Influence of multi-microphone signal enhancement algorithms on auditory movement detection in acoustically complex situations
Lundbeck, Micha; Hartog, Laura; Grimm, Giso; Hohmann, Volker; Bramsløw, Lars; Neher, Tobias

Publication date:
2017

Document version
Publisher's PDF, also known as Version of record

Citation for published version (APA):

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

Take down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.
**INTRODUCTION**

The influence of hearing aid (HA) signal processing on the perception of spatially dynamic sounds has not been systematically investigated so far. Previously, we observed that for elderly hearing-impaired (EHI) listeners concurrent distractor sounds impaired the detectability of left-right (L-R) source movements, and reverberation that of near-far (N-F) source movements (Lundbeck et al., 2017). Here, we explored potential ways of improving these deficits with HAs by investigating the effects of a number of signal enhancement algorithms on the acoustics and detectability of source movements.

Our aims were:

1. To identify HA settings that can enhance changes in the acoustic cues that are presumed to underlie L-R and N-F source movement detection.

2. To evaluate the most promising HA settings for improving L-R and N-F source movement detection with a group of EHI listeners.

**METHODS**

**Setup**
- Simulation of virtual environment with TASCAR toolbox (Grimm et al., 2015)
- Target sound at 0° azimuth and 1 m distance re. virtual listener
- Static maskers sounds at ±45° and ±90°
- Anechoic or echoic (vol. = ~238 m³; T₆₀ = ~0.8 s) conditions

**Stimuli**
- Environmental sounds: Fountain (target), ringing bells, bleating goats, pouring soda, humming bees (maskers)
- Fixed stimulus duration (2.3 s without reverb; 3.1 s with reverb)

**HA settings**

Implemented on the Master Hearing Aid research platform (MHA; Grimm, et al, 2006)
- unproc: Front microphones of left and right BTE devices
- dircoh: Forward-facing cardioid microphones followed by binaural coherence-based noise reduction (Grimm et al., 2009)
- beam: Bilateral beamformer with binaural cue preservation (Rohdenburg et al., 2007)

**Technical measurements**
- Analysis of recordings made with target (static or moving) and four maskers (static) by Movement: 20° (L-R) or 1.5 m (N-F), chosen based on Lundbeck et al. (2017)
- Measures of interest:
  1. L-R dimension: Monaural spectral coloration, SNR improvement
  2. N-F dimension: Direct-to-reverberant sound ratio (DRR), monaural spectral coloration, SNR improvement

**Perceptual measurements**
- Echoc conditions only
- Controlled via play-sampling (Hansen, 2006); 1-interval 2-AFC
- Target detectability: "Did you hear the target sound?"
- Participants divided into groups that could (group 2) or could not (group 1) reliably hear out the target from the signal mixture
- Movement detection thresholds: "Did the target move or not?"
- Based on single-interval adaptation matrix (SIAM; Kaernbach 1990)
- Minimum Audible Movement Angle (MAMA) and Distance (MADM) Thresholds

**RESULTS**

**Technical measurements: L-R dimension**

**Without reverb**
- Group 1: mean of 4.4 dB (± 2.1 dB)
- Group 2: mean of 3.8 dB (± 2.4 dB)

**With reverb**
- Group 1: mean of 4.4 dB (± 2.1 dB)
- Group 2: mean of 3.8 dB (± 2.4 dB)

**Perceptual measurements: Detection thresholds**

**L-R dimension**

<table>
<thead>
<tr>
<th>Spatial dimension</th>
<th>No. concurrent sound sources</th>
<th>HA setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-R (MAMA)</td>
<td>Target signal only</td>
<td>unproc dircoh beam</td>
</tr>
<tr>
<td>N-F (MADM)</td>
<td>Target and four maskers</td>
<td></td>
</tr>
</tbody>
</table>

**N-F dimension**

<table>
<thead>
<tr>
<th>Spatial dimension</th>
<th>No. concurrent sound sources</th>
<th>HA setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-R (MAMA)</td>
<td>Target signal only</td>
<td>unproc dircoh beam</td>
</tr>
<tr>
<td>N-F (MADM)</td>
<td>Target and four maskers</td>
<td></td>
</tr>
</tbody>
</table>

**SUMMARY**

- Analysis of acoustic cues presumed to underlie L-R and N-F movement detection showed that:
  - HA settings based on directional processing and binaural coherence-based noise reduction can enhance salient signal changes
  - Analysis of the perceptual measurements performed with EHI listeners showed that:
    - When tested without masker sounds (group 1), the three tested HA settings improved L-R and N-F movement detection
    - When tested with the masker sounds (group 2), beam processing improved L-R and N-F movement detection, while dircoh processing improved N-F movement detection

**ACKNOWLEDGMENTS**

Funded by the Oticon Foundation and the DFG Cluster of Excellence EXC 1077/1 “Hearing4all”

**REFERENCES**


