Potential Benefits of CROS Systems in Classrooms

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Disclosures

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- Gina Angley (Vanderbilt University Medical Center)
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Funding support
- Phonak

Other support
- Amy Stahl, Haiping Huang, Emily Thompson, Javier Santos, 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

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


Interventions in classrooms

Minimally invasive
- Nothing
- Preferential seating

Surgical options
- Osseointegrated devices
- Cochlear implantation

Amplification options
- FM / remote microphone system
- CROS system
For children who are not surgical candidates, which intervention are you most likely to recommend?

- Wait and see: 0%
- Preferential seating only: 0%
- FM / RM system: 0%
- CROS system: 0%
- Combination RM / CROS: 0%
## Review of available literature for CROS / RM for school-aged children

<table>
<thead>
<tr>
<th>Survey Studies</th>
<th>Laboratory Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Teachers and parents reported favorable adjustment to body worn CROS</td>
<td>▪ RM provides the most consistent benefits and CROS only provides benefits in monaural indirect conditions</td>
</tr>
<tr>
<td>▪ CROS retention rates nearly 70% for children with LUHU</td>
<td>▪ RM improved speech recognition in noise and CROS can make speech recognition worse</td>
</tr>
<tr>
<td>Shapiro (1977)</td>
<td></td>
</tr>
<tr>
<td>▪ 7 of 8 participants reported favorable CROS benefits</td>
<td></td>
</tr>
</tbody>
</table>
What do you think is responsible for the conflicting findings between the survey studies and the laboratory studies?

- The survey studies are too old (0%)
- The laboratory studies are too controlled (0%)
- I don't know, but I hope you'll tell us (0%)

Join at slido.com #4209
How to reconcile the discrepancy between survey and laboratory studies?

Survey studies are out dated?
- Miller (1967) and Shapiro (1977) – little data or methodology reported
- Purcell (2016) – up to date, but observational

Laboratory studies too controlled to reflect contemporary classrooms?
- Perhaps... let’s take a look...
The student...

The speaker...

The legend...

Good
Moderate
Fair
Poor

The result...

Noise
RM helps in noise and CROS hurts in noise

Data from Updike (1994) J Am Acad Audiol, 5, 204-209
CROS benefits depend on configuration

CROS makes speech recognition worse

FM always “wins”
What are classrooms like?

Complex and dynamic

- Noise is present approximately 80% of the time
- Noise primarily surrounds a student
- Noise rarely direct to the side
What are classrooms like?

Complex and dynamic

- Noise is present approximately 80% of the time

- Noise primarily surrounds a student

- Noise rarely direct to the side

- Talkers of interest could be anywhere, but are often from the front or in multiple locations

Classrooms include diverse talker locations

- Normal hearing bilaterally
- Right unilateral loss
Seat assignment affects expected speech understanding in classrooms

Adapted from: Picou, Davis & Tharpe (in review) LSHSS
Classrooms are places of learning and comprehension

Comprehension *more* sensitive to the effects of mild/unilateral hearing loss

Updating evidence for CROS / RM in dynamic classroom situations

Goal was to take into consideration
- Various talker locations
- Diffuse noise
- Updated CROS / RM technology
- Comprehension and recognition
- Live stimuli in simulated classroom
- Survey and laboratory evidence
General Methodology

Participants
- First study: Children with normal hearing, 10 – 14 years old, simulated unilateral hearing loss
- Second study: Children with limited useable hearing unilaterally (LUHU; also known as SSD)

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

Note: Not even close to scale
Hearing Aids: BTE Sky v70 M312

1) CROS
   - Microphone on ear with hearing loss
     - Real Ear Sound
     - Demo hook
   - Receiver on ear with normal hearing
     - Ultrazoom
     - Non-occluding, non-custom eartip

2) Roger microphone
   - Microphone
     - 6 cm in front of loudspeaker in center
     - “Lanyard” directionality
   - Receiver on ear with normal hearing
     - 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

