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The Complex Listening study is a multicenter, longitudinal study focusing on listening skills in children with mild-severe hearing loss.

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What guides our research goals?

New generation of children who are hard of hearing

How does auditory access support listening?

What role do language and cognition play in complex listening?
Quantifying Auditory Access: Speech Intelligibility Index

For each band: Audibility x FIW = weighted audibility

SII = Sum of weighted audibility of all frequency bands
Auditory access is variable in most listening situations!

- Rooms vary by shapes and sizes, desk configurations, carpeting, etc.
- Teachers may be stationary or move around the room.
- Children may only catch parts of what the teacher or other students are saying.
He has been all over the room from 6-12 feet to the right and to the left.

Currently she sits about 3 or 4 feet directly in front of where I stand most often.

She sits in different spots. We switch seats every 4 1/2 weeks.

He usually sits towards the back of the classroom as he is hard working and trustworthy.
• Children need good auditory access to perceive a message in a degraded listening environment like the classroom.

• What happens when a child misses part of a message, due to reduced hearing, poor classroom acoustics, or distance from the speaker?

• How do language and cognition influence the relationship between auditory access and word recognition?
Current Study: Research questions

How do hearing status, age, and sentence predictability affect children’s ability to “fill in the gaps”?

Do vocabulary size and memory skills influence the relationship between aided audibility and word recognition?
Current study: Participants

- \( n = 70 \) children
  - 18 first graders (7 years old) with hearing loss and 15 first graders with normal hearing
  - 22 third graders (9 years old) with hearing loss and 15 third graders with normal hearing

<table>
<thead>
<tr>
<th>Children with hearing Loss ( n = 40 )</th>
<th>( M )</th>
<th>( SD )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographic Characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Better-ear PTA (dB HL)</td>
<td>47.09</td>
<td>14.47</td>
</tr>
<tr>
<td>Better-ear SII</td>
<td>77.92</td>
<td>14.51</td>
</tr>
<tr>
<td>Age at confirmation</td>
<td>10.38</td>
<td>14.62</td>
</tr>
<tr>
<td>Age at HA fit</td>
<td>13.46</td>
<td>18.19</td>
</tr>
</tbody>
</table>
Study participants: Inclusion criteria

- English primary language
- No major secondary disabilities
- No cochlear implants
- Permanent mild to severe *bilateral* hearing loss
Methods

• Children completed listening, language, and cognitive test battery in summer after first grade (age 7 years) or third grade (age 8 years)
Methods: Aided Audibility
Methods: Vocabulary size

- Peabody Picture Vocabulary Test
Methods: Working Memory

Odd One Out task
(visual-spatial complex working memory)
Methods: Time-Gated Word Recognition

• Stimuli: 14 high-predictability and 14 low-predictability sentences from the Speech Perception in Noise (SPIN) test
  – Predictability based on semantic and syntactic context
    • High: “Tree trunks are covered in ____”
    • Low: “She talked about the _____”
Gating task

“She talked about the _____”

Gate 1: 0 ms from word onset

Gate 2: 100 ms from word onset

Gates 3…. +50 ms increments

Acceptance Point: Target word identified two times in a row

“Clock”
Calculating the probability of reaching the acceptance point (i.e., identifying word two times in a row)
Results: Research Question #1

How does hearing status, age, and sentence predictability affect children’s ability to “fill in the gaps”? 
Effects of sentence predictability (high v low)

$p < .001$
Effects of hearing status (CNH v CHH)

\[ p = 0.006 \]
Effect of age (7 v 9 year olds)

$p = .13$
Summary of univariate analysis

• Predictability had a strong effect on how quickly children could identify words (high predictability words identified faster than low)
• Hearing status also had an impact (hearing group identified words faster than hard of hearing group)
• On its own, age did not have an impact
• What happens when we look at the influence of these factors together in one model?
Effects of hearing status, age, and predictability

CNH

- 1st grade, High predictability
- 1st grade, Low predictability
- 3rd grade, High predictability
- 3rd grade, Low predictability

Time (ms)

Probability of Reaching Acceptance

CHH

- 1st grade, High predictability
- 1st grade, Low predictability
- 3rd grade, High predictability
- 3rd grade, Low predictability

0 100 200 300 400 500 600

0.0 0.2 0.4 0.6 0.8 1.0
Age effect for children with normal hearing
No age effect for children who are hard of hearing

CHH

Probability of Reaching Acceptance Point

Time (ms)

1st grade, High predictability
1st grade, Low predictability
3rd grade, High predictability
3rd grade, Low predictability
Effects of hearing status, age, and predictability

C NH

CHH
Summary of trivariate analysis

• Predictability still plays a big role: children take advantage of contextual cues to identify words

• Age and hearing status interact with one another: older CNH are faster than younger CNH, but there is no difference in age for CHH
Why are the CNH improving over time but the CHH aren’t?

