

DIRECTIONAL MICROPHONE HEARING AID USE IN SCHOOL AGED CHILDREN? NOT AS SIMPLE OF A QUESTION AS IT SHOULD BE

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Funding Provided by Grants from the US
Department Of Education and kind hearing
aid support from Phonak AG

**FM SYSTEMS ARE THE MOST EFFECTIVE
AND APPROPRIATE TECHNOLOGY FOR
IMPROVING THE SIGNAL-TO-NOISE RATIO
IN MOST NOISY ENVIRONMENTS THAT
HAVE A SINGLE TALKER OF INTEREST (E.G.
LEWIS ET AL, 2004)**

However, there are multiple school environments for which FM technology may not be optimal or desirable – but communication remains important

Directional Benefit: When is it expected?

- With a good directional HA, average adult hearing aid wearers will receive a directional advantage of **approximately 20% -35%** in cases in which (e.g. Killion, et al., 1988; Preves et al, 1999; Pumford et al, 2000; Ricketts, 2000a; 2000b; Ricketts, et al., 2001; Ricketts & Henry, 2002; Ricketts & Hornsby, 2003; Ricketts, et al., 2005; Valente et al, 2000; Voss 1997; Wouters, et al, 1999):
 - **The sound source of interest is in front and near**
 - **Competing noise surrounds the listener**
 - **Reverberation is moderate or less**
- Implication for Children? Where kids are relative to speech and noise sources – and where their head is pointed is critical when considering the potential for directional benefits and decrements.

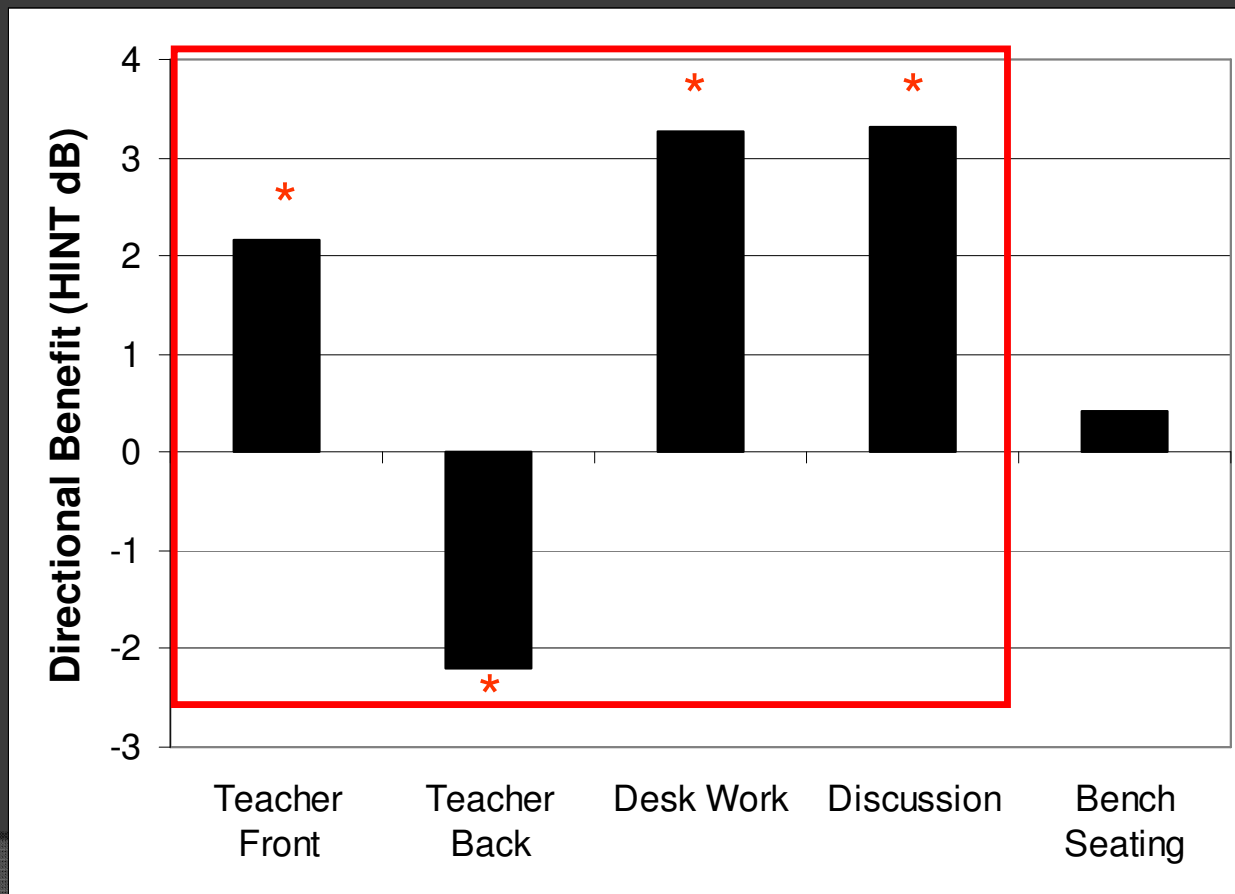
Phase 1: Potential For Directional Benefit?

