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Can CROS aids improve speech recognition and comprehension in classrooms?

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Disclosures

Collaborators

- Dawna Lewis (Boys Town National Research Hospital)
- Gina Angley (Vanderbilt University Medical Center)
- Anne Marie Tharpe (Vanderbilt University Medical Center)



Funding support

- Phonak

Other support

- Amy Stahl, Haiping Huang, Christine Jones, Lori Rakita

Unilateral hearing loss

Highly prevalent

- Unilateral hearing loss more prevalent than bilateral hearing loss *Niskar et al (1998) JAMA, 279, 1071-1075*
- 3% of school-aged children *Bess et al (1998) Ear Hear, 19, 339-354*

Risk of academic failure

- 35% repeat a grade *Bess & Tharpe (1986) Ear Hear, 7, 14-19*
- 10x more likely to fail a grade *Oyler et al (1988) LSHSS, 19, 201-210*

Reduced well-being (stress, self-esteem, social support) *Bess et al (1998) Ear Hear, 19, 339-354*

Poorer speech and language outcomes *Lieu (2004) Arch Otolaryngol Head Neck Surg, 130, 524-530.*

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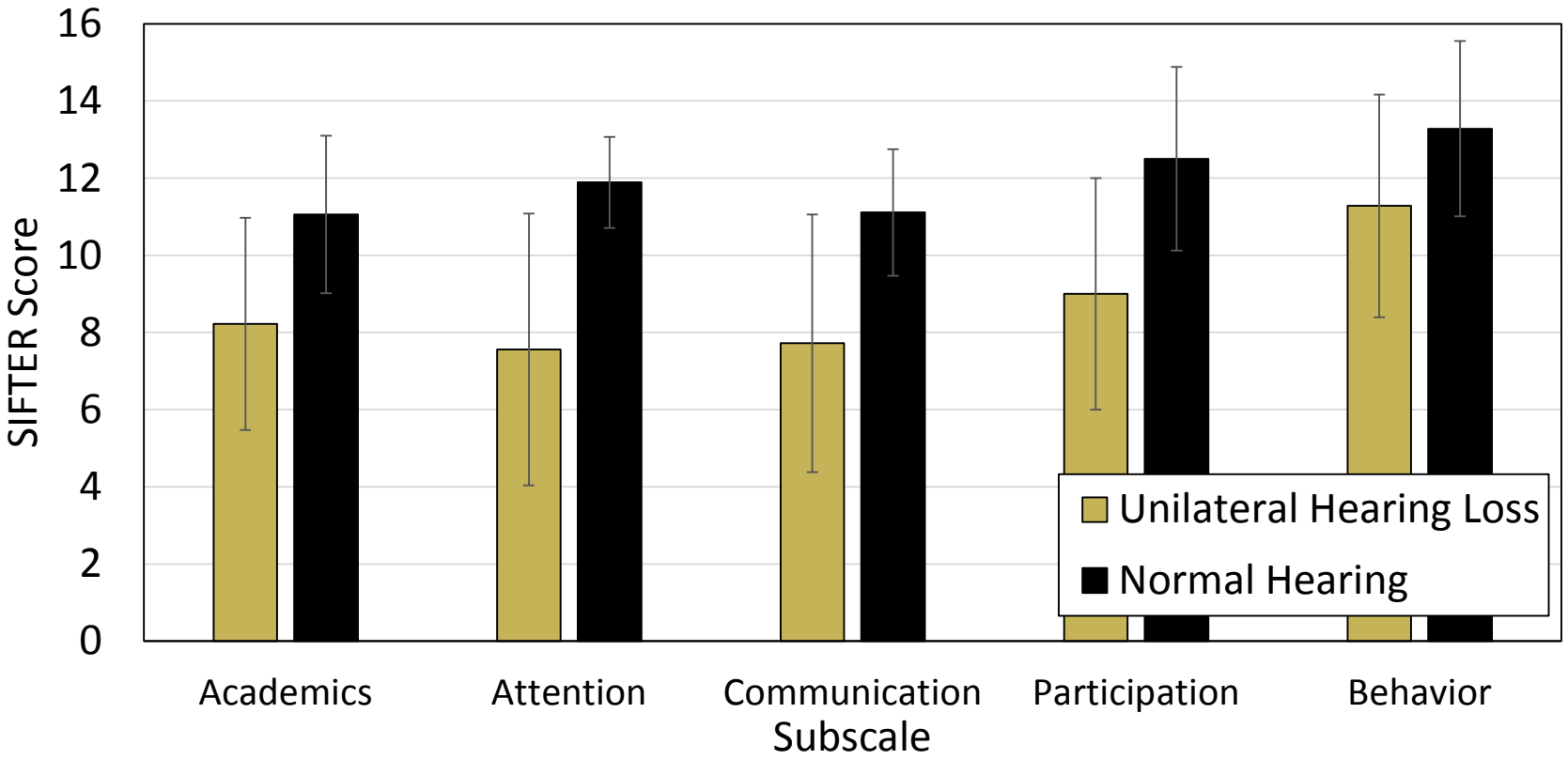
Academic difficulties are also apparent to the teacher



