

CROS Hearing Devices for Adults and Children

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CANADIAN ACADEMY OF AUDIOLOGY

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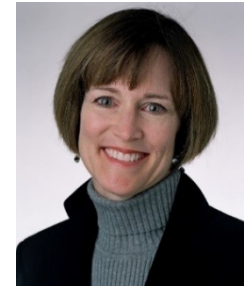
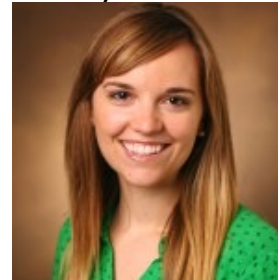
4:15PM-5:10PM



Disclosures

Collaborators

- Dawna Lewis (Boys Town National Research Hospital)
- Ilze Oosthuizen (University of Pretoria)
- Gina Anglely (Nashville's Hearing & Communication Center)
- Hilary Davis (Vanderbilt University Medical Center)
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Other support

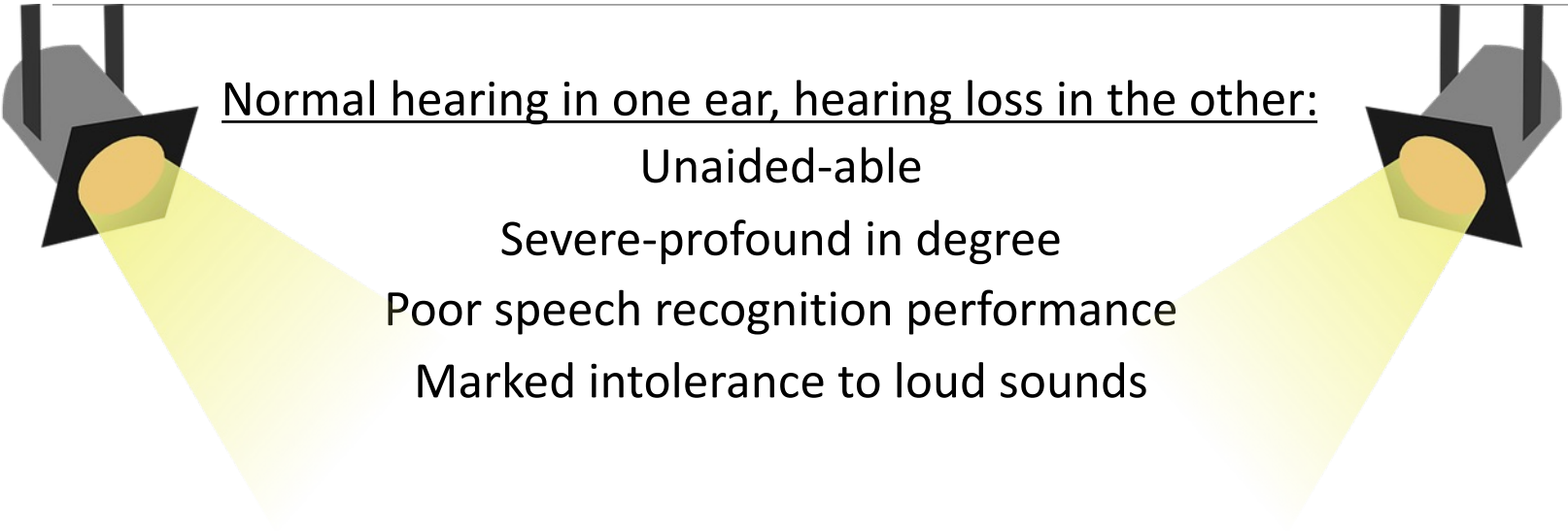
- Amy Stahl, Haiping Huang, Christine Jones, Lori Rakita, Connor Kaminski, Kate Healy

Learning objectives

- 1) Describe potential consequences of unilateral hearing loss for school-aged children
- 2) Discuss the potential benefits of CROS systems for school-aged children
- 3) Describe potential consequences of unilateral hearing loss for adults
- 4) Discuss the potential benefits of CROS systems for adults



Today's spotlight



Normal hearing in one ear, hearing loss in the other:

Unaided-able

Severe-profound in degree

Poor speech recognition performance

Marked intolerance to loud sounds

Single-sided deafness (SSD)

or

Limited useable hearing unilaterally (LUHU)

Meet Jake*

11 years old

6th grader at local public school

Profound unilateral hearing loss in
the right ear following ATV
accident 12 months ago

Mom is noticing some behavior
changes

- Inattention at home
- Quality of schoolwork
- Energy at the end of the day



Learning Outcome 1

Describe
potential
consequences
of unilateral
hearing loss for
school-aged
children



Assumption #1

“Normal hearing in one ear is enough – they’ll be fine!”



Unilateral hearing loss and speech recognition

Localization and less spatial release from masking *Corbin et al. (2021). J Speech Lang Hear Res, 64, 4495-4512*

Monaural indirect conditions (speech directed toward ear with hearing loss; *Ruscetta et al. (2005) Int J Ped Otorhinolaryngol 69, 771-779*

Spatially separated speech and noise *Reeder et al., (2015) Audiology and Neurotology, 20, 31-37*

Poor signal-to-noise ratios *Bess et al. (1986). Ear and Hearing, 7, 20-26*

Complex noises *Corbin et al (2017). Ear and Hearing, 38, 223 - 235*

Unilateral hearing loss consequences

Increased listening-related fatigue *Bess et al. (2020) Language, Speech, and Hearing Services in Schools, 51, 84-97*

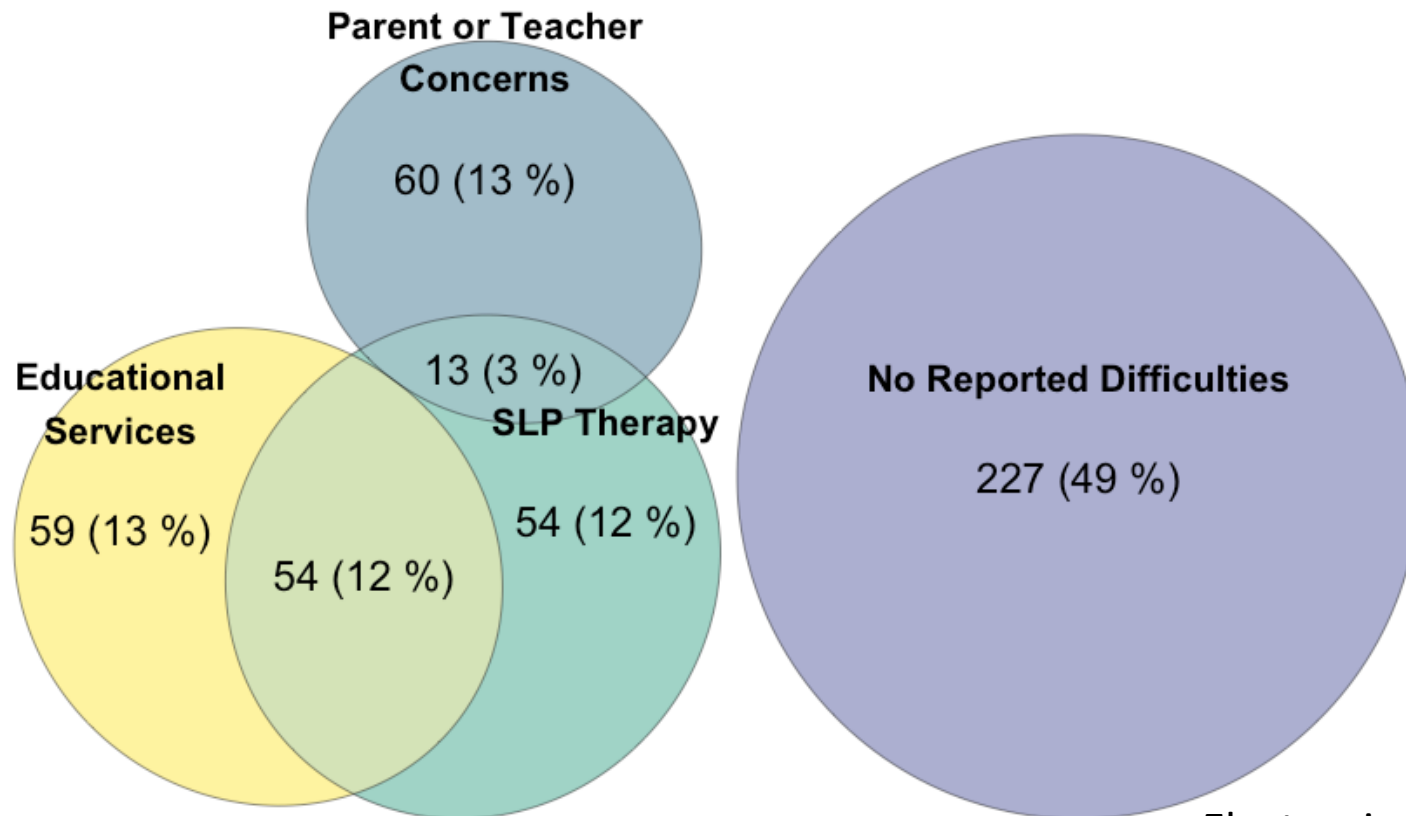
Reduced passage comprehension *Lewis et al (2015) Ear Hear, 36, 136 - 144*

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

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*

About half of students with unilateral hearing loss demonstrate speech, language, or academic difficulties



Electronic health records search
Automated and manual searches
No co-existing educationally-significant conditions

Emerging reality #1

“Unilateral hearing loss increases the risk of speech, language, and academic difficulties”



Learning Outcome 2

Discuss the
potential
benefits of
CROS systems
for school-
aged children



Meet Jake*

11 years old

6th grader at local public school

Profound unilateral hearing loss in
the right ear following ATV
accident 6 months ago

Mom is noticing some behavior
changes

- Inattention at home
- Quality of schoolwork
- Energy at the end of the day



What would you do?

