1. This document is created for accessibility and is intended to be a supplemental resource. If you would like to print a hard copy of this document, please follow the general instructions below to print multiple slides on a single page or in black and white.
2. This handout is for reference only. Non-essential images have been removed for your convenience. Any links included in the handout are current at the time of the live webinar but are subject to change and may not be current at a later date.
3. Copyright: Images used in this course are used in compliance with copyright laws and where required, permission has been secured to use the images in this course. All use of these images outside of this course may be in violation of copyright laws and is strictly prohibited.
4. Social Workers: For additional information regarding standards and indicators for cultural competence, please review the NASW resource: Standards and Indicators for **Cultural Competence in Social Work Practice**
5. Need Help? Select the "Help" option in the member dashboard to access FAQs or contact us.

How to print Handouts

On a Mac

- Open PDF in Preview
- Click File
- Click Print
- Click dropdown menu on the right "preview"
- Click layout
- Choose # of pages per sheet from dropdown menu
- Checkmark Black & White if wanted.

How to print Handouts

On a PC

- Open PDF
- Click Print
- Choose # of pages per sheet from dropdown menu
- Choose Black and White from "Color" dropdown

Maturation of Speech Recognition for Noisy Environments, in partnership with American Auditory Society

Lori Leibold, PhD

Senior Director of Hearing Research
Boys Town National Research Hospital

Disclosures

- **Presenter Disclosure**: Financial disclosures: Dr. Leibold has grant support provided by the National Institutes of Health (NIH) and is an employee of Boys Town National Research Hospital. Non-financial disclosures: Dr. Leibold is an ad hoc reviewer for the NIH and the Hearing Health Foundation; and a member of the American Auditory Society, the Acoustical Society of America, and the Association for Research in Otolaryngology.
- **Content Disclosure**: This learning event does not focus exclusively on any specific product or service.
- **Sponsor Disclosure**: This course is presented in partnership with American Auditory Society.

Limitations/Risks

- The applicability and accuracy of the course content may vary by the clinical, geographical, and cultural context; you should evaluate the course accordingly.
- As healthcare is rapidly evolving, new findings may change the validity of the information presented in this course. Providers should always consult the latest research and guidelines from professional associations.
- The interventions discussed in this course may be limited in generalizability, requiring practitioners to consider specific individual and population factors.
- The course may not cover all possible risk factors, diagnostic methods, or treatment options, and complex cases may require additional considerations.
- Healthcare providers should apply cultural competence and sensitivity to ensure effective and respectful care based on their patients' diverse needs.
- Providers should always evaluate the limitations of diagnostic and screening tools, considering their potential for false results as well as any ethical implications.
- It is the responsibility of course participants to critically evaluate the evidence from multiple sources to guide professional practice.

Learning Outcomes

After this course, participants will be able to:

- Describe how speech recognition in the presence of competing background sounds develops during infancy and childhood.
- Discuss how factors such as age, language skills, and hearing loss may impact the ability to hear speech in noise.
- Propose potential clinical tools for accurately assessing speech recognition in steady noise and in competing speech.

Collaborators and Support


Emily Buss


Lauren Calandruccio


Nicole Corbin


Heather Porter


Ryan McCreery


Christina Dubas

BOYS TOWN National Research Hospital

NIH National Institutes of Health
Turning Discovery Into Health

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

How does the ability to recognize speech in the presence of competing sounds develop?



