

# Complex Listening in Children with Hearing Loss: Effects of Auditory Access, Language, and Cognitive Abilities

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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

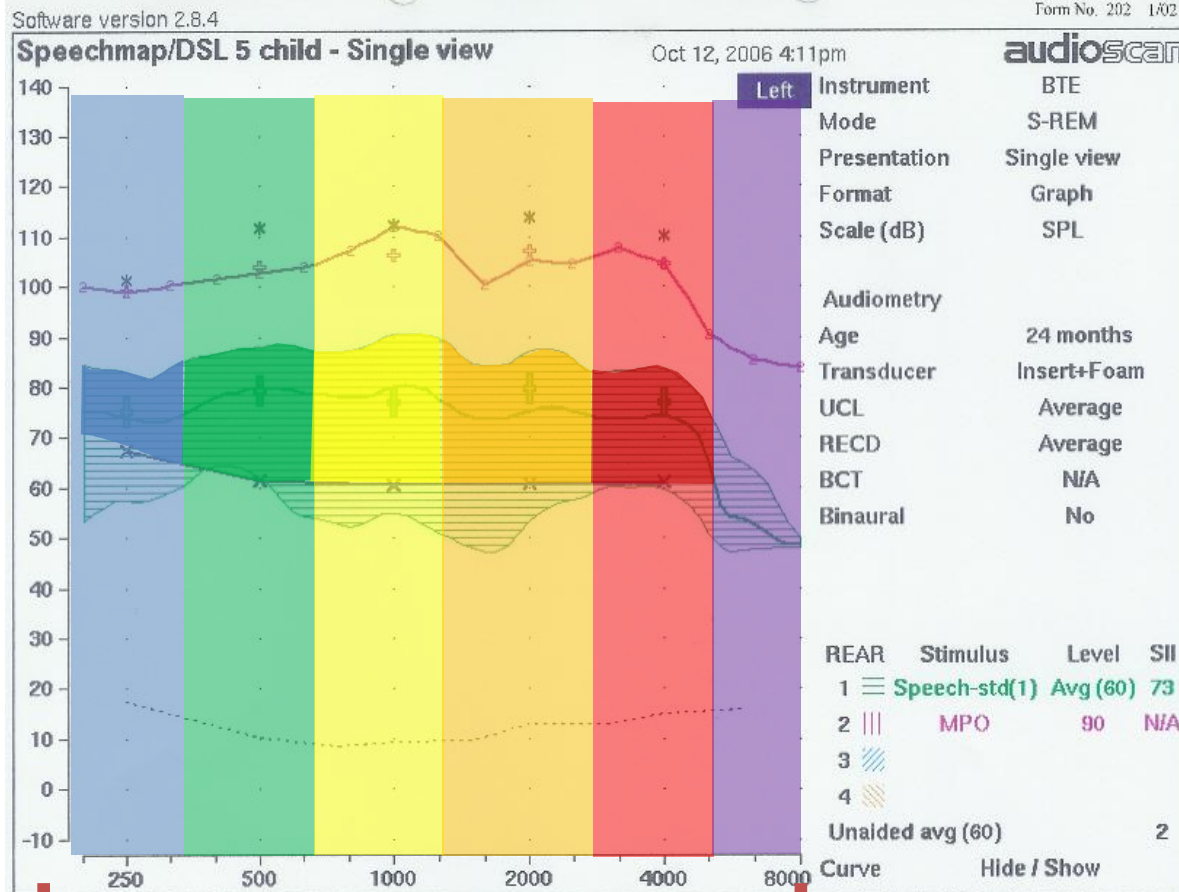


How does auditory access support listening?



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.





# Distance: where are CHH seated?

He has been all over the room from 6-12 feet to the right and to the left.

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

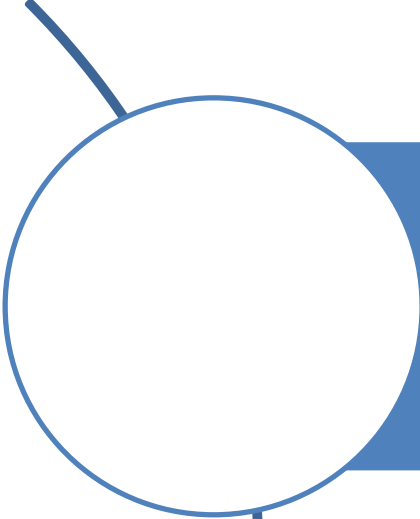
Currently she sits about 3 or 4 feet directly in front of where I stand most often.

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

<i>Children with hearing Loss <math>n = 40</math></i>	<i>M</i>	<i>SD</i>
<b>Demographic Characteristics</b>		
Better-ear PTA (dB HL)	47.09	14.47
Better-ear SII	77.92	14.51
Age at confirmation	10.38	14.62
Age at HA fit	13.46	18.19

# 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



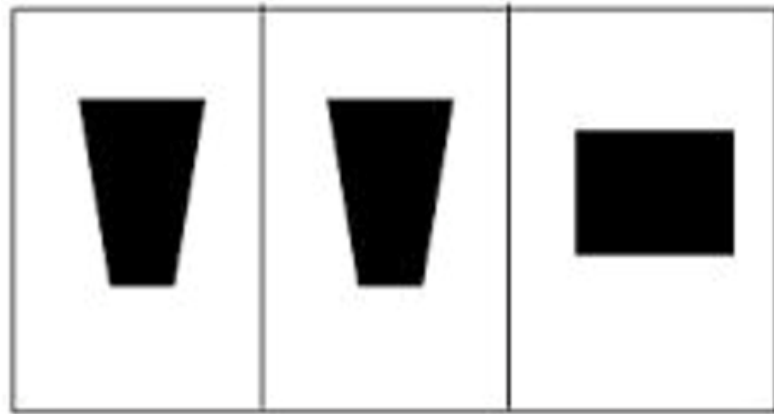
# Methods: Vocabulary size

- Peabody Picture Vocabulary Test

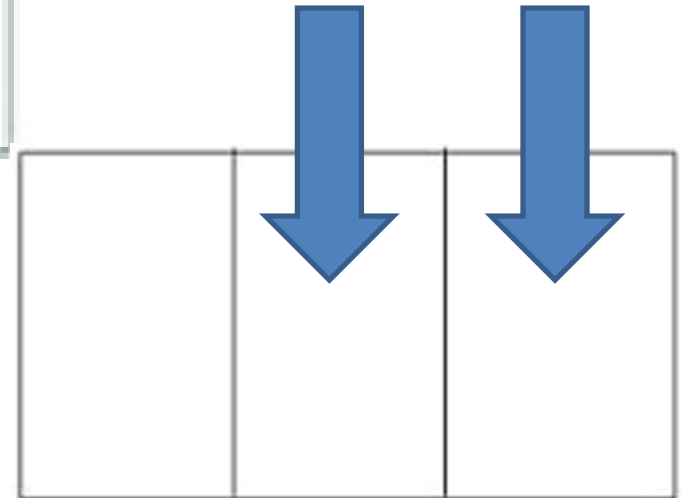
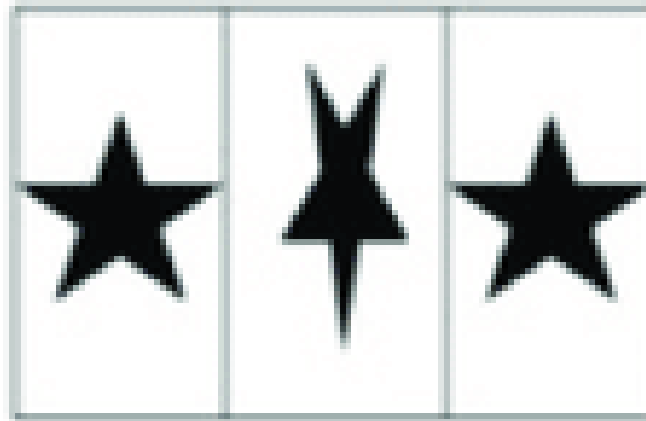




# Methods: Working Memory



Odd One Out task  
(visual-spatial complex  
working memory)



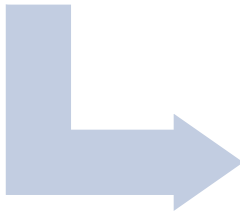
# Methods: Time-Gated Word Recognition

- 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 \_\_\_\_\_”

