Dynamic aspects of noise reduction in hearing aids

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Noise reduction (NR) in hearing aids

Why?
- Increase comfort (ease of listening) in noisy situations
- Increase speech intelligibility in noise

How?
- Estimate speech and noise (modulation characteristics)
- Determine SNR in a number of compression channels (8-24)
- Adjust the gain based on certain rules associated with the SNR

Effect?
- Evaluations of NR:s point towards benefit in comfort (ease of listening), but seldom in speech intelligibility
Long-term average gain measurements

• Hearing aids
  – 12 modern HA:s
  – Mic, OMNI
  – MPO, MAXIMAL
  – Expansion, OFF
  – VC, OFF
  – Feedback reduction, OFF
  – Other sig. proc., OFF

• Equipment
  – Equinox HIT440, IA
  – TBS25 test box, IA
  – 711 coupler, GRAS
  – Mic (ref./meas.), GRAS

• Programming
  – default prescription

• Measurements
  – Pre-conditioning
    30 seconds
  – Long-term average
    30 seconds

Method

• Measurement signals
  • ISTS (ISMADHA draft)
  • ICRA1 (stationary speech-weighted noise)

• Variables
  – SNR in the input signal (8 different)
    • "Speech", +6 dB, +3 dB, 0 dB, -3 dB, -6 dB, -9 dB, -12 dB
  – Sound pressure level (fixed speech level)
    • 62 and 75 dB SPL (ANSI S3.5)
  – Audiogram (3 different)
    • KS100, Flat50, N4
Audiogram

Frequency (Hz)

Hearing level (dB HL)

- KS 100
- Flat 50
- N4
Gain reduction

Gain reduction = ON - OFF

Reduction contours
KS100, 75 dB SPL speech

A

B

C

D

E

F

G

H

I

J

K

L
Short-term average gain reduction – Method

- **Hearing aid**
  - 12 modern HA:s
  - Mic, OMNI
  - MPO, MAXIMAL
  - Expansion, OFF
  - VC, OFF
  - Feedback reduction, OFF
  - Other sig. proc., OFF

- **Programming**
  - default prescription

- **Equipment**
  - Recordings sound card

- **MATLAB processing**
- TBS25 test box, IA
- 711 coupler, GRAS
- Mic (ref./meas.), GRAS

- **Measurements**
  - Pre-conditioning: 30 s
  - Short-term average (1/3-oct): 125 ms
  - Updated every 40 ms
  - Hagerman sentences in ICRA1 noise
  - KS100 audiogram
Results

14 measurements (7 SNR, NR on/off) in the same figure.

We will listen to the speech signal without noise.
Results

Hearing Aid G, 75 dB SPL speech level

<table>
<thead>
<tr>
<th>Frequency [Hz]</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1k</th>
<th>2k</th>
<th>4k</th>
<th>8k</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gain Difference (NR ON - NR OFF) [dB]</td>
<td>-16</td>
<td>-14</td>
<td>-12</td>
<td>-10</td>
<td>-8</td>
<td>-6</td>
<td>-4</td>
</tr>
</tbody>
</table>

- SNR +6
- SNR +3
- SNR 0
- SNR -3
- SNR -6
- SNR -9
- SNR -12
Results

Hearing Aid H, 75 dB SPL speech level

Gain Difference (NR On - NR Off) [dB] vs Frequency [Hz]

-16  -14  -12  -10  -8  -6  -4  0  2  4  6
125  250  500  1k  2k  4k  8k

SNR [dB]
-12  -9  -6  -3  0  3  6

ISTS

SNR [dB]
-12  -9  -6  -3  0  3  6

Frequency [Hz]
Results

Hearing Aid F, 75 dB SPL speech level

Gain Difference (NR:ON - NR:OFF) [dB]

Frequency [Hz]
Results

Hearing Aid J, 75 dB SPL speech level

Gain Difference (NR: ON - NR: OFF) [dB]

Frequency [Hz]

SNR [dB]

-12  -9  -6  -3  0  +3  +6

ISTS
Other ways to illustrate what we have seen in the movies?
3D plots one Hagerman sentence

Hearing Aid I, fast
ORCA
Europe
3D plots one Hagerman sentence

Hearing Aid F, slow
Change in reduction when long-term average NR is subtracted
Change in reduction when long-term average NR is subtracted.
"Spectrogram"
Summary

• Large differences in how the various NR systems work!

• The short-term aspects are needed to describe the noise reduction systems (and they most likely have perceptual relevance)

• Future work
  – Evaluate the systems with hearing-impaired listeners…
Thank you for your attention!

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