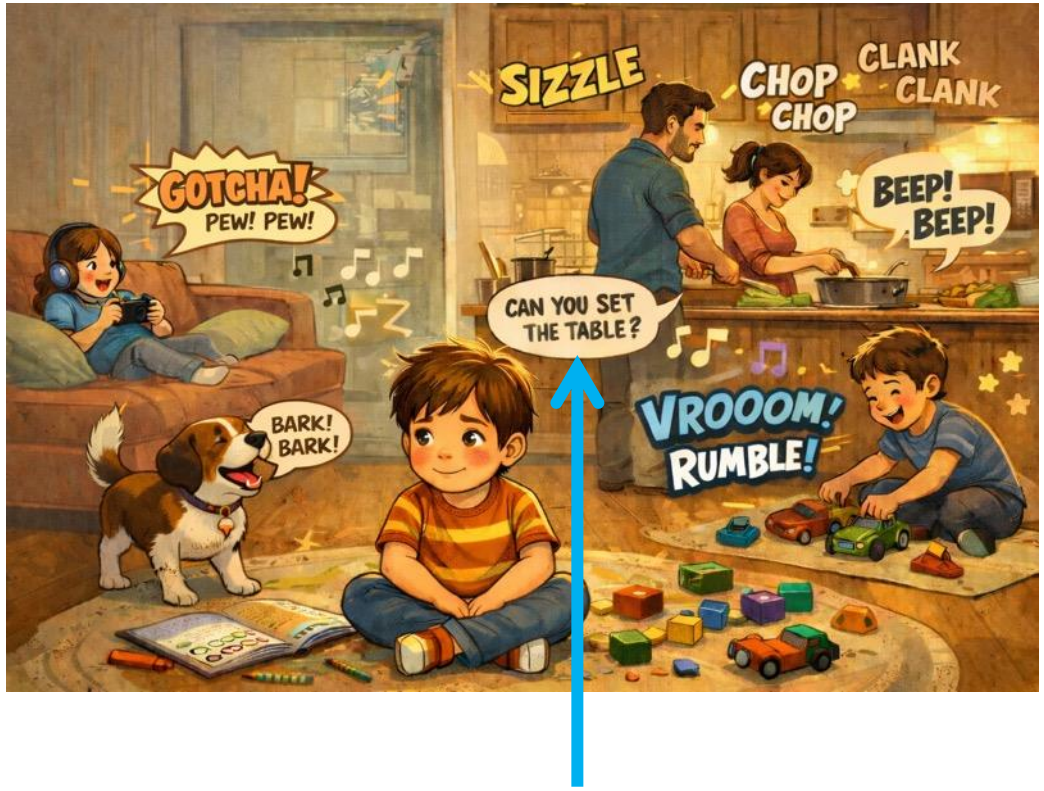

How do we balance scientific rigor with real-world validity?

?

Presentation Outline

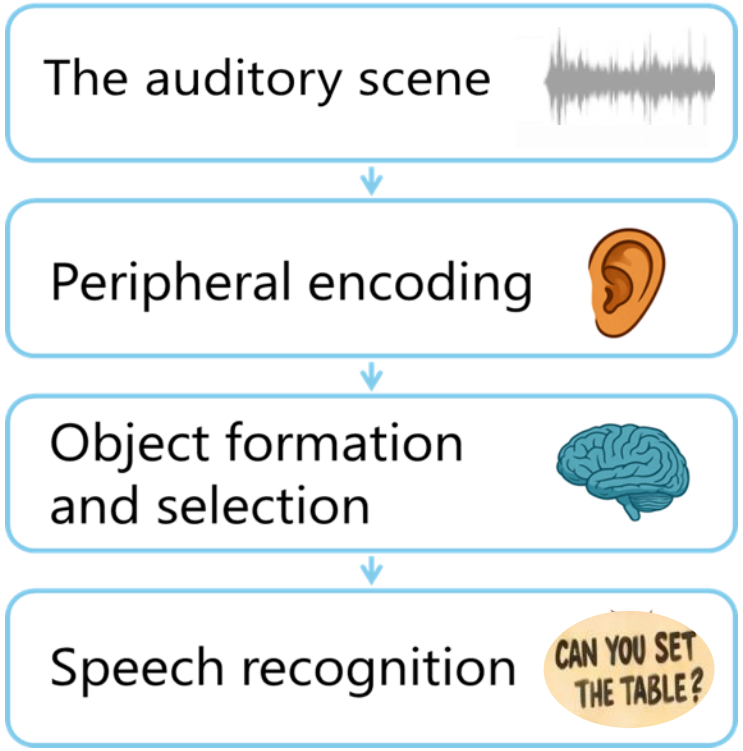
- Conceptual Framework & Background
- Key Scientific Findings
- Clinical Implications & Application
- Unresolved Questions
- Summary & Future Directions

What are we trying to understand?