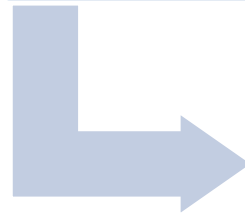
# Gating task

“She talked about the \_\_\_\_\_”

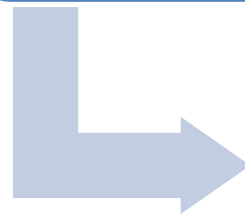
Gate 1:  
0 ms from  
word onset



Gate 2:  
100 ms from  
word onset



Gates 3....  
+50 ms  
increments

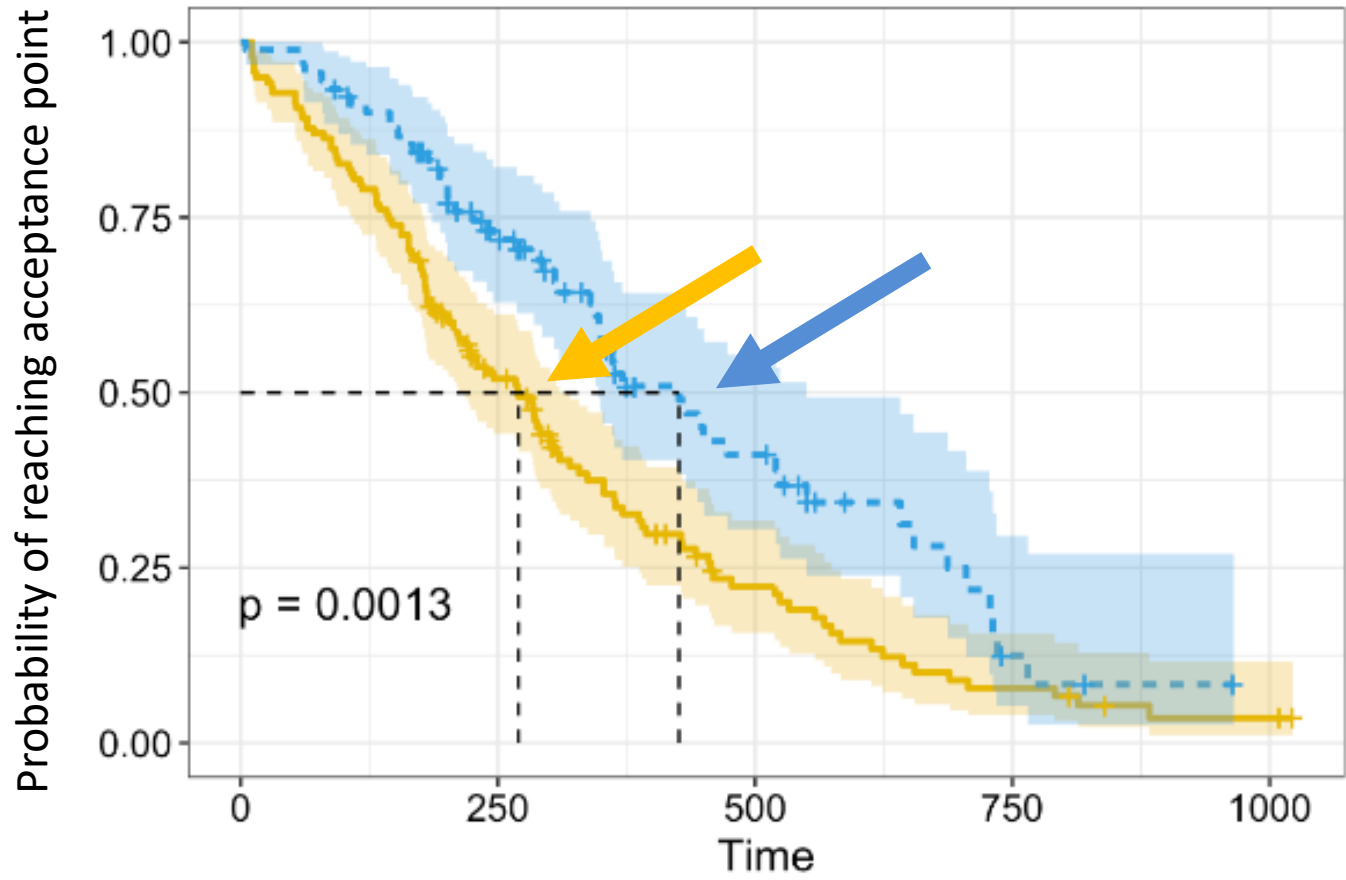


“Clock”