Data from Dancer, Burl & Waters (1995) *Am Ann Deaf*, *140*, 291-294

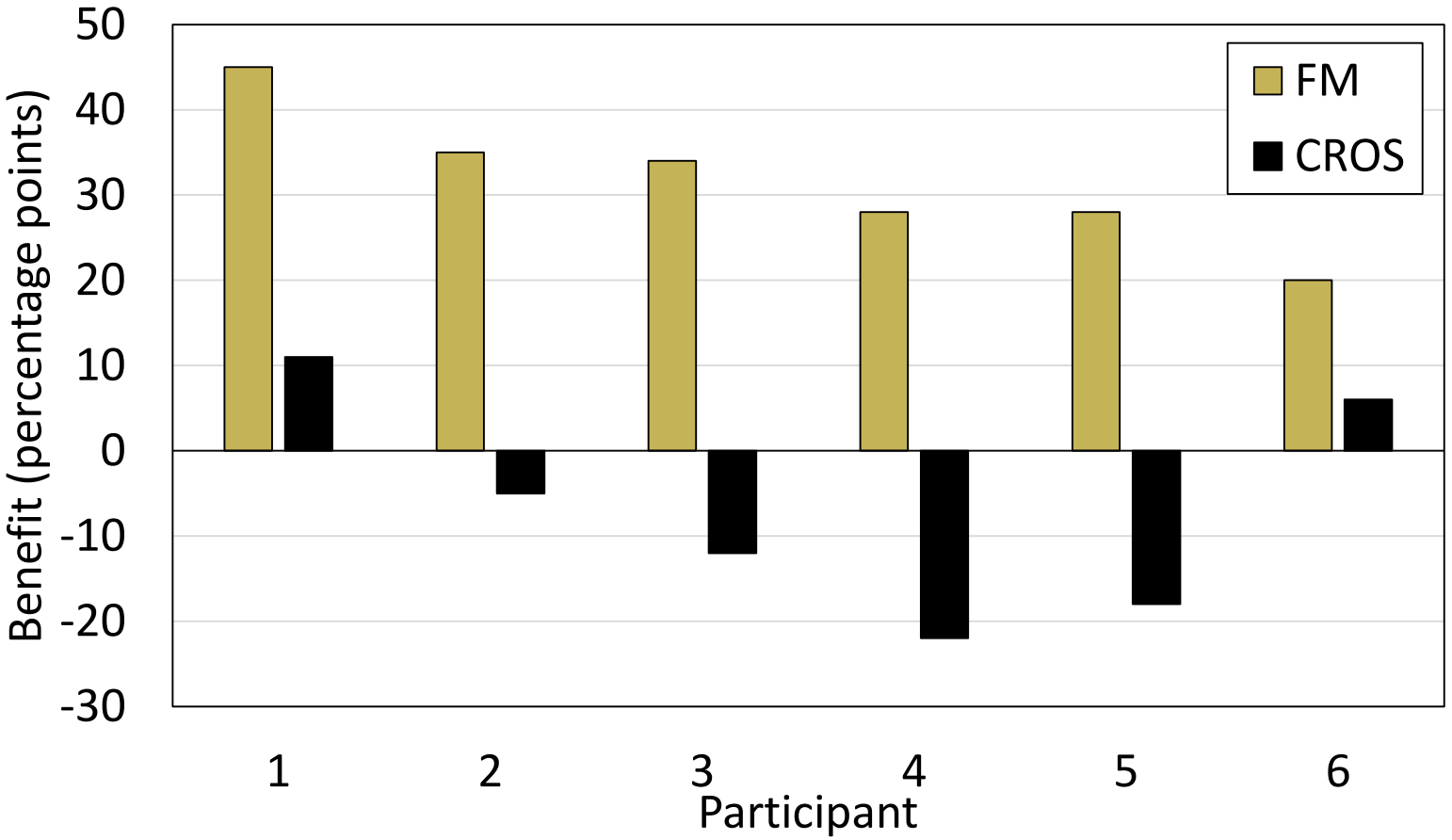
Interventions in classrooms

Minimally invasive
- Nothing
- Preferential seating

Surgical options
- Osseointegrated devices
- Cochlear implantation

Amplification options
- FM / remote microphone system
- CROS system

Previous work suggests FM systems are the best option

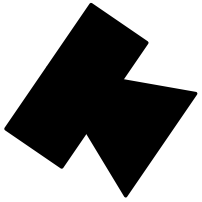


Data from Updike (1994) J Am Acad Audiol, *5*, 204-209

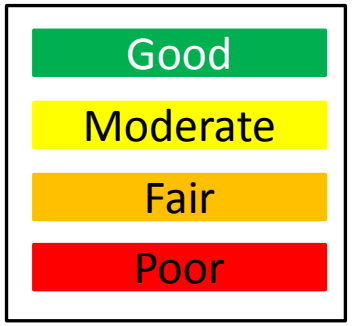
Brief orientation

The student…

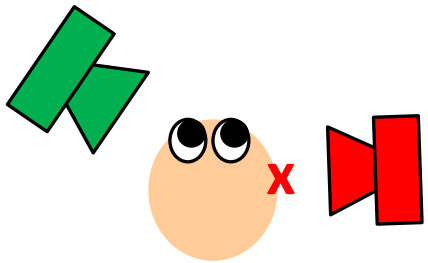
The speaker…



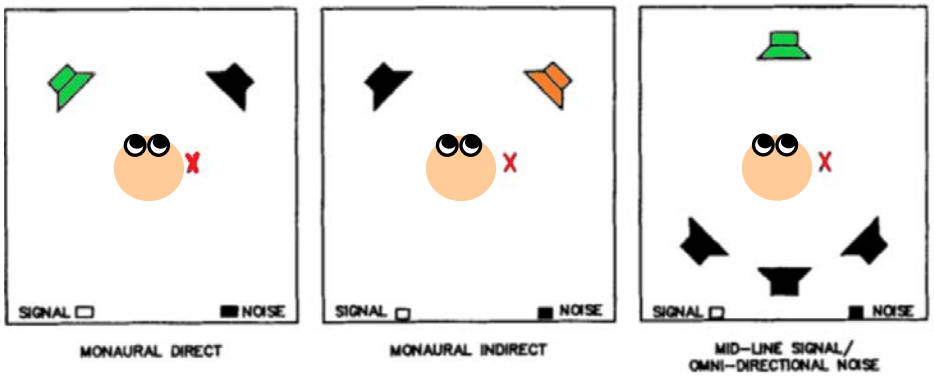
The legend…



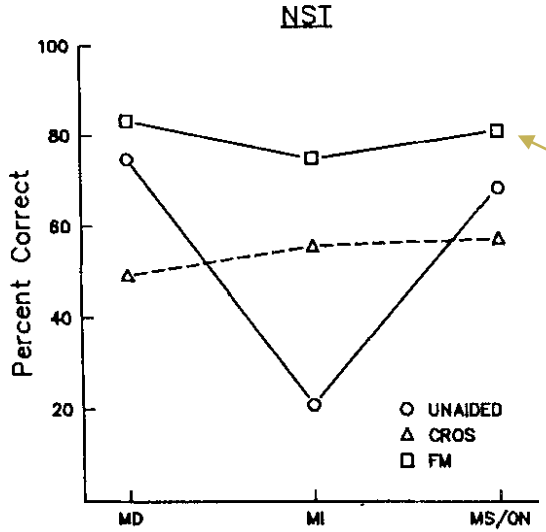
The result…



CROS benefits depend on configuration

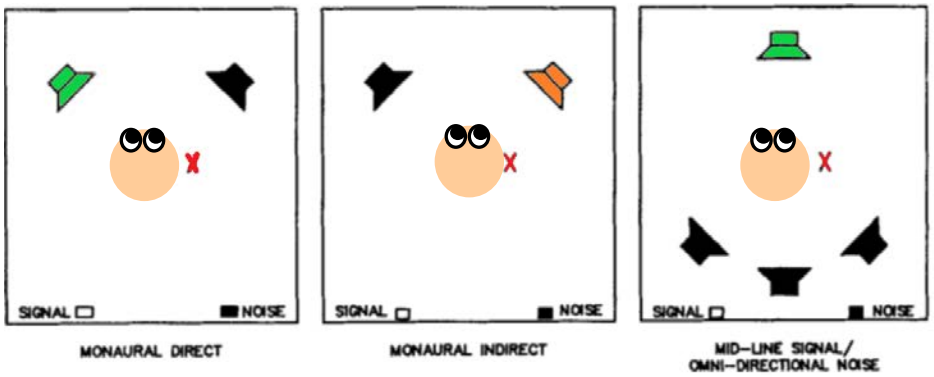


Good
Moderate
Fair
Poor

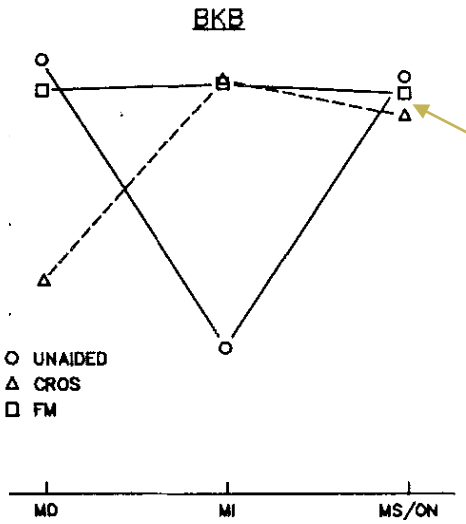


… and the FM always "wins"

Benefits depend on stimuli



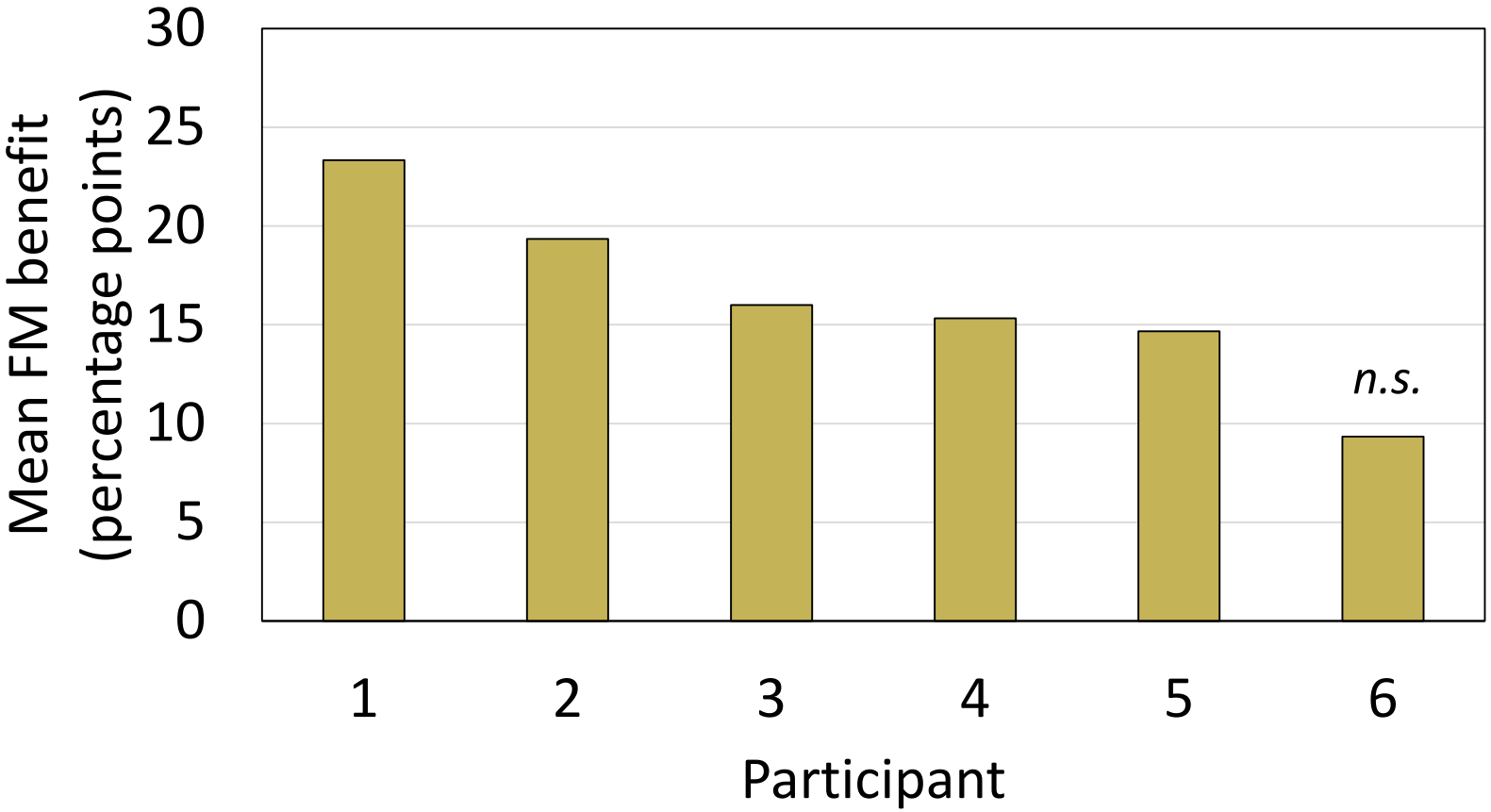
Good
Moderate
Fair
Poor



… with context, benefits smaller

Kenworthy et al (1990)

Collapsed across listening condition FM system provided significant benefits for most children



Data from Kenworthy et al (1990)

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Limitations of previous findings

