Working memory capacity compensates hearing related phonological processing deficit

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INTRODUCTION

Persons with acquired hearing impairment tend to fall behind normal hearers in phonologically challenging tasks. This has been the case even when the task is visually presented, e.g. when making rhyme judgments on written word pairs. The reason is probably gradually declining phonological representations. As the years with impoverished auditory input increase, representations grow less well-defined [1, 2]. According to the model of Ease of Language Understanding (ELU) poorly defined representations will lead to mismatch in phonologically challenging tasks. As a result, reliance on explicit resources, such as working memory capacity (WMC), to resolve the mismatch will increase. Thus the ELU predicts WMC will modulate performance on phonologically demanding tasks in persons with hearing impairment to a higher degree than in normal hearers. Our purpose in this study was to test that prediction. We also wanted to investigate if hearing impairment and WMC had an impact on incidental encoding of phonological material.

METHOD

Participants

21 participants with postlingually acquired, moderate-to-severe hearing impairment (HI). Age: M = 63.9 (SD = 6.24), Best ear PTA: M = 76.7, (SD = 13.87)

21 normal hearing (NH). Age: M = 66.24 (SD = 5.65), Best ear PTA: M = 15.71 (SD = 5.86)

Groups were matched on education level, verbal and non-verbal abilities, and WMC as measured by Reading span and short term memory span

Each group was subdivided into high- and low WMC individuals by a median split of Reading span scores

There were no differences between HI high WMC and HI low WMC on hearing measures (BestEar PTA, duration HI/hearing aid use)

The two high WMC subgroups did not differ on Reading span scores, nor did the two low WMC subgroups

Procedure

• Rhyme judgment task
  - Written word pairs visually presented one word at a time
  - Four conditions: rhymes (R+), non-rhymes (R-), orthographically similar (O+), and orthographically dissimilar (O-)
  - Task: decide if words rhymed or not
  - Most challenging conditions – pairs where orthography and phonology give conflicting cues (R+O+, R+O-)

• Recognition task
  - Stimuli: second words of the rhyme judgment word pairs and an equal number of new words
  - Task: decide if the words had been presented in the rhyme judgment task or not

RESULTS

Rhyme judgment performance

Group performance over the four rhyme conditions were compared in a repeated measures ANOVA with Rhyme (R+, R-) and Orthography (O+, O-) as within subject variables and Group (NH, HI) as between subjects factor

Results showed:

• significant main effects of Rhyme and Group
• significant Rhyme x Orthography x Group interaction (fig 1)

- Results are in support of a phonological processing deficit in persons with acquired hearing impairment.
  - In the demanding R+O- and R-O+ conditions HI performed significantly lower than NH

Impact of WMC on rhyme judgment performance

WMC (High, Low) was added as a between subject factor to the same ANOVA as above

Results showed:

• significant main effects of Rhyme, Group and WMC
• significant Rhyme x Orthography x Group x WMC interaction (fig 2 and 3)

- WMC had no impact on performance in the NH group in either condition
- In the HI group WMC had a significant effect: high WMC individuals outperformed low WMC individuals in the two phonologically demanding conditions, especially R+O+
- Results support the prediction that WMC modulates phonological processing specifically in the HI group and indicate that high WMC help compensate for phonological processing difficulties in persons with hearing impairment

Incidental recognition

Rhyme judgment performance thus showed differences in phonological processing as a function of WMC in the HI group.

Our next question was whether this had an impact on encoding. As those with reduced phonological abilities had larger difficulties in the task, they might have used a different strategy. If so, encoding might differ as well. As R+O+ proved to be the most difficult task we further analyzed the proportion of words from correctly solved R+O+ judgments that were also correctly recognized.

Results showed:

• significant main effect of WMC
• significant Group x WMC interaction (fig 4)

- WMC had no significant impact on recognition in the NH group even if those with high WMC recognized more words than those with low
- In the HI group low WMC was associated to a significantly higher recognition than high WMC
- Results thus suggest HI with lower WMC used a different strategy in the rhyme judgment task resulting in a deeper encoding

CONCLUSIONS

As a group HI showed evidence of phonological processing deficit when task demands were challenging

However, performance on these tasks was highly related to WMC – HI with high working memory performed on a par with NH

Thus results support high WMC can compensate for hearing related phonological processing deficit

Results further suggest WMC capacity influence what strategy individuals with hearing impairment use in phonologically demanding tasks

Recognition scores of hearing impaired with low WMC was significantly higher than those of hearing impaired with high WMC in the most critical condition.

The negative impact of having both a hearing impairment and low WMC probably makes it highly demanding for this group to use a phonological strategy in the rhyme task. Results support they more likely used a semantic, whole word strategy, leading to a deeper encoding.
Figure 2. Correct rhyme judgment by group, WMC, and condition. Error bars 95% CI.

Figure 3. Percent correctly solved in the judgment task that was recognized, R-O+ condition by group and WMC. Error bars 95% CI.