- Children as young as 4 months old can and do orient their heads appropriately to sounds sources of interest 33-40% of the time (Ricketts et al., 2007, Ching et al., 2009).

Phase 2: Directional Benefit: A Little Data From Simulated Classrooms (Ricketts, Galster & Tharpe, 2008)

- 26 Children aged 10 to 17 years old (mean 14).
- 24 were past hearing aid users (none previously used directional HAs).
- All participants wore the hearing aids in fixed directional (1 month), fixed omnidirectional (1 month) and switchable (2 weeks).
- Brought in for laboratory testing in a classroom and questionnaires.

Directional Benefit: Impact of - Speaker Location



Conclusions

- ① Directional advantage in some noisy environments and disadvantage in others provides additional support that full time directional use is NOT appropriate, **even in noise**.
- ① Final recommendation for directional HA use in school aged children is dependent on confidence in appropriate switching.

Additional Questions

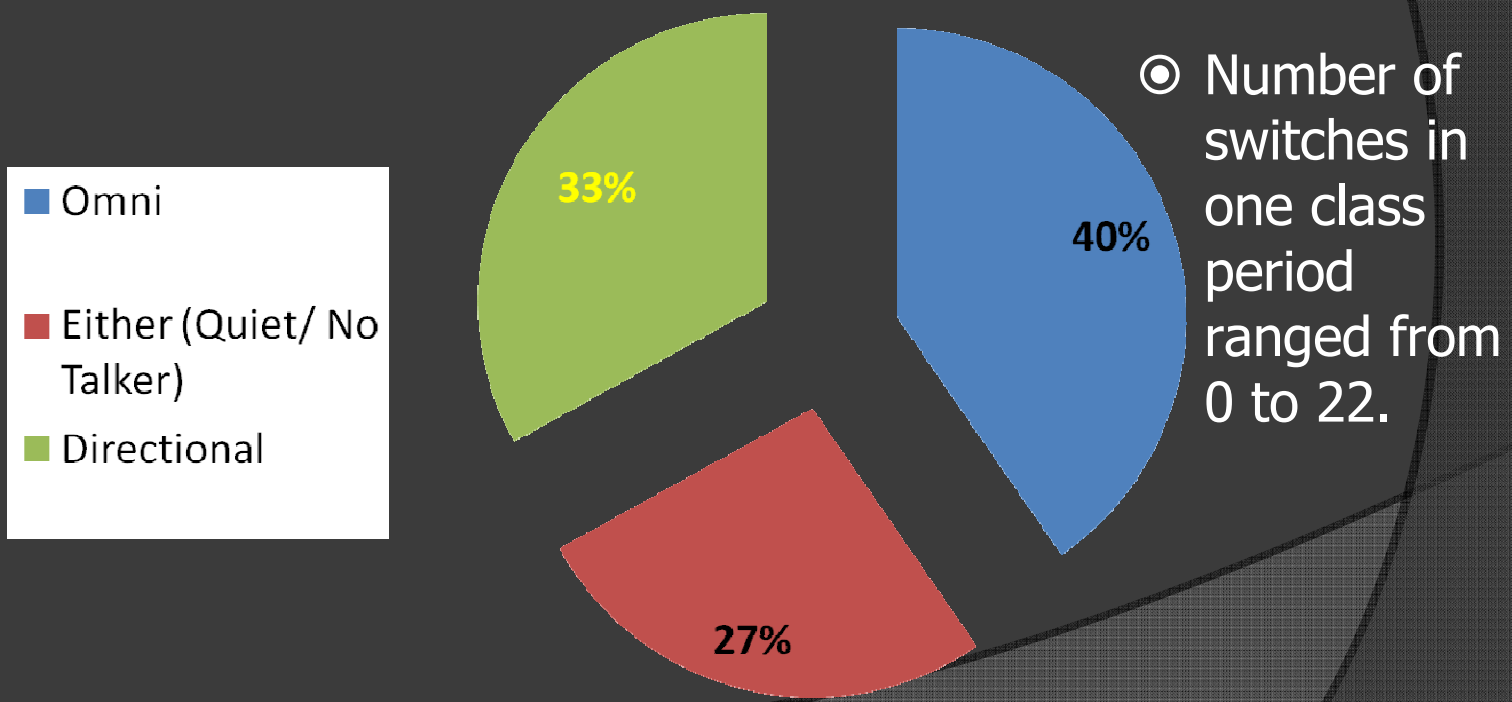
- ① The Best Switching Method?
- ① How often and in what school environments is the directional mode really appropriate?

