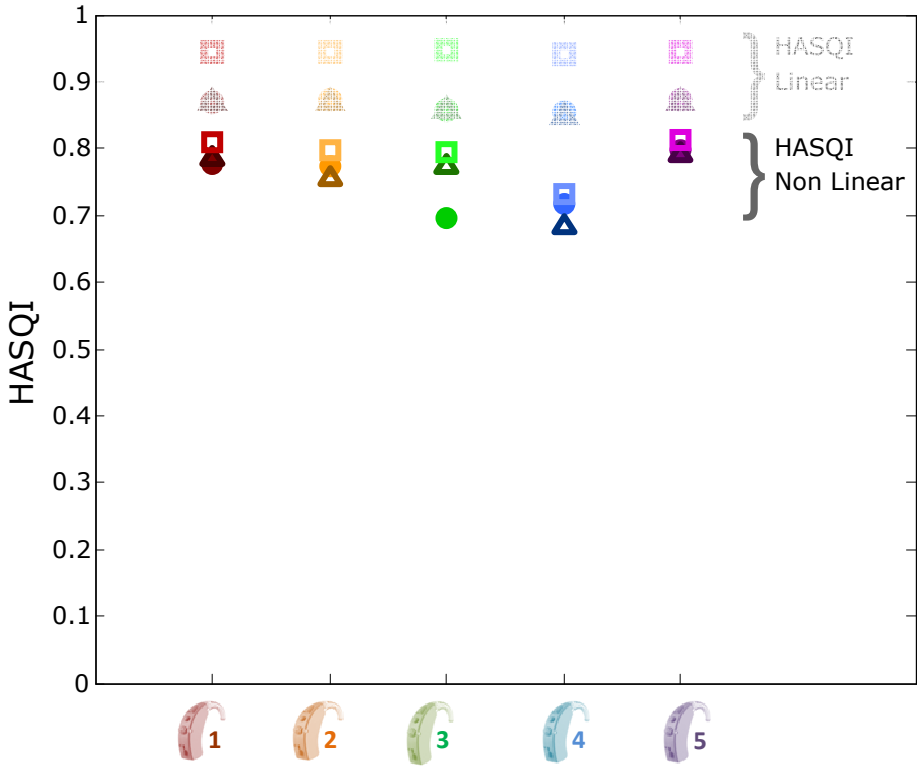
Is the equalized recording good enough?

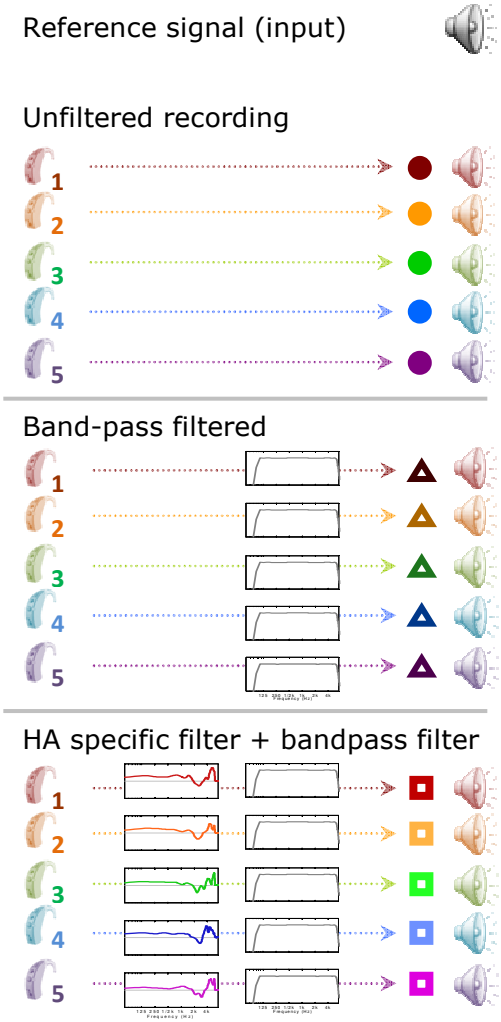


- Evaluation of equalisation filter: comparison of corrected recordings
  without noise reduction

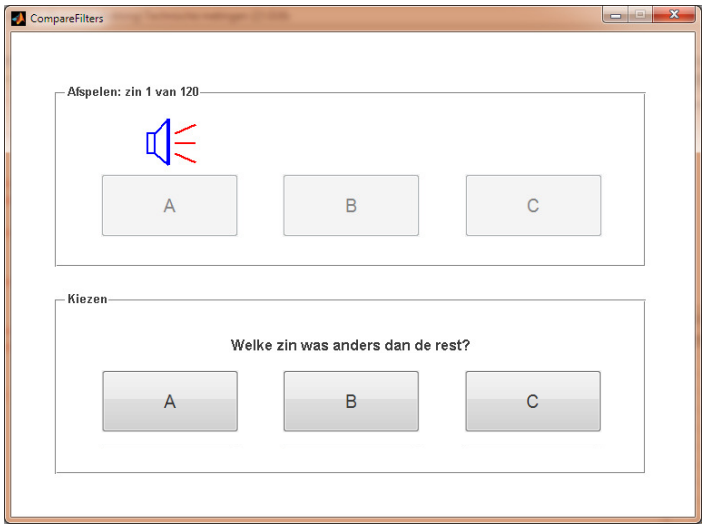
Objective evaluation

- Hearing-aid speech quality index (Kates and Arehart, 2009)
  - HASQI linear: changes in long-term spectral shape
  - HASQI non-linear: changes in signal envelope modulations