Stages of Auditory Processing

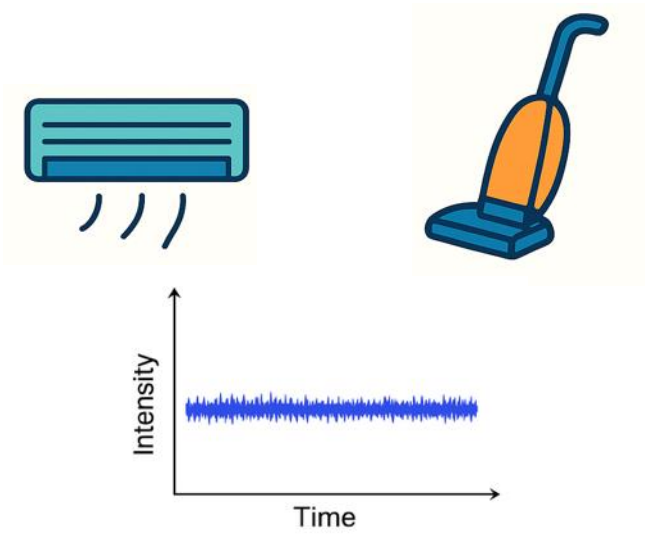
Immaturity within any stage of processing can influence how well children perceive speech in their everyday lives.



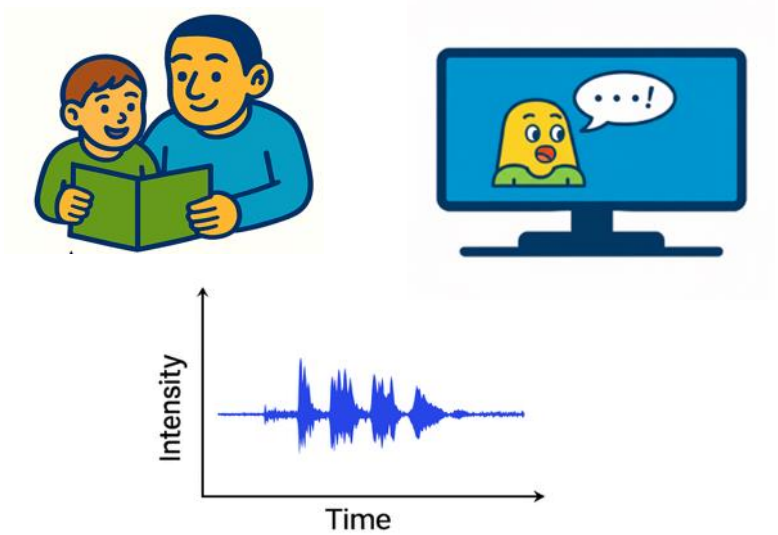
The auditory scene is the combination of all sounds that reach a listener.

Children's auditory scenes are composed of multiple sources of competing sounds.

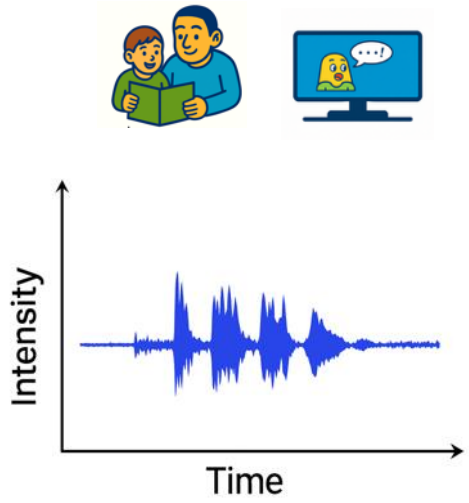
Some sources produce relatively steady sound.