Phase 3: Quantification of Directional Need and Accuracy of Switching Mode in Real School Environments

Assessing Appropriate Microphone Mode: The Brute Force Method

- Quantify what really goes on during the listening day in terms of:
 - Location of primary source of interest (relative to the listeners head).
 - Presence, number and location of other sources of interest.
 - Presence, number, level and location of competing stimuli (noise sources).
 - Overall level, estimated reverberation, type of listening environment.
- All estimates made whenever there was any change in the environment throughout the entire school day (including classroom, lunch, special activities, between classes, etc.)
- Estimate optimal microphone mode based on this information and our best guess as to the listeners wishes.
- Complete for different ages and children with and without hearing loss.

Portion of a Six Hour School Day (Observer Opinion) – Average (N = 27)



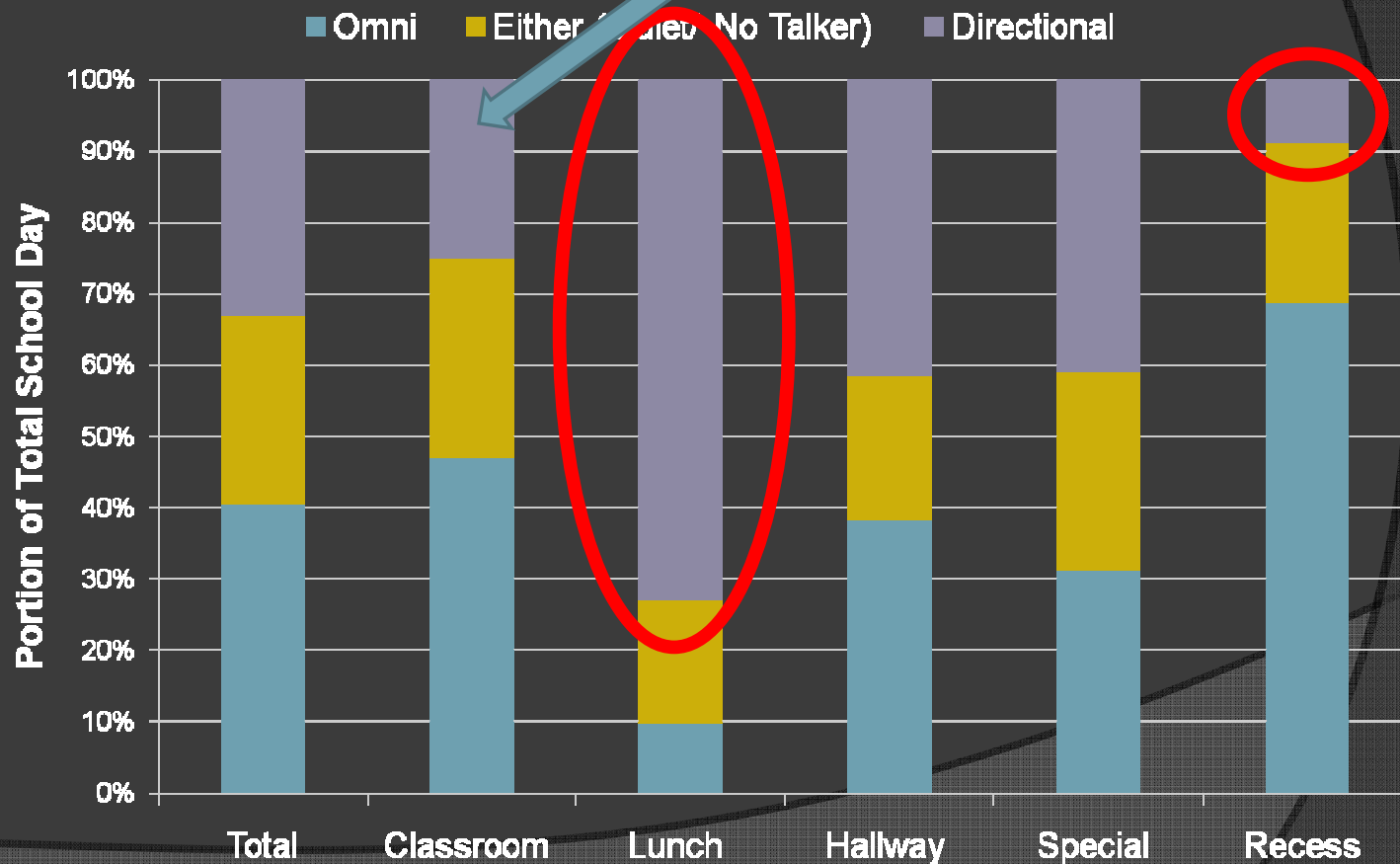
Averaged Results

- ◎ Directional advantage expected in about 1/3 of school environments measured to date.
 - Approximately the same as reported for adults (Walden et al., 2006).
 - Percentage of environments depends on the specific child, day, class type and age (10-40%).
 - Weak correlation with age – more directional environments with middle school children. More group activities with younger and older children.

Type of Environment? (Averaged Data)

FM + Omni Environmental Mic?

FM system best anyway,
but implications for overhearing?



**SO HOW DO WE ENSURE
APPROPRIATE
SWITCHING?**

Methods

- N = 24 (10 F, 14 M), Mean age 8.9 y (5 -17y)
- All children bilaterally fitted with Phonak Savia instruments set to either manual or automatic/adaptive directional modes using the DSL v5.0 prescriptive fitting method.
 - Simulated real ear gain using measured RECD values was matched to the same target values for both directional and omnidirectional modes.
- Both hearing aids coupled to a NOAHLink interface which was worn around the neck, strapped to the arm, or strapped to the chest.
