Using eye-tracking to uncover the effects of hearing aid use on speech comprehension

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Acknowledgments

An Eye-Tracking Paradigm for Analyzing the Processing Time of Sentences with Different Linguistic Complexities

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Are Experienced Hearing Aid Users Faster at Grasping the Meaning of a Sentence Than Inexperienced Users? An Eye-Tracking Study

Julia Habich, Birger Kollmeier, and Tobias Neher

Auditory acclimatization to bilateral hearing aids: Effects on sentence-in-noise processing times and speech-evoked potentials

Julia Habich, Mareike Finke & Tobias Neher

Ear & Hearing, in press
Background

- Conventional speech audiometry is often insensitive to the effects on higher-level processes (e.g. speech comprehension)

- New experimental paradigms needed
  - Eye-tracking paradigm (Wendt et al., 2014)
  - Allows determining how quickly a participant can grasp the meaning of sentence-in-noise stimuli → “Processing time”

- Does hearing aid (HA) experience influence speech comprehension in noise?

Eye-tracking paradigm

(Wendt et al., 2014)

„Der müde Drache fesselt den großen Panda“
Meaning: “The tired dragon ties up the big panda”

Task

“Select the picture that matches the acoustic stimulus by pressing a button as fast as possible after the acoustic presentation!”
**Eye-tracking paradigm**

(Wendt et al., 2014)

**Processing time and reaction time measurements**

![Diagram showing processing time and reaction time measurements]

- **sTDA**: single Target Detection Amplitude
- **PTD**: Point of Target Disambiguation
- **DM**: Decision Moment
- **DDD**: Disambiguation to decision delay (→ "Processing time")

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**Sentence material**

- **Oldenburg Linguistic and Audiological Controlled Sentences (OLACS)** (Uslar et al., 2013)
- Sentence structures with two levels of linguistic complexity: Low vs. high

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Der</td>
<td>müde</td>
<td>Den</td>
</tr>
<tr>
<td>Drache</td>
<td>fesselt</td>
<td>Drachen</td>
</tr>
<tr>
<td>der</td>
<td>großen</td>
<td>große</td>
</tr>
<tr>
<td>Panda</td>
<td></td>
<td>Panda</td>
</tr>
</tbody>
</table>

**Meaning:**
- Low: “The tired dragon ties up the big panda”
- High: “The big panda ties up the tired dragon”
Study I (Habicht et al., Trends Hear 2016)

Are experienced HA users faster at grasping the meaning of a sentence than inexperienced users? An eye-tracking study

Study I: Participants

<table>
<thead>
<tr>
<th></th>
<th>Exp. users (eHA)</th>
<th>Non-users (nHA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size, N</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Mean age (yr)</td>
<td>72</td>
<td>72</td>
</tr>
<tr>
<td>Mean PTA_{3,0k} (dB HL)</td>
<td>62</td>
<td>60</td>
</tr>
<tr>
<td>Mean reading span (%-corr.)</td>
<td>44</td>
<td>39</td>
</tr>
<tr>
<td>Mean SRT_{0db} (dB SNR)</td>
<td>-1.1</td>
<td>-0.6</td>
</tr>
</tbody>
</table>

All p > 0.05
Study I: Methods

• Test setup
  • Headphone-based
  • Master Hearing Aid research platform (Grimm et al., 2006)
  • Stationary speech-shaped noise; 0 dB SNR

• Three HA conditions
  • NAL-R amplification (→ reference)
  • Single-channel noise reduction (Gerkmann & Hendriks, 2012) (with NAL-R amplification)
  • Amplification à la DSL (Humes, 2007)

Study I: Results

• Processing times increase with linguistic complexity ($p < 0.001$)

• Experienced HA users have shorter processing times than inexperienced users, despite the same speech intelligibility!

• No influence of HA condition (all $p > 0.05$)
  ➢ Acclimatization effect?
Study II (Habicht et al., *Ear Hear* in press)

Auditory acclimatization to bilateral hearing aids: Effects on sentence-in-noise processing times and speech-evoked potentials

Study II: Participants

Experienced (>1 year) HA users vs. novice users

<table>
<thead>
<tr>
<th></th>
<th>Exp. users (eHA)</th>
<th>Novice users (nHA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size, N</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>Mean age (yr)</td>
<td>74</td>
<td>73</td>
</tr>
<tr>
<td>Mean PTA_{0.5-4k} (dB HL)</td>
<td>43</td>
<td>38</td>
</tr>
<tr>
<td>Mean SRT_{50} (dB SNR)</td>
<td>−1.6</td>
<td>−1.4</td>
</tr>
<tr>
<td>Mean HA use (hr/day)</td>
<td>11</td>
<td>9</td>
</tr>
</tbody>
</table>

All p > 0.05
Study II: Methods

- HA conditions and fittings
  - eHA group tested with own devices (various brands)
  - nHA group fitted according to NAL-NL1 with same type of device; if needed, one fine-tuning visit within first three days

![Gain plots for eHA and nHA](image)

- Test setup
  - Stimulus presentation: Via earphones
  - Linear amplification according to real-ear insertion gains

- Measurements
  - After 0 and 12 weeks of (continued) HA use
    - \( \frac{2}{3} \) of participants (N = 2 x 10) additionally after 24 weeks
  - Eye-tracking paradigm
    - Stationary speech-shaped noise; individual SRT\(_{80}\)
  - Speech-evoked potentials
Study II: Results

- Experienced users have shorter processing times than novice users.
- Significant improvement over time for nHA group (group × acc. time, p < 0.04).
  - Acclimatization to HAs leads to ~30% improvement in processing times and thus faster speech comprehension in noise.

Study II: Speech-evoked potentials

Oddball paradigm (Finke et al., 2014)
80% standard and 20% deviant (target) stimuli (Rufener et al., 2014)

Task: “Press a button whenever you hear a living being!”

Research questions:
Does acclimatization lead to larger amplitudes and shorter latencies for the N2 and P3 target components?

Components:
N2: Reflect lexical and semantic processing
P3: Reflect stimulus evaluation/classification
Summary

- Using an eye-tracking paradigm for assessing speech comprehension in noise, we found that...
  
  (1) Experienced HA users comprehend sentences in noise faster than inexperienced users, despite no differences in speech intelligibility (Habicht et al., Trends Hear 2016, Ear Hear in press)

  (2) Acclimatization to HAs leads to ~30% improvement in processing times for novice users and thus faster speech comprehension in noise (Habicht et al., Ear Hear in press)

  • Complementary speech-evoked potential measurements revealed larger N2 amplitudes in experienced users compared to novices (irrespective of HA use duration)
Thanks for listening!

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Literature