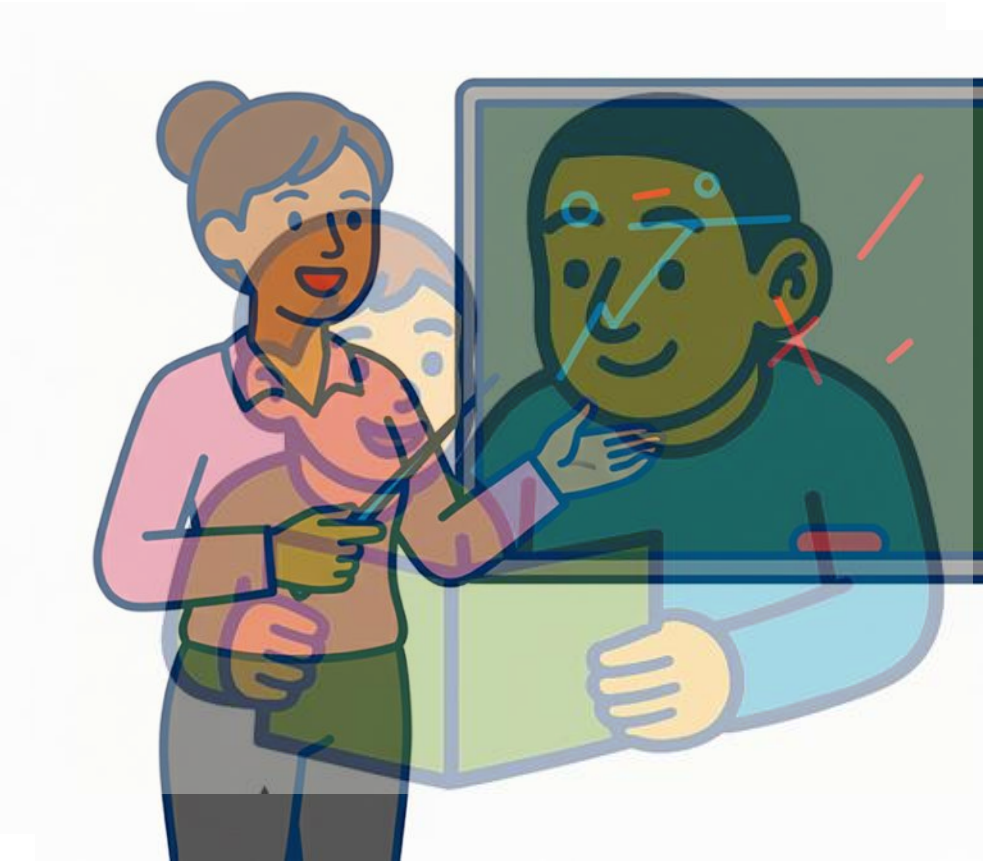


Other sources produce more dynamic sounds.

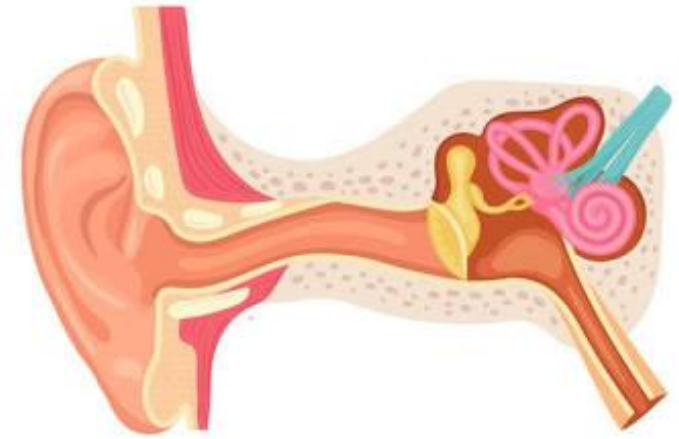


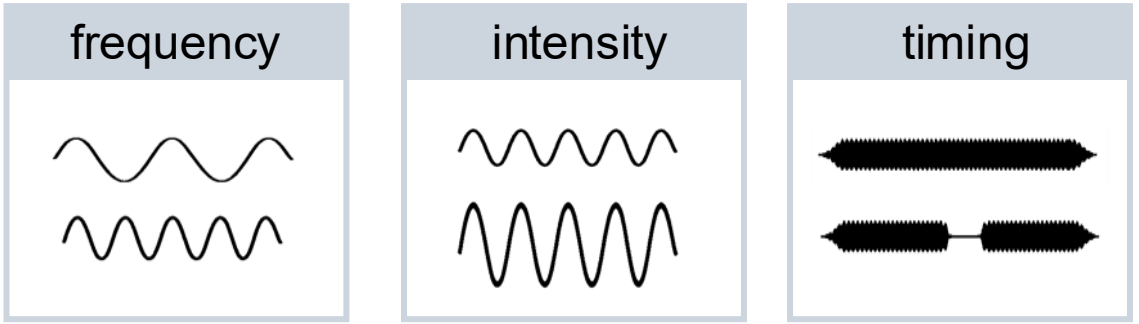
Different processes are responsible for masking with noise and competing speech.