- The rater following the child carried a Bluetooth enabled PDA which provided a time stamped indication of hearing aid state every 0.25 seconds throughout the day.

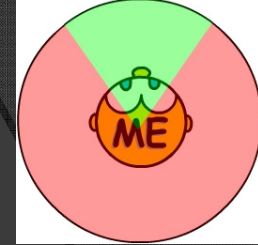
Considering Manual Switching?

- ◎ **If the hearing aid wearer will switch appropriately** this is probably the best method
 - Research suggest 30%+ adults fit with switchable never leave the default mode, even though they obtain benefit from directional (Cord et al, 2002; Kuk, 1996).
 - Older adults and young children may be even worse (or maybe better?).

Can children be taught to manually switch mode?

- If so at what age.
 - Data suggest many children aged 10-17 report switching between microphone modes (Bohnert & Brantzen, 2004), but appropriateness of switching is unclear.
- Training with age appropriate examples using the Phonak WatchPilot remote.
- How well does the optimal microphone mode as determined by the rater agree with the actual microphone mode of the hearing aid in manual switching situations?

Example of Age Appropriate Training Materials



- In this classroom you can see that the teacher is talking and your classmates are behind you making lots of noise. Notice that you are looking right at the teacher. This is a good time to use your two-beep setting.



Results from 24 Children: Agreement in the Manual Mode

- Fourteen participants never left the omnidirectional mode
 - Other than to show the observer they could
- Five participants switched at least twice during the day. Number of switches ranged from 3 to 8 over the entire day and appeared to be at least moderately appropriate.
 - All were between 11 and 17 yo
- One second grader switched to the directional mode during the beginning of Gym class (approximately mid-morning) and left the hearing aids in that mode for the remainder of the day.
- Four students (6, 8, 9 and 10th grade) switched to directional mode at the beginning of the day and left it there.

Why Are Children Not Manually Switching More “accurately”?

- ⦿ Cannot remember to accurately do so?
- ⦿ Too lazy?
- ⦿ Too hard given the young age of some?
- ⦿ Don't notice enough benefit to warrant the hassle?