If you were Jake's audiologist, which of the following would you consider? *(more than one can apply)*

- A. Cochlear implant evaluation
- B. Preferential seating
- C. Remote microphone system (RMS)
- D. Contralateral routing of signals (CROS)
- E. Bone conduction hearing aid
- F. Watch and wait



What would you do?

If you were Jake's audiologist, which of the following would you consider? *(select all that apply)*

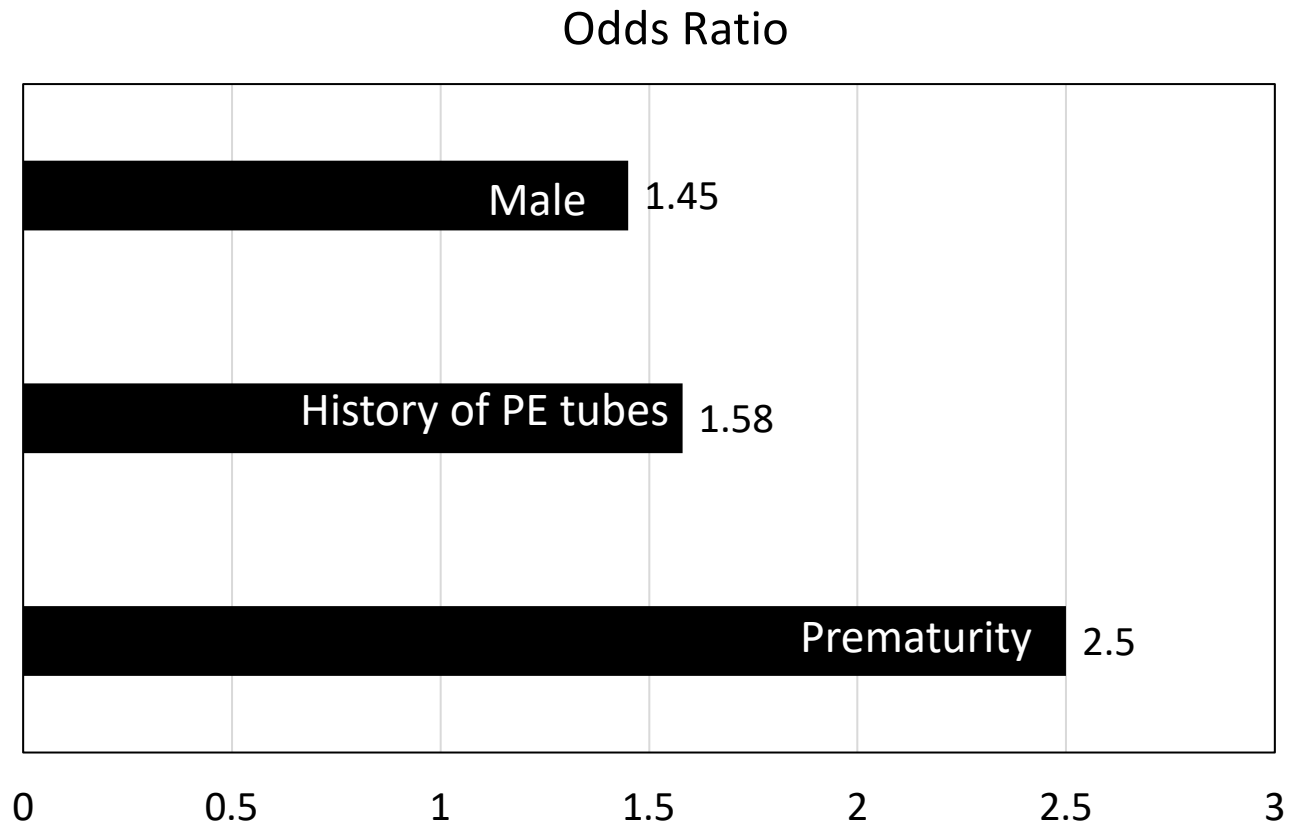
- A. Cochlear implant evaluation
- B. Preferential seating
- C. Remote microphone system (RMS)
- D. Contralateral routing of signals (CROS)
- E. Bone conduction hearing aid
- F. Watch and wait



Difficult to predict who will exhibit difficulties

Difficulty **NOT** related to:

- Degree of loss
- Laterality



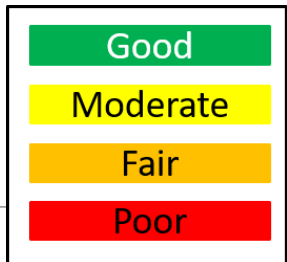
What would you do?

If you were Jake's audiologist, which of the following would you consider? *(select all that apply)*

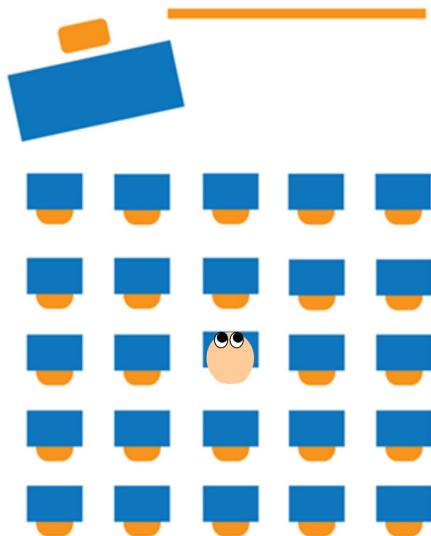
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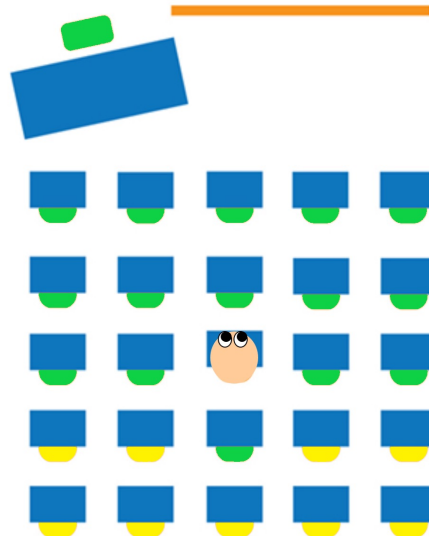
Classrooms include diverse talker locations