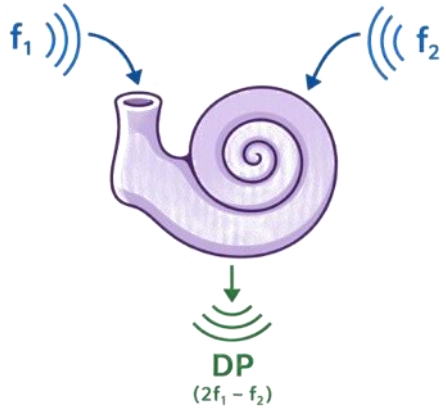
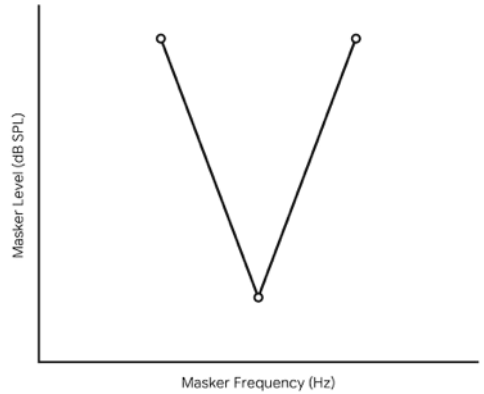


The spectral, intensity, and temporal characteristics of the sound mixture must be adequately represented by the peripheral auditory system.





Peripheral encoding reaches adult-like resolution by 6 months of age.

Anatomical studies	DPOAE tuning curves	Psychophysical tuning curves
		
Rask-Andersen et al., 2012	Abdala & Keefe, 2011	Spetner & Olsho, 1990

#1: Children are worse at recognizing masked speech that adults, particularly when the masker is speech.

Children and adults with normal hearing
- 5-16 years; n=56
- 18-44 years; n=16

Adaptive, open-set procedure

Target speech: monosyllabic words

Masker conditions: (1) speech-shaped noise
(2) two streams of competing speech

Results

SRTs for 5- to 7-year-olds were **~4 dB** worse than 13- to 16-year-olds and adults in noise.

This age effect was **~7 dB** in competing speech.

Corbin et al. 2016

#2: Speech-in-speech recognition is one of the last auditory skills to develop.

Children and adults with normal hearing
- 5-16 years; n=33
- 18-35 years; n=10

Adaptive, closed-set, 4AFC procedure

Target speech: disyllabic words

Masker: one stream of competing speech

Results

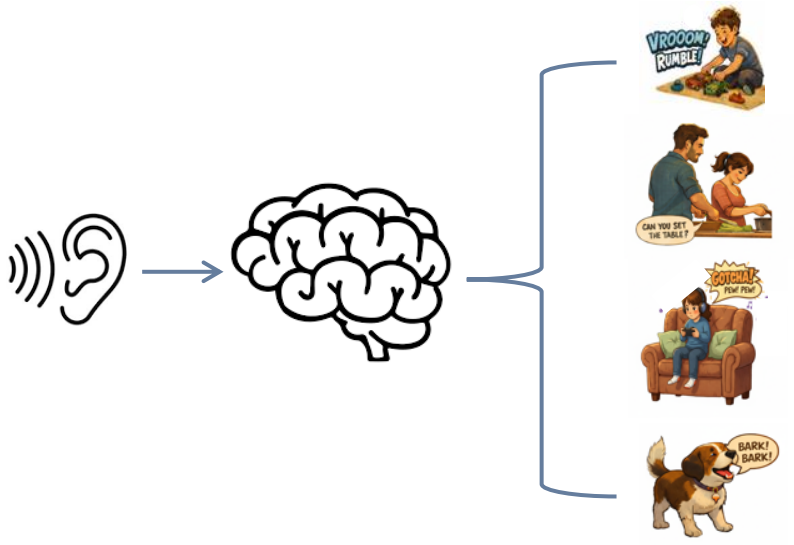
SRTs improved by more than **16 dB** during childhood.

Mature performance was not observed until adolescence (**~13 years of age**).

