Speech-in-noise processing in elderly hearing-impaired listeners with or without hearing aid experience: Eye-tracking and fMRI measurements

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INTRODUCTION

Wendt et al. (2014) developed an eye-tracking paradigm for estimating how quickly a participant can grasp the meaning of an acoustic sentence in noise stimuli that is presented concurrently with two similar pictures, only one of which depicts the sentence meaning correctly (the ‘processing time’). Previously, we found that hearing-impaired (HI) listeners with hearing aid (HA) experience had shorter processing times than HI listeners without HA experience, despite no differences in speech intelligibility (Habicht et al. 2016, 2017). Peelle and Wingfield (2016) suggested that HI listeners recruit regions outside the core speech processing network (comprising middle temporal and inferior frontal gyri) to achieve speech comprehension. Here, we adapted the eye-tracking paradigm for functional magnetic resonance imaging (fMRI) measurements to address the following research question: Is HA experience associated with reduced recruitment of brain regions outside the core speech comprehension network?

EYE-TRACKING MEASUREMENTS

Speech material (Uslar et al. 2013)

Two sentence structures with different levels of linguistic complexity (‘low’ and ‘high’).

Low

Der müde Drache fesselt den Großen Panda.

Meaning: The tired dragon ties up the big panda.

High

Den müden Drachen fesselt der große Panda.

Meaning: The big panda ties up the dragon.

Picture sets

One picture illustrates the situation described in the spoken sentence (→ target). The other picture illustrates the same situation with interchanged roles (→ competitor).

Task

“Select the picture that matches the acoustic stimulus by pressing a button as fast as possible after the acoustic presentation!”

Outcome

Eye-fixation rate over time allows estimating when the participant must have grasped the sentence meaning.

Figure 1: Eye-fixation rate over the course of an example sentence. xTSA: Single-target detection amplitude. xTSD: Ptd of Target detection. xDM: Decision moment for the target picture.

METHOD

Acoustic stimuli presented in stationary speech-shaped noise at an individual SNR corresponding to 80%-correct speech recognition (SRT80).

FMRI MEASUREMENTS

Stimuli

Sentence-in-noise stimuli with corresponding picture sets from eye-tracking (SPINcont, SPINin): Stationary speech-shaped noise with only one picture as baseline.

Task

“Select the target picture by pressing a left or right button after the acoustic presentation!”

Outcome

Brain activation as inferred via blood oxygenation level dependent (BOLD) contrasts.

RESULTS

Eye-tracking measurements

Table 2: Significant effects from mixed-model ANOVA.

<table>
<thead>
<tr>
<th>Factor</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listener group</td>
<td>5.5</td>
<td>0.026</td>
</tr>
<tr>
<td>Ling. complexity</td>
<td>21.0</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Figure 2: Mean processing times for the two listener groups and levels of linguistic complexity.

fMRI measurements

4. A Stimulus type: As expected, relative to the noise-only stimuli, the SPIN stimuli led to more activation in bilateral superior temporal gyrus, left superior and inferior frontal gyrus, right middle occipital gyrus and bilateral middle occipital gyrus (cf. Lee et al. 2016).

4. B Ling. complexity: As expected, relative to the SPINstimuli, the SPINstimuli led to more activation in bilateral inferior and middle frontal gyrus, left precuneus, right middle occipital gyrus and left superior temporal gyrus (cf. Lee et al. 2016).

5. A Listener group x stimulus type: As expected, relative to the eHA group, the iHA group showed more activation for the SPIN stimuli relative to the noise-only stimuli in left precentral gyrus, left cerebellum, right medial frontal gyrus, and left superior temporal gyrus (cf. Peelle et al. 2011).

5. B Listener group x ling. complexity: Consistent with our eye-tracking results (see above), no interaction between listener group and linguistic complexity observable.

CONCLUSIONS

Our results support the idea that HA experience (1) positively influences the ability to process noisy speech quickly and (2) reduces the recruitment of brain regions outside the core speech comprehension network, regardless of linguistic complexity.

REFERENCES


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PARTICIPANTS

Matched groups of experienced (eHA) and inexperienced (iHA) HA users.

Table 2: Mean age, PTA across 0.5, 1, 2 and 4 kHz, reading span (RS) and SRT80 scores for the two listener groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>Age (yr)</th>
<th>PTA (dB HL)</th>
<th>RS (%-correct)</th>
<th>SRT80 (dB SNR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>eHA (N = 13)</td>
<td>66.8</td>
<td>33.9</td>
<td>43.0</td>
<td>-1.8</td>
</tr>
<tr>
<td>iHA (N = 14)</td>
<td>66.8</td>
<td>31.1</td>
<td>38.9</td>
<td>-1.7</td>
</tr>
</tbody>
</table>

AMPLIFICATION

All stimuli spectrally shaped according to the National Acoustic Laboratories-Reviewed (Byrne et al. 2001) prescription rule using the Master Hearing Aid (Grimm et al. 2006) and presented via earphones.

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