Signals originated from front hemisphere

Static head position

30 year old technology

Focus on speech recognition

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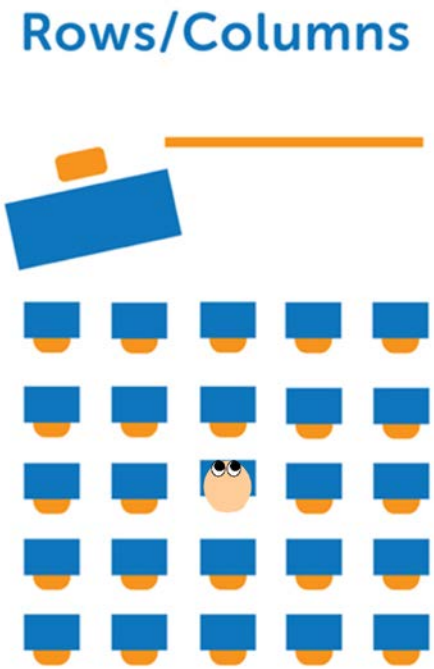
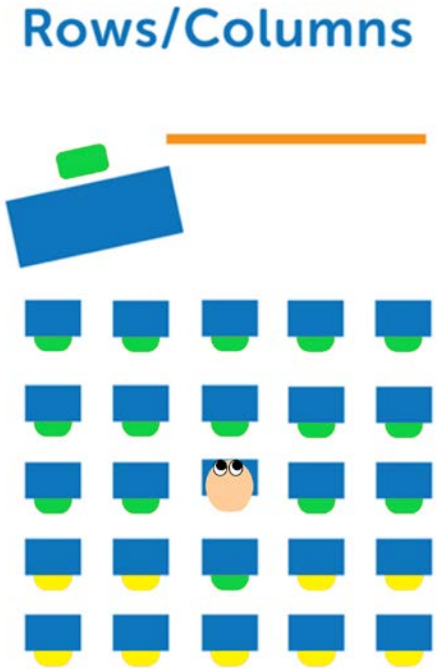
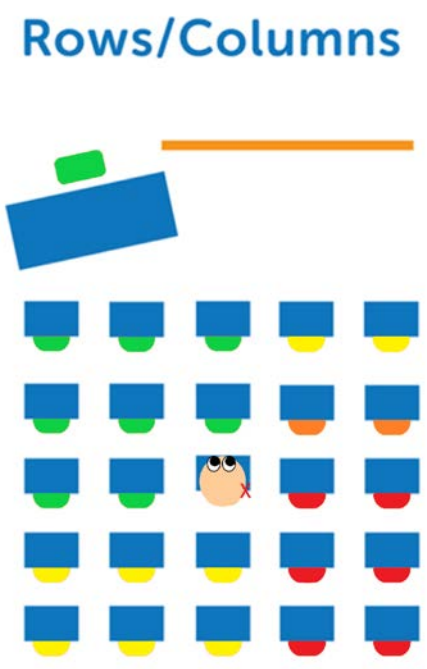
Classrooms include diverse talker locations

Good
Moderate
Fair
Poor





Normal hearing bilaterally



Right unilateral loss

Modern classrooms have diverse seating arrangements

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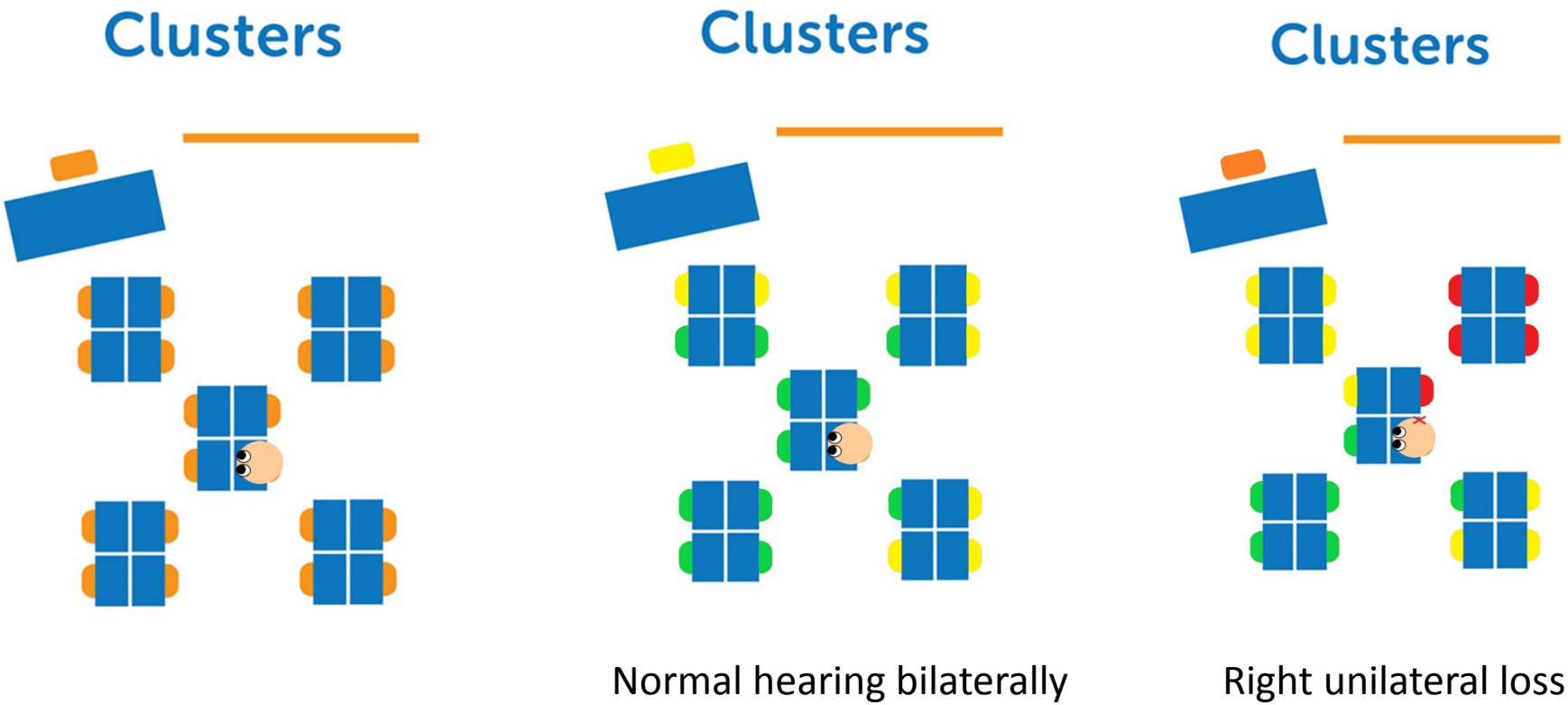

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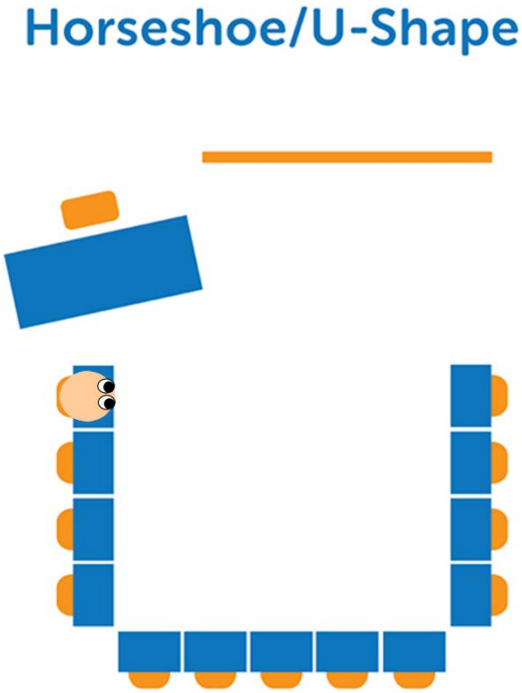
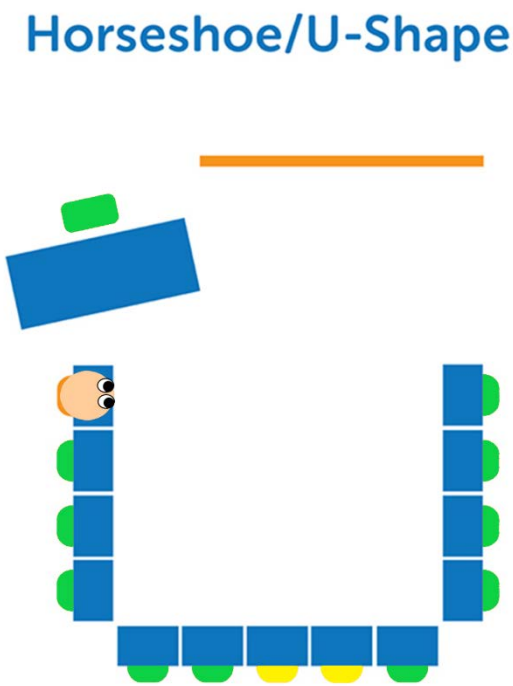
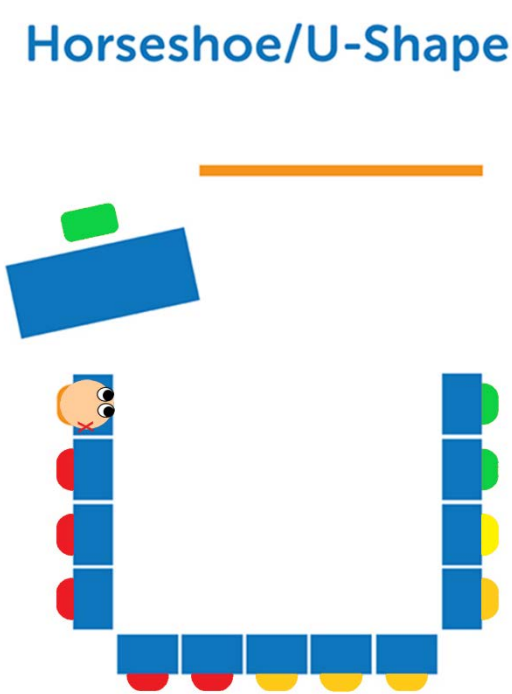