• To be successful at the gating task, one needs to be able to break words into segments
  – Younger children perceive words more holistically. As they add more words to their vocabulary, these global lexical representations become too crowded in the mental lexicon.
  – With age and larger vocabulary size, children process words into acoustic-phonetic segments, allowing for faster, more automatic identification (Metsala, 1997; Walley, 1993).
  – In the current study, CNH move towards processing speech segmentally, but CHH are delayed.
  – Is this because of reduced auditory access, smaller vocabulary size, or slower working memory?
Results: Research Question #2

Do vocabulary size and memory skills influence the relationship between aided audibility and word recognition?
Results: Mediation analysis

- Path A: X → M
- Path B: M → Y
- Path C: X → Y

Aided Audibility

Gated Word ID
Aided audibility “X”

Significant correlation in “Path A”

Third variable “M”

Significant correlation in “Path B”

Significant correlation in “Path C”

Gated word ID “Y”
Results: Vocabulary size as a mediator

Vocabulary size

Take home message: Vocabulary size fully accounts for the association between aided audibility and gated word recognition

Aided Audibility

Gated Word ID

Path C

\[ p = .006 \]

\[ p = N.S. \]

\[ p = .006 \]
Results: Working memory as a mediator

Take home message: Working memory does not account for the association between aided audibility and gated word recognition.
Discussion and Conclusions

- Gating task offers high level of experimental control, allows us to examine listening in complex situations
- Results of research question #1 suggest that children who are hard of hearing experience a prolonged period of reduced sensitivity to acoustic-phonetic information
  - This is concerning: inefficient word processing leads to deficits in sentence comprehension and reading difficulties (Snowling et al., 1986)
  - Decreased sensitivity to phonological structure can lead to verbal working memory (Nittrouer et al., 2017)
- Longitudinal research on adolescents who are hard of hearing is limited, so we can only speculate on the downstream effects.
Discussion and Conclusions

• Results of research question #2 suggest that vocabulary size plays a powerful role in helping children identify words with missing information.
  – Good auditory access via hearing aids is also critical, although its role is more indirect (mediated by higher-level language skills)
  – Working memory is associated with aided audibility, but doesn’t appear to play as significant a role as language (could be related the gating task – children hear sentences over and over and don’t have to rely on memory as much as they would in other situations)
What are the clinical implications?

Higher-level processing: Interventions that focus on building vocabulary breadth and depth

Lower-level input: Hearing aids that are fit to prescriptive targets and worn consistently in all contexts
OCHL Posters...now in Spanish, French, and Greek on www.ochlstudy.org!

¡TU HACES LA DIFERENCIA!

Resultados de la investigación de niños que tienen pérdida auditiva

EL USO DEL APARATO AUDITIVO REAFIRMA EL DESARROLLO DEL LENGUAJE

El uso de los aparatos auditivos al menos 10 horas al día le ayuda a los niños a aprender el lenguaje más rápido que los niños que no los usan de manera consistente, por lo cual es más probable que desarrollen un lenguaje apropiado para su edad. Los niños que usan sus aparatos auditivos menos de 10 horas al día aprenden el lenguaje a un ritmo más lento y pueden atrasarse.

¡Pida ayuda si es difícil lograr que su niño se acostumbre a sus aparatos auditivos!

¡Realice revisiones diarias de los aparatos auditivos para cerciorarse de que tenga un buen acceso al habla!

¡TU HACES LA DIFERENCIA!

RESULTADOS DE LA INVESTIGACIÓN DE NIÑOS QUE TIENEN PÉRDIDA AUDITIVA

EL LENGUAJE DE LOS NIÑOS SE VE INFLUENCIADO POR LO QUE USTED DICE

Los niños aprenden mejor cuando usted les habla sobre algo en lo que están enfocados. Cuando los niños más pequeños hagan gestos o produzcan sonidos, házales saber lo que están mirando. Cuando los niños más grandes hablen, reformule lo que dijeron usando frases un poco más largas.

APRENDA MÁS EN WWW.OCCHLSTUDY.ORG
Danke!