- ⦿ Prefer a single mode (either directional or omnidirectional) for full time use?

Consider Asymmetric?

- Bilateral fitting with omnidirectional mode on one ear and directional on the other.

Asymmetric Fitting:
O/D or D/O

Omni



Directional

Negative Effects of Asymmetric Microphone Modes?

- ⊙ Some support for asymmetric fitting (Bentler et al., 2004; Cord et al., 2006)
- ⊙ However, in more realistic listening environments – Often some degradation in speech understanding (Mackenzie and Lutman, 2005; Hornsby and Ricketts, 2006)
 - **Average** asymmetric “deficits” ranged from 1.5-4.4 dB depending on noise configuration
- ⊙ Our newest data in school environments suggests a 1.1 dB deficit (although a benefit compared to the “wrong” mode).

Clinical Implications

- ⦿ May be some interesting automatic applications, but doesn't look optimal for full time.
- ⦿ However, full time asymmetric fittings appear to be useful for some individuals
 - Those unable or unwilling to use a manual switch and already fitted with one (Cord et al)

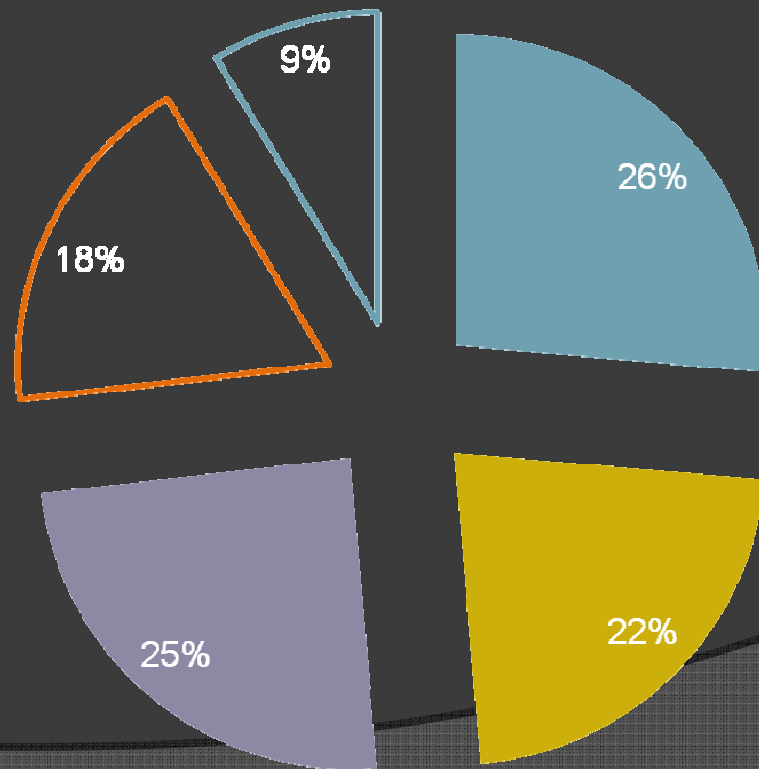
However...

- Given that optimal performance in many reverberant environments will occur when using a symmetric microphone mode (either omni/omni or directional/directional) automatic may be preferable to asymmetric for the average patient if switching accuracy is good enough.

**CONSIDERING
AUTOMATIC SWITCHING?**

Our Averaged Data to Date in Children (N = 24)

■ Agree-O ■ Agree-D ■ No Talker ■ Disagree-HAO ■ Disagree-HAD



HA – O, Observer – D (18% of Errors) : Why were mistakes made?

- ⦿ Main talker position, always front
- ⦿ Noise from various angles (commonly back and surround)
- ⦿ Noise and reverberation levels moderate
- ⦿ Hearing Aid Classifier – Highest probability of speech in quiet.
- ⦿ Conclusion: The few distracting talkers mis-quantified as signals of interest.
 - To be correct the hearing aid would have to switch more aggressively (especially for softer input levels), or know listening intent

HA – D, Observer – 0 (9% of Errors): Why were mistakes made?