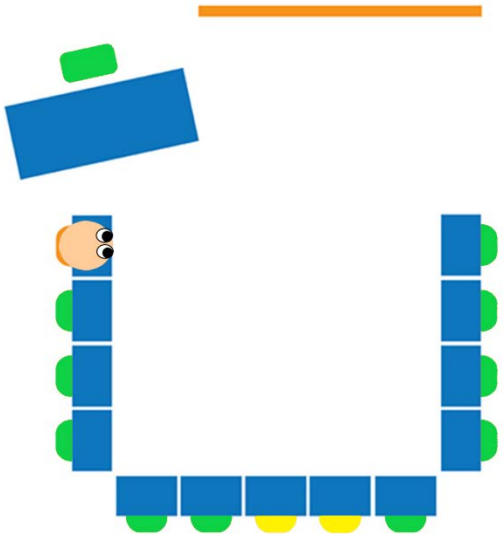
Normal hearing bilaterally



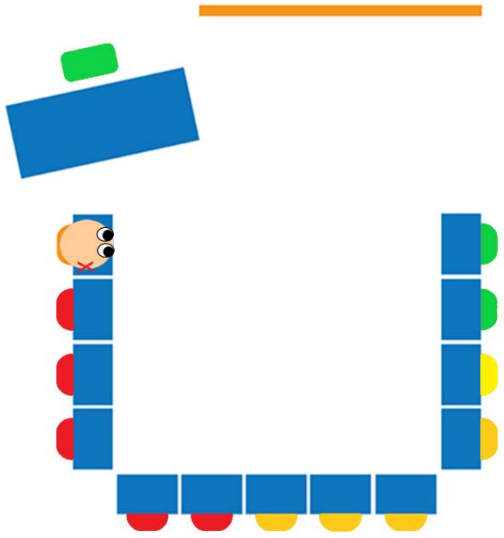
Right unilateral loss

Seat assignment makes a difference

Horseshoe/U-Shape

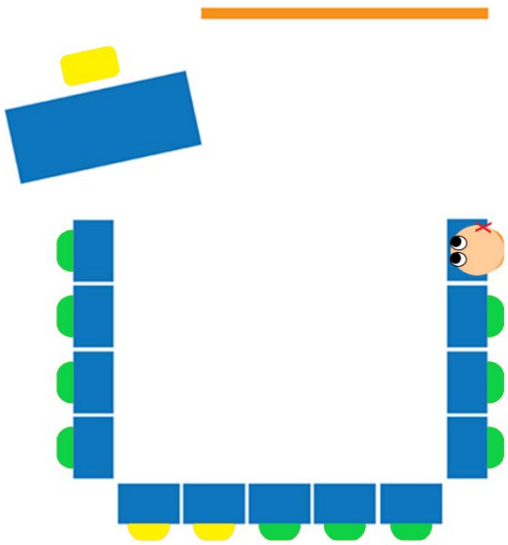


Horseshoe/U-Shape



Right unilateral loss

Horseshoe/U-Shape



Right unilateral loss

Predictions based on seating arrangements complicated by many factors

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Who is the REAL talker of interest?