**Acceptance Point:**  
Target word  
identified two times  
in a row

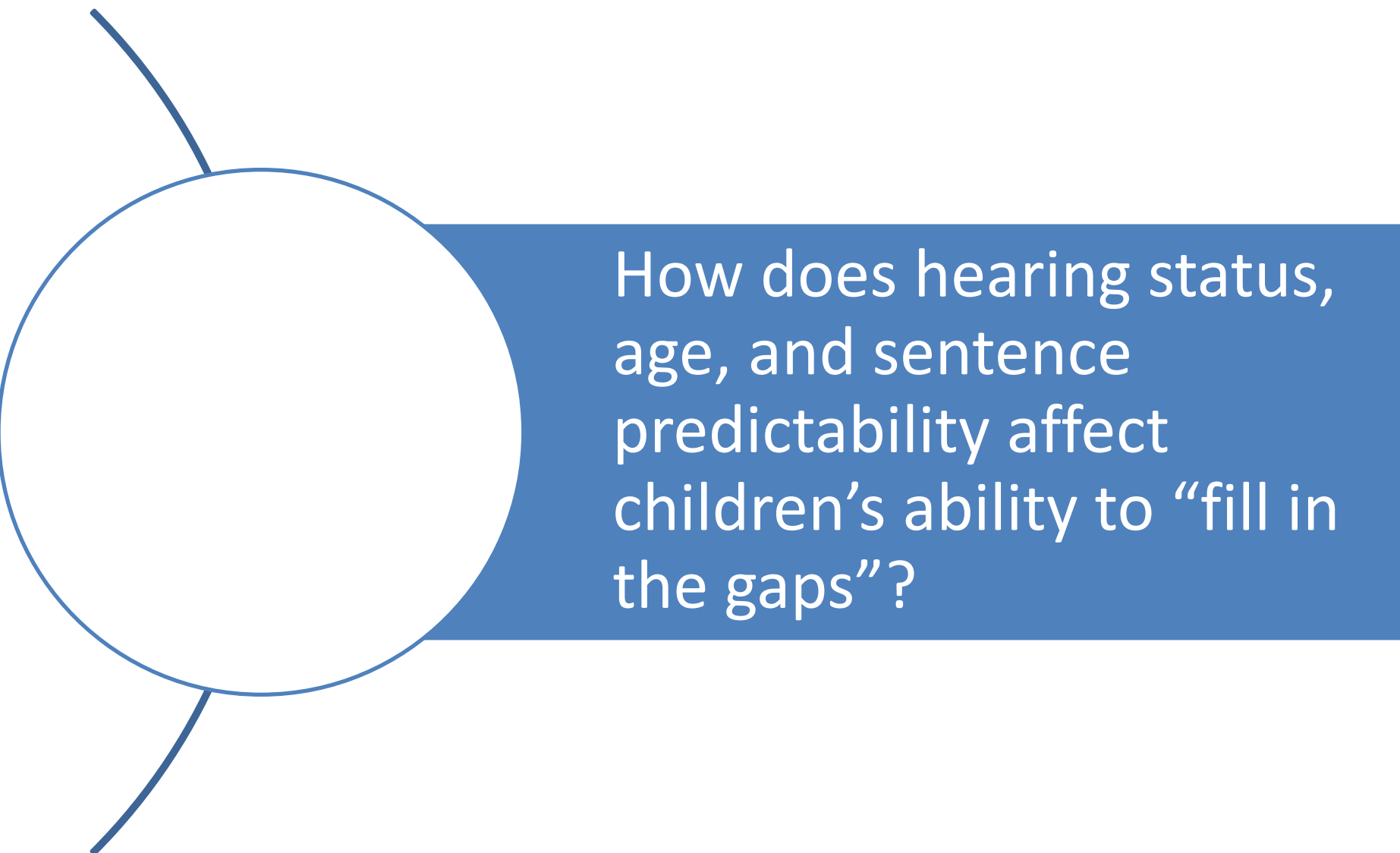


# Statistical Analyses: Time-to-event models



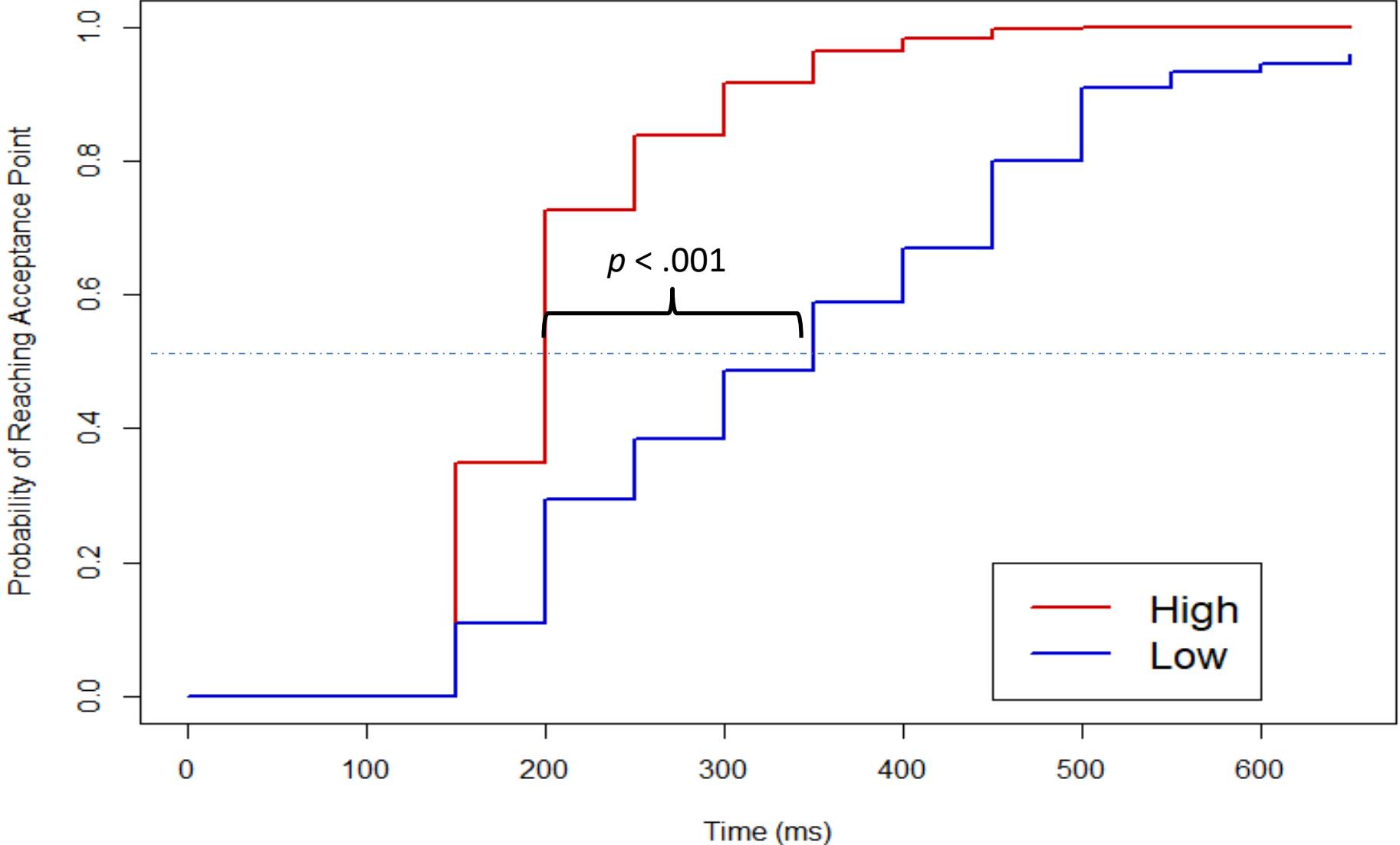
Calculating the probability of reaching the acceptance point (i.e., identifying word two times in a row)

# Results: Research Question #1

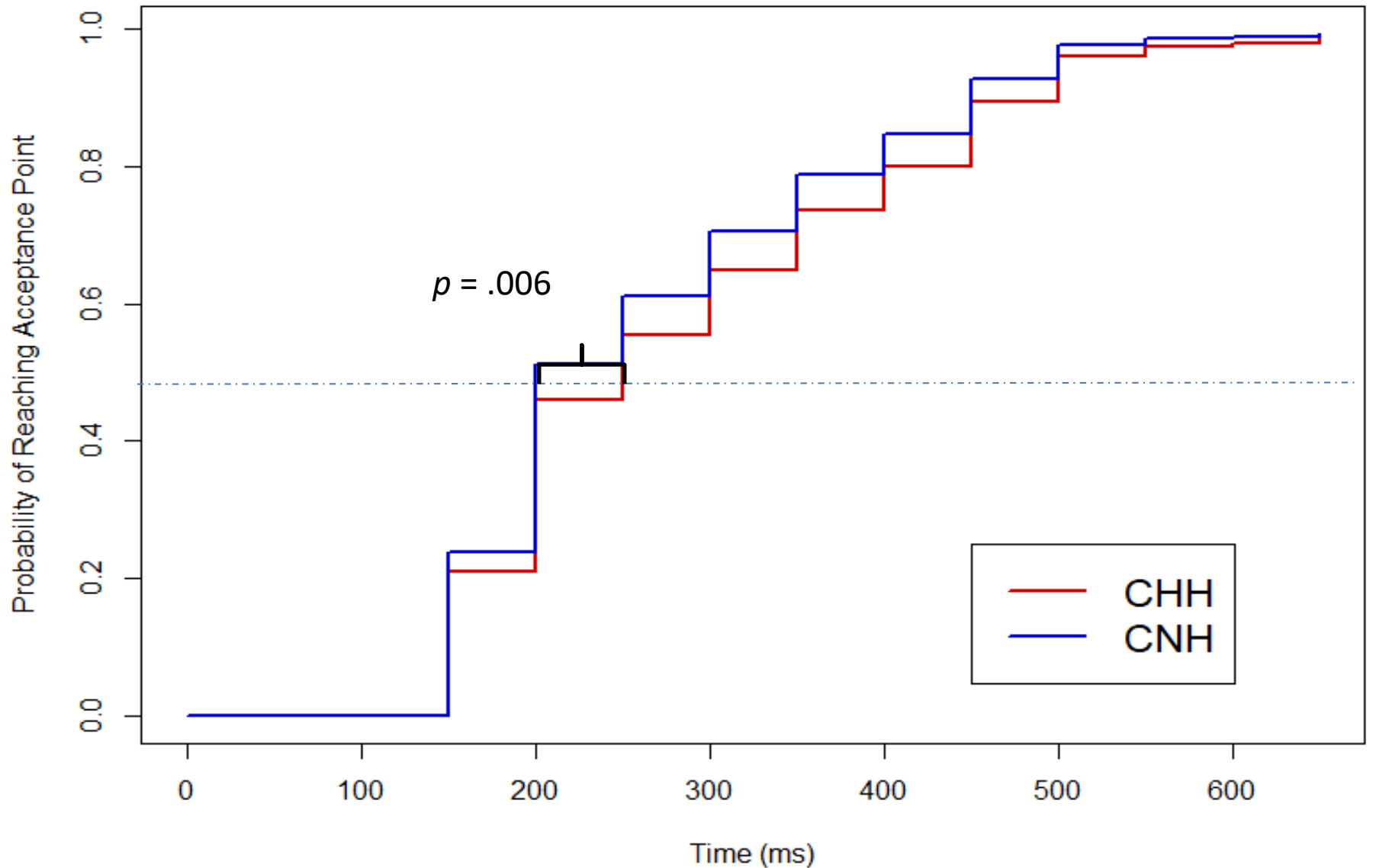


How does hearing status, age, and sentence predictability affect children's ability to "fill in the gaps"?

