Influence of signal enhancement algorithms on auditory movement detection in acoustically complex situations

Lundbeck, Micha; Grimm, Giso; Hohmann, Volker; Bramsløw, Lars; Neher, Tobias

Publication date:
2018

Document version
Final published version

Citation for published version (APA):

Terms of use
This work is brought to you by the University of Southern Denmark through the SDU Research Portal. Unless otherwise specified it has been shared according to the terms for self-archiving. If no other license is stated, these terms apply:

- You may download this work for personal use only.
- 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 this open access version

If you believe that this document breaches copyright please contact us providing details and we will investigate your claim. Please direct all enquiries to puresupport@bib.sdu.dk
INTRODUCTION

Hearing loss can negatively influence the spatial hearing abilities of hearing-impaired listeners, not only in static but also in dynamic auditory environments [4]. Thus, ways of addressing these deficits with advanced hearing aid algorithms need to be investigated. In a previous headpose-based study, we found that two simulated directional processing algorithms could substantially improve the detectability of left-right (L-R) and near-far (N-F) source movements in the presence of reverberation and multiple interfering sounds for a group of older hearing-impaired (OHI) listeners [5]. Here, we used a loudspeaker-based setup and wearable hearing aids to explore the effects of a set of directional hearing aid settings on movement detection and other aspects of spatial awareness perception. Our aims were:

1) To investigate the extent to which our earlier movement detection results obtained with a headphone-based setup and simulated HA settings can be transferred to a loudspeaker-based setup and head-worn devices (experiment 1)

2) To extend our earlier results towards other aspects of spatial awareness perception (experiment 2)

METHODS

Physical test setup
- 16 loudspeakers in the horizontal plane (spaced 22.5° apart)
- Simulation of virtual environment with TASCAR toolbox [1]

Stimuli and simulated sound scenarios
- L-R and N-F movement detectability (Lundbeck et al., 2017):
  - Environmental sounds: Fountain (target), ringing bells, bleating goats, pouring soda, humming bees (maskers)
  - Target at 0° azimuth and 1 m distance re. virtual listener
  - Static maskers sounds at ±45° and ±90°
  - Anechoic or echoic (vol. = -238 m², Tₚ₆₆ = 0.8 s) conditions
  - Fixed stimulus duration (2.3 s without revert, 3.1 s with revert)

- Movement direction and number of concurrent sources:
  - Street scene with remote traffic noise
  - Fixed duration of 15 sec
  - Up to five different sounds, one of which was moving 45° around the listener (e.g. the car), while the others remained static

HA settings
- Implemented in receiver-in-the-ear (RITE) devices
- OMNI: All advanced algorithms turned off. Focus on natural perception of auditory scene
- AUTO: Noise reduction in complex environments while maintaining sufficient information for spatial hearing purposes
- DIR: Fixed forward-facing beamformer; noise reduction for non-frontal stimuli

Experiment 1
- L-R and N-F movement detectability:
  - Echoc conditions only
  - Controlled via psylab [2]: 1-interval 2-AFC
  - Target detectability (→ screening): “Did you hear the target sound?”
  - Participants divided into groups that could (group 1+4) or could not (group 1+2) reliably hear out the target from the signal mixture
  - Movement detection thresholds: “Did the target move or not?”
  - Based on single-interval adaptation matrix [3]
- Outcome: Minimum Audible Movement Angle (MAMA) and Distance (MADI) thresholds

Experiment 2
- Movement direction and number of concurrent sources:
  - On each trial, random number of sounds (1-5) from random positions (0°, ±45°, 90°, 135°, 180°, 225°, 270° or 315°)
  - Two tasks administered using graphical user interfaces (see figures)
  - Task 1: Indicate number of concurrent sound sources
  - Task 2: Indicate movement direction of target sound

RESULTS

L-R and N-F movement detectability

Effect of directional hearing aid settings on different laboratory measures of spatial awareness perception: An exploratory study

PARTICIPANTS
- OHI listeners with symmetric moderate sensorineural hearing losses
- Division into groups for experiment 1 (but not experiment 2)
- Group 1+2 (tested with two masker sounds): mean age of 66.9 yr, mean PTA of 37 dB HL
- Group 1+4 (tested with four masker sounds): mean age of 64 yr, mean PTA of 34.1 dB HL

SUMMARY
- In principle, the transition from a headphone-based setup with simulated hearing aid algorithms towards a loudspeaker-based setup with head-worn devices is possible
- So far, however, no effects of the different hearing aid conditions observable:
  - L-R and N-F movement detectability: For group 1+2 (tested with two masker sounds) no significant differences measured; for group 1+4, trend towards lower thresholds for DIR condition in the N-F dimension (similar to the results in [5])
  - Significant effects of number of concurrent sound sources and starting position for the movement direction and number of concurrent sound sources tasks
- Outlook: Design of scenarios that can show effects of the small differences among hearing aid settings already at the acoustical level

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

REFERENCES