Rows/Columns

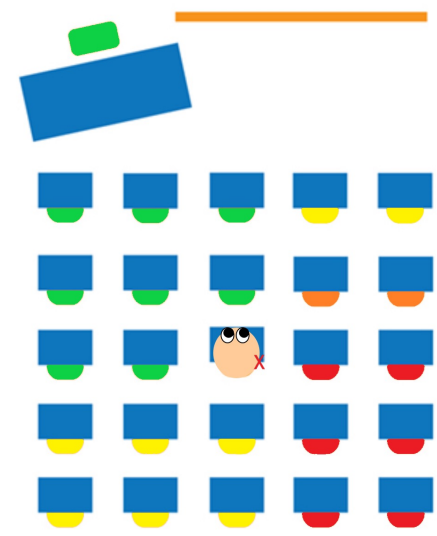


Rows/Columns



Normal hearing bilaterally

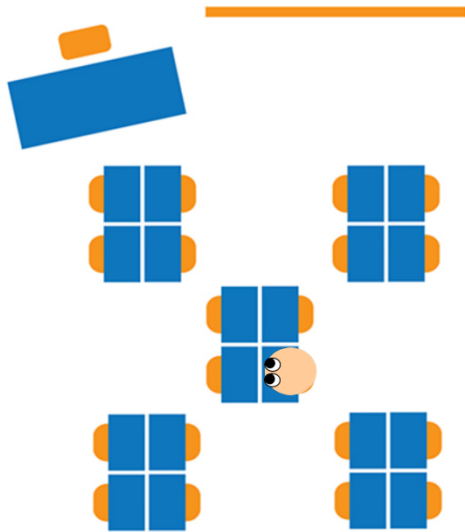
Rows/Columns



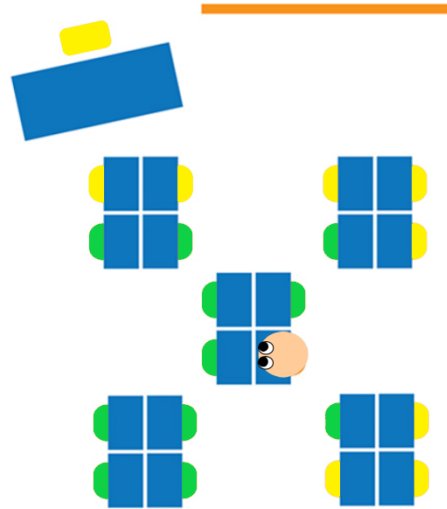
Right unilateral loss

Modern classrooms have diverse seating arrangements

Clusters

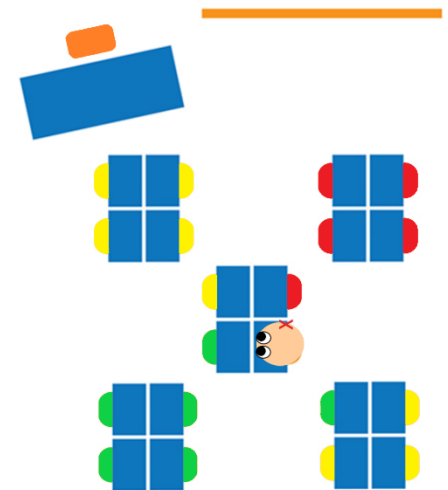


Clusters



Normal hearing bilaterally

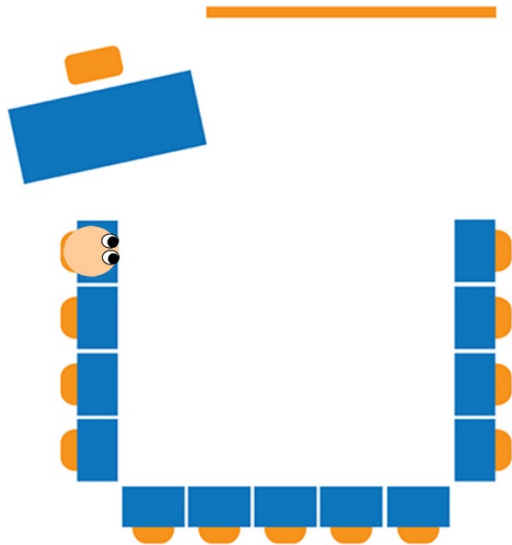
Clusters



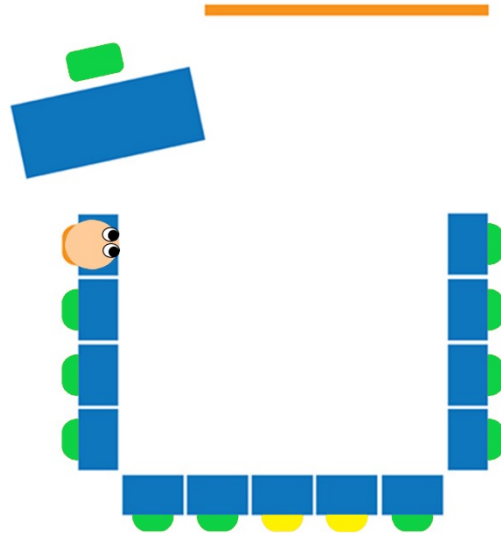
Right unilateral loss

Modern classrooms have diverse seating arrangements

Horseshoe/U-Shape

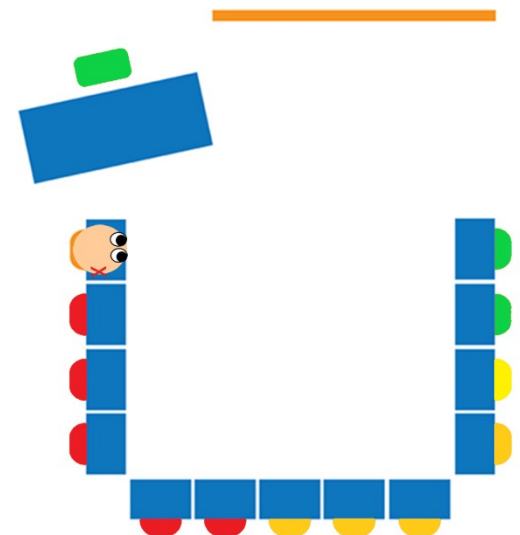


Horseshoe/U-Shape



Normal hearing bilaterally

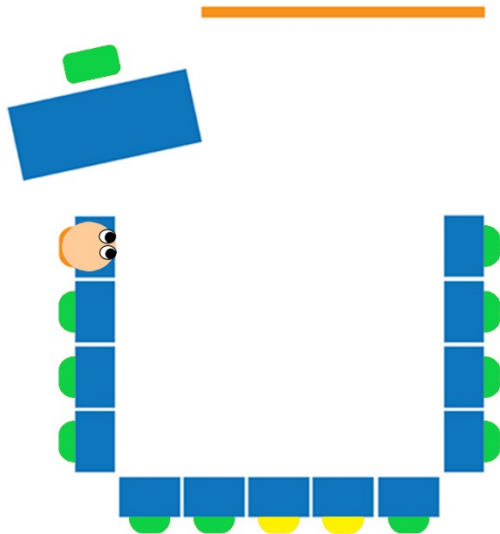
Horseshoe/U-Shape



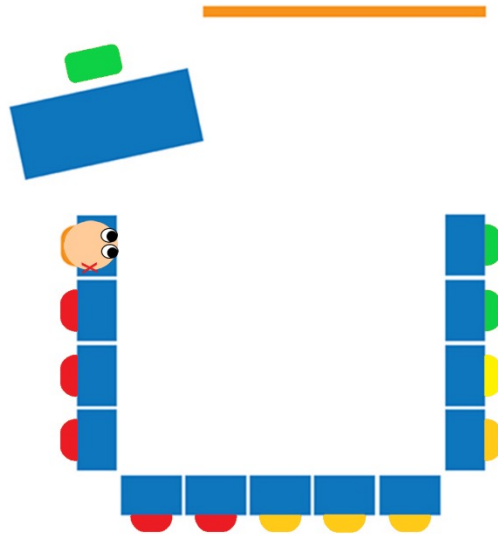
Right unilateral loss

Seat assignment makes a difference

Horseshoe/U-Shape

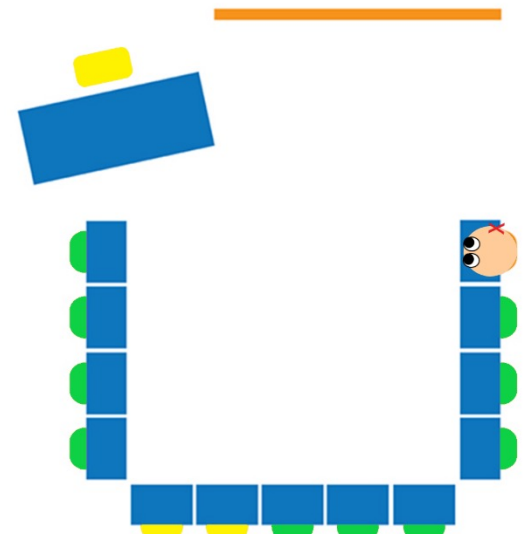


Horseshoe/U-Shape



Right unilateral loss

Horseshoe/U-Shape



Right unilateral loss

What would you do?

If you were Jake's audiologist, which of the following would you consider? *(select all that apply)*

- A. Cochlear implant evaluation
- B. Preferential seating
- C. Remote microphone system (RMS)
- D. Contralateral routing of signals (CROS)
- E. Bone conduction hearing aid
- F. Watch and wait



Assumption #2

“Remote microphone systems are the preferred option for classrooms and CROS systems make things worse”



Consensus statements and advice from professional organizations

American Academy of Audiology (2013). Clinical Practice Guidelines: Pediatric Amplification.

- “with the wireless **remote microphone** receiver coupled to the open, good ear may be **preferable to a CROS** configuration in classroom situations”

Lieu (2015) *Otolaryngologic Clinics of North America*, 48, 1011-1026.

- “the **CROS hearing aid may offer some benefit**, although children may not take to these devices because the perceived benefit may be low; they do not aid in sound localization and they may make speech perception worse in noise”

McKay, Gravel & Tharpe (2008). *Trends in Amplification*, 12, 43-54.

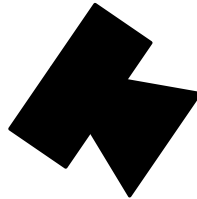
- “**CROS amplification may not be beneficial** in the classroom, where children are in assigned seating arrangements because of the introduction of noise to the normal hearing ear via the microphone on the impaired side”

Brief orientation

The student...



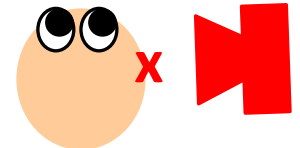
The speaker...



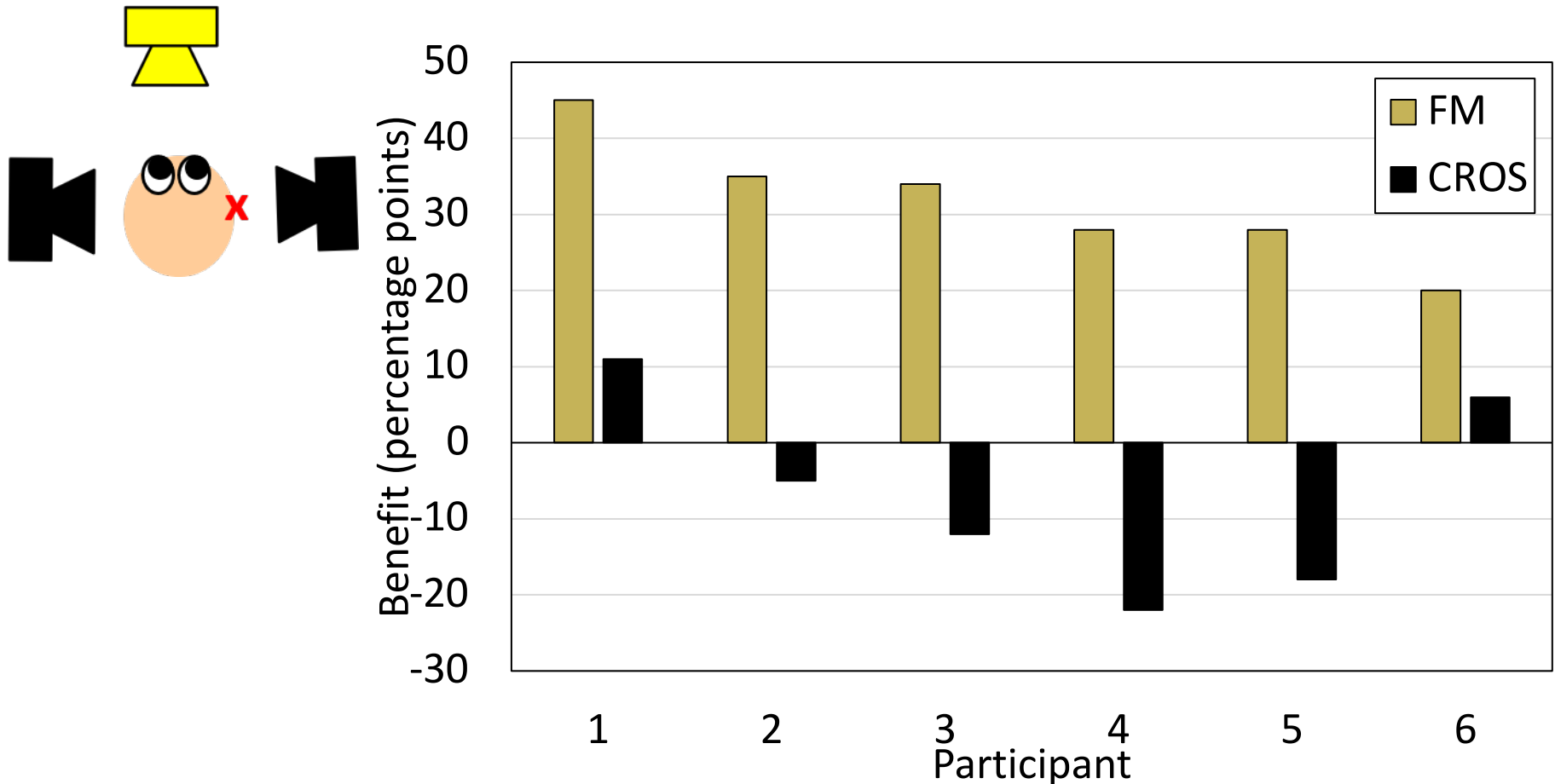
The legend...