- Teacher
- Classmate in group discussion
- Friend who is being social

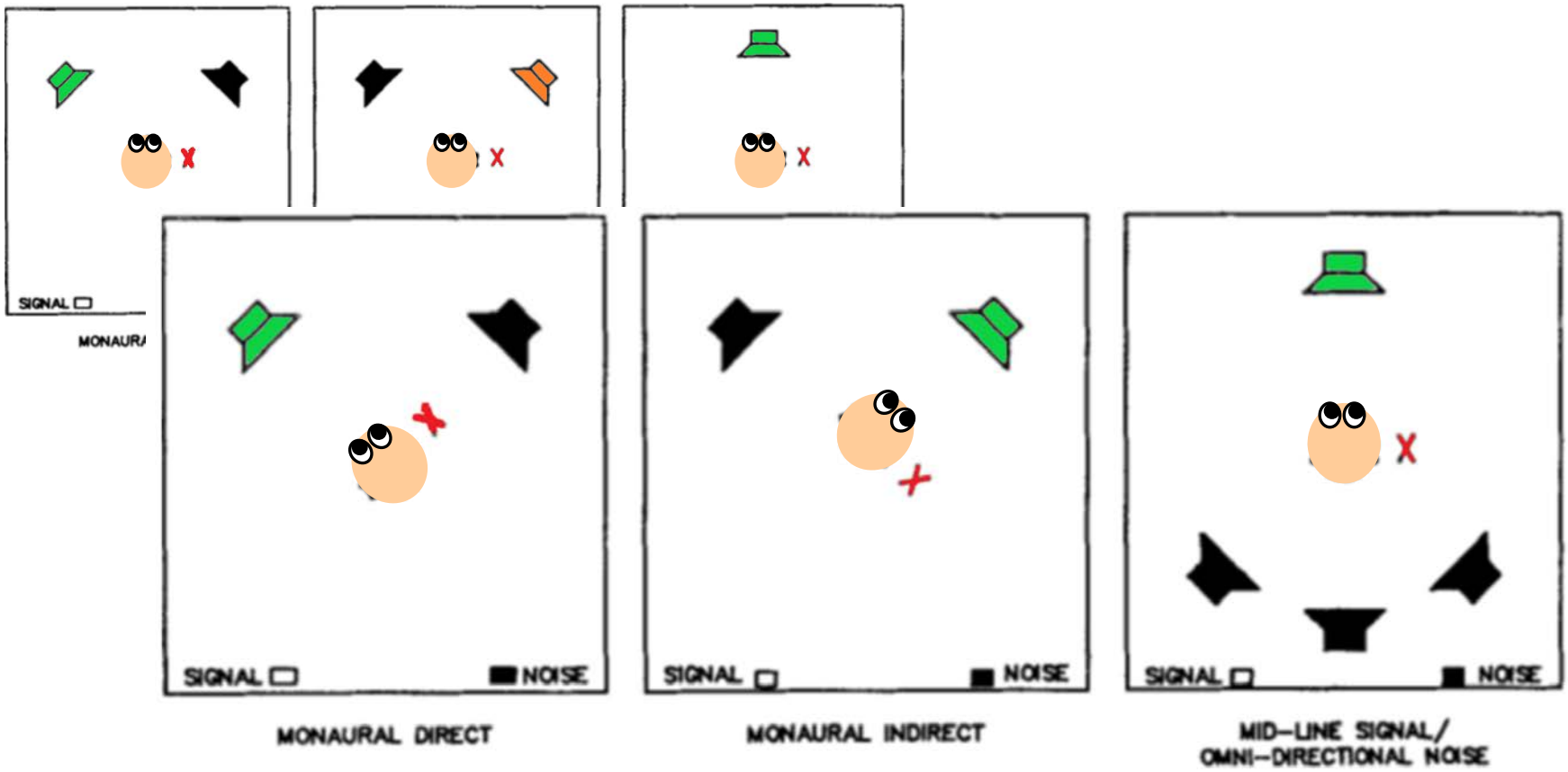
Acoustic properties

- Low noise and/or low reverberation
- High noise and/or high reverberation

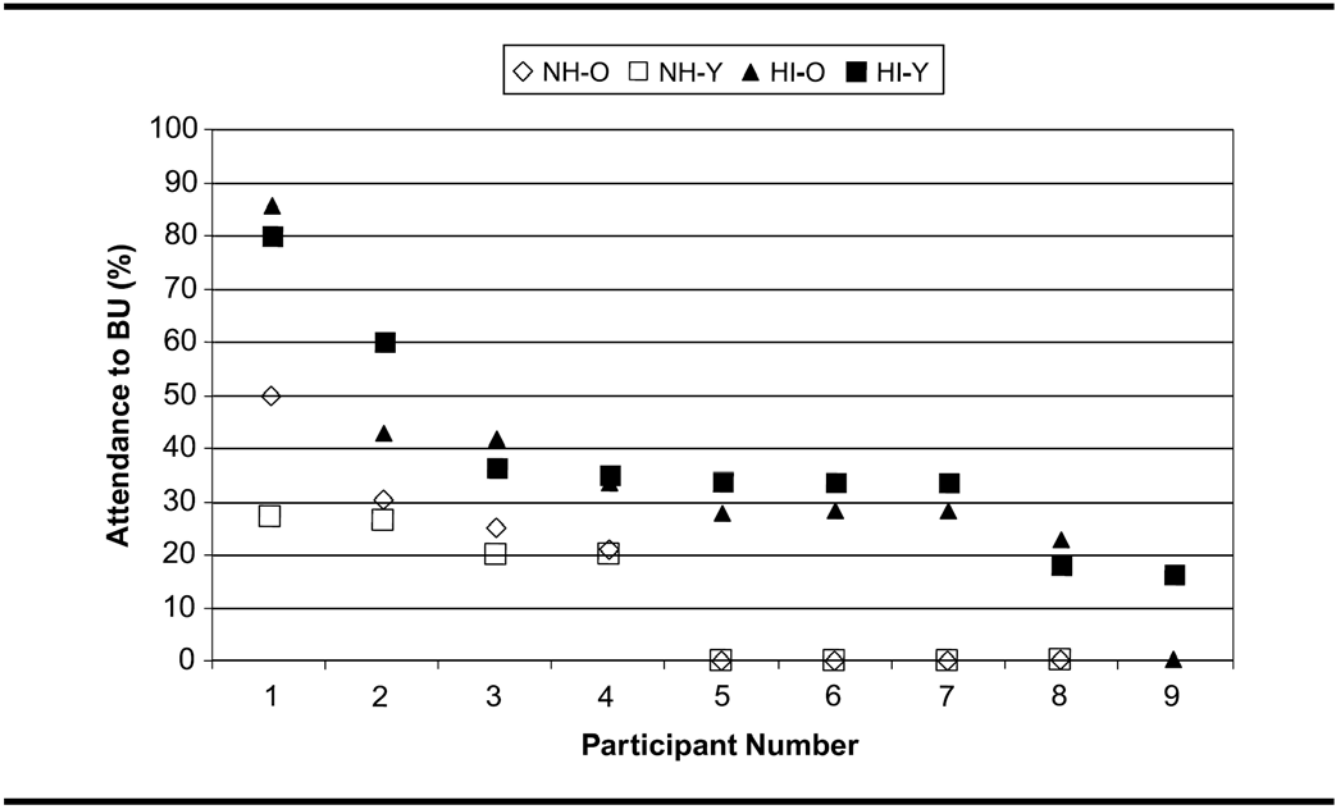
Head movement

- Facing the talker of interest
- Focused on school work at desk
- Looking out the window and daydreaming

The importance of head movement in a classroom



Do children orient themselves in classrooms?



Ricketts & Galster (2008) *J Speech Lang Hear Res, 51,* 516 - 525

Adaptive directional microphones might offer additional advantages

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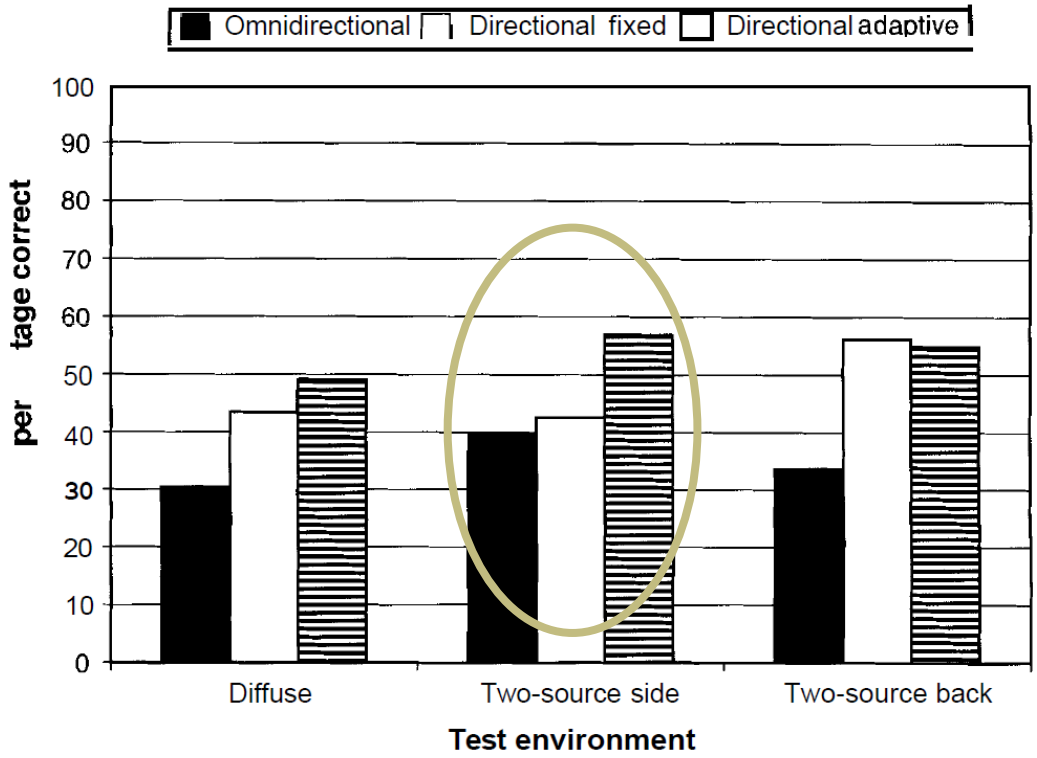


Figure 5. Average speech recognition performance as measured using the CST across the three fixed position noise configurations (diffuse, two-source side, and two-source back) for each of the three microphone modes.

Ricketts & Henry (2002) *Int J Audiol, 41*, 100 - 112

Classrooms are places of learning and comprehension

Story Comprehension

Mild / UHL disrupts comprehension

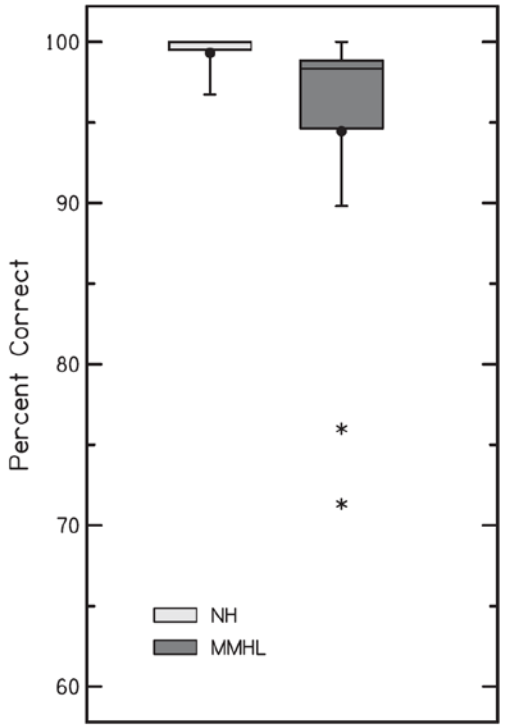


Fig. 2. Scores (% correct) for the sentence recognition task for the children with normal hearing (NH; light gray) and children with minimal/mild hearing loss (MMHL; dark gray). Boxes represent the interquartile range and whiskers represent the 5th and 95th percentiles. For each box, lines represent the median and filled circles represent the mean scores. Asterisks represent values that fell outside the 5th or 95th percentiles.

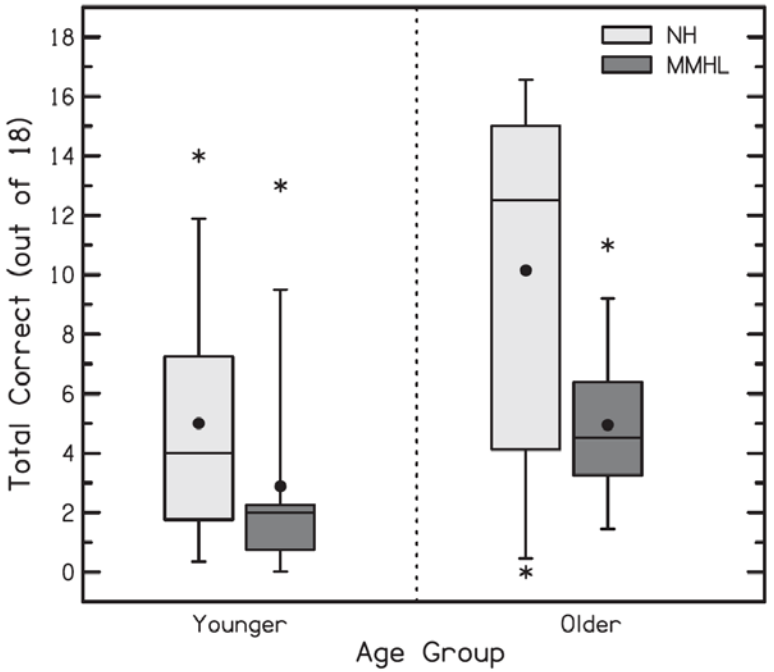


Fig. 3. Scores (total correct/18) for the comprehension task for the children with normal hearing (NH; light gray) and children with minimal/mild hearing loss (MMHL; dark gray). Boxes represent the interquartile range and whiskers represent the 5th and 95th percentiles. For each box, lines represent the median and filled circles represent the mean scores. Asterisks represent values that fell outside the 5th or 95th percentiles.

Lewis et al (2015) *Ear Hear, 36*, 136 - 144

Purpose

Can CROS aids improve speech recognition and comprehension in classrooms?