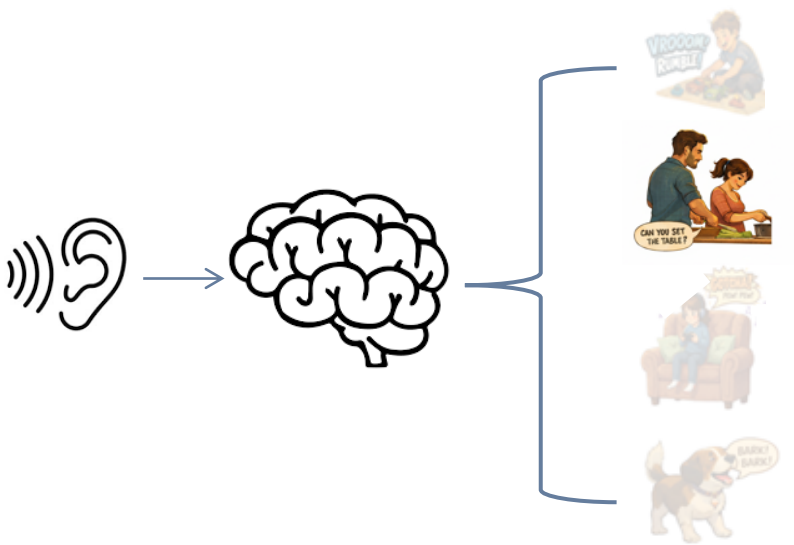
Buss et al. 2017

#3: Speech-in-speech recognition is influenced by central auditory processing.

Grouping sounds into separate auditory objects



Selectively attending to target speech



School-age children, like adults, benefit from a mismatch in target/masker sex.

Children and adults with normal hearing

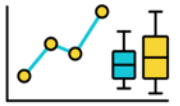
- 5-10 years; n=10
- 19-28 years; n=8

Adaptive, closed-set, 4AFC procedure

Target speech: disyllabic words produced by a male (matched) or female (mismatched)

Masker: two streams of speech, each produced by a male

Results



Children performed more poorly than adults overall.

Children and adults benefitted by a similar amount when target and masker speech were mismatched in sex relative to when they were the same sex.

Leibold et al. 2018

Infants do not appear to benefit from a mismatch in target/masker sex.

Infants and adults with normal hearing

- 7-13 months; n=18
- 18-26 years; n=18

Adaptive, observer-based procedure

Target speech: a disyllabic word produced by a male (matched) or female (mismatched)

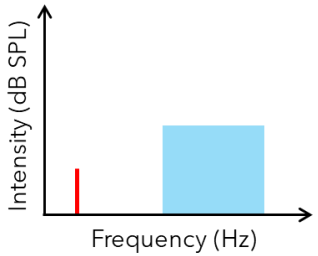
Masker: two-male-talker speech

Results

Using the same stimuli, infants performed similarly when the target and masker speech were produced by talkers mismatched in sex and when talkers were the same sex.

Leibold et al. 2018

Infants and young children listen less selectively than adults.



Children and adults with normal hearing

- 4-9 years; n=23
- 19-33 years; n=8

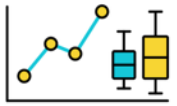
Adaptive, 2IFC detection task

Signal: 1 kHz tone

Conditions: quiet, remote noise (4-10 kHz)

Amount of Masking = SRT_{noise} - SRT_{quiet}

Results



4- to 6-year-olds have elevated detection thresholds for a 1000 Hz tone when it is presented with a remote-frequency noise than when it is presented in quiet.

7- to 9-year-olds and adults show no masking with the remote-frequency noise.

Leibold & Neff 2011

#4: Immature language skills impact children's speech-in-speech recognition.

Preschoolers with normal hearing

- 3-4 years; n=23

Adaptive, closed-set, 4AFC procedure with 'active' familiarization and training

Target speech: disyllabic words

Masker: two streams of competing speech

Results

Preschoolers with larger vocabularies had lower (better) SRTs for speech-in-speech recognition than preschoolers with smaller vocabularies.

Dubas et al. 2023

Children with hearing loss struggle more than peers with normal hearing in noisy environments.

Peripheral encoding  → Hearing loss impacts the fidelity with which sounds are represented by the peripheral auditory system.

Object formation and selection  → Children with hearing loss may have reduced, degraded, and/or variable experience with sound.

Hearing loss exacerbates children's speech-in-noise difficulties.

Children with moderate to severe hearing loss tested wearing amplification and children with normal hearing

- Hearing loss: 9-17 years; n=17
- Normal hearing: 9-11 years; n=10

Adaptive, closed-set, 4AFC procedure

Target speech: disyllabic words

Masker: speech-shaped noise

Results

On average, children with hearing loss required an SNR that was 3.5 dB higher than peers with normal hearing to recognize speech in noise.