Good
Moderate
Fair
Poor

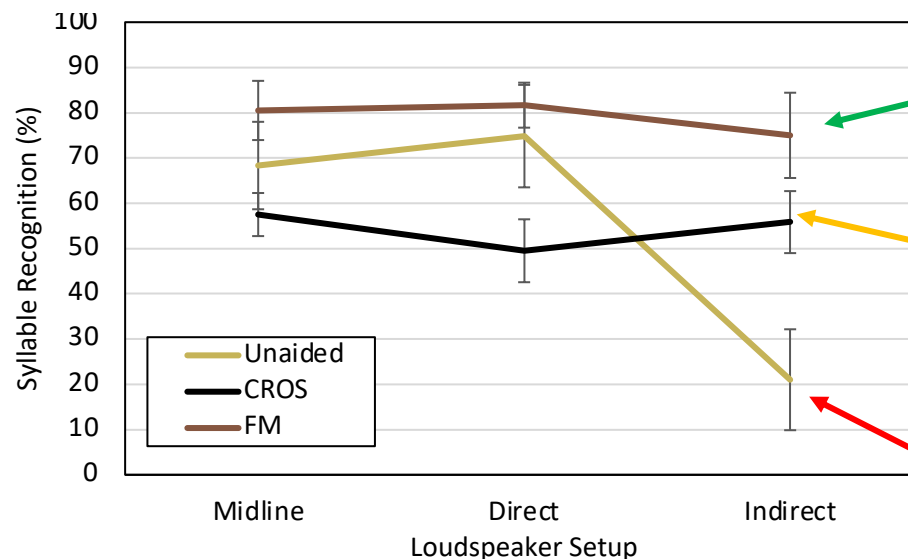
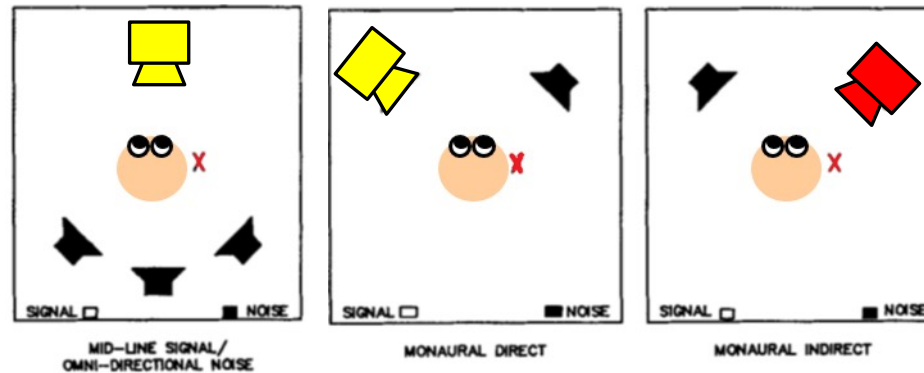
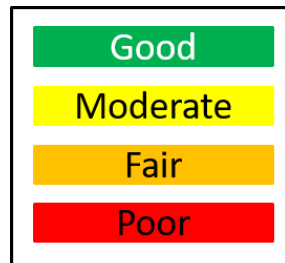
The result...



Previous work suggests FM systems are the best option



CROS benefits depend on configuration



FM always
“wins”

CROS helps in
indirect only

Unaided very
challenging in
indirect

Review of available literature for CROS / RM for school-aged children

SURVEY STUDIES



Miller (1967) J Speech Hear Dis

- Teachers and parents reported favorable adjustment to body worn CROS



Purcell et al (2016)

- CROS retention rates nearly 70% for children with LUHU



Shapiro (1977)

- 7 of 8 participants reported favorable CROS benefits

LABORATORY STUDIES

Kenworthy et al (1990)

- RM provides the most consistent benefits and CROS only provides benefits in monaural indirect conditions



Updike (1994)

- RM improved speech recognition in noise and CROS can make speech recognition worse



Would we expect those situations in contemporary classrooms?

Modern classrooms are complex and dynamic

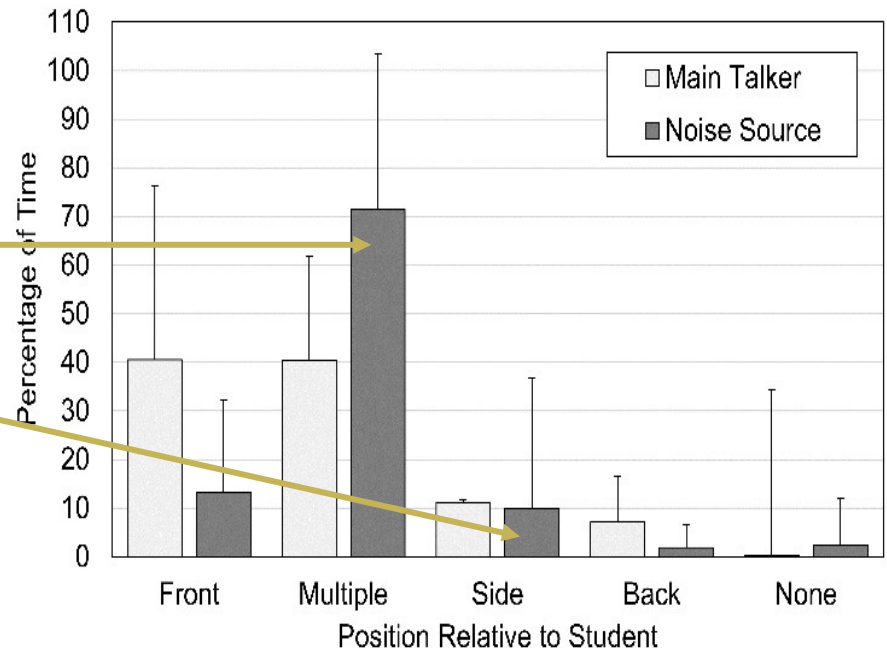
- Noise is present approximately 80% of the time

Cruckley, J., S. Scollie & V. Parsa (2011). *J Educ Audiol*, 17, 23-35

- Noise primarily surrounds a student

Ricketts et al (2017) *JSLHR*, 60, 263 - 275

- Noise rarely direct to the side



Would we expect those situations in contemporary classrooms?

Modern classrooms are complex and dynamic

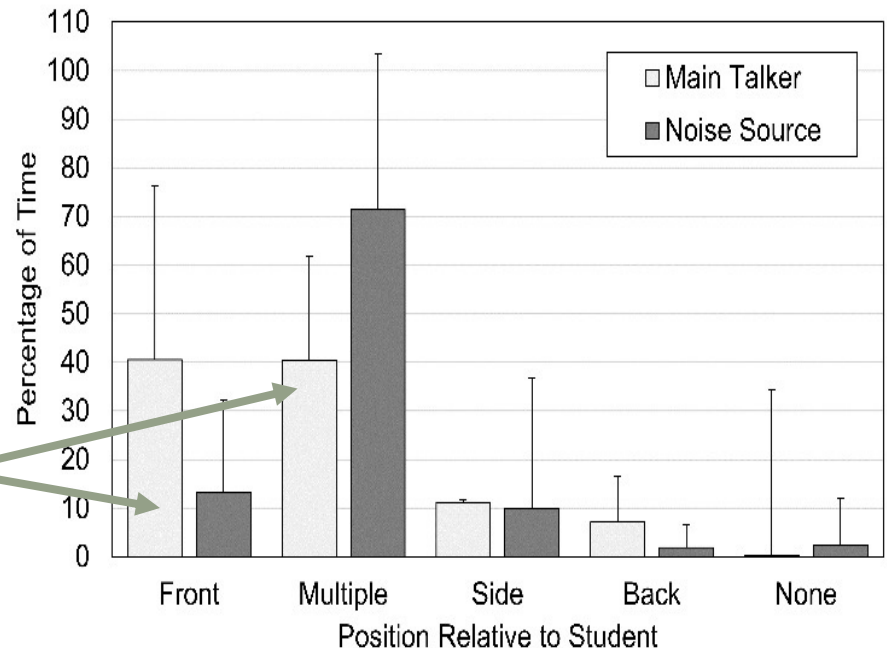
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Cruckley, J., S. Scollie & V. Parsa (2011). *J Educ Audiol*, 17, 23-35

- Noise primarily surrounds a student

Ricketts et al (2017) *JSLHR*, 60, 263 - 275

- Noise rarely direct to the side
- Talkers of interest could be anywhere, but are often from the front or in multiple locations