Goal was to take into consideration

- Talker location
- Updated technology
- Comprehension and recognition
- Live stimuli in simulated classroom

Methods

Participants

- Children with normal hearing
- 10 – 14 years old
- Simulated unilateral hearing loss with 70 dB HL masking in one ear

Tasks

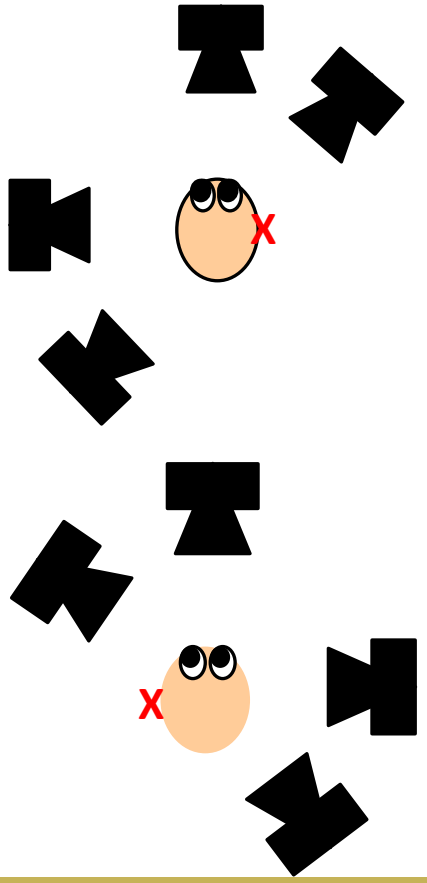
- Speech recognition
- Story comprehension

Test environment

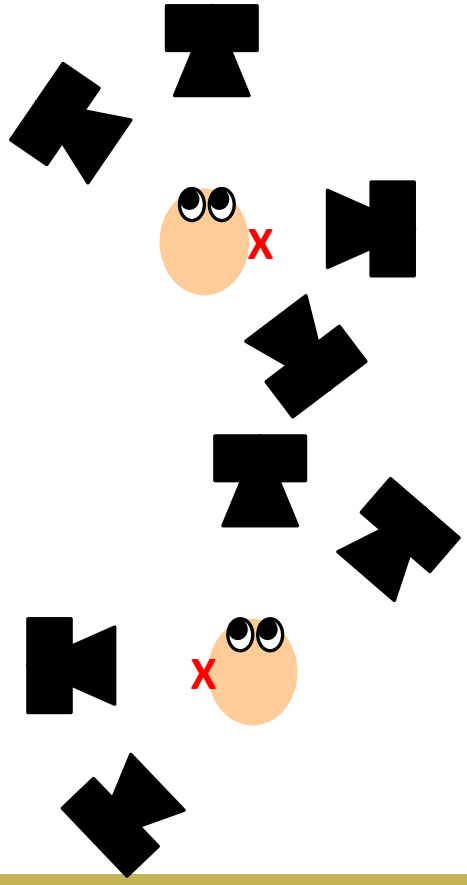
- Moderate reverberation (T30 = 475 ms)
- Signal to noise ratio: +7 (Speech 62: Noise 55)
- Multi-talker babble

Test Environment

Easy Configuration



Hard Configuration

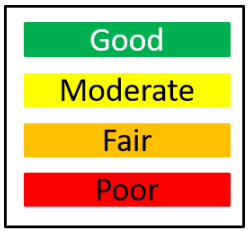


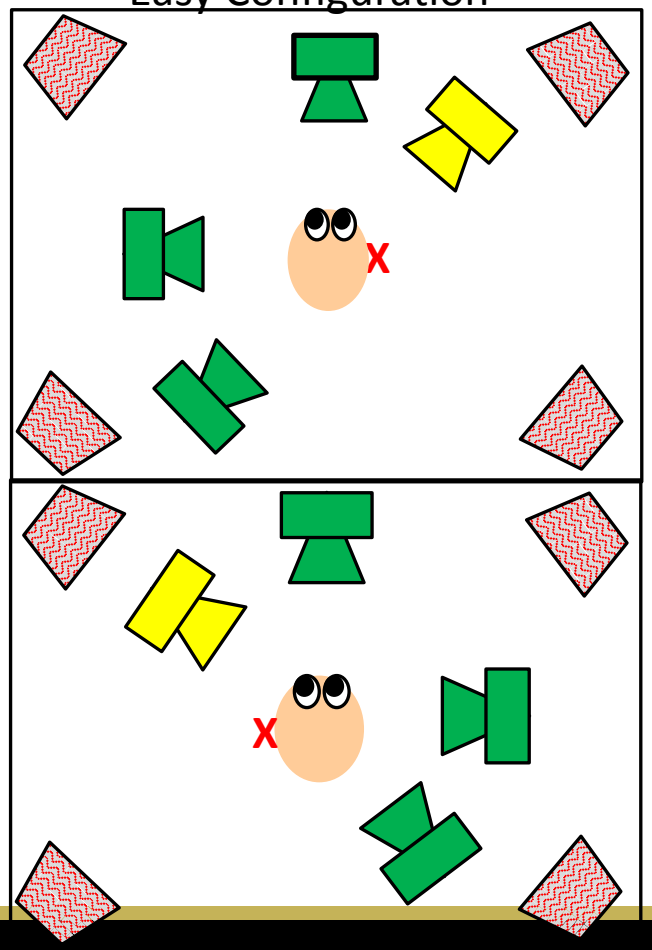
Test Environment

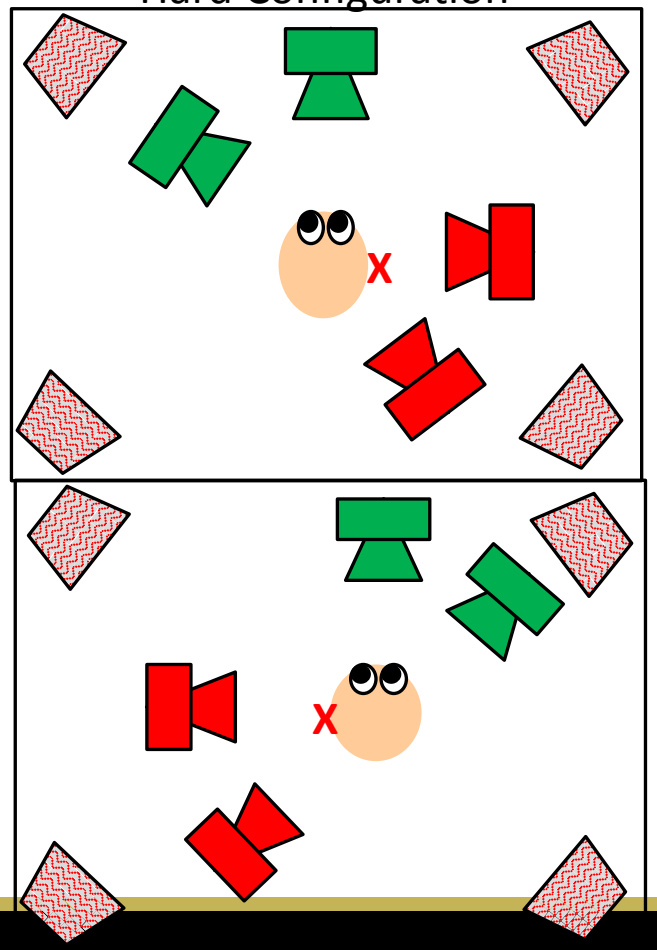
Easy Configuration

Hard Configuration

Note: Not even close to scale







Hearing Aids: BTE Sky v70 M312

1) CROS
- Microphone on “dead” ear
  - Real Ear Sound
  - Demo hook
- Receiver on good ear
  - Ultrazoom
  - Non-occluding, non-custom eartip

2)Roger microphone
- Microphone
  - 6 cm in front of loudspeaker in center
  - “Lanyard” directionality
- Receiver on good ear
  - Ultrazoom
  - Non-occluding, non-custom eartip

Sentence Recognition

Hearing in Noise Test for Children (HINT-C)