SRTs measured in the noise masker were not associated with parent reports of their child's listening difficulties.

Leibold et al. 2013

Children with hearing loss are at an even greater disadvantage when multiple people are talking.

Target speech: disyllabic words

Masker: two streams of competing speech

Results

The disadvantage for children with hearing loss in the speech masker was 8.1 dB.

Speech-in-speech recognition performance was associated with parent reports of their child's listening difficulties.

Leibold et al. 2013

ChEgSS

Children's
English and Spanish
Speech Recognition Test


Carhart


Hall


Elliot


Gravel


Stelmachowicz


Shi

What is the ChEgSS Test?

A computer-based tool for assessing closed-set word recognition in English and in Spanish, in quiet or with a masker that is either speech-shaped noise or competing speech.

The tester does not need to speak the test language or score productions in that language.

ChEgSS uses an adaptive, forced-choice procedure with a picture-pointing response.

Targets: 30 disyllabic words in English and Spanish

- Spoken by the same female talker
- Appropriate vocabulary for a 5-year-old
- Easily illustrated

Masker Conditions: (1) speech-shaped noise (2) two streams of English speech (3) two streams of Spanish speech

Calandruccio et al. 2014

Extensive normative data were collected on 4- to 18-year-old children.

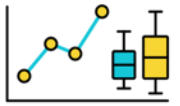
ChEgSS Children's English and Spanish Speech Recognition Test

Participants: 83 Spanish-English bilingual and 89 English monolingual children with normal hearing

Bilingual children completed testing in English and in Spanish, in the noise and the speech masker

Monolingual children completed testing twice in English

Results



Performance was similar in both languages for bilinguals with adequate proficiency.

Prediction intervals have been constructed, for comparison with clinical data.

Leibold et al. 2024

Are we capturing the challenges children face in their everyday lives?

?

Some of our tasks are likely too difficult (relative to the real world).

Children and adults with normal hearing

- 5-14 years; n=33
- 18-39 years; n=16

Adaptive, open-set sentence recognition

Target speech: BKB sentences produced using a clear or a conversational style

Masker: two streams of speech

Results

Young children did not show a clear speech benefit.

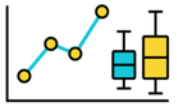
Calandruccio et al. 2020

The answer is different when the task is easier (providing an additional binaural cue)

Children and adults with normal hearing
- 4-7 years; n=20
- 19-39 years; n=10

Adaptive, open-set sentence recognition
Target speech: BKB sentences produced using a clear or a conversational style
Masker: two streams of speech

Now with a binaural cue! M_0T_π

Results 

Young children and adults showed a similar clear speech benefit.

Calandruccio et al. 2020

Generalization is limited by sampling bias.

Considering the child population of the US:

- 16% live in poverty
- 21% speak a language other than English
- 15% receive special education services
- 20% live in rural communities

Speech-in-speech recognition is challenging for individuals with Down syndrome.