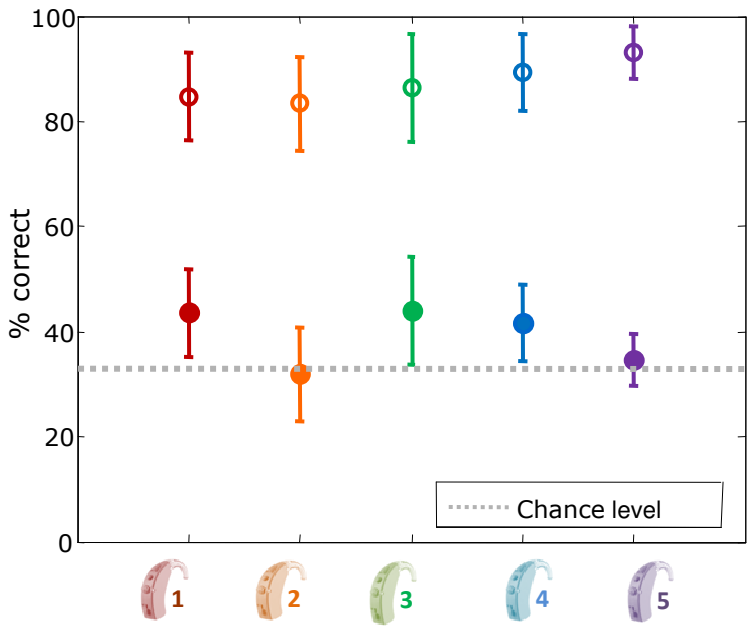


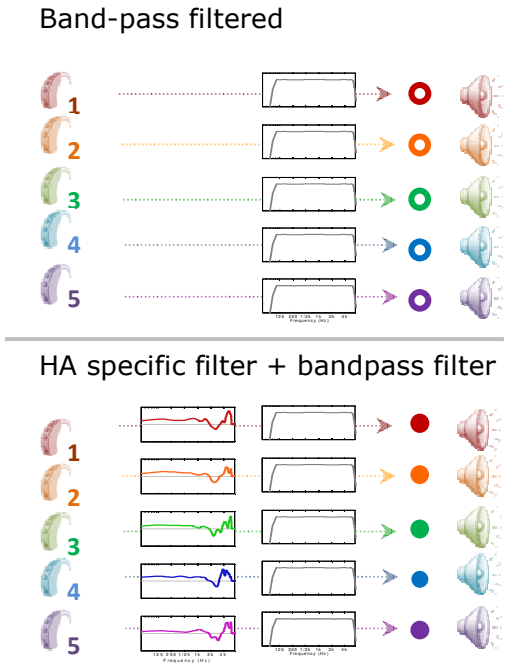
Subjective evaluation



- 6 normally hearing subjects
- Detection task
  - Identify odd stimulus from set of three
- Test sets (not mixed):
  - Recordings with bandwidth limitation
  - Recordings with correction for hearing aid + bandwidth limitation
- Three runs, 60 trials per test set; 120 trials per subject

Subjective evaluation

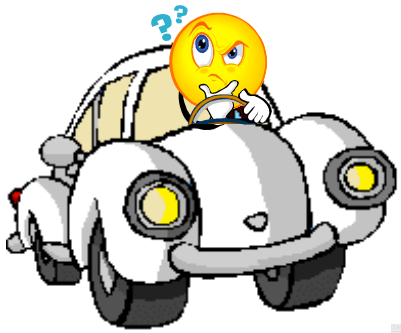


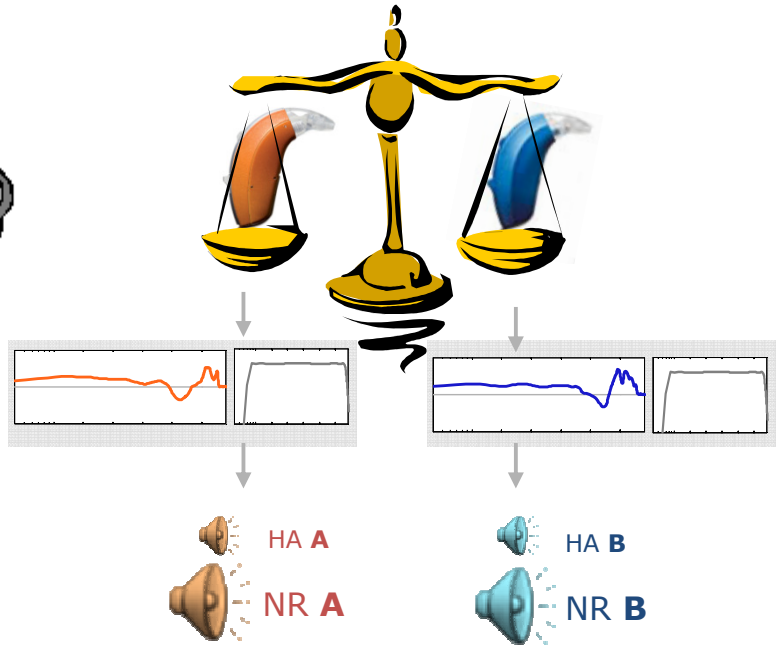


- Band-pass limited signals were detectable (average 87%)
- Detection of fully filtered signals was much more difficult (average 39%)
- Detection of individual recordings did not deviate from chance

Conclusions & Application

Is the equalized recording good enough?





Recordings + equalisation filter

It seems so!

Conclusions & Application

- The equalisation filter levels the ground between devices
  - Differences in HASQI quality index are reduced
  - Detection rate of differences is reduced to about chance level

- This opens the way for future perceptual comparisons
  - The equalisation filter can be applied with noise reduction ON
  - The filter does not influence hearing aid or noise reduction processing in any way
    - Equalization filtering on *output* of hearing aids (*after* HA processing)
  - Differences between aids then originate from noise reduction only

- Perceptual A-B comparison of hearing aid signal processing possible