Task developed by Dawna Lewis and colleagues at Boys Town

Fairy tales translated from foreign languages

Each loudspeaker/monitor combination displays a talker and presents her voice

Each talker reads a few sentences of the story

Story split between 4 loudspeakers

Participants heard each story only once
Story Comprehension Test Environment
Sentence Recognition
Test Environment

Roger
microphone
location

Noise
loudspeaker
Sentence Recognition: Easy Configuration

![Bar chart showing sentence recognition proportions for different configurations and conditions.](chart.png)
Sentence Recognition: Hard Configuration

![Graph showing sentence recognition results with metrics for unaided, cros, and fm categories.](image)

- **Good**
- **Moderate**
- **Fair**
- **Poor**
Story Comprehension: Easy & Hard Configurations
Story Comprehension: Easy & Hard Configurations

Proportion Correct

- unaided
- cros
- fm

Proportion Correct

- unaided
- cros
- fm
Story Comprehension Benefit

![Graph showing comprehension benefit for different participants.](image-url)
CROS also helps children with hearing loss in monaural indirect situations
Comprehension consistently the best with the CROS system
Laboratory study summary

Laboratory situation reflecting contemporary classrooms

- Reverberation
- Head movement
- Dynamic talker location
- Comprehension AND recognition

Updated hearing aid technology

- Non-occluding eartip
- Directional microphones

**CROS can improve speech recognition and comprehension, especially for talkers without the remove microphone**
What about CROS in “real” school listening situations?

I am in a classroom in the front. The teacher in the front is telling the class what to do.

<table>
<thead>
<tr>
<th>UNAIDED</th>
<th>AIDED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very easy</td>
<td>A lot better WITH hearing aid(s)</td>
</tr>
<tr>
<td>A little easy</td>
<td>A little better WITH hearing aid(s)</td>
</tr>
<tr>
<td>Not easy or hard</td>
<td>Same WITH and WITHOUT hearing aid(s)</td>
</tr>
<tr>
<td>A little hard</td>
<td>A little better WITHOUT hearing aid(s)</td>
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Children with UHL have more difficulty in classrooms situations than their peers

Talker Front
- “I am in a classroom in the front. The teacher in the front is telling the class what to do.”

Overhearing
- “I am listening to the teacher in class and kids start talking quietly behind me and I want to know what they are saying.”

Localization
- “I am at a noisy party and I hear someone say my name. I want to find where they are.”
Students with CROS experience note benefits (mostly)

Responses from 10 established CROS users

Asked to consider the same situations:
- Better WITH hearing aids
- Same WITH and WITHOUT hearing aids
- Better WITHOUT hearing aids

Benefits most apparent for “talker front” situations and lowest for “localization” situations
Summary

Unilateral hearing loss significantly increases risk of academic and language difficulties in school-aged children

No consensus on optimal interventions

Previous studies on CROS/ RM revealed mixed results
  ◦ Survey studies suggest CROS beneficial with high use rates
  ◦ Laboratory studies suggest RM provide most consistent benefits

Resolution of the conflicting findings is related to:
  ◦ Age / validity of survey studies
  ◦ Controlled nature of laboratory studies

Updated evidence suggests
  ◦ CROS benefits evident in contemporary classroom laboratory environment
  ◦ CROS benefits evident in survey data regarding classroom experiences
CROS systems help children with unilateral hearing loss in “real” classrooms
Do we need to take RM systems out of the classroom?

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

- Equal weight to teacher and peer
- Specific speaker configuration

FM systems are best for

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

Do consider CROS as a possible solution for students

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

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Take home message

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

Benefits most apparent
◦ Talkers directed towards the ear with hearing loss
◦ Peers without the remote microphone

Combination RM and CROS will work for most situations
◦ RM + CROS simultaneously
◦ RM + CROS with manual / automatic switching
◦ Sound field RM + CROS
Thank you!

Questions?