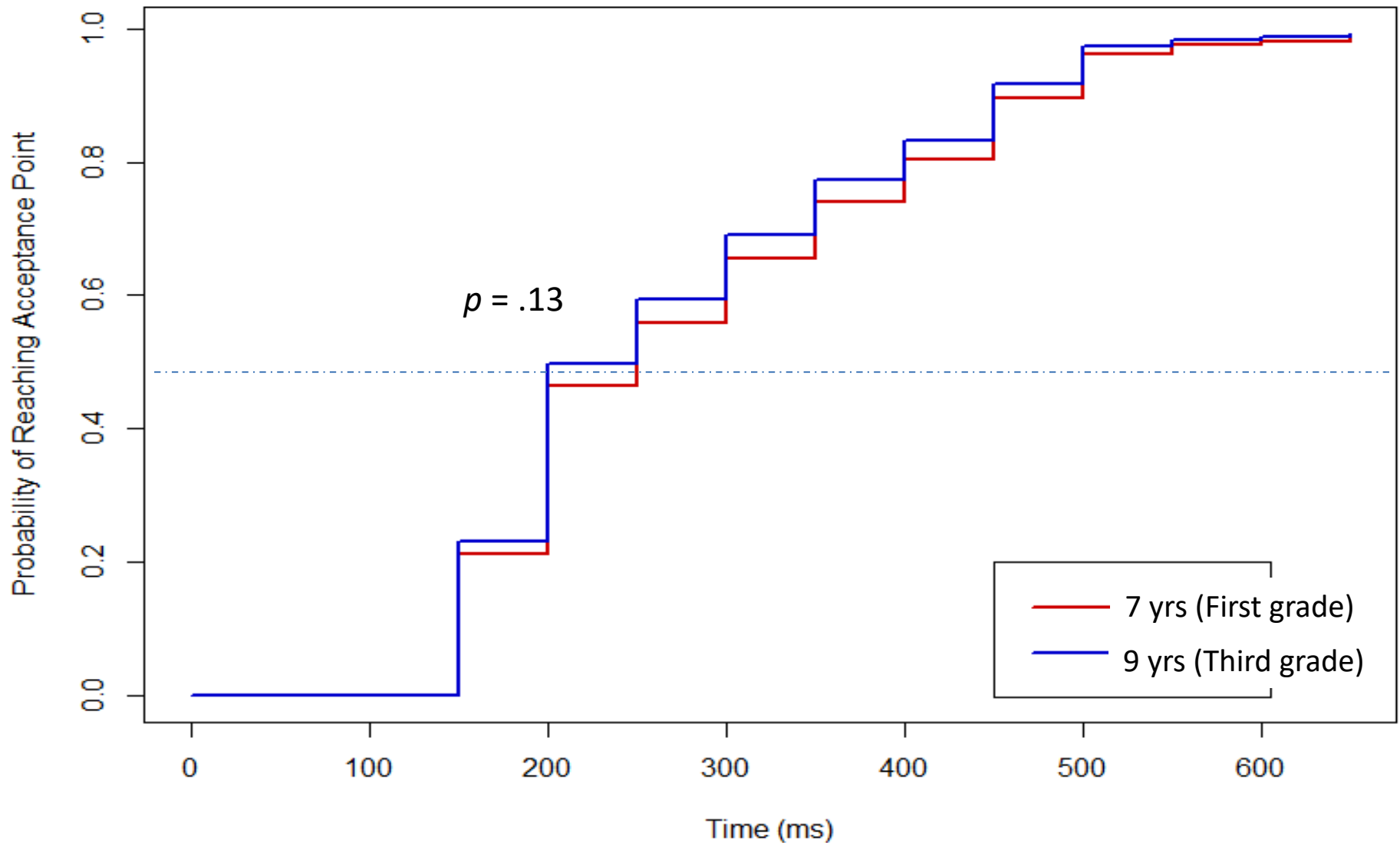
# Effects of sentence predictability (high v low)



# Effects of hearing status (CNH v CHH)



# Effect of age (7 v 9 year olds)

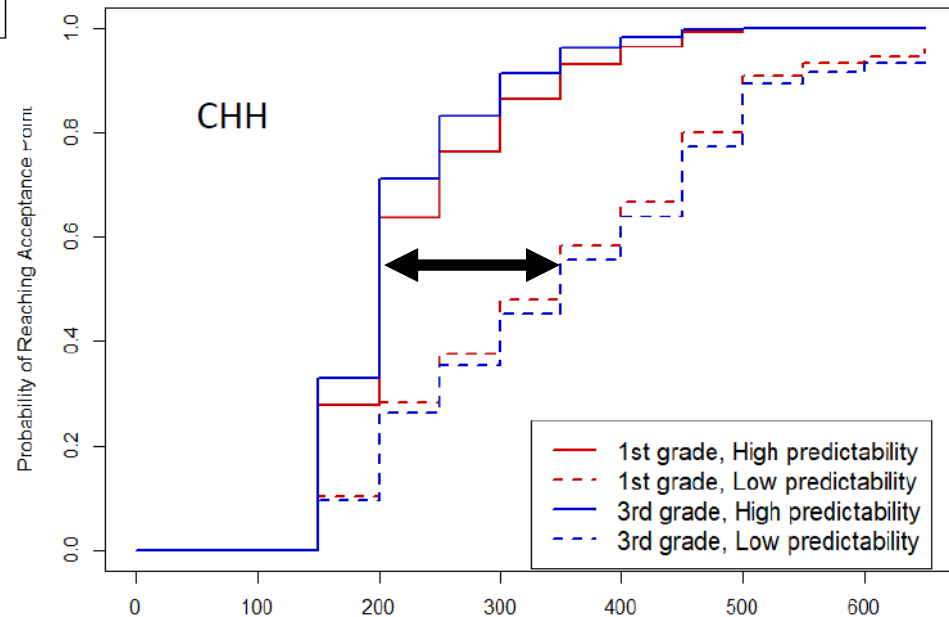
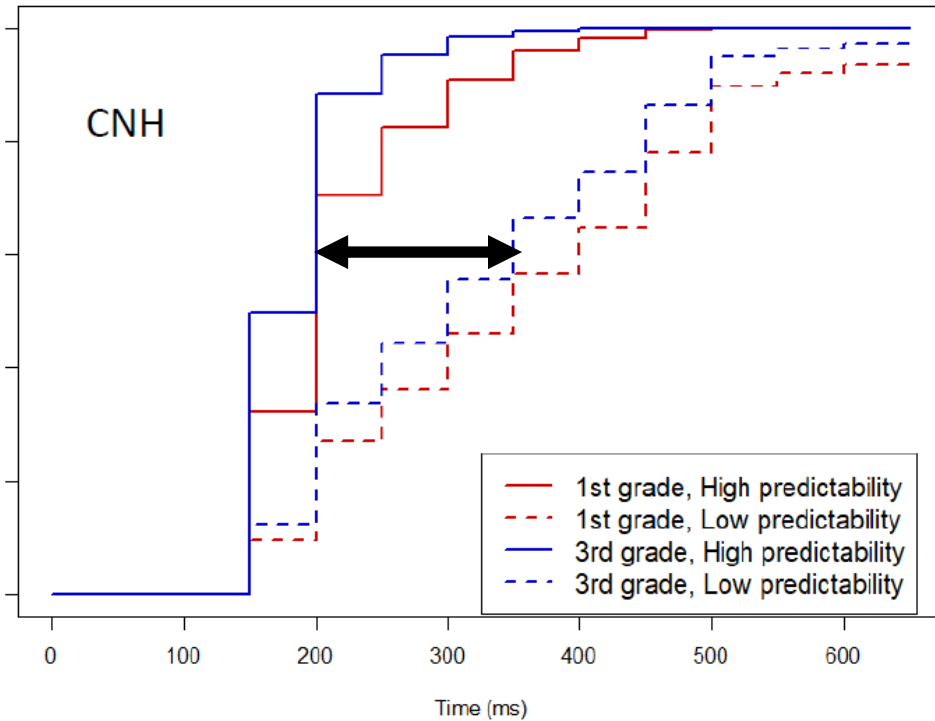