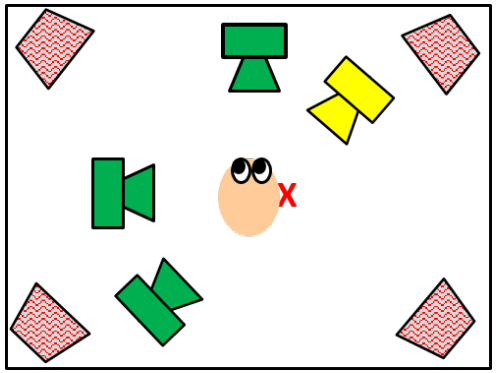
One sentence at a time

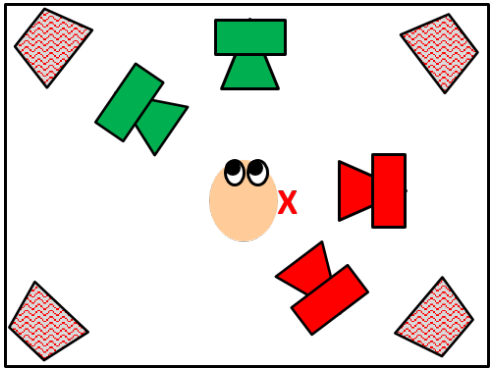
One list per loudspeaker

Interleaved in each configuration

Participant repeated one sentence at a time

Scored at word level by experimenter





Story Comprehension

Stories developed by Dawna Lewis and colleagues at Boys Town

Fairy tales translated from foreign languages

Each loudspeaker displays a talker and presents her voice

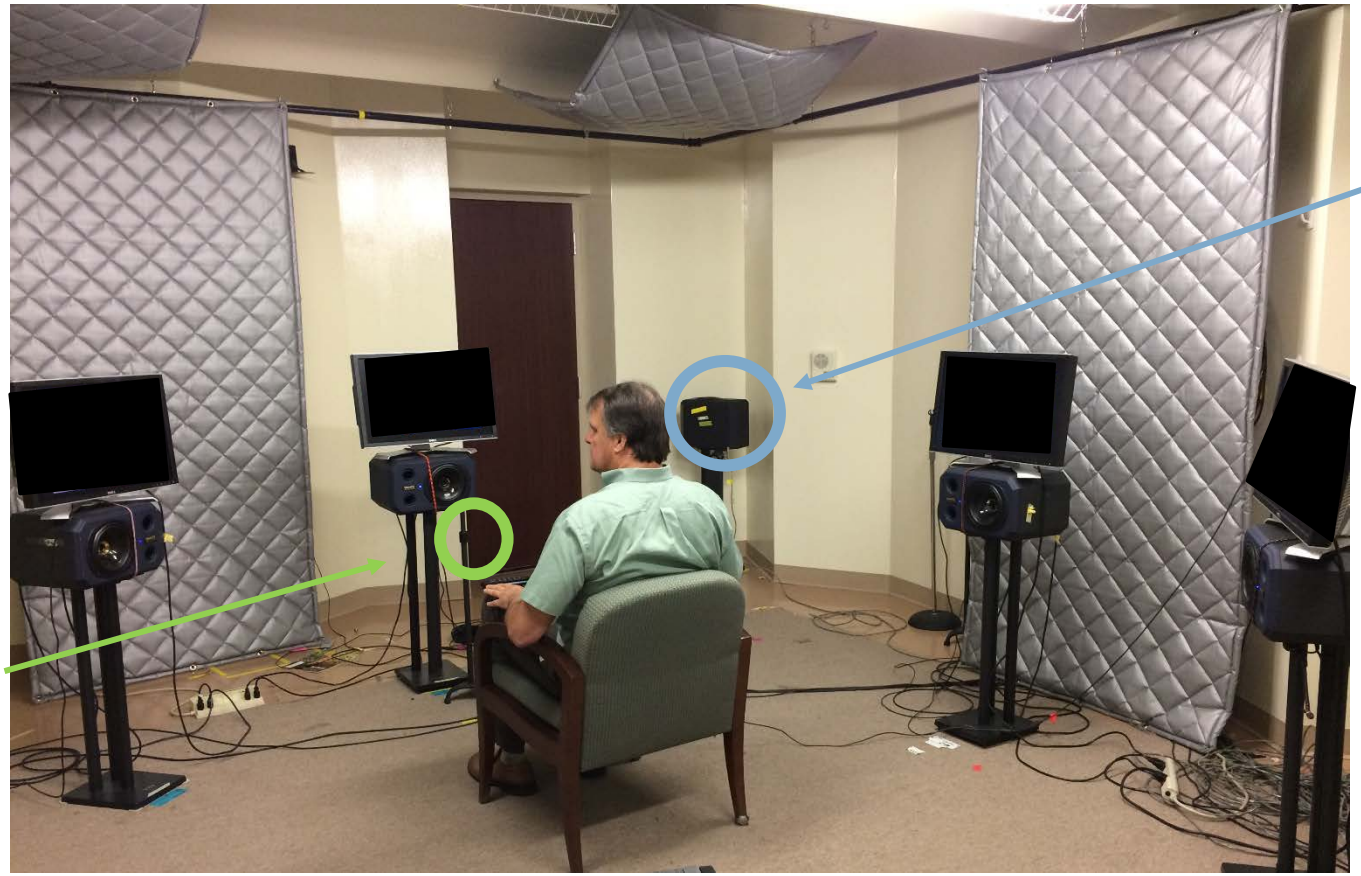
Each talker reads a few sentences of the story

Story split between 4 loudspeakers

Seven stories total divided across 6 conditions

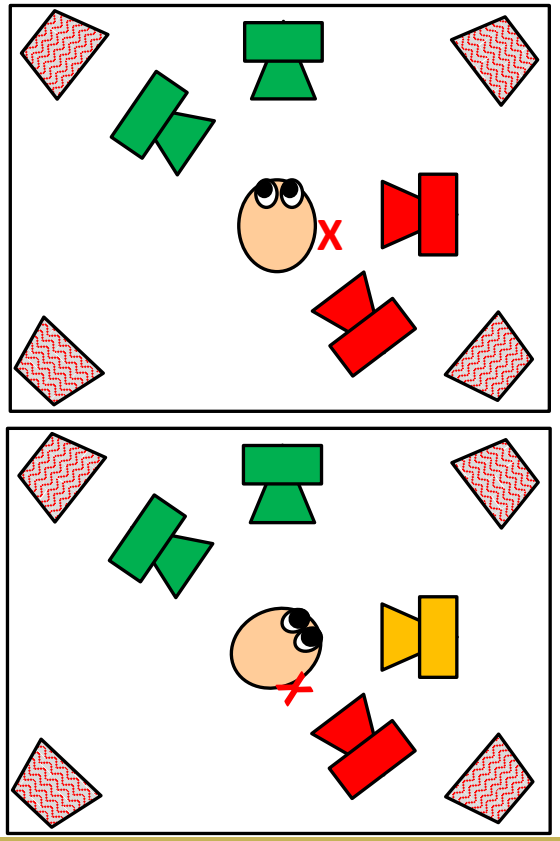
Story Comprehension Test Environment

Sentence Recognition Test Environment

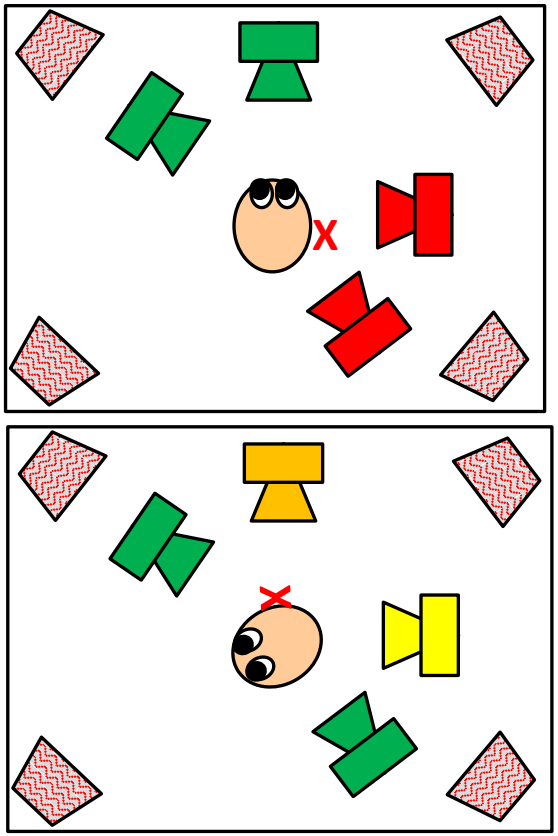


A note on looking behavior

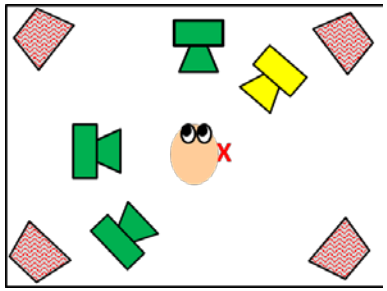
12 year old girl



10 year old girl



Sentence Recognition: Easy Configuration

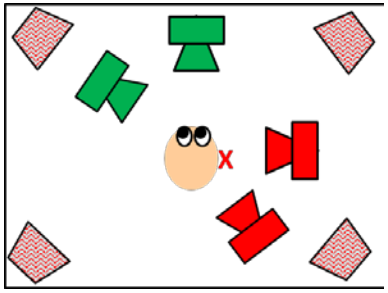


We are preparing data for manuscript publication.

Preliminary analysis revealed CROS benefits for the off-center loudspeaker

Good
Moderate
Fair
Poor

Sentence Recognition: Hard Configuration

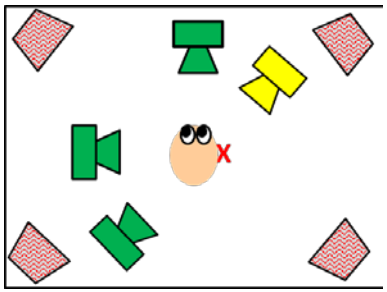


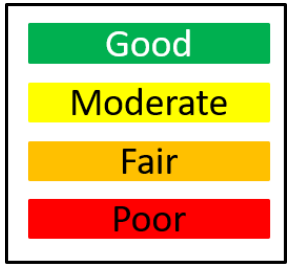
We are preparing data for manuscript publication.

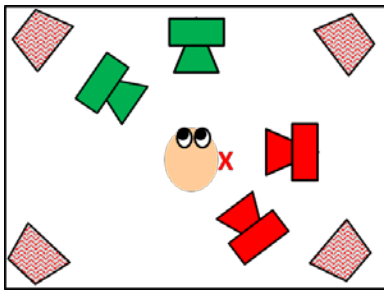
Preliminary analysis revealed CROS benefits for the loudspeakers to the side and back

Good
Moderate
Fair
Poor

Story Comprehension: Easy & Hard Configurations







We are preparing data for manuscript publication.

