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

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

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 headphone-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; $T_{60} = 0.8$ s) conditions
  - Fixed stimulus duration (2.3 s without reverb, 3.1 s with reverb)

- 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 (MAMD) 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

![Graph of L-R and N-F movement detectability](image)

Movement direction and number of concurrent sources

- Count the number of sources
- Indicate movement direction of target sound

![Graph of movement direction and number of concurrent sources](image)

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

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REFERENCES