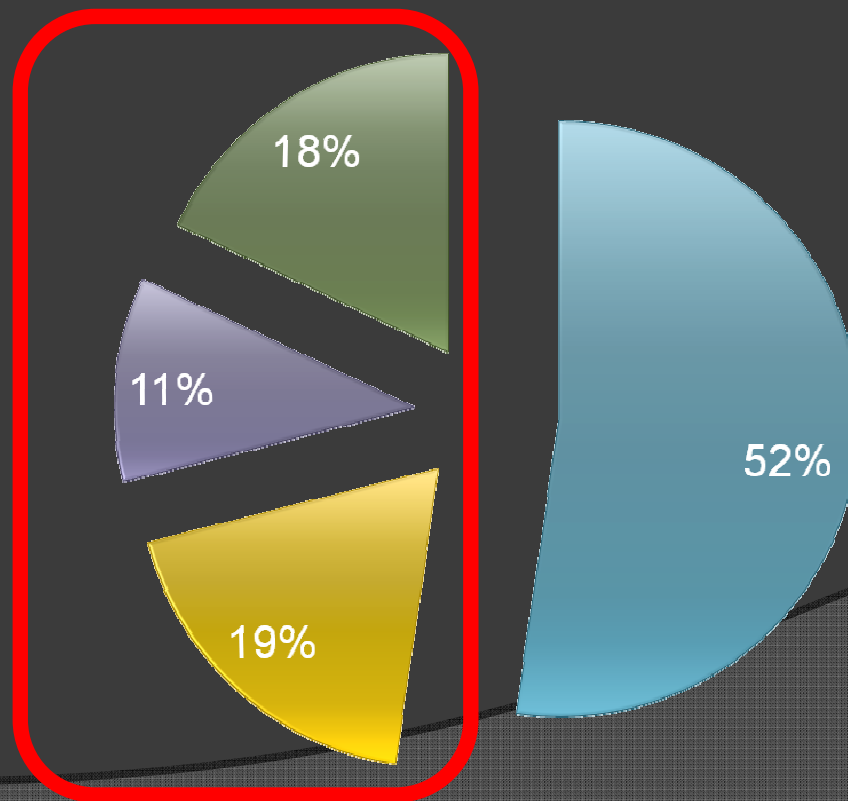
- ⦿ Noise from various angles (commonly back and surround)
- ⦿ Noise and reverberation levels moderate
- ⦿ Hearing Aid Classifier – Highest probability of speech in Noise.
- ⦿ Main talker position?

HA – D, Observer – O: Effect of Main Talker Position

■ Front ■ Side ■ Back ■ Multiple

48% of the time the error resulted from not allowing for overhearing

Is there a fix?



Automatic Switching Accuracy: The Bottom Line?

- ⦿ Accuracy is moderate to good overall, but perhaps this particular system could be made slightly more aggressive.
- ⦿ To correct the majority of mistakes the hearing aid would have to know the listeners intent
- ⦿ Implications for improved automatic accuracy based on acoustic input?
 - Algorithms that allow for adjustment of how aggressively they switch based on individual patient needs may hold promise.
 - Switch at lower levels? Individually selected SNR based on “crossing a border”?
 - Algorithms that switch based on the direction of the speech signal?

ARE DIRECTIONAL HEARING AIDS APPROPRIATE FOR MANY SCHOOL AGED CHILDREN?

Yes, Probably with automatic – but monitor closely.

For some of our subjects this was the “best ever”