# Summary of univariate analysis

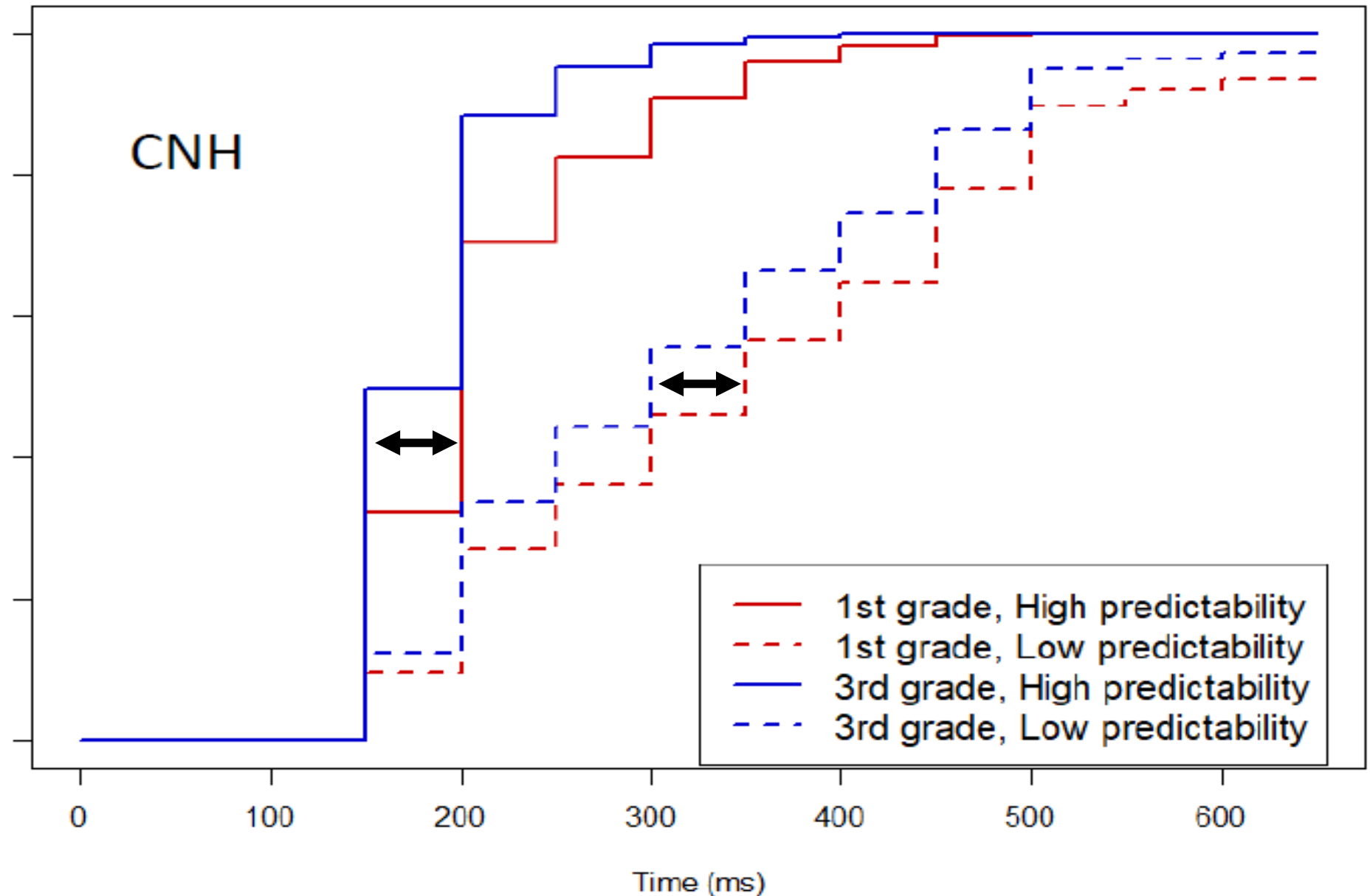
- Predictability had a strong effect on how quickly children could identify words (high predictability words identified faster than low)
- Hearing status also had an impact (hearing group identified words faster than hard of hearing group)
- On its own, age did not have an impact
- **What happens when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



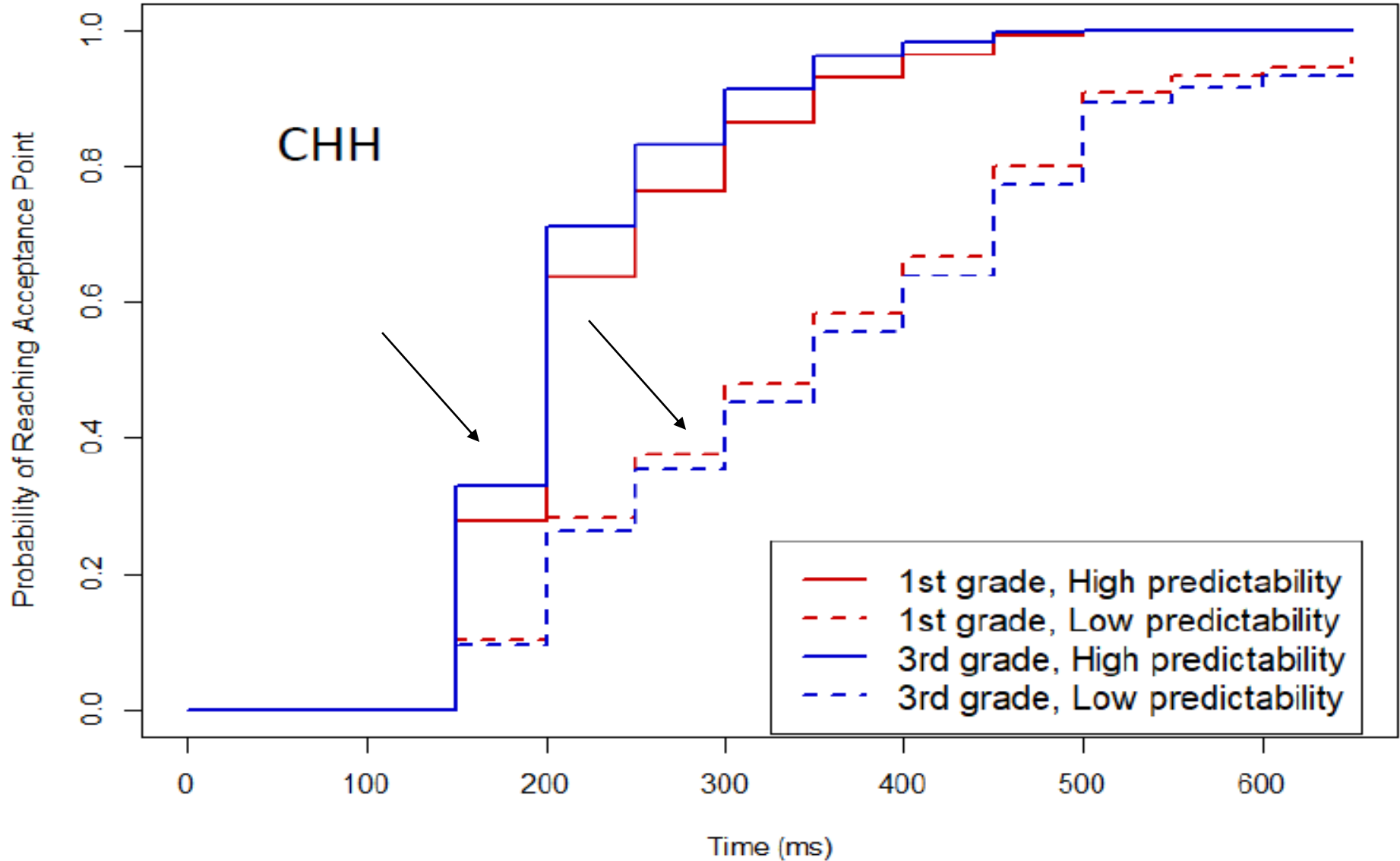
# Effects of hearing status, age, and predictability