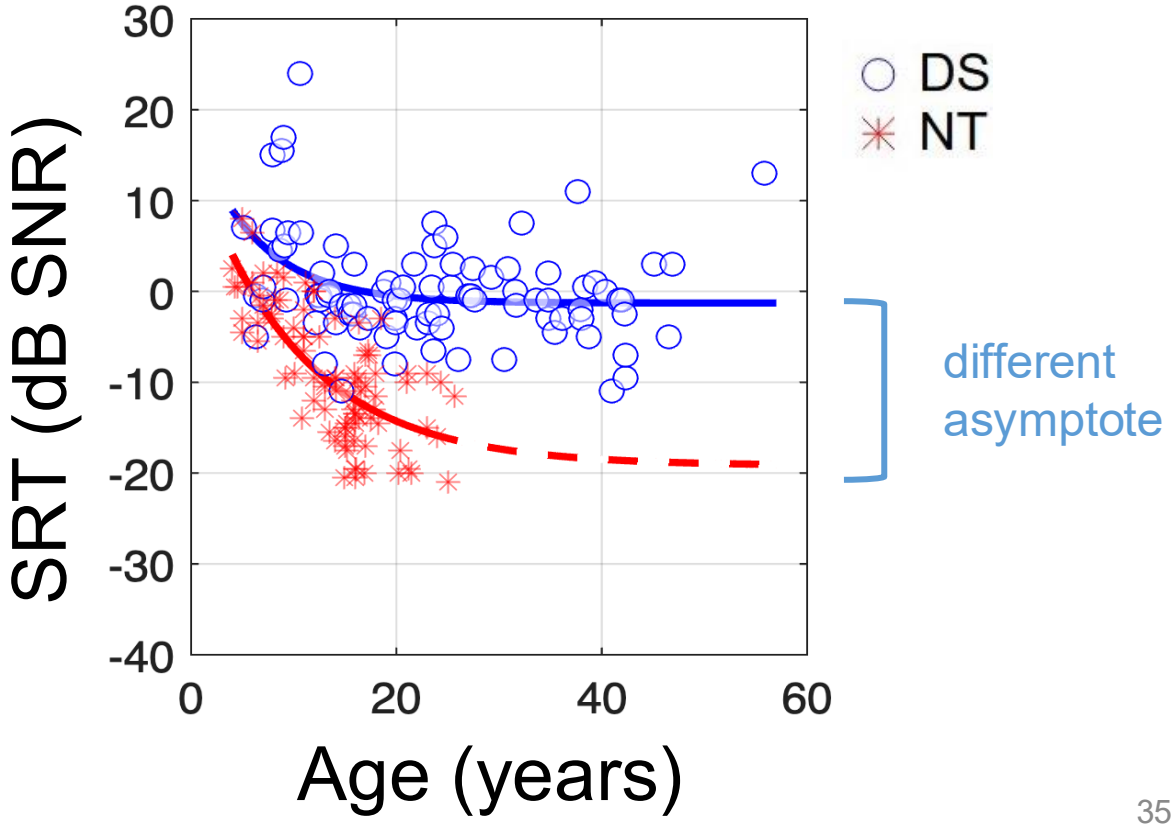
Individuals with Down syndrome and individuals who are neurotypical

- DS: 5-55 years; n=92
- NT: 4-25 years; n=90

Adaptive, closed-set, 4AFC procedure

Targets: disyllabic words

Masker: two streams of competing speech

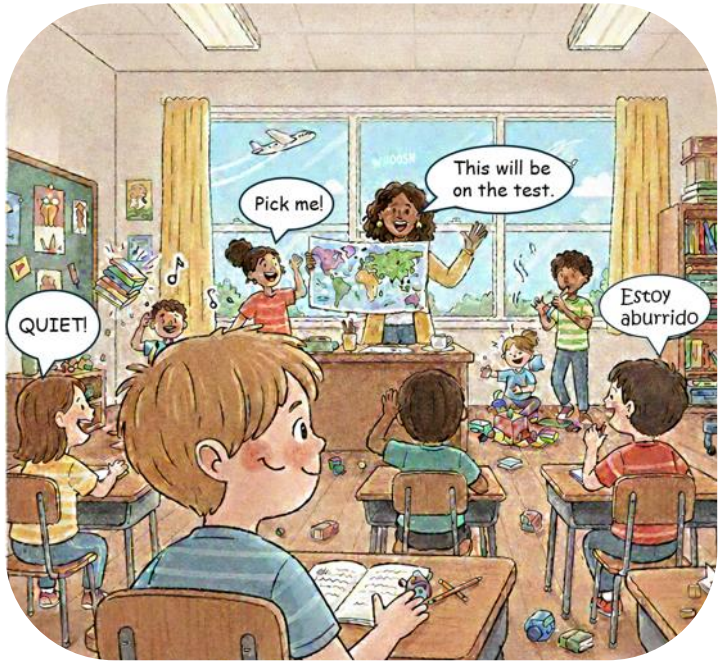


What a child hears in a noisy environment is not what an adult hears.

The ability to recognize speech when multiple people are talking at the same time requires years of experience and maturation of central auditory processing.

Consistent access to high-quality auditory input provides the foundation for language development, social functioning, and school success.

Not all children are afforded this access.



Our future directions include characterizing masked speech recognition for…

Speech produced by a wider range of talkers and styles

A community-based sample of children

Thank you!

Lori.Leibold@boystown.org

Congratulations!

- You’ve completed the course and can move on to the exam!
- From your account:
  - Go to pending Courses
  - Choose take exam