Single channel noise reduction in hearing aids

Recordings for perceptual evaluation

Inge Brons
Rolph Houben
Wouter Dreschler
Introduction

- Hearing impaired have difficulty understanding speech in noise

- Most modern hearing aids have a noise reduction algorithm implemented
Introduction
Introduction

- Hearing impaired have difficulty understanding speech in noise
- Most modern hearing aids have a noise reduction algorithm implemented
- Exact implementations of noise reduction in hearing aids are unknown to clinicians
- Technical properties of noise reduction differ between hearing aids
  - In terms of amount of gain reduction and its dependence on frequency, SNR, level and hearing loss (Hoetink et al. 2009)
- Perceptual effects of these differences are as yet unknown
Study design

Technical measurements

Noise reduction parameters
- Amount of gain reduction
- Dynamics
- Frequencies

Perceptual measurements

Perceptual effects
- Intelligibility
- Personal preference
- Listening effort

Record hearing aid output

Speech
- SNR
- Level

NOISE
Input

- **Input signal**
  - Speech
    - VU sentences; female speaker (1s pause between sentences)
  - Noise
    - Speech shaped steady state noise
    - Car noise
    - ICRA 6 (3 band speech modulated noise; 1 female, 1 male)
    - Multitalker babble
  - SNRs: -12 -10 -8 -6 -4 -2 0 2 4 6 8 10
  - Level: ~70 dB SPL
  - ~ 2 Minutes per condition (1 min pre-conditioning)
Recording – hearing aids (1)

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

- Programming
  - Audiogram: 50 dB sensorineural loss at all frequencies
  - Gain function: NAL-NL1 or default prescription
  - Omnidirectional
  - All other features OFF
  - Noise reduction OFF and MAX
Recording – setup (1)

Head and torso simulator with Hearing aid

Recording with microphone behind HA

Free field HA input
Recording – examples (1)

SNR = +4 dB

- Effect of hearing aids >> effect of noise reduction
- Equalization of response without noise reduction required
Recording – hearing aids (2)

- Programming
  - Equal insertion gain (difference between aided and unaided response)
  - Compression ratio 1.0 (= no compression)
  - Microphone omnidirectional
  - All other features OFF
  - Noise reduction OFF and MAX

![Graph showing insertion gain for different hearing aids across various frequencies.](image)
Recording – setup (2)

- Added: filter after recording
  - Correction for ear canal
  - Correction for frequency response of hearing aid (with NR off)
  - Band pass limitation
Effect of hearing aids << effect of noise reduction
Comparison of noise reduction methods possible
Recording – examples (2)

<table>
<thead>
<tr>
<th>SNR = -4 dB</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speech shaped</td>
<td><img src="Image" alt="NR off" /></td>
<td><img src="Image" alt="NR off" /></td>
<td><img src="Image" alt="NR off" /></td>
<td><img src="Image" alt="NR on" /></td>
<td><img src="Image" alt="NR on" /></td>
</tr>
<tr>
<td>Babble</td>
<td><img src="Image" alt="NR off" /></td>
<td><img src="Image" alt="NR off" /></td>
<td><img src="Image" alt="NR off" /></td>
<td><img src="Image" alt="NR on" /></td>
<td><img src="Image" alt="NR on" /></td>
</tr>
</tbody>
</table>

- Effect of hearing aids << effect of noise reduction
- Comparison of noise reduction methods possible
Technical measurements

- Steady state analysis
  - Maximum gain reduction
  - Frequency dependency
  - SNR dependency

Frequency (Hz)

Gain reduction (dB)

1. Ruis
2. SNR-12
3. SNR-8
4. SNR-4
5. SNR0
6. SNR4
7. Spraak

Clinical & Experimental Audiology
Technical measurements

- Steady state analysis
- Dynamic analysis
  - Maximum gain reduction
  - Frequency dependency
  - SNR dependency
  - Speed of changes
    - From noise to speech in noise
    - From speech in noise to noise
Conclusion

- Large differences between noise reduction strategies
  - In terms of amount and velocity of gain reduction and its dependency on noise, SNR and frequency

- Method for recording and filtering facilitates perceptual evaluation
  - Effect of noise reduction >> effect of hearing aid

- Follow-up research: perceptual effects of noise reduction
  - Intelligibility
  - Preference: comparison category rating
    - Distinction between signal, noise and overall quality
  - Listening effort: rating scale