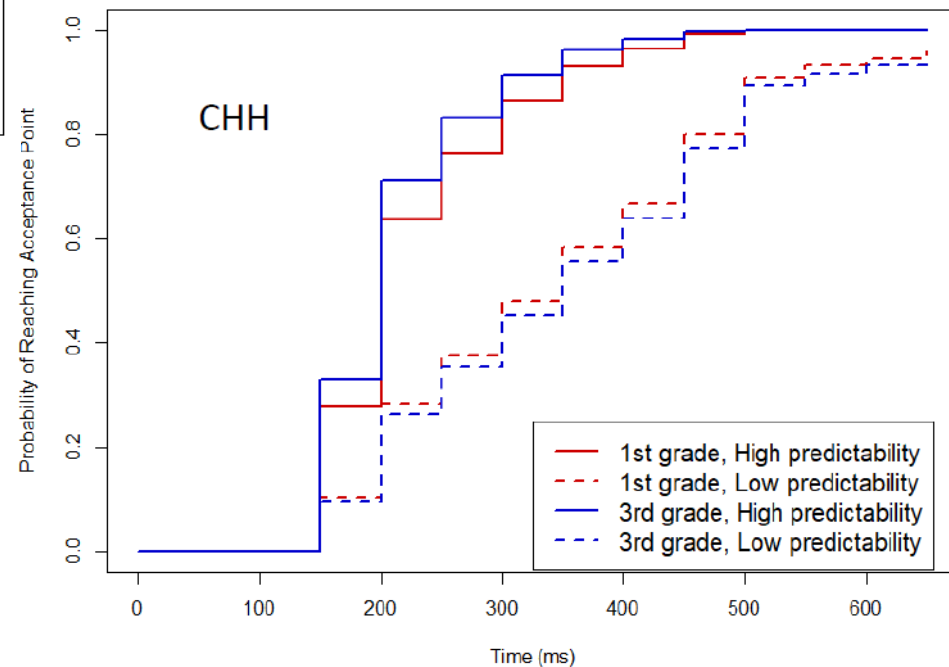
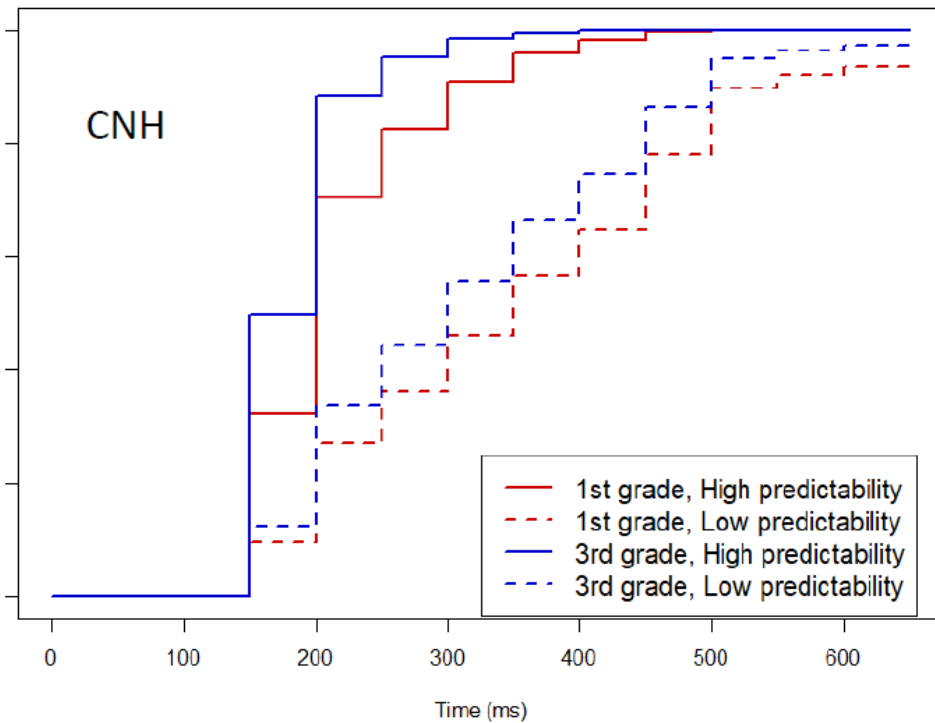
# Age effect for children with normal hearing



# No age effect for children who are hard of hearing



# Effects of hearing status, age, and predictability



# Summary of trivariate analysis

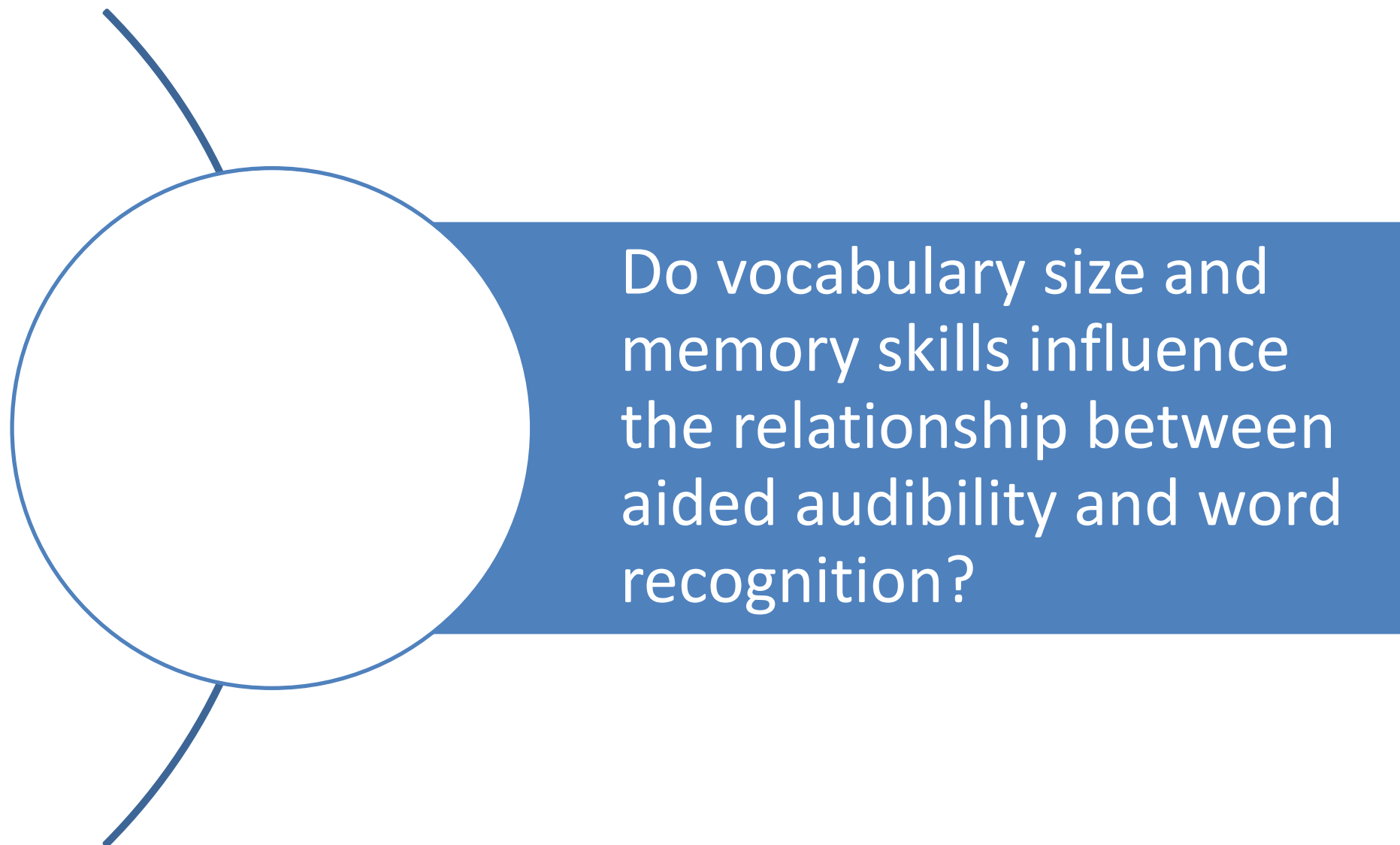
- Predictability still plays a big role: children take advantage of contextual cues to identify words
- Age and hearing status interact with one another: older CNH are faster than younger CNH, but there is no difference in age for CHH