Limitations of previous findings

30-year-old technology

Remote microphone always near the talker of interest

Signals originated from front hemisphere

Directional noises

Static head position

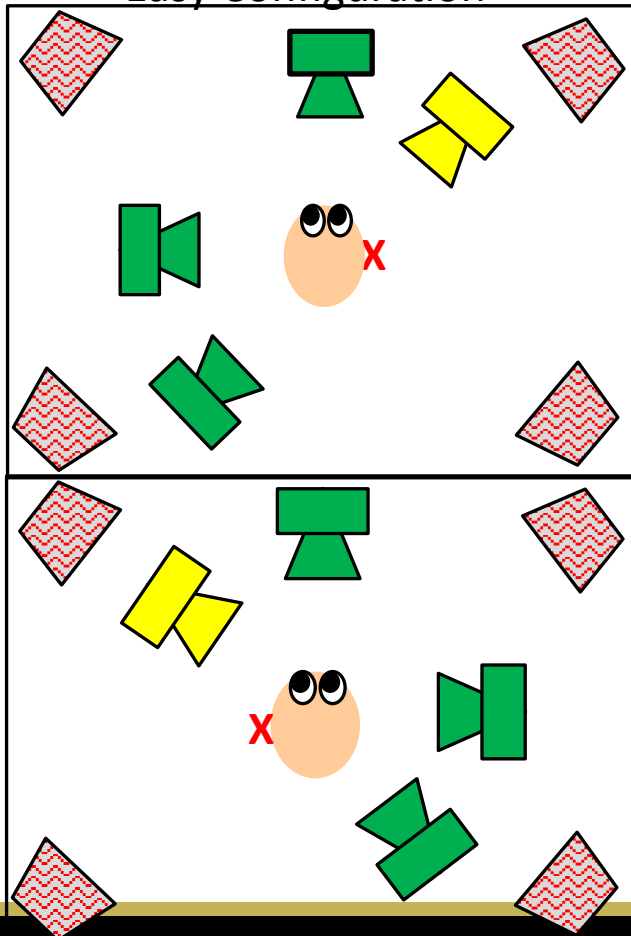
Focus on speech recognition



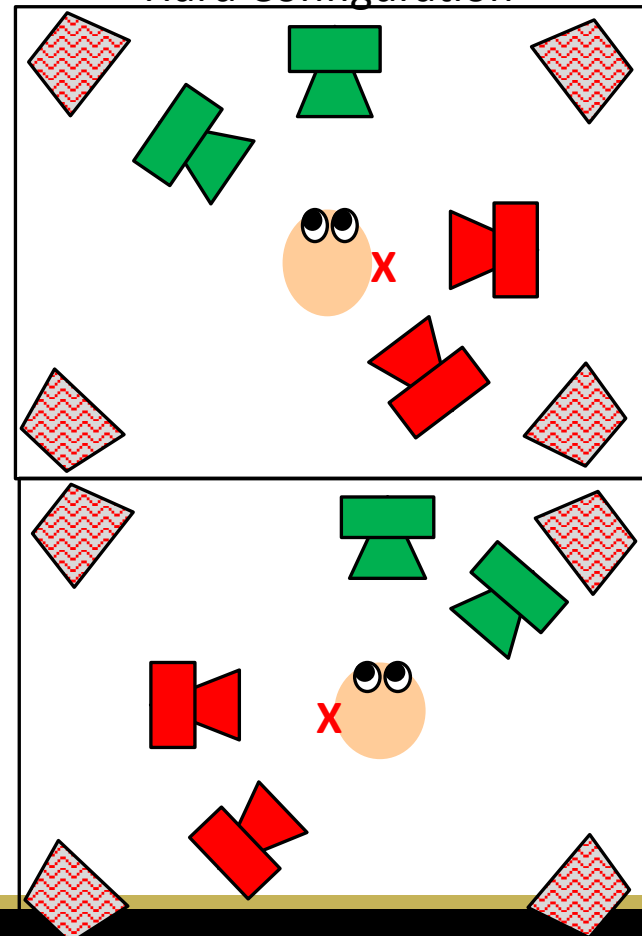
Complex setup in different configurations

Note: Not even close to scale

Easy Configuration



Hard Configuration



Good

Moderate

Fair

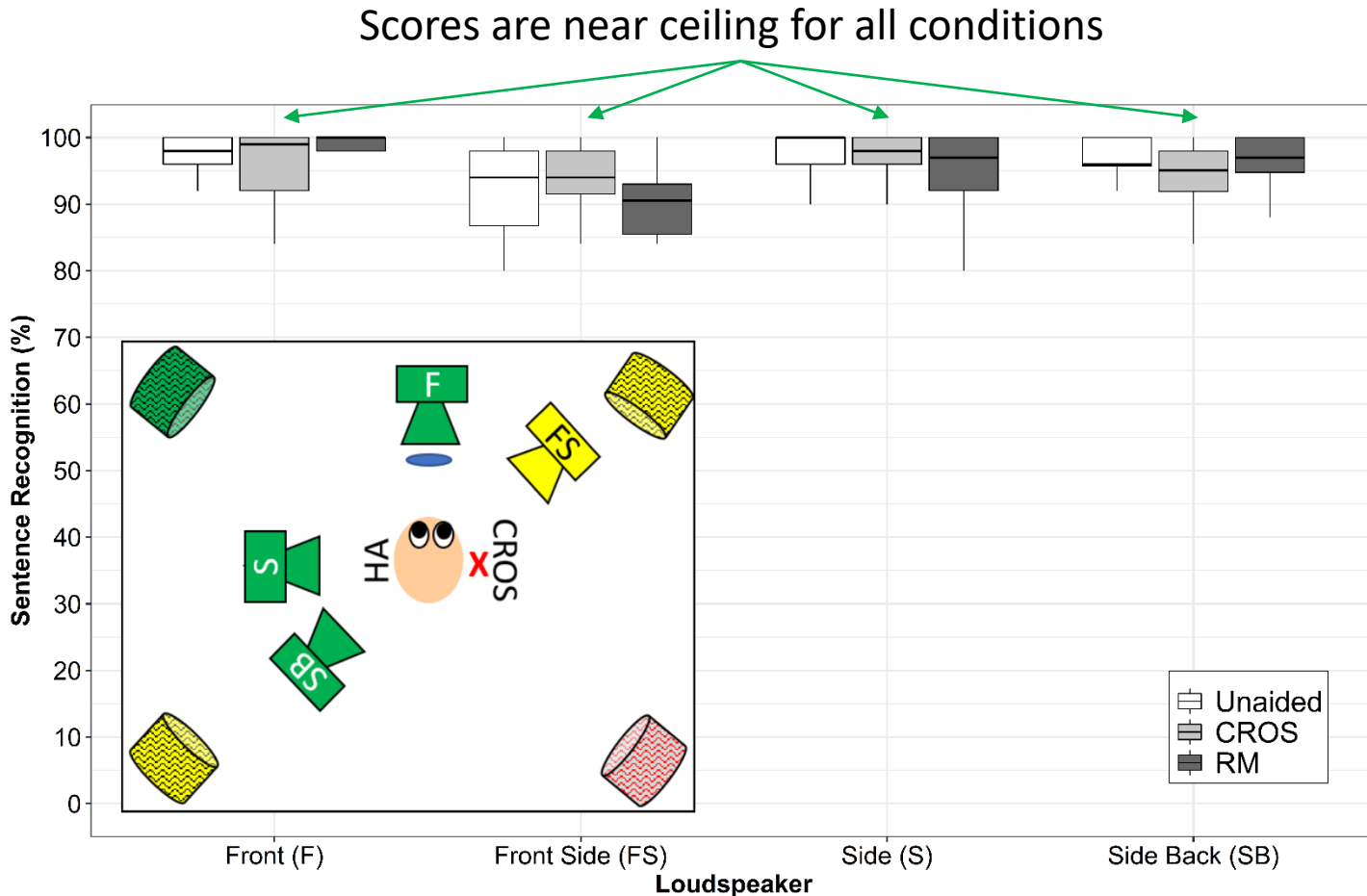
Poor

Story comprehension and sentence recognition test environment

Remote
microphone



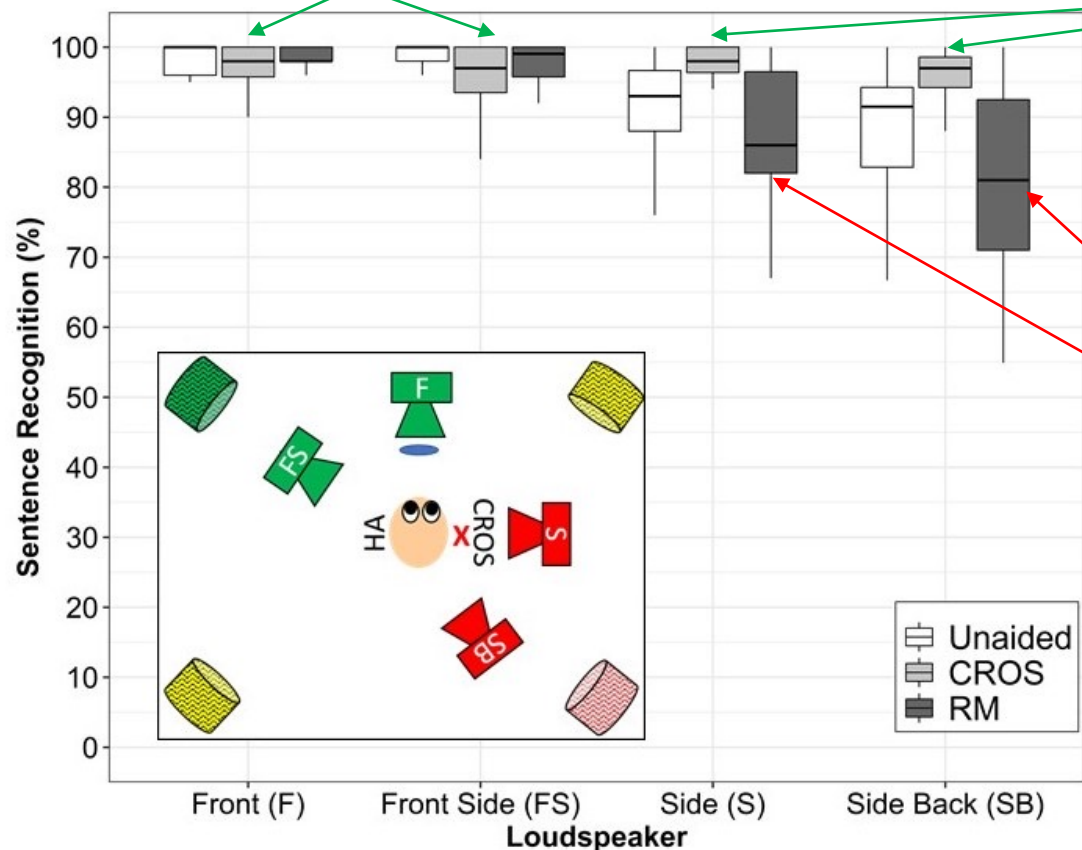
None of the interventions affect performance when it's easy