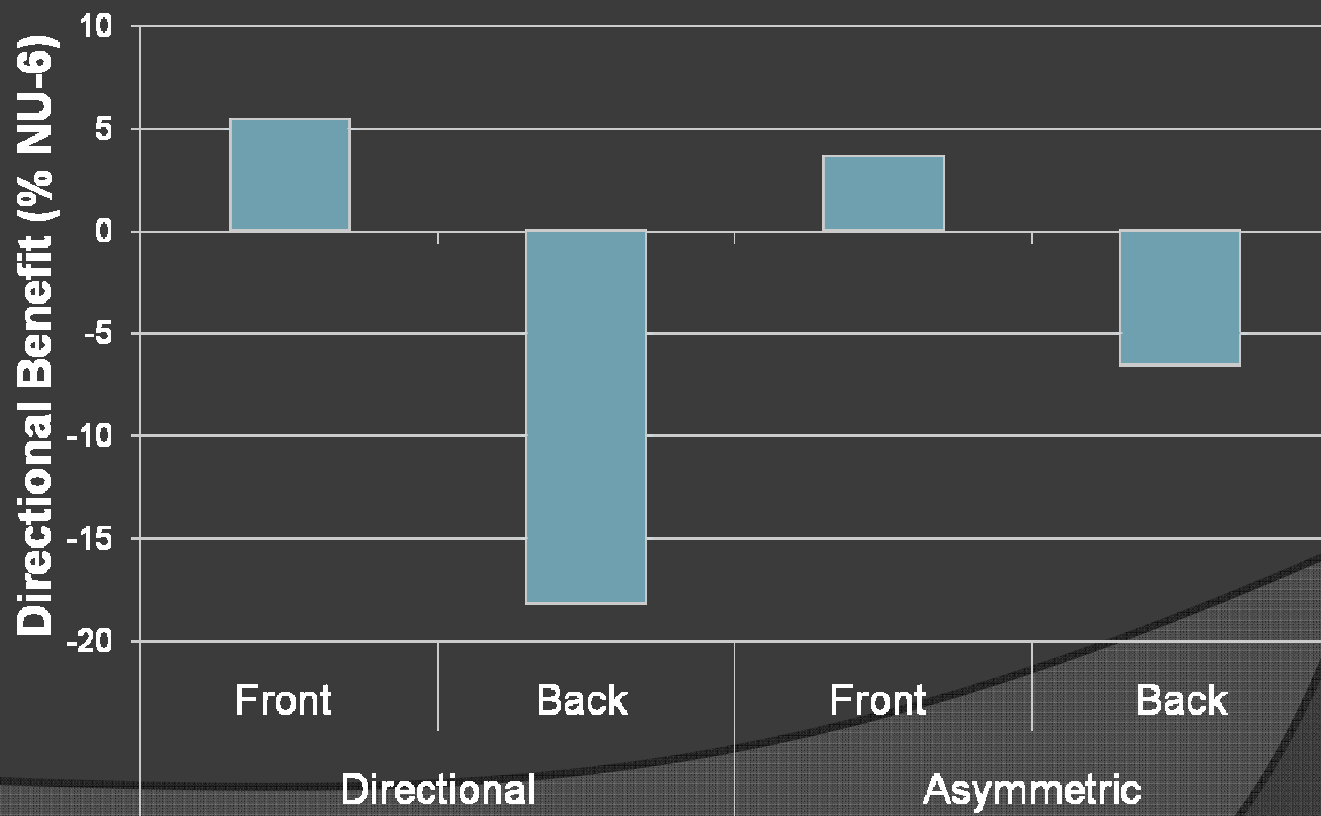
The biggest concern related to directional microphone use in kids remains the missing of important listening and learning opportunities from overhearing when in directional mode.

Counseling regarding use (e.g. point your nose at the talker) is probably critical!

The Importance of Overhearing: Is Being Able to Orient to Sounds Enough?

- ◎ Overhearing and learning?
 - Learning from overhearing is clearly important including being important for social development (Akhtar, 2005; Forrester, 1993; Rogoff, Mistry, Göncü, & Mosier, 1993)
 - Children appear to learn novel words even when not “paying attention” (Moeller et al., 2009).

Directional Benefit in an “Overhearing” condition: 12 Kids, Equal # of Front and Back Presentations



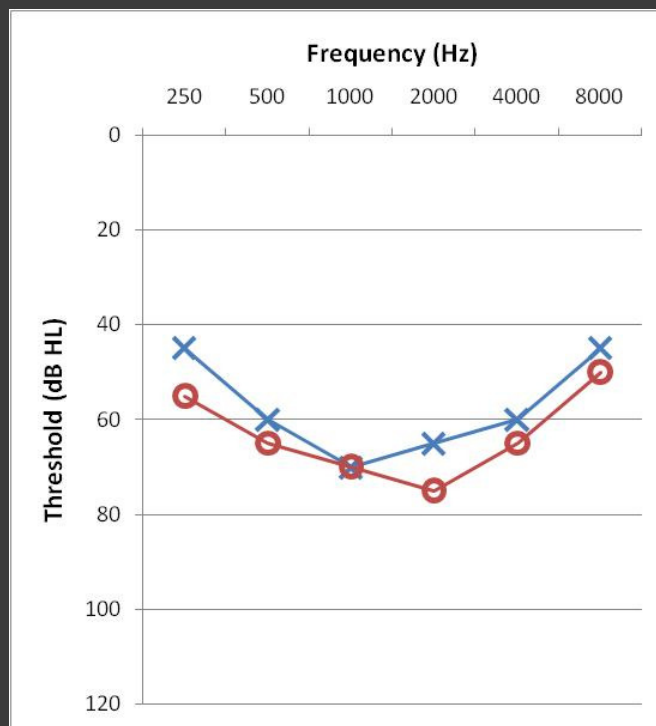
A Little Indirect Evidence that Overhearing is Important To Listeners – After 1 Month Trials (Ricketts et al., 2008)