# 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?**

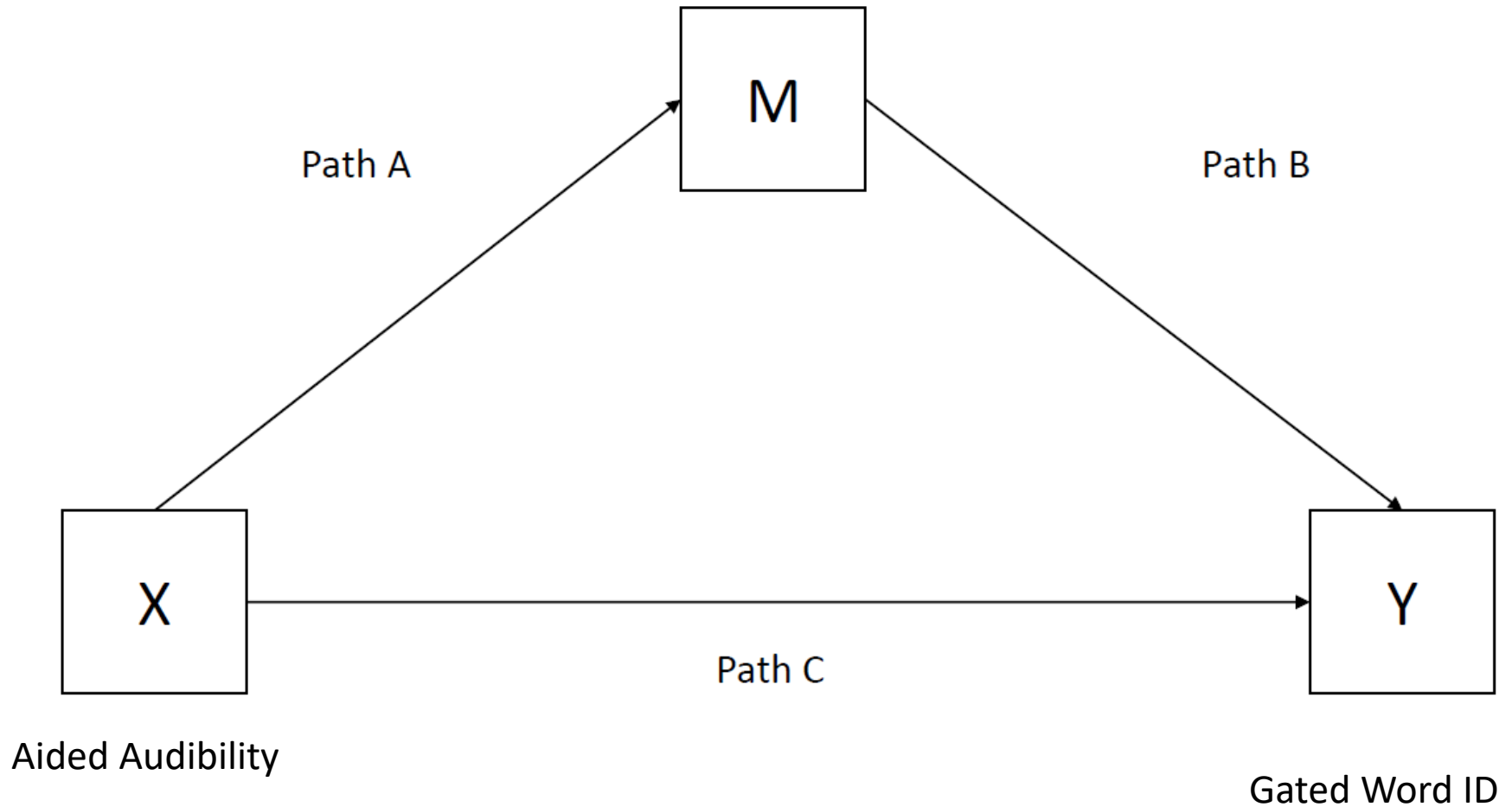


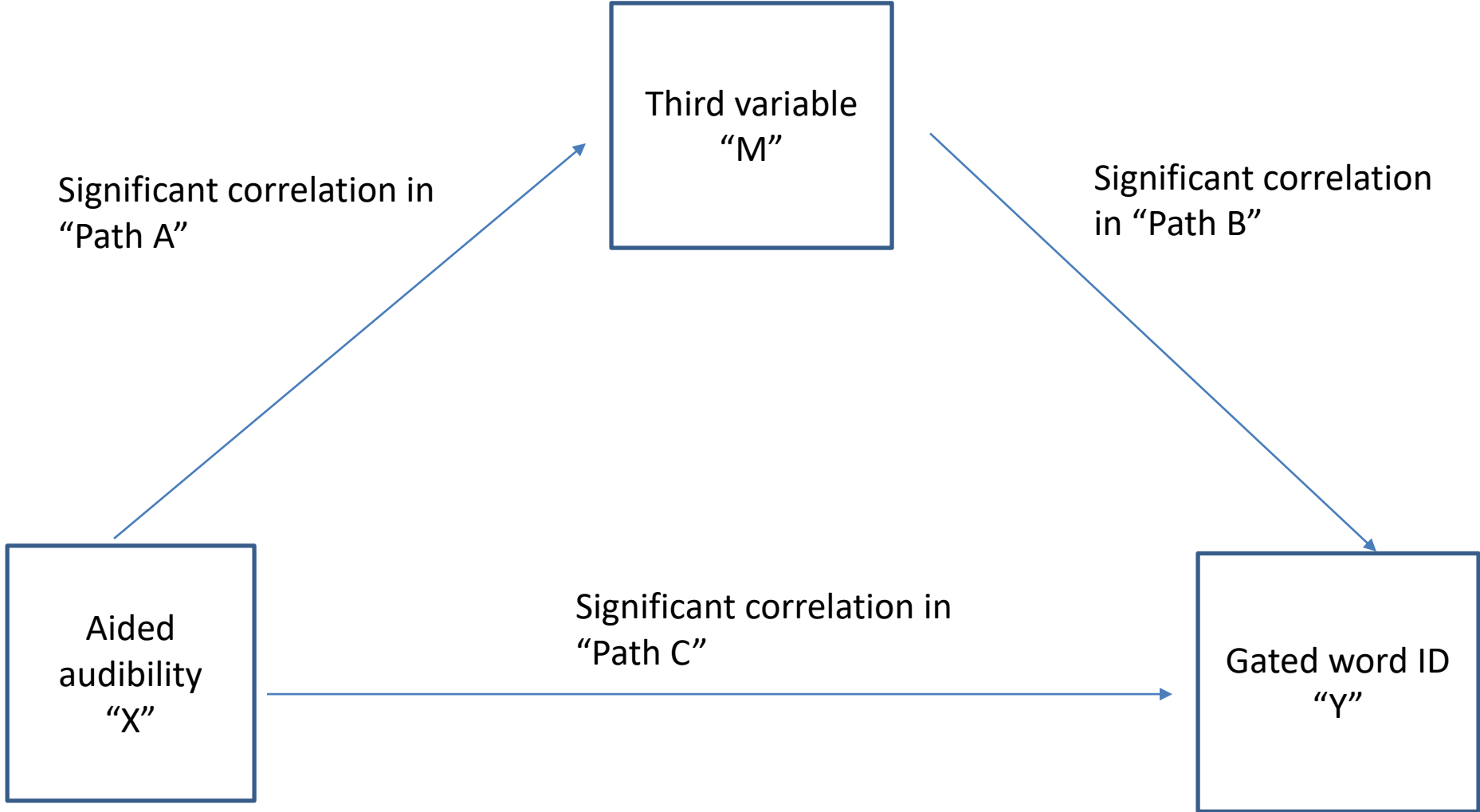
# Results: Research Question #2



Do vocabulary size and memory skills influence the relationship between aided audibility and word recognition?

