Spectral and binaural loudness summation in subjects with bilateral hearing loss

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Background --> Goal

- Many hearing aid users have complaints about loud sounds
- Understand the complaints about loud sounds in hearing aid users and find a solution.
Subjects

- Average age: 70 yrs, 12 females, 10 males

<table>
<thead>
<tr>
<th>Bisgaard</th>
<th>Nr of ears</th>
<th>Nr of subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>N2</td>
<td>11</td>
<td>4</td>
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<tr>
<td>N3</td>
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<td>8</td>
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<tr>
<td>N4</td>
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<td>2</td>
</tr>
<tr>
<td>S3</td>
<td>2</td>
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</tbody>
</table>


Loudness scaling

- Too loud
- Very loud
- Loud
- Medium
- Soft
- Very soft
- Not heard

- 4000 Hz
- Respons
- Loudness function

CU vs. DB(HL) graph
Loudness scaling for NB signals

tested at 250, 500, 1000, 2000, 4000, 6000 Hz

Individual results (Example)

CR results vs dB(HL) per ear per subject for all NB signals
Group results at 500 Hz

CR results vs dB(HL) per ear for different signals

Group results at 6000 Hz

CR results vs dB(HL) per ear for different signals
Broadband signals

- Spectra and bandwidths of the test signals

![Graph showing broadband signals](image)

Spectral Summation

![Graph showing spectral summation](image)
Binaural Summation

Spectral Summation

Left

Right

No summation
Binaural summation only

Individual results

- Application of this approach for gain compensation is able to restore normal loudness perception for NB signals
- However, huge inter-individual variability is found for broadband signals and for binaurally presented signals
- This may explain the subjective complaints in subjects with bilaterally fitted hearing aids.
- A fixed gain reduction in bilateral fittings (e.g. 3 dB) seems to be inadequate for some subjects in this study
Loudness matching

- Preliminary experiments show equivalent results in less testing time
- Large inter individual differences, but the same trend in loudness matching and Loudness scaling, with pink noises

Conclusions

- A clear spectral - and binaural loudness summation is found in this study
- However there are large inter individual differences
- There is a need to adjust fitting rules for bilaterally fitted hearing aids, based on a fast clinical test instrument (Loudness Matching)