- 16 questions which focused on situations in which the directional microphone was expected to be beneficial or detrimental.
 - 10 point scale from easy to very difficult
- Completed by both children and parents “separately”.
- Only two questions came out significantly different (approximately 1 rating point) – though they were consistent across parent and child.
 - Both involved listening to someone behind - the directional mode was rated as poorer.

How Does Concern for Not Overhearing Effect Switching Recommendations?

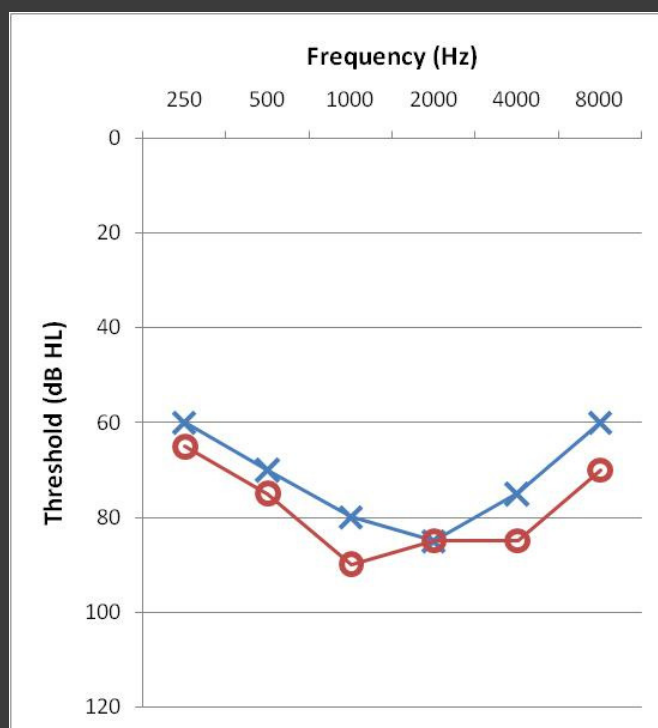
- Given the negative reaction to “directional deficits” occurring in noise we recommend...
- Automatic directional in program 1, **OMNI** in program 2
 - Instruct to go to program 2 “if you are having difficulty hearing someone who is not in front of you”
- But this doesn't always work!
 - A few clinical examples

A Few Outliers: Individual Differences Matter! Patient JC (12 yo female)



- Congenital sensori-neural loss
- Aided HINT-C score +9 dB
 - Considerable trouble understanding speech in noise
- Preferred setting?
 - Full time equalized directional (also uses FM)
 - “I can’t understand as well in the other setting”

A Few Outliers: Individual Differences Matter! Patient LW (19 yo female)



- Congenital sensori-neural loss
- Aided HINT-C score +4 dB
 - Limited audibility, but good understanding speech in noise
- Preferred setting?
 - Full time omni, with directional in program 2 and heavy FM use
 - “I constantly miss talkers I can’t see in the other setting – I don’t even know they are talking to me”

A Few General Clinical Considerations When Considering Directional HAs

- Can the patient understand some speech in noise without visual cues (people behind them)?
 - If so, they may prefer full-time omnidirectional mode
- Are off-axis voices or environmental sounds important to the individual? If so, is audibility for these sounds limited even in omnidirectional mode?
 - If so, they may prefer full-time omnidirectional mode.
- Are off-axis voices relatively unimportant to the individual (can't understand them regardless) – and speech recognition is so poor that speech recognition in noise requires the directional mode?
 - If so, they may prefer full-time directional mode (or FM).

Final Thoughts for Discussion

- ◎ Directional for school aged children?
 - Potential benefit for development of a test method to help determine:
 1. SNR/Level for optimal switching?
 2. Candidacy for children that might prefer full-time directional or full-time omnidirectional?
- ◎ Overhearing and possible implications for directional hearing aid use in very young children?
 - Is FM + an omnidirectional environmental microphone generally preferable to a directional hearing aid due to overhearing advantage?

THANK YOU!



Questions?