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?

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

HA first fit
Flat sensorineural 50 dB HL
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

Input → Hearing aids → Recordings → Designed filter → Bandpass filter → Filtered recording

Clinical & Experimental Audiology
Results

Is the equalized recording good enough?

It seems so!

- 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
Is the equalized recording good enough?

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