# Results: Mediation analysis





# 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

$p = \text{N.S.}$   
 $p = .006$

Path C

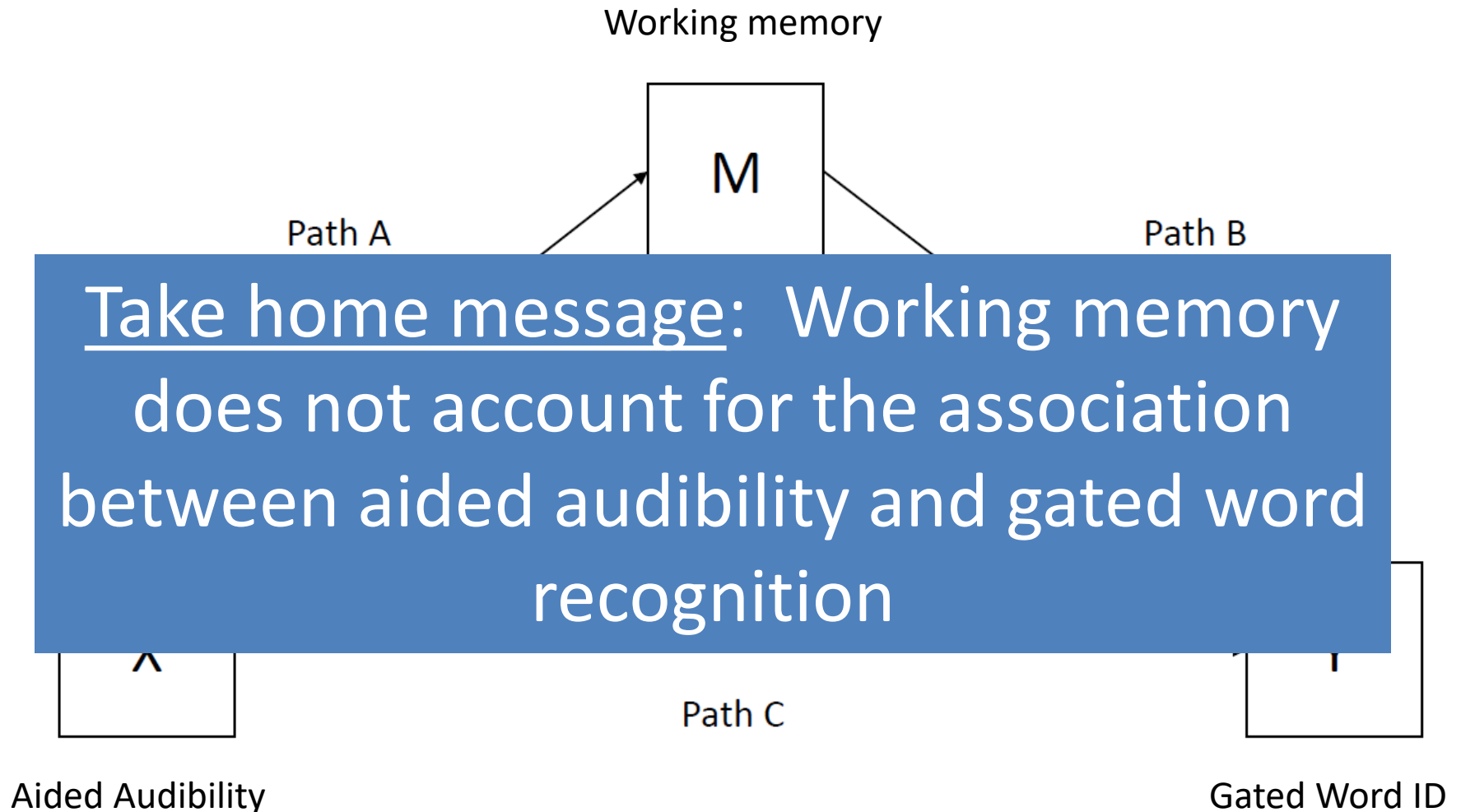
X

Aided Audibility

Y

Gated Word ID

# Results: Working memory as a mediator



# 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 (Nitttrouer et al., 2017)
- **Longitudinal research on adolescents who are hard of hearing is limited**, so we can only speculate on the downstream effects.

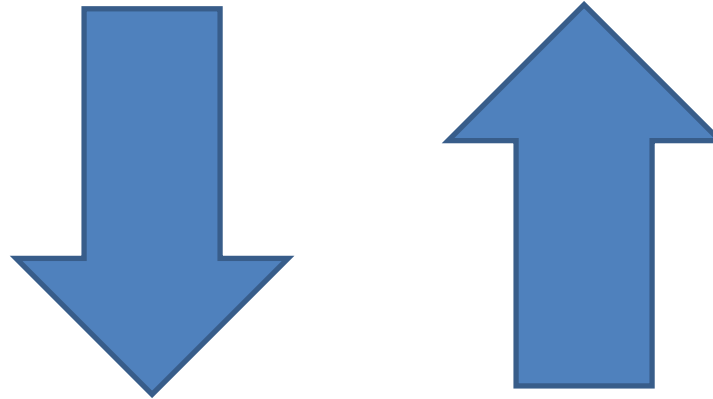
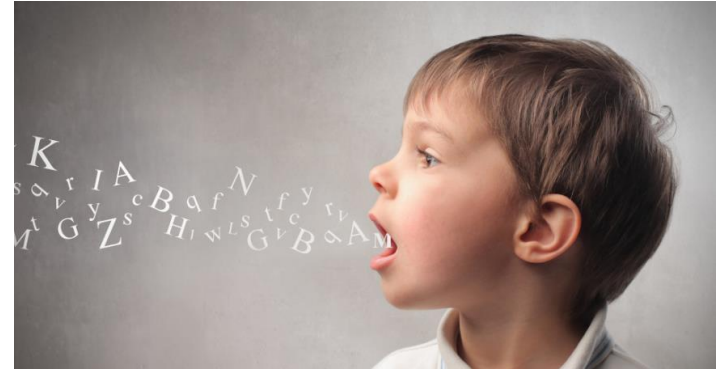


# Discussion and Conclusions

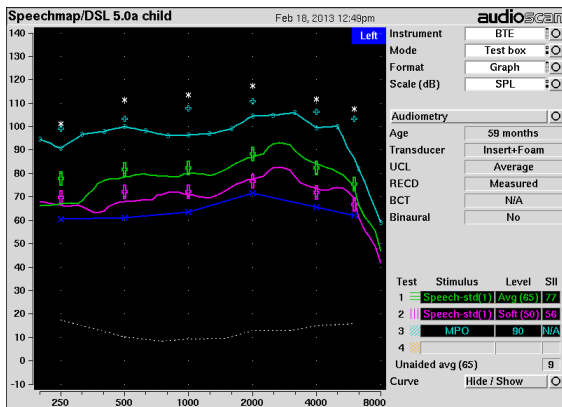
- Results of research question #2 suggest that vocabulary size plays a powerful role in helping children identify words with missing information.
  - Good auditory access via hearing aids is also critical, although its role is more indirect (mediated by higher-level language skills)
  - Working memory 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



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## ¡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.



Hable con su proveedor sobre qué tan bien escucha su niño cuando usa sus aparatos auditivos.



Pida ayuda si es difícil lograr que su niño se coloque los aparatos auditivos.



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

### 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, hableles sobre lo que están mirando. Cuando los niños más grandes hablen, reformule lo que dijeron usando frases un poco más largas.



Los niños aprenden el lenguaje y las habilidades sociales cuando usted habla sobre lo que usted y los demás están pensando. Use palabras como recuerda, cree y siente.



Los niños se benefician del lenguaje que es un poco más complejo del que están acostumbrados a usar. ¡No simplifique mucho lo que diga!



Para que su niño escuche y aprenda más fácilmente, manténgase cerca de su niño y limite el uso de la TV y otros ruidos en su casa.



## ¡Los aparatos auditivos importan!

Resultados de la investigación de niños que tienen pérdida auditiva



### El uso de aparatos auditivos reafirma el desarrollo del lenguaje.

Habilidades gramaticales de niños con pérdida auditiva leve y de niños con audición normal.



Los niños con pérdida auditiva que usan continuamente los aparatos auditivos tienen habilidades gramaticales y vocabulario similar a los niños con audición normal. Los niños que usan inconsistentemente los aparatos auditivos, independientemente del nivel de pérdida auditiva, están en riesgo de adquirir habilidades limitadas de lenguaje.

Si los niños usan los aparatos auditivos por lo menos 10 horas al día, son más propensos para aprender el lenguaje más rápido y de tener habilidades de lenguaje adecuadas a su edad para cuando entran a la escuela. ¡Sea persistente con los niños pequeños en motivar el uso de los aparatos auditivos!



### Beneficio de los aparatos auditivos = acceso al habla.

La cantidad de beneficio, o acceso a los sonidos del habla, depende de la audición de su niño y en la forma en la que los audiólogos programan los aparatos auditivos. El mayor beneficio se logra cuando los audiólogos ajustan los aparatos auditivos de acuerdo con la pérdida de audición personal del niño, usando medidas de oído real mediante la verificación de sonda microfónica.



Hable con el audiólogo de su niño acerca de que tan bien escucha con sus aparatos auditivos.



Realice revisiones diarias de los aparatos auditivos para cerciorarse de la buena calidad del sonido.



Manténgase cerca de su niño y límite el uso de la TV y otros ruidos en su casa y así sea más fácil para que su niño escuche y aprenda.



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# Danke!