Preliminary analysis revealed small, but consistent benefits of the CROS hearing aids relative to the unaided condition

Summary

Previous research suggests FM systems provide benefits in classroom listening situations for most children

Findings limited by

- Location of talkers
- Dated technology
- Recorded stimuli
- Focus on speech recognition

Conducted a study in a simulated, modern classroom with updated hearing aid technology and natural looking behavior

Findings suggest benefits of CROS and FM systems depend on listening situations

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Can CROS aids improve speech recognition and comprehension in classrooms?

CROS aids CAN improve recognition and comprehension in classrooms!

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Comprehension more sensitive to the effects of technology

- Consistent with the findings of Kenworthy et al (1990), who found NST more sensitive to interventions than contextually rich sentences

CROS benefits largest in the “hard” situations, which are loaded towards the patient’s bad side

Collapsed across all configurations and tasks, CROS aids provide small, but consistent, benefits

Do we need to take FM systems out of the classroom?

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No. These data demonstrate small, but consistent, benefits in a contrived listening situation

- Equal weight to teacher and peer
- Specific speaker configuration

Do consider CROS as a possible solution for students in classrooms, especially if

- Peer input is important
- Student is older
- Student rejects an FM system

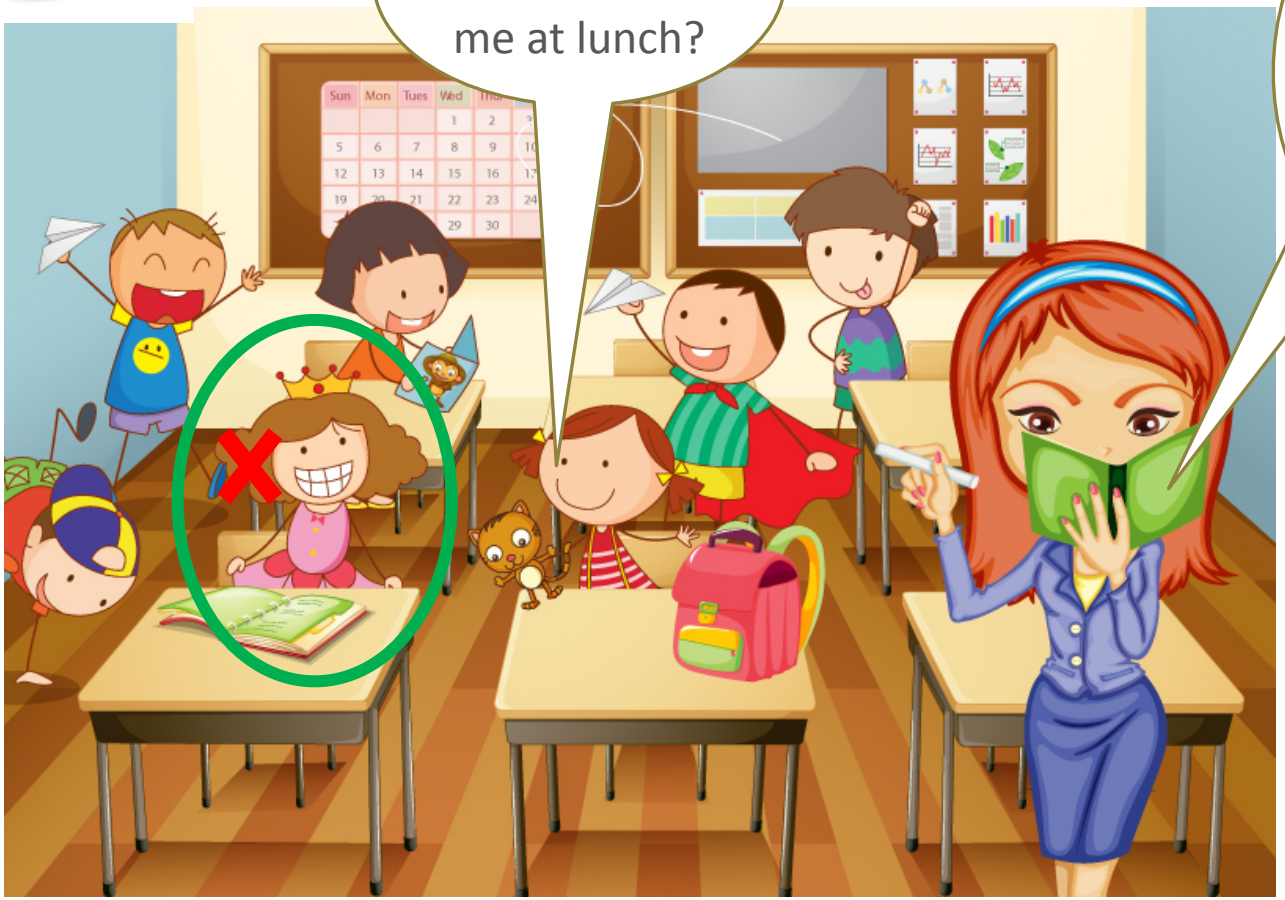
FM systems are best for

- Situations with a single talker (structured lecture, play)
- Younger children who might not orient themselves towards the talker


Do you want to sit with me at lunch?
Let's get started. Please turn to page 13…


PHONAK
SubNet
Network
Connect
roger


Do you want to sit with me at lunch?
Let's get started. Please turn to page 13…


Do you want to sit with me at lunch?
Let's get started. Please turn to page 13…


Sun Mon Tues Wed Thur Fri Sat


Do you want to sit with me at lunch?
Let's get started. Please turn to page 13…


PHONAK
SubNet
Network
Connect
roger


Do you want to sit with me at lunch?
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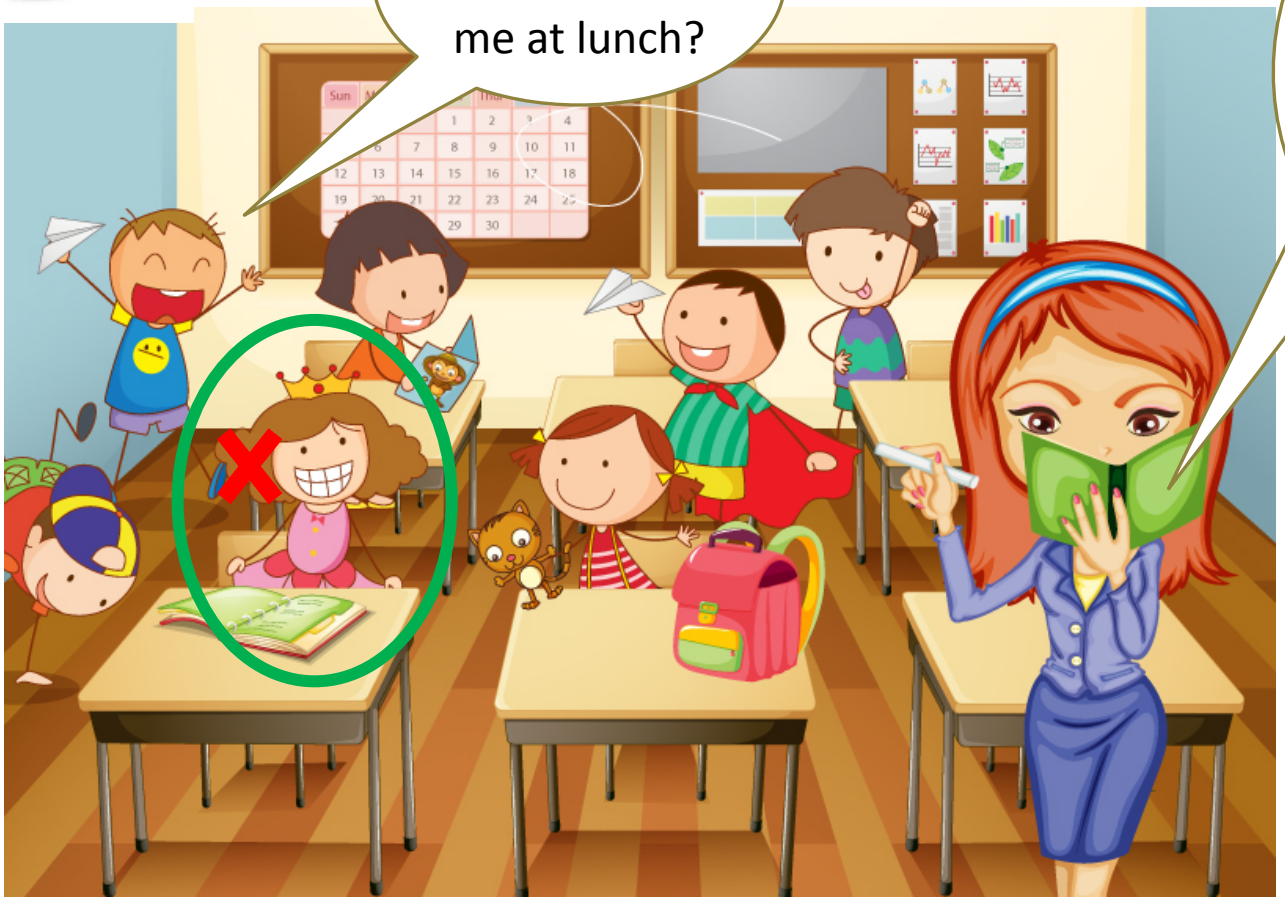
Do you want to sit with me at lunch?
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Take Home Message

CROS has the potential to help children with unilateral hearing loss in modern classrooms

Benefits most apparent for talkers on the “bad side”

Benefits of CROS relative to an FM most notable in multi-talker situations with peers who are not using the remote microphone


Thank You!
Questions?