CROS helps sentence recognition in noise

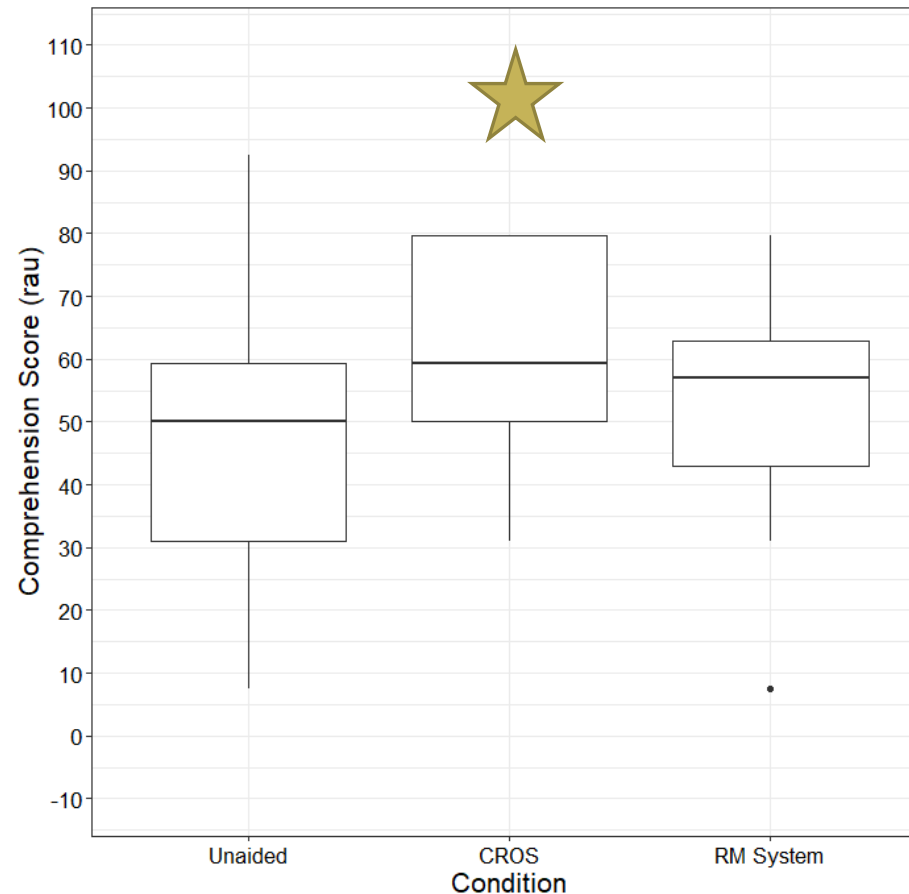
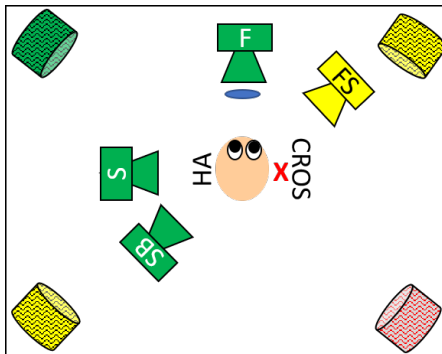
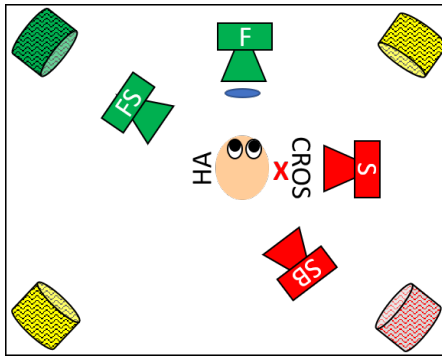
Performance is good when it's easy

Performance is best with CROS



Performance is lowest with RM system

CROS helps comprehension in both configurations



In dynamic classrooms, the balance of direct/indirect talkers might not matter for CROS –

Re-routing sound is beneficial

CROS aids can
improve
recognition and
comprehension
in classrooms



CROS aids CAN improve recognition and comprehension in classrooms!

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

Limited evidence that CROS makes things worse, even for monaural direct loudspeaker locations









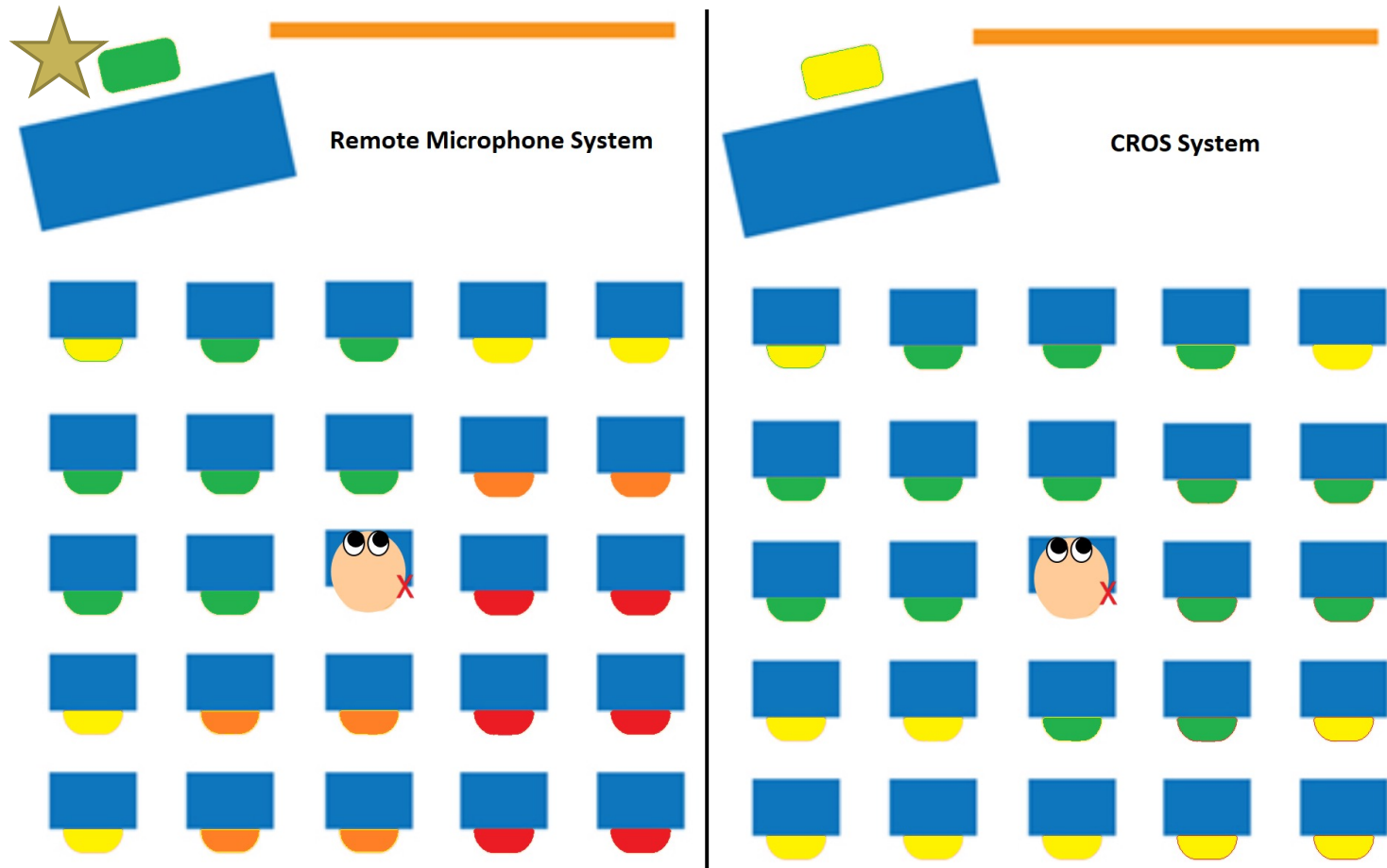
Let's get started.
Please turn to page 13...



Do you want
to sit with
me at lunch?

Let's get started.
Please turn to page 13...

Applying laboratory data to hypothetical seating arrangement



Can CROS help in actual classrooms?

Evidence from the Vanderbilt Classroom Listening Assessment Survey (V-CLASS)

FRONT



I am eating lunch at school; my friend across the table is telling a story

BEHIND



I am in a quiet room talking to my friend who is studying behind me

LOCALIZE



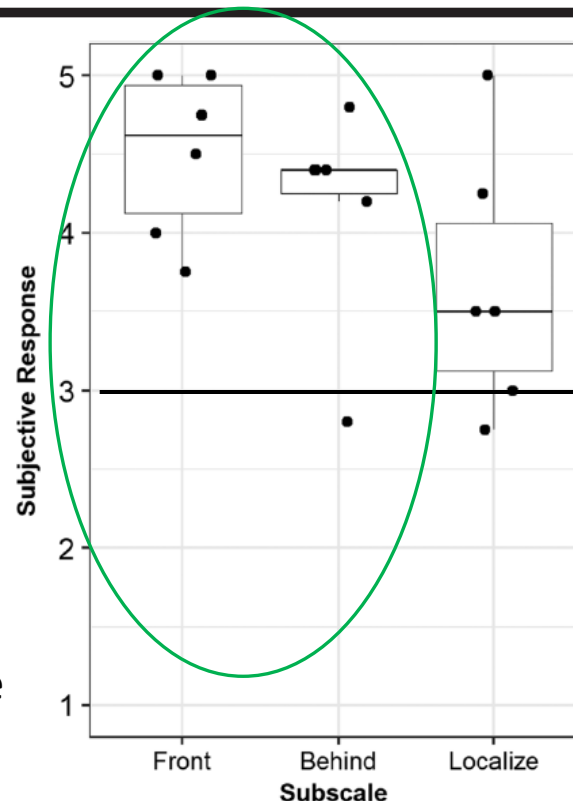
I am hanging out with my friends. Someone's phone starts to ring and I want to figure out where the ringing is coming from.

