Cognitive functioning as an additional explanatory factor in hearing and in intelligibility in noise

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Cognitive functioning and hearing

Pure-tone Audiometry

Speech-Reception-in-Noise (SRT) test

Hearing Status (SRT as function of PTA)

Hearing and speech perception in the presence of background noise;
underlying components involved:
Peripheral auditory
Central auditory
Cognitive / Linguistic (explicit processing)
Psychological

...disentangle modality-specific auditory processes from more global cognitive functioning......
Speech-Reception-Threshold in noise *

- List of short everyday Dutch sentences
- Two types of masks (stationary, 16 Hz modulated-block)
- Adaptive procedure
- SRT: threshold at which 50% correctly reproduced

* (Plomp & Mimpen, 1979 b)

Visual analogue

TRT score: percentage unmasked text needed to read 50% of the sentences correctly.

28% unmasked text
34%
40%
46%
52%
58%
64%
70%
Two experiments

1. Normally hearing
   Correlation SRT en TRT

2. Hearing impaired (and normally hearing)
   Regression analysis with Speech-in-Noise as the dependent variable

Experiment 1
The relationship between
the Speech-Reception-Treshold in noise (SRT) and
the Text-Reception-Threshold (TRT: a visual analogue)

Participants, normally hearing (N=34)

Gender: 24 females, 10 males
Ages: M=34 yrs (sd 18.4), 19 – 78 years
PTA at 0.25, 0.5, 1, 2kHz: < 15 dB HL
PTA at 4 kHz: < 30 dB HL
Normal vision
Native speakers

Procedure

Two Blocks
3 x TRT
1 x SRTstat
2 x SRTmod

Result (normally hearing subjects)

R = 0.54 (p < 0.01)

R = 0.54 (p < 0.01)
Conclusion experiment 1:

About 30% of the interindividual variance in both the TRT and SRT test appears to be associated with modality a-specific skills (cognitive or linguistic).

Experiment 2

Hearing impaired and normally hearing

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age range, mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal hearing</td>
<td>13 5/8 53 – 78, 63.5</td>
</tr>
<tr>
<td>Hearing impaired</td>
<td>21 9/12 46 – 81, 65.5</td>
</tr>
</tbody>
</table>

Normal vision
Native speakers

Aim: to predict the SRT score

Test battery

Pure-tone audiometry
2 blocks:
3 x Test-Reception-Threshold test (TRT)
2 x Speech-Reception-Threshold, modulated noise (SRTmod)
Temporal Acuity
Spectral Acuity

Regression Analysis

Dependent (to predict) variable:
Speech-Reception-in-Noise test (SRTmod)

Independent variables (predictors):
Pure-tone audiometry
Temporal acuity
Spectral acuity
Test-Reception-Test (TRT)
Age

Result Experiment 2

(Normally hearing, N=13)

<table>
<thead>
<tr>
<th>Correlations</th>
<th>SRTmod</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure-tone Audiometry</td>
<td>0.48</td>
<td></td>
</tr>
<tr>
<td>Temporal acuity</td>
<td>-0.09</td>
<td></td>
</tr>
<tr>
<td>Spectral acuity</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>Test-Reception-Threshold (TRT) test</td>
<td>0.60 p &lt; 0.01</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.43</td>
<td></td>
</tr>
</tbody>
</table>

Stepwise multiple regression analysis

(Predict the outcome on the Speech-in-Noise test)

<table>
<thead>
<tr>
<th>Step</th>
<th>Predictor</th>
<th>Cum R²</th>
<th>Multiple R</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Temporal Acuity</td>
<td>0.45</td>
<td>0.85</td>
</tr>
<tr>
<td>2</td>
<td>Test-Reception-Test</td>
<td>0.73</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Result Experiment 2

(Hearing impaired, N=21)
Once again

About 30% of the interindividual variance in both the TRT and SRT test appears to be associated with modality a-specific skills (cognitive or linguistic)

Conclusion experiment 1:

TRT may be clinically relevant to determine part of the origin (auditory or non-auditory) of deteriorated speech reception among hearing impaired listeners

….about 30% of the interindividual variance in both the TRT and SRT test appears to be associated with modality a-specific skills

What are the cognitive or linguistic skills?

Non-verbal cognitive tests

Cambridge Neuropsychological Testing Automated Battery (CANTAB)

• Rapid Visual Processing
• Spatial Working Memory

Language independent!

Hearing loss and cognitive decline: conflicting evidence

<table>
<thead>
<tr>
<th>Study</th>
<th>Hearing</th>
<th>Cognition</th>
<th>Relation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cacciarelli et al., 1996, N = 1332</td>
<td>Self-report (quiet)</td>
<td>MMSE</td>
<td>Yes</td>
</tr>
<tr>
<td>Bazargan et al., 2001, N = 969</td>
<td>Self-report, 1 item</td>
<td>MMSE</td>
<td>Yes</td>
</tr>
<tr>
<td>Naramura et al., 1999, N = 750</td>
<td>PTA</td>
<td>MMSE</td>
<td>Yes</td>
</tr>
<tr>
<td>Carabellese et al., 1993, N = 1791</td>
<td>Whispered voice</td>
<td>MMSE</td>
<td>No</td>
</tr>
<tr>
<td>Thomas et al., 1983</td>
<td>PTA</td>
<td>Verbal</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-verbal</td>
<td>No</td>
</tr>
</tbody>
</table>

Rapid Visual Processing (RVP), sustained attention

RVP-d (sensitivity to target sequence) and RVP-ß (tendency to respond regardless of presence of target sequence)
Spatial Working Memory

SWM-errors (number of times a used box is opened) and SWM-strategy (efficient search strategy, i.e. following a predetermined search sequence)

Regression analyses

Dependent variables:
- RVP-\(d\)’
- RVP- \(\beta\)
- SWM-errors
- SWM-strategy

Independent variables:
- Model 1: Age, IQ
- Model 2: Age, IQ, PTA

Results

Hearing loss, over and above Age and IQ, explained additional variance in:

Spatial Working Memory SWM (effective search strategy), \(\beta = -0.45\)

<table>
<thead>
<tr>
<th>Model</th>
<th>Age</th>
<th>IQ</th>
<th>PTA</th>
<th>17%</th>
<th>37%</th>
<th>30%</th>
<th>(p &lt; 0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Model 2</td>
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<td></td>
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</tr>
</tbody>
</table>

- No support for the hypothesis that hearing loss (PTA) is associated with cognitive decline
- More extensive use of working memory in daily life to compensate for the loss?

Relationship cognitive functions and PTA

Correlations Cantab, SRT, TRT (N=60)

- SRT
  - \(R = 0.60\)
  - \(R = 0.43, p < 0.01\)

- TRT
  - \(R = 0.60\)
  - \(R = 0.37, p < 0.01\)

- sustained attention

Relationship cognitive functioning with SRT and TRT?
Future

HEAD: brain implant?

More details:


Thanks for your attention!