Scores on questionnaire also demonstrate CROS benefits

Figure 5. Subjective ratings for each subscale of the questionnaire. Lines indicate medians, and boxes indicate lower and upper quartiles. Data from individual participants are indicated with black dots.

CROS makes it better

CROS makes it worse



Review of available literature for CROS / RM for school-aged children

SURVEY STUDIES



Miller (1967) J Speech Hear Dis

- Teachers and parents reported favorable adjustment to body worn CROS



Purcell et al (2016)

- CROS retention rates nearly 70% for children with LUHU



Shapiro (1977)

- 7 of 8 participants reported favorable CROS benefits



Picou et al (2020)

- Report benefit for 'front' and 'behind' listening situations from 6 established CROS users

LABORATORY STUDIES

Kenworthy et al (1990)

- RM provides the most consistent benefits and CROS only provides benefits in monaural indirect conditions



Urdike (1994)

- RM improved speech recognition in noise and CROS can make speech recognition worse



Picou et al (2019, 2020)

- CROS improved speech recognition and comprehension in a dynamic environments



Emerging reality #2

“CROS systems can be beneficial in realistic, dynamic 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

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

- Peer input is important
- Student is older
- Student rejects a RM system

RM systems are best for

- Situations with a single talker (structured lecture, play)
- Younger children who don't position themselves

Summary for school-aged children

Consequences of unilateral hearing loss for school-aged children

- Difficulties understanding speech in noise
- Increased academic fatigue
- Academic difficulties

Variety of non-surgical interventions available for classrooms (which are diverse and challenging listening situations)

- Choose preferential seat carefully considering all talkers
- RM system with a single microphone can only address one talker at a time
- CROS systems have the potential to improve auditory access for the most talkers in classrooms

Meet Jon^{*}

42 years old

Active realtor

Jake's father

Profound unilateral hearing loss in the right ear (same ATV accident as Jake)

Wife notes some concerns

- Inattention at home
- Fatigued at the end of the day
- Difficulty localizing potential buyers in large homes



Learning Outcome 3

Describe
potential
consequences
of unilateral
hearing loss for
adults



Assumption #3

“Normal hearing in one ear is enough – they’ll be fine!”



Unilateral hearing loss in adults

Highly prevalent

- 3% of school-aged children *Bess et al (1998) Ear Hear, 19, 339-354*
- 7% of adults *Golub et al (2018) Laryngoscope, 128, 1681-1686*

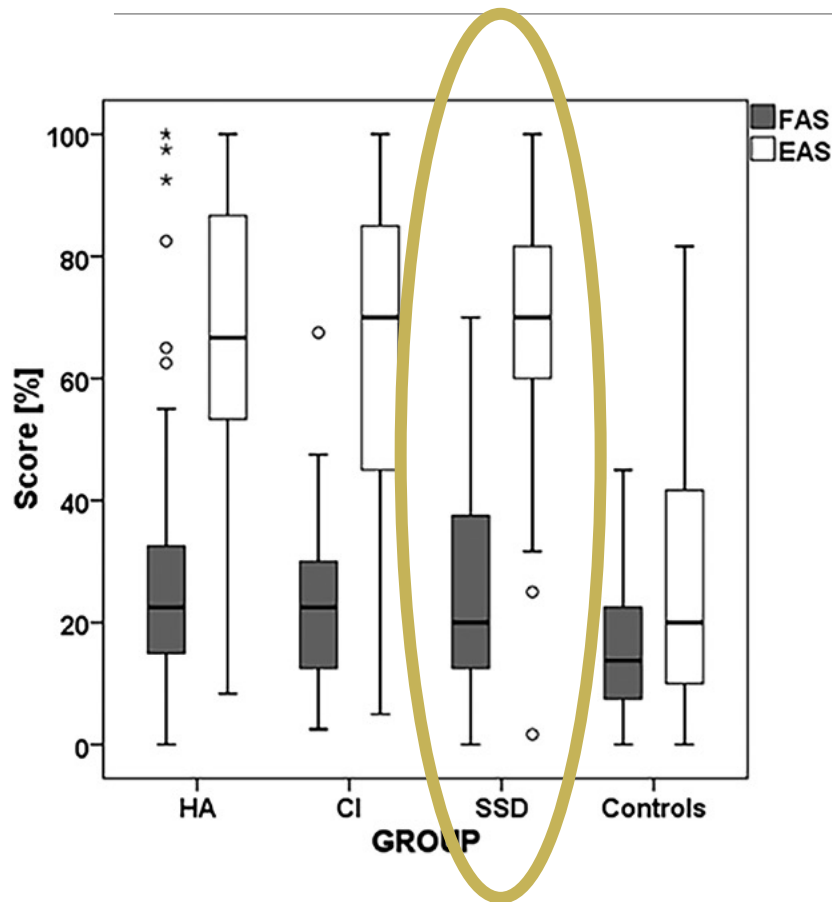
Difficulty localizing sounds in space *Douglas et al (2007) Laryngoscope, 117, 1648-1651*

Difficulty understanding speech in noise *Vannson et al (2017) Neuropsychologia, 102, 135-143*

Increased psychosocial effects (loneliness, poor health) *Pierzycki et al (2021) Ear Hear, 42, 520-530*

Reduced quality of life *Wie et al (2010) Ann Otol Rhinol Laryngol, 119, 772-781*

Listening-related fatigued similar for unilateral and bilateral losses



Compared to a control group with normal hearing, all three groups reported similar degrees of increased effort and more fatigue

- *HA – mild-moderate loss and 6 months of hearing aid experience*
- *CI – cochlear implant user for at least 6 months*
- *SSD – LUHU due to acoustic neuroma removal and normal hearing in the other ear*

Emerging Reality #3

“Unilateral hearing loss increases the risk of lower reported quality of life and listening difficulties”



Learning Outcome 4

Discuss the
potential
benefits of
CROS systems
for adults



Meet Jon^{*}

42 years old

Active realtor

Jake's father

Profound unilateral hearing loss in the right ear (same ATV accident as Jake)

Wife notes some concerns

- Inattention at home
- Fatigued at the end of the day
- Difficulty localizing potential buyers in large homes



What would you do?

If you were Jon's audiologist, which of the following would you consider? *(select all that apply)*

- A. Cochlear implant evaluation
- B. Preferential seating
- C. Remote microphone system (RMS)
- D. Contralateral routing of signals (CROS)
- E. Bone conduction hearing aid
- F. Watch and wait



Why are adults different than school-aged children?

Less classroom listening time

Less likely to use RM system

More established conversational patterns (?)

More experienced at orienting themselves

More knowledge and context to support communication



Lessons learned from research with students

Disconnect between laboratory results and real classrooms

Downsides of CROS in “real world” might not be as significant due to:

- Diffuse noise
- Multiple talkers of interest
- Modern technology

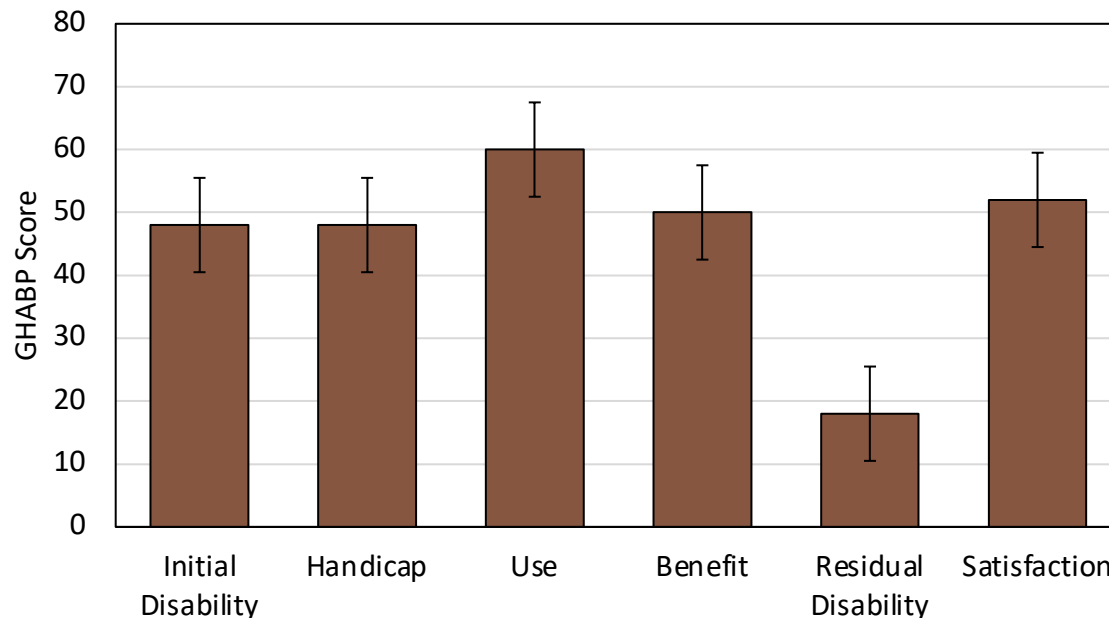


Recent evidence suggests benefits with modern CROS

Evaluated adults with CROS or bone conduction experience

Glasgow Hearing Aid Benefit Profile

- High benefit, use, and satisfaction scores with CROS
- Low residual disability scores with CROS

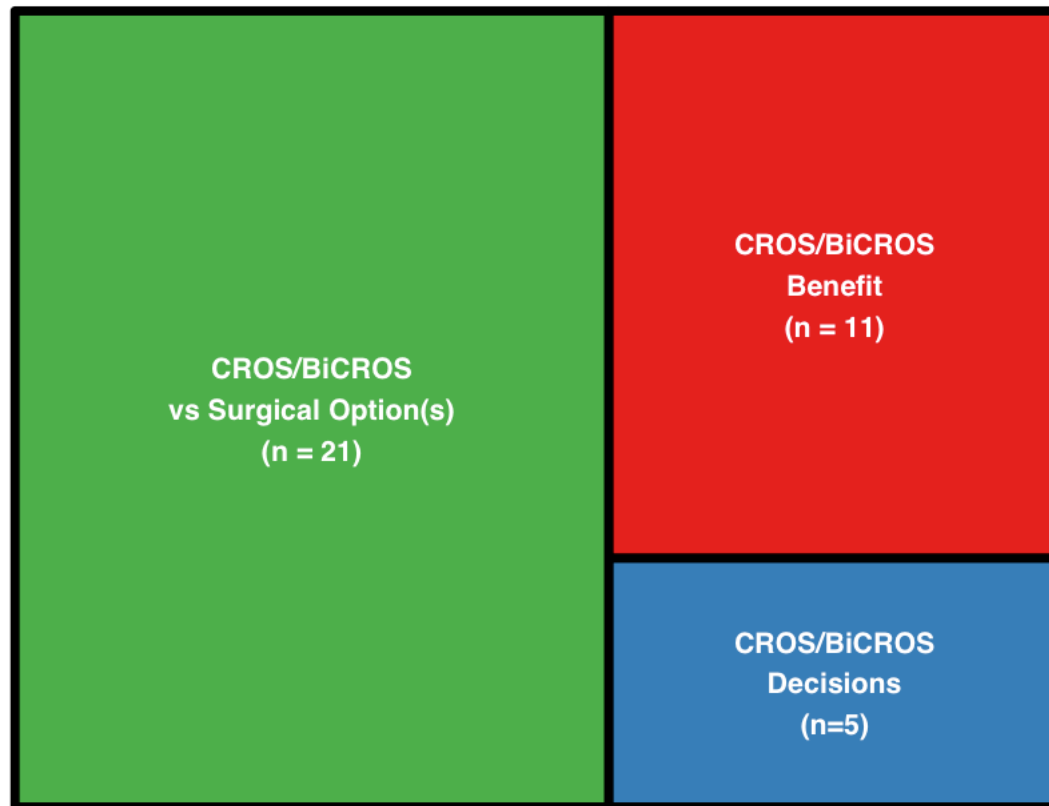


Assumption #4

“Bone conduction devices are more beneficial than CROS devices”



Evidence-base supporting CROS decisions in adults



Expected CROS and BAI benefits similar

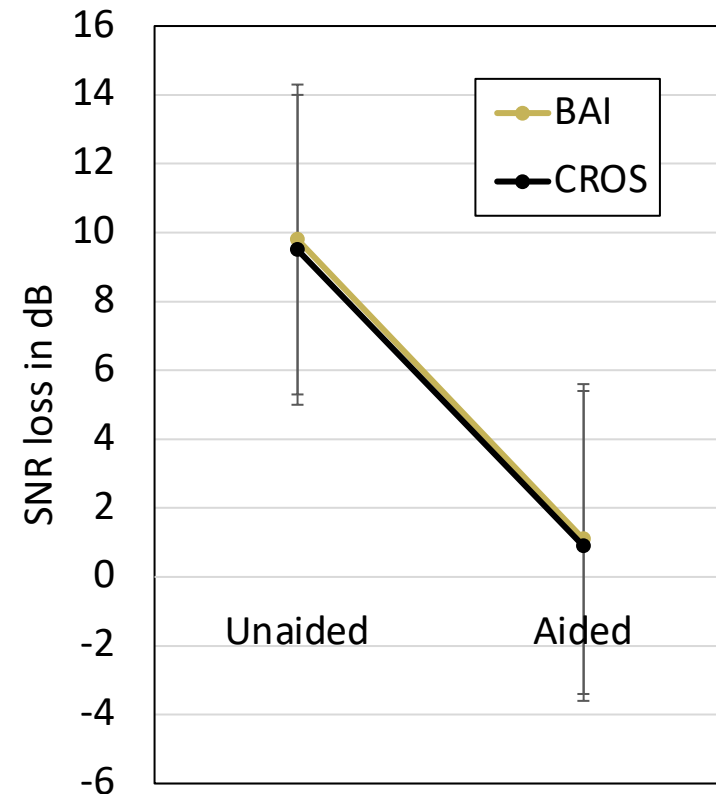
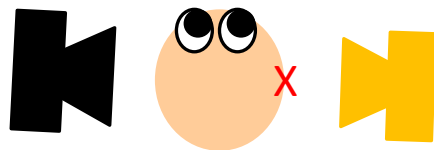
Evaluated adults with CROS or BAI experience

Localization

- No device benefit
- Large localization errors

Speech recognition in noise

- Similar benefits for CROS and BAI



Emerging reality #4

“CROS offers similar benefits to bone conduction devices, without the surgery, and can improve speech recognition and reduce residual disability.”



Recommendations from peer-reviewed research for CROS fitting in adults

Ensure patients have adequate trial period

- Variability in acceptance and use

Fit modern technology

- Benefits more robust for modern CROS systems

Activate noise reduction

- Improves subjective outcomes

Fit advanced directionality

- Ensure microphones are adaptive and can change with the situation

Provide accessible on/off switch with appropriate counseling

- Can improve benefit and make the system aids more appropriate in a variety of listening situations





Learning Outcomes

1. Describe potential consequences of unilateral hearing loss for school-aged children

Difficulties academically, with speech and language, with quality of life

2. Discuss the potential benefits of CROS systems for school-aged children

Benefits with multiple talkers, diffuse noise, and modern technologies

3. Describe potential consequences of unilateral hearing loss for adults

Difficulties with speech and language, with fatigue, with general health

4. Discuss the potential benefits of CROS systems for adults

Benefits with multiple talkers, diffuse noise, and modern technologies

Managing unilateral hearing loss: How can CROS aids help?

School-aged children

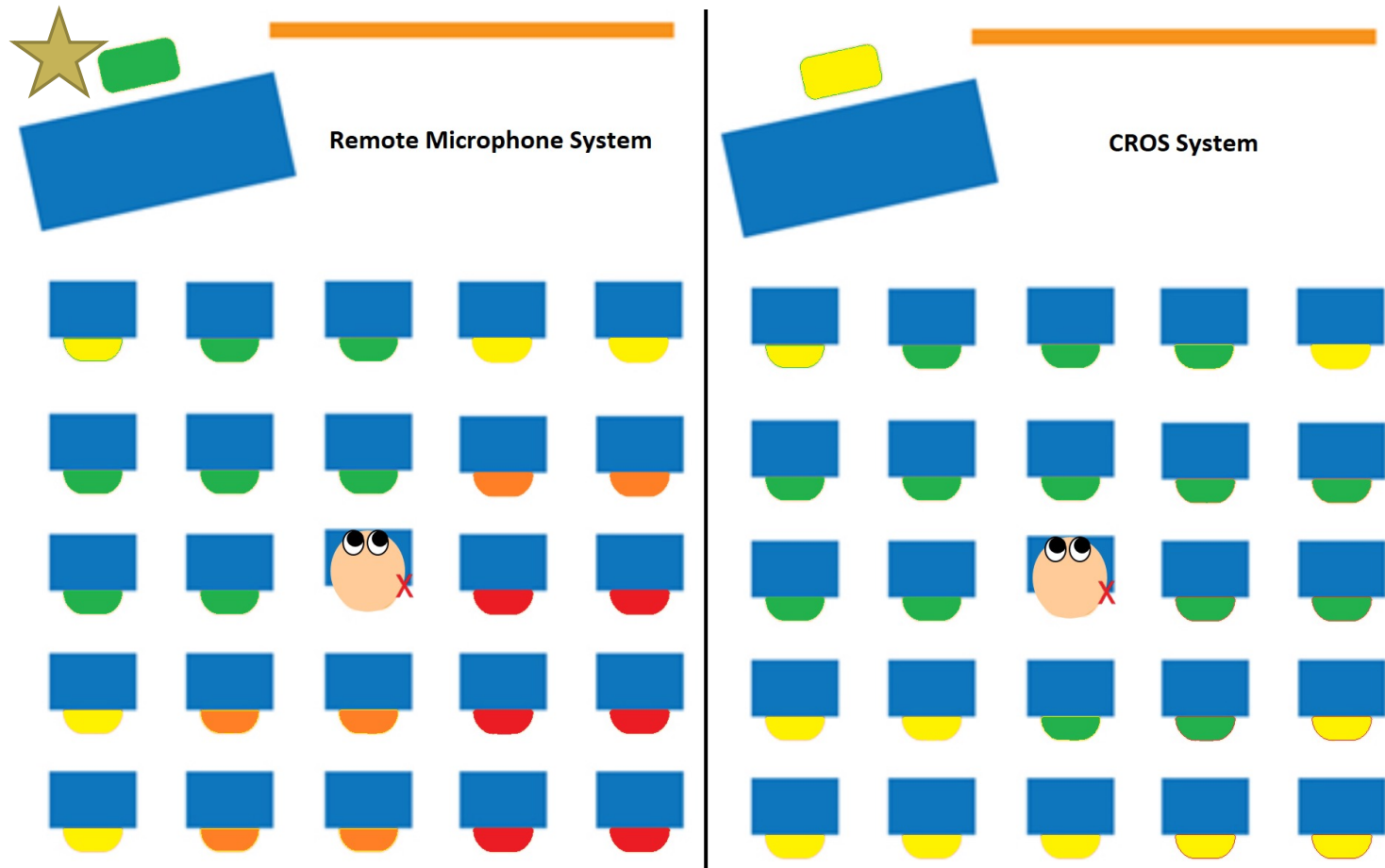
- Multiple talker scenarios
- Diffuse noise
- Prefer to not use RM system
- Older children

Adults

- Multiple talker scenarios
- Diffuse noise
- Prefer not to use companion microphone system
- Situations where bone conduction aids are being considered
- Better with an on/off switch
- Not surgical candidate



Applying laboratory data to hypothetical seating arrangement



Thank You!



Questions?